



Helicopter safety offshore

**OFFSHORE TECHNOLOGY REPORT
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FOREWORD

This report is based on a dissertation *Helicopter Safety at Offshore Installations* submitted by the author in part-fulfilment of the degree of Master of Science in Safety Engineering, Reliability and Risk Assessment at the University of Aberdeen during November 1999. The report has been substantially revised and updated to include more recent information. Helicopter accident and statistical information was provided by John Burt Associates and from International Civil Aviation Organisation, CAA, HSE and other records. Several pilots and ex-pilots volunteered their views. Captain Mike Ginn of Consultavia Ltd, in particular, gave considerable assistance.

The study provides background material about helicopter accidents offshore throughout western Europe not previously summarised elsewhere, a review of relevant reports and a bibliography of reference material and associated research. Conclusions are drawn by the author from this information and from his own experience of working offshore as an Offshore Structural Design Engineer and later as an HSE Inspector.

Since the original report was written, a major study carried out by SINTEF of Norway on behalf of seven oil companies and the Norwegian Civil Aviation Authority has been published. This study, *Helicopter Safety Study 2* (1), was carried out independently at the same time as the dissertation was being prepared. Although the present report does not incorporate a detailed review of the Norwegian work, the concept of risk influencing factors, ie conditions affecting risks to helicopter passengers, aircrew, helideck crew and offshore workers on an installation, is common to both. The conclusions of the two studies are broadly similar.

The Health and Safety Executive of Great Britain (HSE) encouraged the author to undertake this project and made time available for research as part of his work as a Specialist Inspector with HID Offshore Division (OSD).

I believe I have obtained a consensus view. However, the opinions expressed are my own and should not necessarily be taken to represent those of the individuals and organisations who contributed.

A handwritten signature in black ink that reads "Graham Morrison". The signature is fluid and cursive, with "Graham" on the left and "Morrison" on the right, connected by a single stroke.

Graham Morrison

SUMMARY

Helicopter travel to and from offshore installations generates one of the main sources of risk for offshore workers. Particularly on more modern installations where other risks are low, helicopter transport may be the dominant risk.

This study by Graham Morrison of the Health and Safety Executive, with support from Aberdeen University, John Burt Associates and Consultavia Ltd, and after discussion with pilots, ex-pilots and workers offshore, provides background material about offshore helicopter accidents throughout western Europe not previously summarised elsewhere, a review of relevant reports and a bibliography of reference material and associated research. After establishing the history and the current status of helicopter safety and the regulatory environment, the report examines how helidecks are designed and the influence on helicopter safety of the types of operation being carried out on an installation.

Risk reduction over time has occurred, as for other forms of air transport. The accident rate for medium sized rotorcraft – the type of helicopter most in use offshore - has reduced considerably over the last few years. About one hundred helicopters operate to offshore installations from the countries bordering the North Sea. Over 500 take-offs and landings take place every day, amounting to some 100,000 flights every year. The incidence of accidents is very low and risks to passengers are now comparable with flights in similar fixed-wing aircraft. The five-year moving average of fatal accidents has reduced from 0.8 per 100,000 flights before 1985 to less than 0.2 today. The number of reported incidents has similarly reduced over the period.

Although the overall trend is downward, the extrapolation into the future of relatively low accident figures from a small sample period should not be taken for granted. There are currently considerable economic and other pressures on installation and helicopter operators and their staff that could eventually have an effect on safety.

Risks from helicopter travel are shown in safety cases that Installation Duty holders produce for assessment and acceptance by the Health and Safety Executive's Offshore Safety Division to be one of the higher ranking risks, alongside occupational risks, ship collision and fire and explosion from hydrocarbon releases from drilling, topsides processing, etc.

The risks from helicopter travel are:

- risks to personnel while they are in the air (passengers and aircrew) from collision impact, fire or drowning
- risks to personnel onboard an installation due to helicopter impact with the installation and possible hydrocarbon events such as helifuel fires escalating to fires and explosions elsewhere.

Accident statistics show that 145 people died in western Europe during the last 30 years in 19 separate helicopter accidents related to work to produce oil and gas offshore. In 14 cases, helicopters crashed in the sea, killing all or most of the people on board. The most serious accident was the Chinook crash off Shetland in 1986 that killed 44 people. The most recent helicopter accident offshore was to a Super Puma flying to the Norne field in the Norwegian sector of the North Sea in 1997. The aircraft crashed as a result of a progressive mechanical failure due to vibration, killing all 12

passengers and crew. There have been no fatalities in the UK sector from helicopter accidents since 1992.

Seven accidents occurred within the 500 metre zone around an installation. Four of these involved personnel onboard visiting helicopters:

Cormorant A, 1992 - shuttle flight to nearby flotel - 11 people killed

Ekofisk, 1991 - main rotor struck flare - 3 killed

Brent Spar, 1990 - helicopter hit crane while manoeuvring to land - 6 killed

Forties, 1976 - tail rotor failure - crash landing on helideck - 1 killed.

Three separate accidents were to helideck crew on installations during helicopter turnaround between landing and taking off. One accident occurred onshore in the air above a heliport, killing the pilot and co-pilot.

Causes of accidents can be divided between aircraft mechanical failure and human factors, usually pilot error. Historically, most fatalities to passengers and crew have been from drowning as a result of mechanical failure leading to aircraft ditching in the sea.

In recent years, aircraft systems have become more reliable and a greater proportion of accidents can now be attributed to human error. Nearly all accidents can be traced back to show a human factors contribution at the operational, maintenance, manufacturing or design stage.

Helicopter landing areas, whether on land or offshore, require areas suitable for lift-off, for the airborne part of the take-off manoeuvre and for touchdown. Offshore, the take-off and landing areas are co-located and there is no run-on area. Such an arrangement produces the smallest area overall where a helicopter can operate. (Most onshore heliports have one or more FATOs linked to an apron or parking area. In the most sophisticated situations onshore, ie at heliports alongside airports, there are separate take-off and landing areas, and runways nearby.)

CAA and HSE have carried out research together to examine the environmental effects of exhaust gases and wind turbulence on helicopters during landing and take-off. A report is available as CAP 99004 *Research on offshore helicopter environmental issues*.

Future improvements in helicopter safety offshore are most likely to be achieved through continuous improvements to:

- the design of helicopters by aircraft manufacturers
- increased use of helicopter onboard monitoring systems such as HUMS
- improved maintenance of aircraft
- influencing human factors that affect the behaviour of aircrew, helideck crew, radio operators, logistics staff and others
- designing and operating helidecks to take full account of operations on an installation.

The Chinook accident in 1986 was the driver for the voluntary introduction of HUMS (health and usage monitoring systems) by oil companies in the UK sector to monitor vibration in helicopters travelling offshore. This measure is considered by many experts to be the most significant advance in aviation safety in recent years.

Improving communications between Helicopter Operators and Installation Duty holders and with helicopter manufacturers and designers of installations is probably the most important way to reduce the risks from helicopter travel even further.

Health risks from the uncomfortable levels of noise and whole-body vibration to which aircrew and passengers in helicopters and helideck crew on installations are exposed may require research to be carried out into the possible long-term effects.

Welfare issues may also require further attention. Helicopter travel is perceived by many offshore workers to be one of the most hazardous and stressful parts of their job. Anything that can reasonably be done to reduce travel risks and to improve the welfare and comfort of passengers, including using new and quieter types of helicopter with more reliable control and operating systems and lower noise and vibration levels, seems likely also to improve the morale of workers and their perception of the risks of working offshore.

Industry investment in new helicopters can not be delayed much longer, given the advanced age of many aircraft in use offshore. Several types of helicopters still in use are older designs that are no longer manufactured, and so do not reflect the technological advances that have been made over the last few years. (No new S61s have been built since 1980, for example, although many are still in service for North Sea passenger transport.) Improvements should be possible to the health and welfare of people working offshore by using the more advanced types of aircraft now coming into service.

In deciding whether to invest the considerable sums of money involved in buying new models of helicopter, the benefits to staff in terms of improved health, safety and welfare should be considered alongside the reduced operating costs that can be expected.

ACKNOWLEDGEMENTS

I am gratified that the Health and Safety Executive of Great Britain and the University of Aberdeen consider *Helicopter Safety Offshore* to be worthy of dissemination to a wider audience within the offshore industry, its workforce and others with an interest in offshore safety.

The author acknowledges the great help and advice given to him in aviation matters by:

- John Burt of John Burt Associates for providing much of the accident data and commenting on helicopter safety and maintenance procedures
- John Hopson of CAA for his advice and comments on the aviation regulations
- Mike Ginn of Consultavia Ltd for reviewing the draft and giving many helpful comments from his years of aviation experience as a pilot, as Manager of Helicopter Operations for a major operator and as an aircraft consultant.

Bill Quinn of the Marine and Aviation Operations section of Offshore Division at HSE provided advice on the safety regulations applying to helicopter operations at offshore installations.

Professor Michael Baker at Aberdeen University taught that reliability analysis based on a few simple concepts is a powerful mathematical tool to update our views on the probability of system failure as more information becomes available.

My wife, Helen Haggerty, helped me enormously with her support and encouragement.

Finally, I should like to thank all those people from the offshore workforce who were prepared to speak to me about their experiences of flying and working offshore.

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1. INTRODUCTION

Risks are assessed both to people travelling to offshore installations by helicopter during take-off, while in flight and landing, and from helicopter accidents while they are on an installation. Figure 1 shows a helicopter coming in to land on a fixed installation.

The study consists of a search and evaluation of the available literature and incident data obtained from HSE, CAA and John Burt Associates. Accident and injury information is summarised and categorised in section 2 and reviewed and analysed further in section 3 in the light of the author's experience. The author has worked as an offshore structural design engineer on a number of major offshore projects since 1983. He is now a Senior Structural Inspector with the Offshore Division of the Hazardous Industries Directorate of the Health and Safety Executive in Aberdeen. As far as he is aware, no summary has previously been made of helicopter accidents relating specifically to travel to offshore installations.

The emphasis is on European offshore helicopter operations, and particularly in Great Britain. Europe is defined for the purpose of this study as western Europe - the European Union and EFTA countries. Many helicopter flights also take place every day in the Gulf of Mexico and other oil-producing regions. Western Europe is a fairly homogenous world region with common standards, where an overall assessment can reasonably be made of the risks involved in helicopter travel.

The regulations governing the safety of helicopters while landing and taking off on helidecks on offshore installations are summarised. Findings are noted of studies that have examined the effectiveness of the interface between HSE and CAA, the two bodies responsible for enforcing the safety regime in Great Britain. These are summarised in section 4.

In Great Britain, the Health and Safety Executive (HSE) for offshore installations and the Civil Aviation Authority (CAA) for aircraft activities are the principal regulatory bodies. Other government agencies involved in the regulation of helicopter operations offshore include the Department of the Environment, Transport and the Regions (DETR) (including the Coastguard and Marine Safety Agency), the Department of Trade and Industry (DTI), the Environment Agency (EA) (in England and Wales) and the Scottish Environmental Protection Agency (SEPA).

All types of civil helicopters require to be certificated. This is done by CAA in the United Kingdom, sometimes by recognising certificates issued in other countries. All UK helicopter operators must also obtain and maintain an Air Operator's Certificate involving ongoing monitoring of their standards of operation by CAA.

This report indicates factors that can affect the final approach of a helicopter and the conditions immediately after take off. A later section discusses the dynamic response of the helideck during landing. How it might be possible to include some of these factors in a more rational method of helideck design based on a synthesis of reliability methods with existing codes and standards is described.



Figure 1: EH101 helicopter landing on a fixed platform
(photograph courtesy of European Helicopter Industries Ltd)

Aims and objectives

The objectives of the study were to:

- Summarise all reported helicopter accidents involving fatalities in connection with operations to offshore installations in western Europe
- Note significant factors and effects that may have influenced the accident rate
- Summarise the major injury events
- Note in which countries and sectors of the North Sea accidents occurred
- Compare the accident rate for each category of personnel affected - passengers, aircrew and helideck crew
- Summarise in which phases of a flight the accidents happened - at the heliport, in the cruise or at or near an installation
- Compare the number of people killed in helicopter crashes in connection with offshore petroleum operations with the total from all causes for the sample period 1991 to 1999
- Consider the effects that the layout and design of the topsides of an installation may have and how these factors can influence the overall level of safety
- Consider the adequacy of current regulations on helicopter safety offshore UK
- Assess the adequacy of structural design methods for offshore helidecks.

Background

There have been 19 fatal helicopter accidents occurring as a result of helicopter flights to and from offshore installations in western Europe (2). In 16 cases, the initiating event for the accident happened while the aircraft was in flight and resulted in the deaths of the people onboard. Seven accidents occurred within the 500 metre zone surrounding an installation, where the design of the installation might conceivably have contributed to the accident. Of these, three accidents involved personnel onboard the installation, all helideck crew. One person was killed in each case.

A detailed and quantitative assessment of the data indicates such important factors as the risks from each phase of the flight - onshore, in the cruise or near an offshore installation and whether the personnel affected are crew or passengers. The study puts numbers to these occurrences. A fuller analysis is given in Section 2.

The environment around an installation arising from physical obstructions such as cranes, drilling derricks and flares may be an important influence on helicopter performance. Helicopters may operate near an installation in air affected by wind turbulence and turbine exhaust and cold gas venting, where these are not properly controlled (3). The loads applied to the helideck are critically dependent on the behaviour of the helicopter as it lands or makes a rejected take-off. By adversely affecting aircraft behaviour in flight, environmental factors can change the normal landing loads.

Critical factors affecting safety when helicopters land and take off offshore are those that affect performance in the closing gap between the helideck and the helicopter in the air before it begins to be supported by the landing structure. The interaction between the undercarriage and the helideck at touchdown is important in determining the load capacity of the combined system. This is a relatively complex dynamic issue. Rather than a simple deterministic evaluation, a reliability analysis might be suitable in

order to try to take account of the wide range of landing loads and structural response that is possible.

Helicopter maximum landing loads given in current guidance and used in design are based on relatively arbitrary criteria related to specified drop-heights and are intended to produce aircraft velocities at touchdown of 1.8 and 3.6 metres per second for the defined 'normal' and 'emergency' landing cases, respectively. (These values compare with landing velocities in the most common operating conditions offshore that can be measured in centimetres per second.) The emergency landing condition governs the structural design of the helideck (4, 5).

The proposed ISO code for Offshore Structures, which includes the section dealing with Topsides Structures, is currently being drafted (6). The intention is to harmonise standards worldwide. The Topsides part of the code includes a section on the design of helidecks. Where possible, the intention is to relate aircraft design criteria, particularly undercarriage design, to the structural design of helidecks for all types of installation - fixed steel, fixed concrete, floating systems and Arctic structures.

Human factors, most notably those associated with pilot error, are of the greatest importance. Minor difficulties for the pilot, including some distractions, may result in little more than slight mishandling of the controls, for example in response to wind gusts. More severe effects could be the root cause of a major accident. Although pilots are trained to fly in fog and darkness, more difficult flying conditions will occur in a reduced visual cue environment. In combination with other factors, these may affect a pilot's ability to make a safe landing or departure.

The offshore safety case regulations for offshore installations made under the Health and Safety at Work Act (7), require operators and owners to identify risks, carry out a risk assessment and implement any control measures necessary to reduce these to as low as is reasonably practical (ALARP) (8). The Installation Operator is also responsible under the Design and Construction Regulations (9) for ensuring that decks are designed and built to suitable standards and their construction is verified by an independent and competent person.

Traditionally, aviation standards are set out in an almost completely prescriptive manner. Helicopter Operators may wish to use a particular type of helicopter, but it is not they who set the performance standards for their helicopter operations, but the helicopter manufacturer, working with the aviation regulator to define parameters such as the maximum gross weight and cruise speed. This is in contrast to the risk-based goalsetting approach now in use for performance standards for offshore installations, which are generated by the Installation Duty holder (9) before being submitted to the regulator for comment and eventual acceptance or not.

To date, Installation Duty holders have not defined cases of emergency landing or helicopter crash in any other way than using the criteria set out in existing helideck design guidance, such as that included in CAP 437 (10). As with ship design, most aviation standards are 'rules' derived from years of experience. As with all prescriptive standards, there may be cases that are not fully identified for a particular installation or set of circumstances. The rules are updated as more information becomes available.

When compiling Safety Cases for offshore installations, helicopter crashes on to an installation are generally considered as residual accidental events. Quantitative risk analysis often discounts these from further consideration on the grounds of their very

low probability of occurrence. There have been no accidents where a helicopter has collided directly with an installation. In a few cases, a helicopter has collided with a minor structure, but this has not escalated to cause major damage to the installation. Regulations are examined further in section 4.

Use of helicopters offshore

A large industry to exploit offshore oil and gas resources has developed since the 1960s. There are now over 200 fixed platforms and over 50 jack-ups and semisubmersible rigs in the waters around the United Kingdom. There are also many installations in the Norwegian, Danish, Netherlands and neighbouring sectors of the seas around Europe.

Offshore installations may be steel jacket or concrete structures, jack-ups or semisubmersibles, and are positioned from within about 40 miles offshore to over 300 miles out into the northern North Sea. There are several FPSOs (floating production storage and offloading systems), including in the very harsh metocean environment west of Shetland, where high waves and strong winds and currents prevail for much of the year.

Helicopters are the normal means of transport for personnel to and from offshore installations due to their speed, convenience, flexibility of operation and use in even rough weather. Apart from these considerations, helicopter transport may be healthier and less hazardous in terms of reduced travel sickness and easier personnel transfer onto an installation compared with travel on ships.

One Installation Duty holder has recently proposed to introduce in-field helicopters to replace standby vessels. The company asserts that safety standards in rescuing people would not be compromised as a result, and should even be improved. The proposed BP "Project Jigsaw" would use dedicated Super Pumas, based on a number of platforms offshore, along with one each at onshore bases in Aberdeen and Great Yarmouth. BP said: *The proposal offers staff a maximum of 90 minutes rescue time in all weathers and offshore trials have verified these timings.* (11)

The proposals are currently out for consultation with standby vessels operators, trade unions, the workforce generally and other interested parties. The matter has been raised in the UK and Scottish parliaments and has created a great deal of controversy. The General Secretary of the oil workers' trade union, OILC, claims that BP's proposals *constitute the most fundamental change to offshore health and safety since the Cullen enquiry.* He notes that *An integrated comprehensive rescue and recovery system which provides the best possible prospects of recovery would gain workforce support. Surely this can only be obtained with helicopters and standby vessels, the one complementing the other's shortcomings* (12). He sees the consultation process as a test of the industry's readiness to fully engage with the workforce on safety matters generally.

In the Norwegian sector, it is common practice for helicopters to take the place of standby vessels (SBVs). At present, SBVs are in use around offshore installations in the British sector, although some sharing of facilities already occurs.

Crew changes are normally required at the end of two or three week shifts. Staff also need to travel offshore on less regular trips to carry out particular tasks over shorter periods. Equipment may need to be transported quickly offshore by helicopter, rather than by the more usual and slower supply boat. In an emergency, helicopter transport is

the preferred mode of evacuation of an installation and may need to be performed in very bad weather.

There have been about five million flights and over 50 million passenger movements in the UKCS since oil exploration began. Installations in the UK sector are served by helicopters travelling from Aberdeen and Shetland (Sumburgh and Scatsta) in Scotland and from Great Yarmouth, Humberside and Blackpool in England.

Types of helicopter commonly in use for long distance flights from shore include the Eurocopter Super Puma SA332 and Sikorsky S61 and S76. Chinooks are no longer used for transport in the offshore industry anywhere in Western Europe, though still in use by the military. A Royal Air Force Chinook Mark II (the Sumburgh crash off Shetland in 1986 was of an earlier model) crashed on land in 1994 after coming in over the sea to the Mull of Kintyre (also in Scotland), killing all 29 people on board.

Pilot error was eventually found to be the cause following investigations at the time. However, a number of commentators have raised doubts about this verdict, suggesting that a mechanical failure following a software error in the aircraft's FADEC engine control system, was more likely (13). Safety Engineers now accept that it is almost impossible to de-bug complex software completely. The best that can be done is to institute a suitable testing regime to detect bugs and reduce these to an acceptable level. The extent of testing should relate to the SIL level (Safety Integrity Level) specified at the design stage of the system.

As a result of the downturn in the oil industry during the period of low oil prices in the late 1990s, and efficiency drives such as CRINE, there are now far fewer personnel working offshore and fewer flights compared with the 1980s. There has been a reduction of over 25% in flying hours over the last ten years. (See Appendix 1.) Helicopters operating in the North Sea from Aberdeen have been flying at an average of 83% of capacity until recently. However, there has been an increase of some 5% in flying hours for the first nine months of 2000 compared with the same period in 1999 as a result of recent increases in the oil price encouraging industry activity.

Installation Operators are now looking at sharing helicopters with other companies to save money and to allow them to consider investment in new helicopters. Only three of the helicopters currently operating offshore UK are less than three years old and the average age of a helicopter is estimated at 15 years (14).

Helicopter landing areas

Helicopter landing areas, whether on land or offshore, require areas suitable for lift-off, for the airborne part of the take-off manoeuvre and for touchdown. Offshore, the take-off and landing areas are co-located and there is no run-on area. Such an arrangement produces the smallest area overall where the helicopter can operate. (Most onshore heliports have one or more FATOs linked to an apron or parking area. In the most sophisticated situations onshore, ie at heliports alongside airports, there are separate take-off and landing areas, as well as runways nearby.)

In summary, the landing area must provide an area suitable to allow:

- space for the landing gear configuration
- sufficient area to provide a 'ground cushion' effect from the rotor downwash
- room for crew and passengers to board and disembark
- clearance from obstacles for both main and tail rotors
- some margin to allow for touchdown position inaccuracies caused by deck movement, turbulent conditions, crew mismanagement or helicopter control difficulties.

Most landing areas onshore are at surface-level heliports, except those located on top of buildings. By comparison, an offshore helideck is always defined as an elevated site, where the final approach and take-off area (FATO) coincides with the touchdown and lift off area (TLOF).

The FATO at an onshore heliport is surrounded by a safety area to reduce the risk of damage to a helicopter caused to move off the FATO by the effect of wind turbulence or cross wind, mislanding or mishandling. For use in visual landing conditions, this safety area must extend outwards beyond the periphery of the FATO by the greater of 3 metres or 0.25 times the overall length of the largest helicopter using the landing area. Generally, it is much larger, being part of a runway or apron.

The offshore helideck is much smaller, because space is limited. The performance of helicopters operating to offshore installations is such that there is very little margin for error, either from pilot handling or the physical characteristics of the aircraft. Hot gas from turbines and process equipment is a consideration for all types of offshore installation. Wind flow over the highly obstructed environment of a topsides can also affect helicopter landings. Helideck environmental considerations are discussed further in section 6.

The minimum safe size for a landing area for a single main rotor helicopter is specified as an area that can accommodate a circle whose diameter is not less than the largest dimension overall, when rotors are turning, of the largest helicopter the helideck is intended to serve. This dimension is known as the *D value*. The dimensions of a FATO are intended to allow clearance to all parts of a helicopter touching down in the middle of an area of minimum size, including providing protection to the main rotor and tail rotor blades when manoeuvring to touch down. The landing circle on the helideck is used by pilots to guide them to a safe landing position. There is only limited latitude for touching down further inboard than the centre of a FATO.

More information is given in the ICAO Heliport Manual (15) and CAP 437 (10).

Helidecks on offshore installations

Fixed platforms

These steel jacket or concrete tower structures have bases fixed to the seabed. Early platforms, particularly in the southern North Sea, were designed and built with boat landing stages around the legs, from which personnel were transferred by winching to or from an attendant vessel. The vessel was required to approach the installation and heave-to. This operation was not without risk even in relatively good weather and is now largely discontinued.

An offshore helideck is normally made of steel or aluminium (though a few fire-protected timber helidecks still remain on older platforms in the southern North Sea). The helideck is usually located above the accommodation module and raised on steel trusses to allow clear air to flow under the deck. Sometimes the helideck is offset from the accommodation on a cantilevered truss structure as shown in Figure 2.

Heliops facilities are located so as to provide convenient access to the HLO's office, radio room, personnel reception and accommodation. Information about wind speeds and other environmental data is monitored in the radio room. Refuelling facilities are provided if required from bulk storage or portable tanks below the helideck. Firefighting equipment, including foam monitors to spray foam over the deck and portable equipment, is located nearby.

The helideck is painted with a white line around its perimeter. A letter H is painted in white, offset 0.1D from the centre, and surrounded by a concentric landing circle in yellow. The platform name is displayed conspicuously. The helideck is surrounded by a 1500 mm wide safety net extending from the structure.

An approach and departure sector of 210 degrees extending out for one kilometre must be kept clear of any obstruction more than 250 mm above the level of helideck. Within the remaining 150 degree arc and out to a distance of 0.83D no object should exceed 0.05D high, where D is the overall length of the largest helicopter in use including the rotors. The limits of the obstacle-free and limited obstacle sectors are normally marked by a chevron painted on the helideck. (See figures 5 and 6.)

Fixed platforms may be considered to be the default case for offshore helideck design, where no consideration of helideck motion is required. An example of a helideck on an older fixed installation is shown in figures 3 and 4.

Mobile installations (mobile offshore units or MOUs)

Helicopter operations to mobile installations are specified to be carried out to the same standards as for fixed installations, but with the added constraint of specified maximum heave, roll and pitch from motions caused by waves that the installation can undergo, beyond which helicopters are not permitted to land and take off (16).

FPSOs (floating production, storage and offloading facilities)

Helidecks for FPSOs are similar to those for mobile installations and differ from helidecks on many ships in that these are mounted above the superstructure. Like other topsides structures, the helideck structure and its supports are designed to resist the heave, roll, pitch and yaw forces generated by the ship's motion.

The wind and turbulence environment for FPSOs is generally simpler than on freely manoeuvring ships, such as survey or diving support vessels, which can change their heading (though these vessels are not subject to control by SHOLs - see below).

Helidecks on ships

Due to space constraints, some ships have helicopter operating areas suitable only for winching. Otherwise, areas may be provided directly on the deck structure, either amidships or at the bow or stern. An example of a helicopter landing area on the deck of a vessel is shown in figure 7.

Helicopter landing areas at any location on the deck of a ship are susceptible to wind turbulence compared to raised helidecks, where a relatively unobstructed airflow is possible under the deck. Larger ships that have been purpose-built for offshore use generally have helidecks located above the ship's structure. Similar design and operating criteria apply as for helidecks on offshore installations. An example of a helideck on a diving support vessel is shown in figure 8.



Figure 2: Super Puma landing on a fixed platform
(photograph courtesy Britannia Operator Ltd)

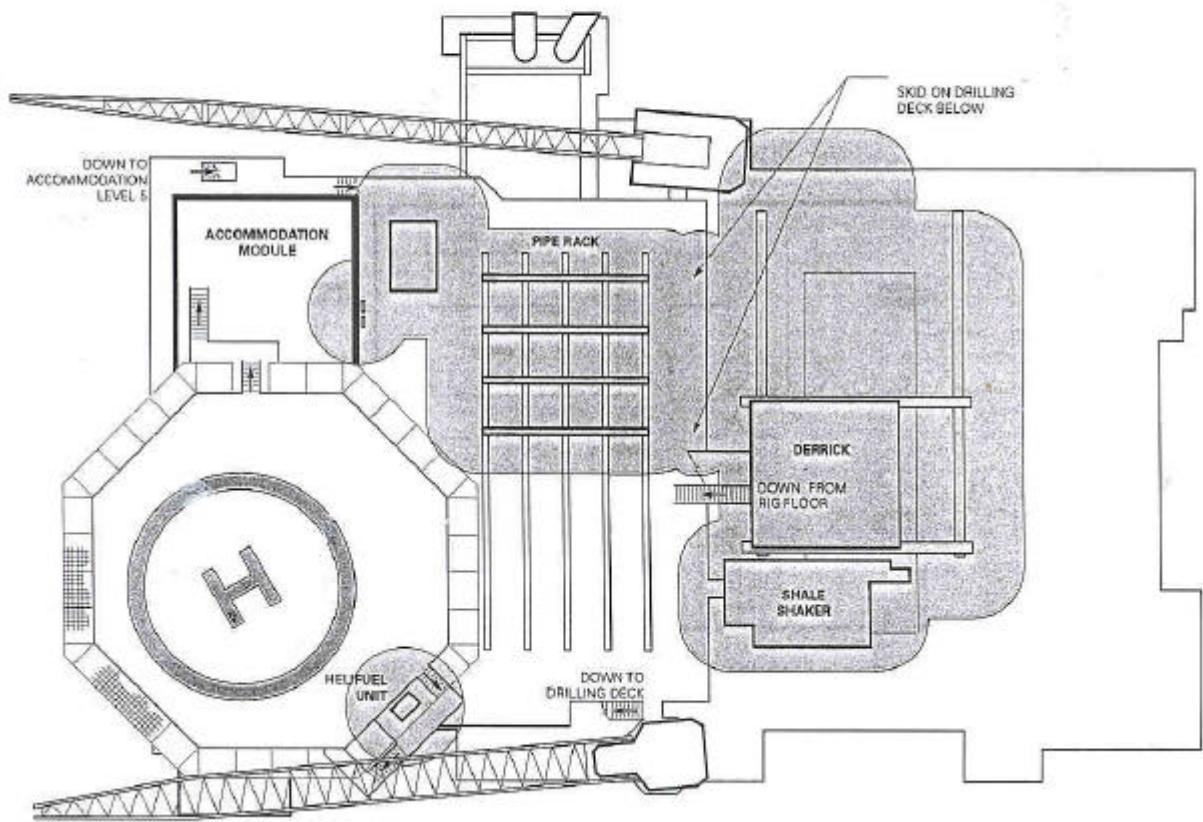


Figure 3: Helideck on an older fixed installation: plan

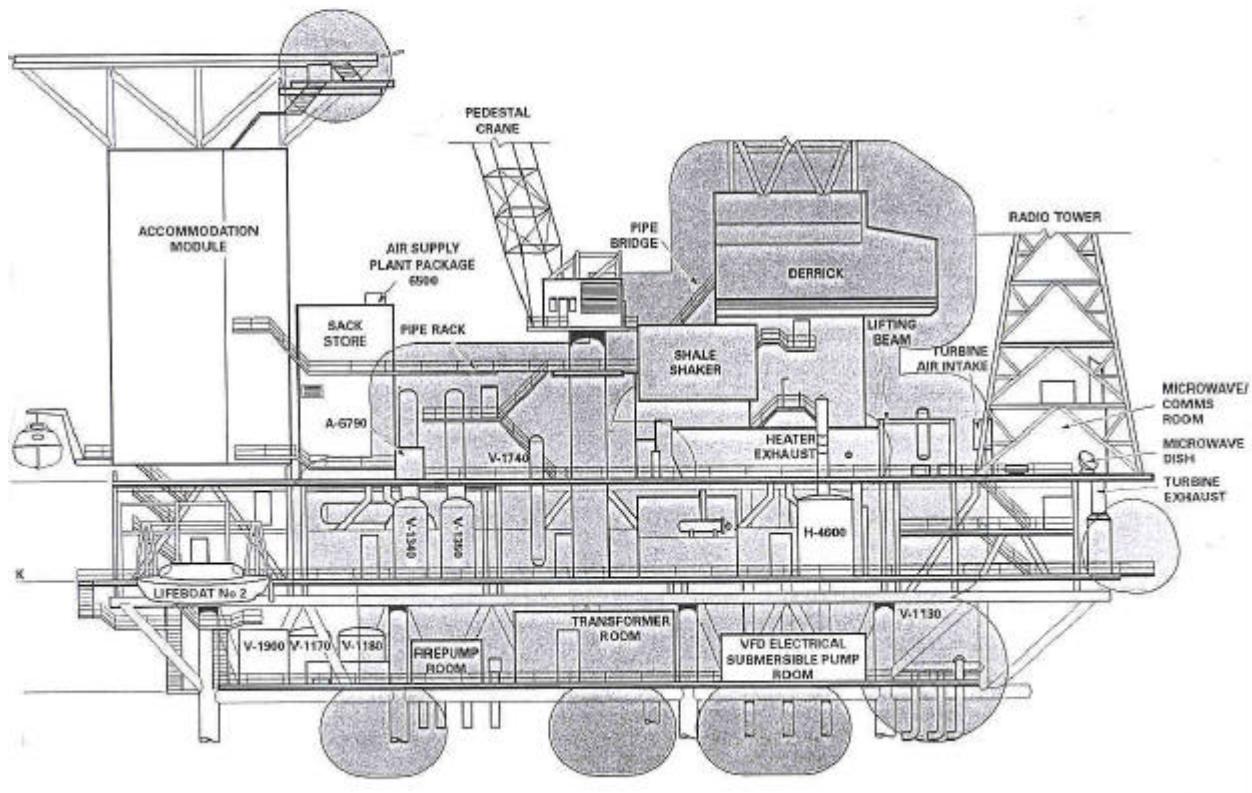


Figure 4: Helideck on an older fixed installation: elevation

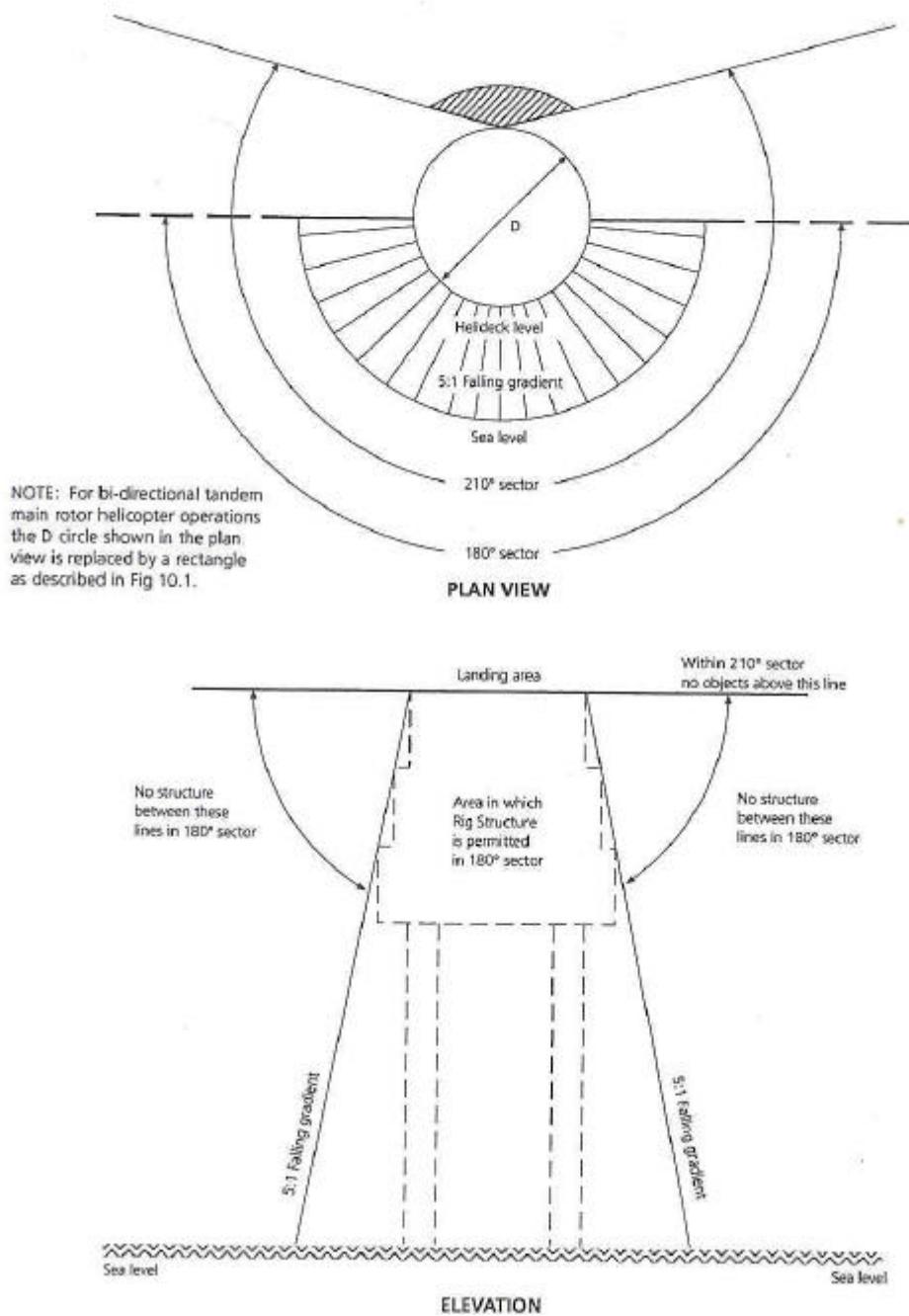


Figure 5: Helideck obstacle-free areas

(from CAP 437 figure 3.2)

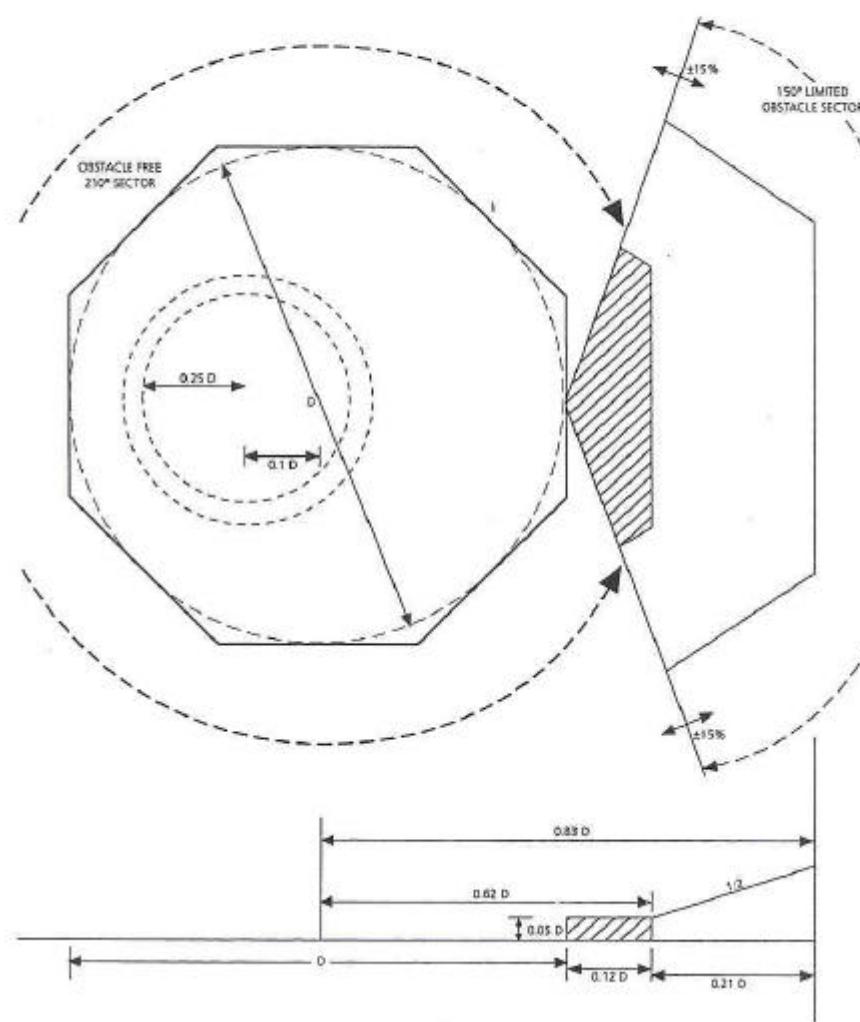


Figure 6: Helideck obstacle limitation sectors

(from CAP 437 figure 3.1)



Figure 7: Super Lynx landing on a ship

(photograph courtesy European Helicopter Industries Ltd)



Figure 8: Helideck on a diving support vessel (DSV)

(photograph courtesy Coflexip Stena Offshore Ltd)

Research into helicopter operations carried out for CAA and published in 1994 as CAP 94004 *Motion Limits and Procedures for Landing Helicopters on Moving Decks* (17) refers to a review by DERA of helicopter experience over British Navy flight decks. The study examined 130 accidents to helicopters flying routine missions to and from naval ships for the period 1987-97. Of these, only 17 were considered relevant to the present study and in only five cases was turbulence from superstructure cited as a factor:

No particular conclusions were drawn from this review except that pilot error and turbulence were linked, indicating that high workloads due to turbulence increase the risk of a pilot making an error of judgement despite the high level of skill normally associated with helicopter flying. This same conclusion will apply to offshore helicopter operations although the levels of turbulence encountered are likely to be less than those associated with naval operations due both to the better exposure of offshore helidecks and the fact that wind speeds over naval helidecks are generally increased by the forward speed of the ship.

The most severe effects of the airwake over a naval flight deck are mitigated to some extent by the fact that helicopter operations are subject to restrictions [often quite onerous] imposed by the Ship Helicopter Operating Limits [SHOLs]. These are established by test pilots during 1st of class trials and represent safe limits on wind speed and direction for which normal service operations are permitted.

There also exists an MoD Design Guide for naval flightdecks which identifies points of good design practice which should minimise adverse environmental effects.

The lack of either an equivalent design guide for offshore helidecks or anything equivalent to the SHOL system, means that any transfer across from naval experience to the offshore situation is of limited value.

Although the effect of temperature increases may not necessarily pose a problem, the complex effects of the ship's motion and wind flow over obstructions on the superstructure can sometimes cause considerable turbulence for both ship's side and amidships located heliports. These considerations will not always apply to floating installations, where motions are generally less severe during helicopter operations (except perhaps during an emergency) and the helideck is raised to reduce turbulence. More information is given in guidance published by the International Maritime Organisation (IMO) for different types of vessels.

Helicopter design and performance in service

Helicopters are designed and developed for a worldwide market that is continuing to grow. Manufacturers focus considerable research and development resources on designing machines that are more cost-effective, easier to operate and have lower environmental impact from noise over the flight path than earlier models. (Flyover noise levels are much lower for the new EH101 than for the older Super Puma, for example.) The comfort of passengers and aircrew is seen as increasingly important and cabin noise and vibration are greatly reduced compared to earlier designs.

Several types of helicopters still in use offshore are older designs that are no longer manufactured, and so do not reflect the technological advances that have been made over the last few years. No new S61's have been built since 1980, for example, although many are still in service for North Sea passenger transport. There are now more Super Pumas in use offshore than any other type of helicopter and this model is still in production. The numbers of different types of helicopter currently in use are summarised in Appendix 1.

Older designs of helicopter are noisy and subject to noticeable vibration. (The main rotor is the principal vibration source, mainly due to the inherent asymmetry of disc loading.) New designs of helicopter make extensive use of recently developed vibration reduction and suppression measures, using modern materials such as carbon fibres for rotors and fibreglass body parts. Significant advances have been made in rotor blade design in recent years, including new aerofoil sections operating at lower speeds with more aerodynamically efficient blade tips. New designs of tail rotor anti-torque systems in combination with lower drag fuselages have also improved helicopter efficiency and response. Cruise speeds have increased from about 220 km/h (120 knots) for the S61 to 330 km/h (180 knots) for the EH101 (17).

New designs of helicopter also have multi-system redundancies and long-stroke undercarriages, measures that should improve safety as well as performance compared with older models. A big effort has been made by manufacturers to reduce the cost of manufacture of components and increase expected service lives and maintenance intervals. As well as being easier to maintain, modern helicopters are more reliable and fuel-efficient. However, even if cheaper to operate, the capital cost of purchase is still very high, being several million pounds, so it is difficult for operators to justify getting an adequate return on their investment in a new design.

As well as being expensive to build, helicopters are more expensive than fixed wing aircraft to maintain in operation, due to their relatively complex mechanical arrangements, with highly loaded moving parts and a comparatively high fuel requirement. Maintenance takes considerable financial and technical resources. In terms of service life, regular overhaul and replacement mean that safety-critical components are effectively kept in an *as-new* condition.

One engine inoperative (OEI)

In Europe, civil helicopters flying in the relatively harsh environment offshore are required to be multi-engined. (This is not so in other parts of the world.) Aircraft are required to operate so as to be able to continue in flight and land safely, even with one engine inoperative. Take-off and landing are the most critical phases of any flight for engine failure, due to the temporary high power requirement at these times.

The power required for a helicopter to fly level is a minimum at an aircraft speed of about 40-60 knots in still air. The air inflow at this optimum speed allows the rotor to operate most efficiently. At lower speeds, especially close to the hover, more power is required. A single engine failure when approaching the hover (landing) or attempting to climb away from the hover, will initially require the remaining engine(s) to increase power to compensate. This is normally provided for by the rotor speed-governing system. However, where the remaining power transmitted is insufficient, the pilot will be forced to adopt a less demanding flight path (angle and rate of climb or descent), or to make a forced landing.

The rules recently introduced by the European Joint Airworthiness Authority (4) require all helicopters operating to elevated helidecks to be able to sustain a single engine failure and still be able to fly away or land safely on the helideck. This so-called 'Class 1 performance' relates to the capability of the helicopter to recover from single engine failure within a specified time period in all weather conditions and currently applies to helicopters carrying more than 19 passengers. Helicopters carrying fewer passengers will continue to receive dispensations under various headings until at least 2005.

Until the regulations become fully effective, all types of helicopter currently carrying passengers offshore continue to operate subject to a Code of Practice developed in the 1970s. Existing designs of helicopter suffer an exposure period of several seconds (depending on weather conditions) after take-off during which failure of one engine could result in loss of altitude and possibly an accident. Hitherto, such an accidental event has been considered an acceptable risk by the regulatory authorities on the grounds of very low probability of occurrence.

Manufacturers are now specifying engines with 30 second engine power ratings that allow much greater power in an emergency. The pilot can call upon this reserve power from the remaining engines if one engine fails and so carry out a safe flyaway or landing to achieve Class 1 performance. The EH101 is the only design of helicopter flying offshore at present (on test flights) that currently achieves Class 1 performance (with a slight reduction in maximum gross weight at temperatures above 15 degrees Celsius in still air). Other new designs of helicopter under development will also be able to operate at near maximum all up weight (MAUW) and still meet Class 1 requirements. The power-to-weight ratio of the three-engine EH101 greatly exceeds that of the two existing designs most used offshore, the Super Puma and the S61, as shown below:

Helicopter	MAUW Kg	OEI power kW	OEI power/MAUW kW/kg
S61-N	9299	1199	0.12
Super Puma	8600	1310	0.15
EH101	14600	2982	0.20

One experienced pilot told the author that pilots are more concerned to use additional lift performance as a safety feature to counter the effects of wind shear and downdraughting rather than to enhance heavy landing and take-off capabilities.

The EH101 is currently available for service. The S92 and Super Puma Mark III helicopters, both still at the design stage, will meet the new standards in operation.

Helicopter logistics and maintenance (17, 21)

Logistics

New aircraft are bought only one or two at a time. The cost is amortised over 12 to 15 years. Helicopter operators say it is not possible to get an adequate return on replacement aircraft over the period of a single contract. Business pressures seem likely to lead Duty holders to share flights to installations using fewer aircraft. Helicopter operators may try to sell empty seats to contractors, as is already done in the Gulf of Mexico, where this does not conflict with their existing contracts. There will likely be regional sharing to optimise payload, the use of the asset and to minimise cost. Competition for helicopter support operation contracts is currently very keen and said to be almost entirely on price.

Aberdeen helicopter bases are the biggest civil heliports in the world. There are about 100 aircraft in the British sector, and about half this number in other countries bordering the North Sea.

Until a few years ago the 'workhorse of the North Sea' was the Sikorsky S61. Now the Eurocopter SA332S Super Puma is the most common type of helicopter in service. For shuttling between installations and flotels, etc, a smaller aircraft such as the 14-seat Bell 214ST may be used. The 12-seat S76 variants, A, A+, B and C, are relatively fast at 145 knots cruising speed. The Bell 212, a 60's design, is no longer used for shuttling or as a search and rescue aircraft for offshore use. The British Coastguard uses S61s with NVG (night vision). These, too, will soon need to be replaced.

For the future, the Bell Agusta 609 with tilt-wing rotors may be a promising development. The wings of this rotorcraft tilt to a vertical position for take off and landing vertically, and rotate to normal for the cruise, thus reaching a top speed of 280 knots. This aircraft may be suitable for flying to deep water far from shore due to its high speed. These helicopters will carry 9 people, rather than the 18 or 19 of the Super Puma or 30 of the EH101. Some are expected to be in use for offshore operations somewhere in the world by 2002, although only at test flight stage in Europe.

Operators have to keep helicopters in the air and service others at the same time. A helicopter is high performance machinery. There is intensive maintenance from the moment an aircraft is bought, and this maintenance is very labour intensive. For every six helicopters in operation, one is in maintenance at any one time.

Public transport helicopters have a medium lift requirement. Maintenance needs are based on the manufacturer's requirements. The operator develops maintenance schedules with the manufacturer based on their master servicing guide. This schedule is amended for the North Sea to account for the high rate of corrosion and the number of landings. An approved maintenance programme is issued after examination by the CAA airworthiness department after inclusion of any additions they require.

Helicopter operators say that aircraft do not leave the hangar if the maintenance engineers and technicians suspect a defect. In general, there are relatively few accidents due to maintenance error (though there are some concerns this may have been the cause of the most recent accident in Norway). Surveys of pilots have shown they have few concerns over the state of maintenance of the aircraft they fly.

Maintenance is at two levels of service:

- Day to day at base - checking the radio, equipment, washing salt off, flushing the engine compressor, etc.
- Scheduled inspection and maintenance.

In the morning, there is a pre-flight inspection by an aircraft engineer or technician. This is visual and includes tyre pressures, external examination, etc. The helicopter is then towed out for use. When the aircraft is returned from duty, a similar turnaround inspection is made.

The pattern of inspection required depends on the aircraft maintenance schedule. This usually details inspections on a flying hours and calendar basis. Typically, there are detailed checks at 25, 30, 40, 50, 100 and 200 hours flying time, and one month, three months, up to fifty-four months calendar time, even if the aircraft is left in the hangar. Engines are inspected at intervals and overhauled at specified TBO (time between overhaul), including with borescopes. There is also a requirement to remove major components after a specified number of flying hours for overhaul or scrap and replacement. Times between major component overhauls are specified. For example, for the Super Puma the main rotor head is removed at 1800 hours and sent to France

for overhaul. Major gear box overhaul is at 3000 hours. There are similar requirements for alternators, autopilots, etc.

At much longer intervals, perhaps 20,000 hours depending on the model, the aircraft is stripped down to the rivets, a paint strip is carried out to a bare hull and a structural check made. The check includes stripping down the helicopter internally, removing the engine, the wiring looms and systems and automatic float system if fitted, all as set out in the maintenance manual. The rotor tracks are replaced at this time and at the 3 monthly, 6 monthly, etc inspections. The whole process can take from a few days to over a week. The helicopter is then re-sprayed and rolled out like a new machine.

There is a constant renewal of parts. Although an airframe may be 17 years old, the most safety-critical parts comprising it may be no more than 18 months old (17).

HUMS (Health and Usage Monitoring System)

It is important to keep both the main and tail rotors in balance, so as to minimise rotor-induced vibration. Equipment to ensure this has advanced in parallel with advances in microprocessor technology.

HUMS have been developed in the last ten years to analyse the vibration patterns in the main and tail gearboxes and connected transmission shafts and rotors. It is now possible to detect from minute changes in the pattern of vibration the presence of defects such as a crack in a gear wheel, loss of a gear tooth or excessive wear in a bearing. Once identified, the component can be inspected and removed before the defect becomes a significant hazard.

Typically, there are four vibration sensors at the engines and twenty under the transmission, plus a passive infrared tracker. Outputs from these feed into the flight data recorder and a data processor, together with data about engine speeds and other engineering information. In one proprietary system, this data is stored on a 'smart card' which the pilot removes and hands to the maintenance staff after a flight. In another, the maintenance staff download data daily, using a hand-held data retrieval unit.

CAA may ask to see the recordings made. They can also ask for CVRs (Cockpit Voice Recordings) and flight data recorders to look at these records, including 'excedances' during flight. The crew have a limited display of the functions of HUMS, including power in the engines. If engines have been operating for too long at full power, this is noted by the computer. The readout diagnosis includes *no defects* and a list of any possible problem areas. There are specialists at each base to trend problems where these can not be solved immediately.

Many people in the aircraft industry think HUMS is *the greatest advance in helicopter safety since the second engine*. Hitherto voluntary, the CAA is now about to propose legislation to make HUMS a legal requirement, so as to provide a higher level of safety in the UK than current airworthiness standards demand, especially with regard to rotor balance and tracking. There is some evidence that a number of potential mechanical failures have already been avoided by the use of HUMS. Increases in helicopter reliability observed over the last few years may be largely due to this development.

Management of helicopter operations offshore

The offshore industry has become much more aware of the need to improve its safety and environmental record since the Piper Alpha disaster of 6 July 1998, including the

effects on a company's reputation and its future viability, as well as the more obvious immediate economic effects.

In the UK sector, operators of offshore installations are required to put in place management systems to reduce risks to people working offshore to as low as reasonably practicable (ALARP). Management systems for all phases of helicopter operations: onshore, in the cruise phase of the flight and on the approach to, take-off from and while the helicopter is at an offshore helideck are regulated by the civil aviation and health and safety authorities. As noted above, many of these regulations are procedural and prescriptive.

UKOOA Industry Guidelines for the Management of Offshore Helideck Operations (18) provide advice on helideck management and operation and indicate what arrangements are necessary to ensure the availability of the landing area in both normal and emergency situations. The Guidelines set out goals and objectives for different aspects of equipment, manning and operation and indicate what is good industry practice in setting and achieving suitable performance standards.

Helicopter hazards at an installation

Hazards identified in the UKOOA Guidelines for the Management of Offshore Helideck Operations include:

- excessive wind turbulence due to adjacent structures
- process thermal effects, eg turbine exhausts, normal and emergency hydrocarbon cold venting
- obstructions in the approach and departure sectors
- fuel spillage during refuelling requiring rapid emergency response
- aircraft engine or cabin fire requiring emergency response by aircrew and helideck and firefighting crews on the installation
- personnel contact with main or tail rotors while on deck
- aircraft accident on the helideck, with associated passenger injuries and/or fuel spillage, requiring rapid emergency response
- loose items (of baggage, equipment, etc) being sucked into rotors or air intakes by structure-induced turbulent airflow or rotor downwash
- flying debris, eg from disintegrating rotor, hitting personnel following a crash
- aircraft or rotor-plane movements while the helicopter is on the deck after landing, (especially when the deck is subject to significant movements as on mobile installations and FPSOs in bad weather).

As with all operations at an installation, the offshore installation manager (OIM) remains responsible for the safety of the installation at all times, including during helicopter operations, even if he delegates this responsibility to the helicopter landing officer (HLO). The HLO supervises helicopter operations assisted by a fire team, normally of two or three other people. This team is located around the helideck during flight operations. The pilot is responsible for the safety of the helicopter and its passengers and crew. In order to carry out helicopter operations successfully, the two Duty holders should agree on how the proposed offshore helicopter operations will be carried out before these begin. The helicopter pilot should be aware of limitations on manoeuvring around the installation.

The helideck management systems should be incorporated into the Installation Duty holder's safety management system for the installation. Details should be provided of procedures covering:

- normal operations, eg landing and take-off, embarking and disembarking passengers and freight and refuelling
- helideck emergencies
- evacuation of the installation.

Operating limitations

A helicopter should be operated in accordance with the instructions in the flight manual prepared by the helicopter manufacturer and the Helicopter Operator's operations manual. The regulators may inspect the Helicopter Operator and Installation Operator to check that they are correctly implementing the requirements of the regulations.

Gross mission weights

Maximum all-up weights (MAUW) are specified for helicopters using the installation.

Approach and departure sectors - IVLLs (installation/vessel limitation lists)

The drilling derrick, turbine exhausts and radio mast on an installation will usually obstruct approaches from particular compass directions. The prohibited flight zone subtends to an arc of 150 degrees, with the remaining 210 degrees being clear for approach and take-off.

Adverse weather policy

Depending on the standards set by the Installation Operator, helicopter operations must cease when the mean wind speed and significant wave heights reach specified values, eg 60 knots and 7 metres. At mean wind speeds greater than, say, 45 knots, operators may mobilise additional helideck crew to assist the safe movement of passengers. Most Installation Operators set performance standards that limit weather and metocean conditions to more restrictive values than those in the manufacturer's Flight Manual or Helicopter Operator's Operations Manual. The OIM and Helicopter Operator generally use their discretion to limit operations to those lower values, unless a flight can not be delayed due to some urgent requirement. The use of an adverse weather policy may well have contributed to reducing the accident rate in recent years.

Crane operating restrictions

Cranes are required to be stationary during helicopter operations, lowered as far as possible and clear of the helideck obstacle height-restricted sectors.

2. HELICOPTER ACCIDENTS OFFSHORE EUROPE

Accident history

People have been going to work on offshore installations by helicopter from countries bordering the North Sea for over thirty years. Millions of flights have taken place during that time. Unfortunately, there have been a number of accidents involving fatalities and major injuries. The accident rate in Europe may not be considered excessive by comparison with helicopter travel in other regions of the world or with travel in fixed-wing turboprop or small jet aircraft over land. Nevertheless, risks from helicopter travel are a significant proportion of the overall risks to people working offshore.

Generally, the accident rate (usually measured as the number of fatalities per 100,000 flying hours) has been greater for all types of helicopter transport compared with larger fixed-wing aircraft used on scheduled flights. This may be almost inevitable given the added complexity of helicopters and the need for helicopters to intrude more often into what in aviation terms are hazardous situations. To compare making a pilot-interpreted manual approach to a helideck on a crowded installation with making an automatically controlled Instrument Landing System approach on a direction-finding system at a major airport, the difference is obvious.

Statistics taken over a fairly long period show that helicopter accidents are more likely to happen during flight than when taking off or landing. This is a significant difference from passenger travel in fixed wing aircraft, where the most hazardous part of any flight is during take-off and landing. A difficulty with drawing significant conclusions from aircraft (and other) accident data arises from the rapid changes in technology that have taken place over the period. For example, if only accident statistics for the last five years in the UK (offshore and on-) are chosen, the comparative fatal accident rates are:

- fixed-wing public transport 0.4 per million flights
- heavy and medium-weight helicopters 0.0 per million flights.

The use of accident figures derived from such a short time period is unlikely to reflect the 'true' risks involved.

Incident data

Records made available to the author give details of all incidents notified to CAA in the United Kingdom and of fatal accidents notified to the civil aviation regulatory authorities of other Western European countries (2).

In general, all aviation accidents involving fatalities are reported to the regulatory bodies and are thoroughly investigated. After investigation, control measures may be recommended to reduce the risk of a recurrence.

In the UK, there is a statutory requirement for Mandatory Occurrence Reports (MORs) to be completed by aircrew to record incidents in which they were involved, and which could be considered in some way to have an effect on safety (ref CAA paper 87007 *Report of the Helicopter Human Factors Working Group*) (19). The filing of an MOR does not necessarily imply that something was wrong or may have been a hazard, only that a particular event may require investigation. MORs may not therefore be strictly comparable with *dangerous occurrences* notifiable to HSE under RIDDOR (20).

The term *incident* is not used in aviation terminology. *Accidents* include both fatalities and dangerous occurrences as well as minor and more serious injuries. As noted

above, *incidents* are considered to be events, however minor, that may have an influence on safety. There can be hundreds every year. These are allegedly seen by aviation staff as useful pointers towards controlling hazards and reducing potential accidents. Aviation reporting was said by some of those interviewed to be based on a culture where reporting of even minor incidents is likely to be open and complete.

The summary tables below were written using information provided by John Burt Associates, aviation consultants, and by CAA from reports held by the CAA Safety Data and Analysis Unit. These reports were themselves derived from reports from helicopter operators in the UK and other countries for the period 1976 to 1999.

The MOR database was initiated in 1976, almost at the start of the widespread use of helicopters offshore. Incident data for earlier periods has been provided by John Burt Associates for the period from 1968 to 1975. Brief accounts of the six most serious incidents occurring in this early period are included in Table 1.

The data is believed to be accurate and complete for fatal accidents within Western Europe, and for incidents of other types (major injuries and dangerous occurrences) within the UKCS. Information regarding injuries for other states has not been verified.

Reference 1 includes a summary of incidents involving fatalities and major injuries and dangerous occurrences associated with flights to offshore installations, based on information from some 400 MORs and other information. CAP 87007 (19) notes that only limited data, including a brief description of an incident, is available from MORs.

Analysis of accident data

The incident data has been organised into categories by the author and summarised in tables in the pages following. Although some authorities would argue that there is no point in including accidents before about 1990 due to the rapid changes in technology during the period, particularly the widespread introduction of HUMS, the author has included this information in order to give a historical perspective to the study and because to omit this information would reduce the size of the sample population to a perhaps unrealistically small level. (Similar arguments were put forward by some Installation Operators to attempt to justify not including data from the Piper Alpha accident in 1988 in Quantified Risk Assessments of the frequency and consequences of hazards from fire and explosion.)

Accidents involving fatalities

Table 1 summarises the fatal accidents associated with helicopter travel to and from offshore installations throughout the European Union and EFTA countries during the period January 1968 to December 2000.

Accident data is summarised in three categories:

- onshore at or near a heliport
- in flight during the cruise phase
- offshore within 500 metres of an installation.

ANALYSIS OF EUROPEAN OFFSHORE HELICOPTER ACCIDENT DATA
1968 to December 2000

Table 1: SUMMARY OF FATAL ACCIDENTS

(page 1 of 3)

Year	Fatal- ties/ POB	Flight phase	Location	Description of accident	State
1997	12/12 2 crew/ 10 passengers	en route over sea	North Sea near Norne FPU	Mechanical failure - Super Puma engine drive shaft caused overspeed then disintegration - loss of control - crash in sea 08/09/97 Report 56	Norway
1992	1 1 helideck crew	at offshore installation	DSV Mayo near Heather A	S76 rotors running turnaround - movement of aircraft on deck in rough seas - HLO killed 18/04/92 Report 42	UK
1992	11/17 1 crew/ 10 passengers	shuttle flight near offshore installation	Cormorant A	Pilot error - Super Puma flying in adverse weather - crash in sea 14/03/92 Report 41	UK
1992	1 1 helideck crew	at offshore installation	Viking B	Super Puma - rotors turning refuel, rotor deflected from horizontal - HLO entered rotor area - helideck limited in size and obstructed by crane 22/09/92 Report 43	UK
1991	3/3 3 crew	at offshore installation	Ekofisk	Pilot error - Bell 212 main rotor struck flare while lifting underslung load 10/08/91 Report 40	Norway
1990	6/13 2 crew/ 4 passengers	at offshore installation	Brent Spar	Pilot error - S61 hit crane while manoeuvring to land - fell on to helideck then fell off into sea and sank 25/07/90 Report 37	UK

ANALYSIS OF EUROPEAN OFFSHORE HELICOPTER ACCIDENT DATA
1968 to December 2000

Table 1: SUMMARY OF FATAL ACCIDENTS

(page 2 of 3)

Year	Fatal- ities /POB	Flight phase	Location	Description of accident	State
1986	44/46 2 crew/ 42 passengers	cruise/ onshore approach	Sumburgh	Chinook gearbox failure - twin rotors desynchronised (no HUMS) - crash in sea 06/11/86 Report 29	UK
1984	3/3 2 crew/ 1 passenger	en route over sea	North Sea near Dan Field	Bell 212 tail rotor/gearbox failure - crash in sea 02/01/84 Reports 23 and 127	Denmark
1984	2/2 2 crew	en route over sea	Jack-up NE of Humber	Bell 214 - loud bang, cause not established - loss of power - crash in sea 20/11/84 Report 26	UK
1982	2/2 2 crew	onshore at heliport	Aberdeen airport	Super Puma pilot training - engine failed under power at 200m and caught fire - crash on runway 10/10/82 Report 18	UK
1981	4/4 2 crew/ 2 passengers	en route over land	near Peterhead	S76 training flight - rotor head fatigue failure - main rotor blade separated - aircraft broke up in flight 12/03/81 Report 14	UK
1981	1/14 1 passenger	en route over sea	near Dunlin	Bell 212 pilot became disoriented in very poor visibility - crash in sea 12/08/81 Report 15	UK

ANALYSIS OF EUROPEAN OFFSHORE HELICOPTER ACCIDENT DATA
1968 to December 2000

Table 1: SUMMARY OF FATAL ACCIDENTS

(page 3 of 3)

Year	Fatal -ties/ POB	Flight phase	Location	Description of accident	State
1981	13/13 2 crew/ 11 passengers	en route over sea	off Bacton	Wessex loss of power to main rotor gearbox - crash in sea - immediate cause not established 13/08/81 Report 16	UK
1979	1 1 helideck crew	at offshore installation-helideck	Frigg	Bell 212 helideck management error - rotors turning turnaround 26/08/79 Report 129	Norway
1978	18/18 2 crew/ 16 passengers	en route over sea	North Sea near Bergen	S61 main rotor gearbox failure - crash in sea 26/06/78 Report 11	Norway
1977	12/12 2 crew/ 10 passengers	en route over sea	North Sea near Stavanger	S61 main rotor gearbox failure - crash in sea 23/11/77 Report 10	Norway
1976	1/10 1 passenger	at offshore installation	Forties	S58 tail rotor control failure - forced landing onto side of helideck then crashed onto barge below 21/04/76 Report 7	UK
1974	6/6 2 crew/4 passengers	en route over sea	North Sea	S61 main rotor blade broke off - strong vibration - crash in sea 10/05/75 Report 5	Nether-lands
1973	4/13 4 passengers	en route over sea	North Sea near Stavanger	S61 strong vibration caused tail rotor failure - ditching and capsized in sea 09/07/73 Report 4	Norway

The data for each accident includes the number of people on board (usually two crew, the others being passengers), the cause of the incident and the end event (or immediate consequences).

All but three of the 145 fatalities from 19 separate accidents were to passengers and aircrew on board helicopters. The other three accidents each led to the death of a member of the helideck crew on board the installation.

The most recent fatal accident was on 8 September 1997 when all twelve people on board a Super Puma en route for the Norne Field off Norway died after the helicopter crashed into the North Sea. The immediate cause was mechanical failure - disintegration of a gearbox from vibration caused by a defect in an engine drive shaft. This vibration immobilised the overspeed protection device, leading to overspeeding and subsequent engine failure. The HUMS detector installed near the driveshaft may not have been working properly before the incident. Concerns have been expressed about possible design and maintenance deficiencies.

The accident causing most fatalities was the 1986 Chinook crash into the sea off Shetland in 1986 that killed 44 people.

Two of the accidents took place in conditions of low visibility from fog or low cloud.

Major injuries

Table 2 summarises major injuries reported during the period. It is notable that the number of major injuries in comparison with the number of fatalities (Table 1) is relatively small compared to the distribution found from work activities in other industries.

**ANALYSIS OF EUROPEAN OFFSHORE HELICOPTER ACCIDENT DATA
1968 to December 2000**

Table 2: SUMMARY OF MAJOR INJURY ACCIDENTS

Year	Injuries/ POB	Flight phase	Location	Description of incident	State
1992	1/17 (and 11 killed) 1 passenger	At offshore installation - shuttle flight in 500m zone	Cormorant A	Pilot error in adverse weather - crash in sea - survivor injured in escape 14/03/92 Report 41	UK
1987	1/18 1 passenger	onshore - parked at airport	Aberdeen airport	Passenger tripped while disembarking - broke collar bone 19/03/87 Report 107	UK
1986	1/4 1 passenger	personnel transfer by winching	southern North Sea	bad weather - excessive vessel motions 04/04/86 Report 106	UK
1983	3/18 3 passengers	airport runway on approach	Aberdeen airport	Loud bang - strong vibration - aircraft struck runway on landing	UK

European states affected

Table 3 shows the distribution of fatalities and major injuries between the different European states principally involved in work offshore, ie the UK, Norway, the Netherlands and Denmark. Eighty six people were killed in UK waters, 50 in Norway, 6 in the Netherlands and 3 in Denmark. The number of deaths is seen to be roughly in proportion to the number of people employed offshore in each country.

ANALYSIS OF EUROPEAN OFFSHORE HELICOPTER ACCIDENT DATA 1968 to December 2000					
	Europe	UK	Norway	Nether- lands	Denmark
Fatalities	145	86	50	6	3
Major injuries	6	6	0	0	0
Combined fatalities and major injuries	151	92	50	6	3
Number of incidents involving fatalities	19	11	6	1	1
Number of major injury incidents	4	4	0	0	0
Combined fatality and major injury incidents	23				
Number of dangerous occurrences	179				
Total number of reported incidents	202				

Personnel affected

Table 4 shows the distribution of fatalities and serious injuries amongst passengers, aircrew and helideck crew.

All fatalities were to passengers and aircrew on board helicopters except for three helideck crew killed on board installations.

ANALYSIS OF EUROPEAN OFFSHORE HELICOPTER ACCIDENT DATA 1968 to December 2000

**Table 4: FATALITIES AND MAJOR INJURIES
DISTRIBUTION: PASSENGERS, AIRCREW AND HELIDECK CREW**

	Fatalities	Serious injuries	Total
Passengers	116	6	122
Aircrew	26	-	26
Helideck crew	3	-	3
Total	145	6	151

Flight phase: onshore, during cruise and at or near an offshore installation

Table 5 summarises the flight phase in which the fatal and major injury accidents occurred: onshore at a heliport, during the cruise phase of a flight or offshore at or near an installation.

Onshore

Two aircrew were killed when a helicopter crashed on a runway at Aberdeen airport during a training flight.

In cruise during a flight

One hundred and nineteen people died on their way to or from installations in eleven incidents that occurred during the cruise phase. The helicopter crashed into the sea in all but one case.

Accidents at or near an installation

There have been 24 deaths from seven fatal accidents offshore at an installation or within the 500 metre zone. There has never been a fire on a helideck leading to fatalities. (There have been no recorded helideck fires at all in the UK sector.)

**ANALYSIS OF EUROPEAN OFFSHORE HELICOPTER ACCIDENT DATA
1968 to 2000**

**Table 5: FATALITIES AND MAJOR INJURIES BY FLIGHT PHASE -
ONSHORE DURING CRUISE AND AT OFFSHORE INSTALLATION**

Flight phase	Fatalities	Major injuries	Number of fatal accidents	Number of major injury incidents
	Europe [UK]	Europe [UK]	Europe [UK]	Europe [UK]
Onshore - at heliport	2 [2]	4 [4]	2 [2]	2 [2]
Cruise - over land or sea	119 [65]	- [-]	10 [4]	- [-]
Offshore installation - at helideck or within 500m zone	24 [19]	2 [2]	7 [5]	2 [2]
Total	145 [86]	6 [6]	19 [11]	4 [4]

Personnel on board a helicopter

There have been four fatal accidents at or near an installation affecting people on board the helicopters. In two cases, collisions occurred between the helicopter and the structure of the installation. These events were part of the chain of cause and effect (the escalation path) that led to the accident, even though the primary cause of the accident was ascribed by accident investigators to other causes. These accidents were:

- at Brent Spar in 1990, and
- the Ekofisk accident in 1991

In the **Brent Spar** accident (22), a Sikorsky S61 helicopter was approaching the installation to allow a crew change on the installation. The tail rotor hit part of the crane while manoeuvring to land. The aircraft fell onto the helideck and then slid off and fell into the sea, where it quickly sank. The design of the installation may have been a contributing factor. The helideck was smaller than normal size and the approach path was partly obstructed by the crane. There had been a previous helicopter strike when the tail rotor hit a cable supporting this crane. In order to land and take off, pilots had to manage the risks of manoeuvring in these difficult conditions. four passengers and the pilot and co-pilot were killed. Seven passengers managed to escape and were rescued.

The **Ekofisk** accident involved a Bell 212 helicopter hoisting a reference bar into position during construction work at the flare tower when the main rotor blade struck the flare tower structure. The aircraft crashed into the sea and sank. The three aircrew on

board died. The primary cause of the accident was ascribed by the Norwegian air accident investigation organisation to pilot error.

In the other two cases of helicopter crash at or near an installation, no contributory effects from hardware defects or management failures on the installation were found by the official enquiries:

- the Cormorant A accident in 1992, and
- the Forties accident in 1976.

The **Cormorant A** accident involved a Eurocopter AS332 Super Puma on a routine shuttle flight taking personnel from the installation to a flotel 200 metres away. The aircraft departed in adverse weather - high winds and waves and snow showers - and made a right hand turn to a position 400 metres downwind of the flotel. The aircraft lost height due to insufficient forward speed, struck the sea and sank. The subsequent Fatal Accident Inquiry found the primary cause of the accident was pilot error. The secondary cause was the very bad weather at the time.

Rather than turning shortly after take-off, the helicopter should have gained a normal forward flying speed (ie in excess of 60 knots) before turning downwind to approach the flotel. If the pilot had flown a gently orbit radius of about half a mile, the accident almost certainly would not have happened.

In the **Forties** accident in 1976, vibration resonance started in the tail rotor of the Sikorsky S58 on its approach to land on the helideck of this fixed platform. As a result, the control system failed and the pilot carried out an emergency landing. The aircraft made a forced landing, but fell off the edge of the helideck onto the barge Thor 45 metres below. The aircraft was damaged by the impact and a subsequent fire. One passenger was killed. The two crew and remaining seven passengers escaped with minor injuries.

Personnel on an installation

The three accidents leading to the deaths of helideck crew on an installation were:

- the diving support vessel Mayo accident in 1992
- the Viking B accident, also in 1992
- the Frigg accident of 1979.

One person was killed by the turning rotors of the helicopter, in each case while it was being made ready during the turnaround between landing and take-off.

Dangerous occurrences

A number of dangerous occurrences involving collision, entanglement or other interaction between a helicopter and equipment on an installation are recorded in MORs. These incidents are summarised in reference 2.

Damage to a helideck

Minor damage has occurred in a small number of cases. No helicopter accidents, emergency landings or other dangerous occurrences have led to a structural failure of a helideck sufficient to limit the ability to respond suitably to an emergency.

Fatalities from helicopter activities versus all offshore activities

Table 6 shows the number of fatalities to people working in the offshore oil and gas industries as a result of helicopter activities in the UK compared with deaths offshore from all work-related causes. Although included for comparison, this information applies only to the last ten years - a relatively short period (43).

There have been no helicopter travel related deaths offshore Britain since 1992. There was one fatal accident in the Norwegian sector in 1997, that left 12 people dead.

The number of people employed and travelling offshore declined by over a third during the period.

ANALYSIS OF EUROPEAN OFFSHORE HELICOPTER ACCIDENT DATA									
Table 6: FATALITIES AND MAJOR INJURIES FROM HELICOPTER OPERATIONS versus ALL OFFSHORE WORK ACTIVITIES April 1991 to March 2000 UK sector only									
	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00
Estimated offshore workforce	33,200	29,500	34,200	27,200	29,003	26,853	23,000	25,500	19,000
Helicopter operations									
Fatalities	12	1	0	0	0	0	0	0	0
Major injuries	0	0	0	0	0	0	0	0	0
Combined fatal and major injuries	12	1	0	0	0	0	0	0	0
All oil and gas offshore activities									
Fatalities	13	5	1	1	5	2	3	1	2
Major injuries	73	111	87	68	67	44	74	74	52
Combined fatal and major injuries	86	116	88	69	72	46	77	75	54

Trends in helicopter safety

The CAA tables and graphs of operating statistics for the UKCS in Appendix 1 show:

- The number of accidents leading to fatalities has declined from a maximum five-year moving average of 0.8 per 100,000 hours flown in the period before 1985 to 0.4 from 1985 to 1989, and has since declined to less than 0.2.
- Reportable incidents decreased from 4.0 per 100,000 hours flown before 1985 to 3.2 from 1984-89, and declined further to less than 1.5 after 1995. However, there has been an increase in serious incidents (to a total of 3) in 1999. The reasons for this are not yet obvious - a statistical blip resulting from the small amount of input data, a greater willingness to report incidents or other factors, perhaps resulting from a reduction in aircraft maintenance, for example.
- The number of hours flying time for helicopters offshore increased from 1968 to 126,000 flight hours in 1984, declined to 97,000 hours in 1987, increased again to 134,000 in 1990 and declined again to 97,000 hours in 1998. Following the recent recovery in the oil industry worldwide, it is expected that the number of hours and flight stages flown will show an increase of some 5% per year during 1999 and 2000.

Causes of accidents

CAP87007 (19) notes:

The causes of the fatal accidents [all helicopter accidents in the UK 1976-1984] were split equally between mechanical failures and human error, but most of the latter were operational in character, eg flying into obstructions, flying in meteorological conditions for which the pilot was not qualified or pilot disorientation.

3. RISKS FROM HELICOPTER TRAVEL OFFSHORE

Helicopter travel contributes significantly to the overall risks to individuals working offshore. Health and safety risks from helicopter travel involve:

- **risks to personnel while they are in the air** (helicopter passengers and aircrew) from collision impact, fire or drowning
- **risks to personnel on board an installation** (including people in a helicopter at rest on the helideck) due to helicopter impact with the installation, and hydrocarbon events, eg a helifuel fire, escalating to fire and explosion elsewhere.

Depending on site-specific features such as the type of installation (fixed or floating, integrated or separate production, drilling and accommodation facilities, the wind, wave and current environment, local soil conditions, applicable earthquake zone, proximity to shipping lanes, etc), the greatest risks to the safety of people on board an installation can often be simplified to include:

- occupational risks (related to job function)
- process fire and explosion risks
- helicopter accidents
- riser and pipeline accidents
- ship collision
- extreme weather
- dropped objects
- earthquake.

Safety cases that Installation Duty holders are required to produce for assessment and acceptance by the Health and Safety Executive's Offshore Safety Division (6) indicate that helicopter travel is one of the higher ranking risks for many modern installations, alongside occupational risks, ship collision and risks from fire and explosion from hydrocarbon releases from drilling and topsides processing.

Based on historical data (which may not necessarily indicate the current levels of risk), helicopter travel to and from offshore installations is shown to generate one of the main sources of risk for offshore workers. Particularly on more modern installations (where other risks may be low), helicopter transport may be indicated as the dominant risk.

A risk assessment, which may be qualitative or quantitative, must be included in the safety case. Explicit quantitative risk assessment based on statistical data has been made for a number of installations.

Risk assessment is now central to understanding all kinds of health, safety and environmental improvements. Risk research over the last three decades has focused on the development of methods and procedures for risk analysis and risk management and is now done routinely for assessing different hazards. There is also now more understanding of the uncertainties involved in this process, with the result that quantification through a technical assessment, though often considered to be useful, may not be the most important guide to risk management and acceptability. Technical [qualitative] assessment may provide the best method of judging the average probability of an adverse occurrence. It does not replace the need to draw up suitable performance standards for safety critical systems and equipment and set overall acceptance criteria. These will come from societal concepts based on public perception of risk as well as on

regulations and guidance based on consensus judgements of good practice set out in codes and standards.

Safety practice is now more and more based on more qualitative areas of human factors. (29)

As mentioned in Section 2, some experts argue that statistics going back earlier than 1990 are not truly representative of current risks. The author feels that it is still too early to make such an assumption. Good reasons would require be given to use anything other than the complete figures in any QRA, and so avoid the increased uncertainty associated with the use of a relatively small population database.

Many installation safety cases refer more to the prescriptive requirements of CAP 437 (10) and to a generic risk assessment using historical data rather than to a more specific assessment of the risks on a particular installation.

In the UK, risks from a helicopter crash must be demonstrated in the safety case to be so low that these can be accepted by the Installation Duty holder and HSE. It is good practice that the safety case should take into account the views of the offshore workforce where possible and show that all reasonably practical measures to reduce risks to personnel on the installation from helicopter operations are being employed.

Helicopter hazards at an installation

Hazards from helideck operations include:

- human factors, especially pilot error, affecting helicopter performance
- adverse weather conditions, including low cloud at helideck level and poor visibility
- mechanical failure of a helicopter on the approach, past the decision point
- obstructions related to the layout of the topsides structures and equipment
- strong vibration from collision with external structures, explosion or mechanical failure or failure of aircraft systems. (Severe vibration has been identified in several air accident investigations as part of the escalation path leading to the loss of airworthiness and crash of the helicopter.)
- operational hazards such as a badly placed crane or unsecured items on or near the helideck (plastic bags, tarpaulins)
- birds (seagulls)
- process thermal effects, eg turbine exhausts and hydrocarbon hot and cold venting
- wind turbulence from topsides structures
- any deficiencies in the design and construction of the helideck.

Risks to people on a helicopter

Passenger safety

Helicopters flying personnel to offshore installations operate as *non-scheduled passenger aircraft*. Helicopter Operators manage their operations at an onshore heliport, in the cruise part of the flight and near an installation largely by relying on standard procedures prescribed by the aviation regulatory authorities with regard to obstruction-free approach paths, measures applicable to adverse weather conditions, particular types of helicopter, etc.

Passengers check in at heliports where staff confirm the individual's identity from a company-provided computer pass and passport. A check is made that the prospective passenger's Offshore Survival Certificate and Medical Certificate are current.

Personnel waiting to board prepare for their flight in a waiting room near the reception area at the heliport or for the return journey on the installation. A safety video is shown to passengers in the departure lounge shortly before boarding. This describes the safety systems and emergency procedures that apply to the particular type of helicopter being used. Instructions are given for use in an emergency of the particular types of lifejacket, immersion suit and other rescue and survival equipment provided.

Every person boarding or disembarking at an onshore heliport on a fixed or mobile installation or at a ship at sea or on a helicopter in flight is expected to follow the instructions given by the pilot and Helicopter Landing Officer and attendant crew.

Offshore helicopter passengers and crew are made to wear immersion suits. By contrast, passengers transiting over water onshore in comparable twin-engined small aircraft, such as the Twin Otter, are not. Although the risk of an accident is comparable, the perceived risk is greater offshore. Some Installation Operators have suggested that immersion suits should be dispensed with, provided they can demonstrate with the benefit of HUMS and other technological developments that the accident rate is now no worse than for a typical small turboprop aeroplane. Understandably, the regulatory authorities have rejected what could be seen by the public as a move to reduce current safety standards offshore.

Improving helicopter operational performance

CAP 87007 (19) noted a number of areas where improvements to aircraft design and operation might reduce risks, including:

- Avionics and instrumentation

In older designs, equipment may not have been designed specifically for use in helicopters but adapted from equipment already in use in fixed wing aircraft. This equipment suffered from problems not encountered on fixed wing aircraft, largely due to vibration.

- Ability to fly 'hands off'

Being able to maintain level flight automatically goes a long way to reducing pilot workload and discomfort. Even on long sectors, heading and height hold facilities are not always provided.

- Low visibility rig approaches
- Engine health, power assurance checks and on board computer
- Fuel and oil gauging - use of more sophisticated fuel management systems
- Loading indication

The performance of helicopters ... is such that there is little margin for error. The possibility of becoming airborne with a gross weight error endangers the operation. A number of cases of gross loading error have occurred and a direct means of measuring load should be sought.

- Intake blockage
- Automatic stabilisation systems - see above re the usefulness of having the capability for hands-off flight.

A criticism of some autostabilisation systems currently in operation was the inadequate redundancy provided in relation to the handling qualities following a first failure. Coupled models which enable the helicopter to be flown 'hands off' greatly reduce the

pilot workload and hence fatigue, which would be particularly valuable on the longer sectors. Although coupled modes are available as an option on some autopilots, this equipment is not always fitted.

- Loss of rotor speed
- Noise and vibration

Noise and vibration contribute to the fatigue of aircrew and passengers, as well as mechanical degradation. This is recognised as a major problem. The reduction and suppression of vibration has been the subject of considerable research by aircraft manufacturers.

Risks to people on an installation

Crash onto the helideck has been identified by Installation Duty holders as the credible event most likely to affect people already on an installation, though the probability of occurrence is very low. A possible crash onto other topsides structures is usually subsumed into the assessment of the crash-on-helideck case, given the limited footprint of a helicopter over an installation. There are two possible scenarios:

- In preparation for **landing**, the pilot has completed the approach to the installation and is close to or in the hover above the helideck, when an equipment failure or pilot error occurs
- During **take-off**, equipment failure or pilot error results in a rapid descent and possible missiles if the rotors are damaged.

Both the above scenarios are credible routes to a major accident. The consequences may be a heavy or emergency landing, or a crash onto the helideck. The potential for escalation may be low, given the relatively large separation between the helideck and process equipment on many installations. Accommodation is sometimes protected by having the helideck structure overhead.

The S58 crash onto a Forties platform in 1976 as a result of failure of the tail rotor control and the S61 accident on Brent Spar in 1990, where the helicopter hit a crane on its descent to land, are examples of past incidents. Escalation risks associated with helicopter impact onto an installation are usually assessed as very low and subsumed into the overall risks from helicopter travel.

To assist helicopter operations and to reduce collision risks, helidecks are identified by approved markings and lighting systems. During close approach, two-way communication is maintained between the helicopter and helideck crews to warn of any hazards that become apparent.

Activities by the operator of the installation that could give rise to hazards to helicopters during take-off and landing include movement of the cranes in the vicinity of the helideck and approach and take-off sectors, flaring of gas, turbine operation and obstructions that could cause turbulence in the airflow around the helideck. The effects of the helicopter operating environment are considered further in section 6.

Combined operations, involving a drilling rig carrying out a workover for example, or a flotel positioned near an installation, can infringe the obstacle free zone in some configurations. This kind of infringement used to occur in the past on occasion. It is a matter for the now better-informed safety management to prevent such occurrences.

Part of the bad weather hazard that can affect helicopter safety is spray from high waves. Spray can come close to reaching a helicopter approaching or taking off, especially on mobile installations.

There is an obvious risk if the pilot does not have an up-to-date copy of the AERAD plate showing the physical characteristics of the installation or has not been notified in advance on the IVLL of any new hazards (from a newly installed module, for example).

In-flight risk in the 500 metre zone

The in-flight risk near a drilling or production installation of a helicopter accident may include the possible consequences of fractures of impacted risers and pipelines and other subsea structures.

The likelihood of surviving an in-flight failure while an aircraft is close to an installation might be thought to be relatively higher than during the cruise phase of a flight. The helideck on the installation would most likely be available to make an emergency landing. If the helicopter ditched in the sea, rescue services from the installation and any standby vessel should be stationed nearby. However, difficulties in making a controlled descent in an emergency situation, and the presence of physical obstructions on the installation such as the flare and drilling derrick, could counteract these advantages.

The Cormorant A accident of 1992 (23) was an example of an accident occurring in flight in the 500 metre zone. The helicopter was on a shuttle flight from the installation to a nearby flotel (a semi-submersible used for accommodation), the Safe Supporter. In very bad weather, the (Super Puma) Tiger helicopter did not attain sufficient forward speed before attempting to turn in the direction of the flotel moored a few hundred metres away. The aircraft lost height rapidly and crashed into the sea. There were six survivors, including the pilot.

Pilot error was blamed for the accident. The Fatal Accident Inquiry found that the pilot had not taken action to maintain suitable height and speed, had failed to monitor instruments and did not take timely and effective corrective action when necessary. The co-pilot failed to communicate the loss of air speed to the captain. If the pilot had flown a larger circuit, the accident probably would not have happened.

Bad weather contributed substantially to the accident: it was the coldest night in the North Sea for six years, with winds gusting to 80 knots and very high waves. The Installation Duty holder subsequently modified their adverse weather policy, restricting helicopter operations further and setting limits for flying in bad weather.

Health risks

Noise and vibration

There is little published information available relating to risks to health from the uncomfortable levels of noise and whole-body vibration to which aircrew and passengers in helicopters and helideck crew on installations are exposed and any resulting effects over time. This may be an area requiring further research.

Effects of installation design

A small number of fatal accidents have occurred where a deficiency in the layout or design of the topsides modules or deck structure has been identified in accident reports

as contributing to the accident. In two cases, approaching helicopters collided with a topsides structure around the helideck while in the air: the Brent Spar accident in 1990 (22) and at Ekofisk in 1991.

Brent Spar was a semisubmersible offshore storage and tanker offloading unit (now decommissioned and scrapped). The accident happened while the helicopter was manoeuvring to land. After the pilot of the S61 approached to a hovering position near the helideck, the tips of the tail rotor blades contacted a handrail surrounding the anemometer mast attached to the crane A-frame. As noted above, the helicopter crashed onto the helideck then fell over the side of the deck into the sea. Seven survivors were rescued. Six occupants died, including both aircrew.

Although the subsequent AAIB investigation and Fatal Accident Enquiry indicated pilot error as the primary cause of the accident, design factors may also have contributed. The accident report indicates that:

- the helideck was smaller in size than recommended in CAP 437
- a crane may have increased the obstruction of the approach and take-off paths.

In the **Ekofisk** accident, pilot error was again indicated as the cause. The main rotor of the Bell 212 came into contact with a flare on the production platform while carrying an underslung load during maintenance work.

A number of dangerous occurrences (not involving fatalities or major injuries) have taken place where helicopters have come into contact with structures and equipment on the installation during landing and take-off. In the **Claymore Accommodation Platform** heavy landing of 1995 (3), the design of the turbine exhausts was the cause of the poor helicopter operating environment around the platform at the time. Further discussion of the influence of installation layout and design on helicopter risks is included in Section 6 Helicopter Operating Environment.

Offshore workers' perception of risk

The majority of respondents felt safe when completing their work tasks. However, working with radioactive materials, completing a task started by others and being on the platform while drilling is taking place only produced feeling safe responses in half of the sample. Well interventions, non-routine operations and being on the platform during a process start-up were the next group, with around 60% of the sample reporting feelings of safety in relation to these tasks. Helicopter travel was another item that showed fewer people feeling safe (51%), which is very similar to the 57% of Norwegians feeling safe in relation to helicopter travel reported by Rudno (1990). This may be an accurate assessment of the relative risks as helicopter flight is the most hazardous aspect of offshore life (in terms of QRA) for a number of installations across the North Sea (44).

4. REGULATIONS

Regulatory and advisory bodies

International requirements agreed by the International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO) are set out in ICAO Annex 14 (24), the Heliport Manual (15) and other documents and enacted in national regulations and guidance such as CAP 437 (10). IMO Rules apply to ships. For FPSOs and mobile offshore drilling units (MODUs), both ICAO and IMO rules apply.

Standards for all aspects of helideck design are set out in these documents and in the American Petroleum Institute Recommended Practice for Fixed Platforms API RP2L (25). This last document is the *de facto* international standard and is often specified in countries where a national standard is not available. CAP 437 (10) also has wide international acceptance. The new ISO international standard for Offshore Structures (6), currently under development, is intended to harmonise existing standards worldwide for offshore helidecks on both fixed and floating installations.

The *Health and Safety at Work, etc Act 1974* (HSW Act) (7) is the principal legislation in Britain that provides for the health, safety and welfare of workers, including those employed in the offshore oil and gas industry. The Act was extended offshore in the HSW Act 1974 (Application Outside Great Britain) Order 1995 to include helideck activities on offshore installations. However, the Act does not apply to people on board helicopters in flight. (See Appendix 2.)

The applicable UK Acts and Regulations are listed in section 8 References. The Duty holder for an offshore installation is the Installation Operator (or Owner in the case of a floating installation).

There are different responsibilities for helicopter safety offshore as between Helicopter Operators and Installation Duty holders. In the United Kingdom, the Civil Aviation Authority (CAA) regulates the former, and the Health and Safety Executive (HSE) regulate the owners and operators of offshore installations.

CAA regulates activities at onshore heliports and when a helicopter is in UK airspace and HSE regulates risks to the health and safety of personnel when they are on an offshore installation from the time they touch down to the time they leave.

There is an interface between these two areas of responsibility and this is the subject of a Memorandum of Understanding between CAA and HSE. The regulatory regime is summarised in the joint HSE and CAA publication *How offshore helicopter travel is regulated* (26).

Both HSE and CAA are semi-independent statutory organisations (*non departmental government bodies*) reporting to UK Government ministers. Government normally puts provisions for legislation before the UK parliament on advice from HSE and CAA.

Helicopter operator

Civil aviation in the United Kingdom is regulated through Air Navigation Orders made under the Civil Aviation Act of 1982 (27) and enforced by the Civil Aviation Authority (CAA) with reference to European Joint Airworthiness Requirements (JARs) (4, 5).

JAR OPS 3 imposes a requirement on Helicopter Operators to authorise the use of each helideck. They do this through BHAB (British Helicopter Advisory Board) surveys.

Helidecks on offshore installations in the UK are classed as *unlicensed aerodromes* and therefore their design, construction and operation do not require to be approved by CAA. The responsibility for ensuring safe operations rests almost entirely on Helicopter Operators and Installation Duty holders acting together.

Civil aviation regulations in the UK are supported by Civil Aviation publications (CAPs). The most useful guidance for helicopter operations offshore may be CAP 437 *Offshore Helicopter Landing Areas: Guidance on Standards 1998* (10). This document includes guidance on the design and construction of offshore helidecks, management of helicopter operations and the firefighting equipment to be available near the helideck.

CAP 437 is designed to assist helicopter operators meet their legal duties under an article of the Air Navigation Order (27) which requires them *not to permit the aircraft to fly for the purpose of public transport without first satisfying himself by every reasonable means that the aerodrome at which it is intended to take-off or land ... [is] suitable for the purpose and in particular [is] adequately manned and equipped ... to ensure the safety of the aircraft and its passengers.*

Risks to personnel on board a helicopter are not generally considered explicitly in aviation regulations and guidance. Risk reduction is considered to be inherent in the aviation requirements.

Offshore installation duty holder

As the Installation Duty holder is normally the company employing the Helicopter Operator as a contractor, a large part of the responsibility for safe operation of helicopter landing areas offshore rests with the former. The HSW Act (7) and regulations made under it, including the Management of Health and Safety at Work Regulations (MHSWR) (28) require the Installation Duty holder to audit and review the policies and procedures being implemented by their contractors.

The part of the Offshore Installations (Safety Case) Regulations 1992 (8) dealing with helicopter operations is written from the point of view of protecting the health and safety of personnel on board an installation from helicopters, where the helicopter is treated as a hazard, rather than to protect people on board helicopters while they are in the air.

It is worth noting that mere compliance with CAP 437 may not be sufficient for the Installation Duty holder to demonstrate that they have carried out the duties imposed by the Safety Case and other regulations applying to helicopter operations offshore.

The regulations that apply particularly to Installation Duty holders include:

The Offshore Installations (Safety Case) Regulations 1992 (SCR) (8)

Offshore Great Britain, the responsibility for demonstrating that a helicopter can safely be operated to a helideck for a particular installation rests with the Duty holder for that installation. The Installation Duty holder is required by the Offshore Installations (Safety Case) Regulations to identify the routes to a major accident, (including for example the collision of a helicopter with the installation), to assess the resulting risks to personnel and to control these risks so as to reduce them to as low as reasonably practicable (ALARP).

Regulation 2 specifically defines a helicopter crash on to an installation as a major accident. There is therefore an explicit requirement to assess the risk to personnel on

the installation from this event. It is important to note is that it may not be enough simply to consider the prescriptive requirements of any one landing condition, even though this may be the limiting condition identified in current guidance and should therefore be given due weighting. It is possible that other credible major accident scenarios could be identified by the Duty holder and the safety case would therefore require to consider these. Some of the other regulations applicable to the Duty holders for offshore installations include:

Offshore Installations (Prevention of Fire and Explosion, and Emergency response) Regulations 1995 (PFEER) (29)

Regulation 6(1)(c) requires a sufficient number of personnel trained to deal with helicopter emergencies to be available during helicopter movements.

Regulation 7 requires the operator/owner of a fixed/mobile installation to ensure that equipment necessary for use in the event of an accident involving a helicopter is kept available near the helicopter landing area. Equipment provided under Regulation 7 must comply with the suitability and condition requirements of Regulation 19(1).

Regulations 9, 12 and 13 make general requirements for the prevention and control of fire and explosion. This includes helicopter accidents on an installation.

Regulation 17 of PFEER requires arrangements to be made for the rescue of people near the installation from helicopter ditching and to ensure that there is *good prospect of recovery*. This regulation makes it necessary for an Installation Operator (and their contractor, the Helicopter Operator) to implement an Adverse Weather Policy.

In addition, CAA enforces legislation that requires aircrew to wear immersion suits over water in some circumstances. The extension to include helicopter passengers was originally made voluntarily by the Installation Operators through the Helicopter Operators and may now be enforceable under PFEER.

Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995 (MAR) (30)

Regulation 8 requires people to co-operate with the Helicopter Landing Officer to enable him to perform his functions, referred to in regulation 13.

Regulation 11 requires comprehensible instructions to be put in writing and brought to the attention of everybody to whom these relate. Circumstances where written instructions might be needed include helideck operations (particularly involving part-time helideck crew).

Regulation 12(b) requires arrangements which are appropriate for health and safety purposes, to be in place for effective communication between installation, the shore, aircraft and other installations.

Regulation 13 requires the operator/owner of a fixed/mobile installation to ensure that a competent person is appointed to be in control of helideck operation on the installation. The Helicopter Landing Officer should be present on the installation and in control throughout helicopter operations. Procedures should be established and plant provided to secure helideck operations, including landings and take-offs, that are without risks to health and safety so far as is reasonably practical.

Regulation 14 requires the duty holder to make arrangements for the collection and keeping of meteorological, oceanographic and information relating to the movement of the offshore installation, as environmental conditions may affect helicopter operations and the ability to implement emergency plans.

Regulation 19 requires the Installation Operator to ensure that the installation displays its name in such a manner as to make the installation readily identifiable by sea or air, and displays no name, letters or figures likely to be confused with the name or other designation of another offshore installation. [This regulation is intended to make *wrong-rig landing* less likely.]

Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 (DCR) (9)

Regulation 11 requires the Installation Duty holder to ensure that every landing area forming part of an installation is large enough and has sufficient clear approach and departure paths to land and take off in any wind and weather conditions permitting helicopter operations, and is of a design and construction adequate for its purpose.

BHAB

The British Helicopter Advisory Board (BHAB) is the industry association representing helicopter operators and manufacturers. The Helideck Subcommittee has the responsibility for recommending the suitability or otherwise of the design and construction of helidecks offshore UK to its members to help them fulfil their legal requirement to satisfy themselves as to suitability.

BHAB maintain data on helidecks, equipment and operating environments for offshore installations in UK waters. They also inspect the hardware on helidecks, monitor infringements and standardise any limitations that may need to be applied.

OIAC

The Offshore Industry Aircraft Committee (OIAC) Helicopter Liaison Group was formally constituted in 1993 *to advise as required on the development and operation of the safety regime for offshore helicopter operations, under the HSW Act and its subordinate legislation, and on any related safety matters.*

Following the transfer of offshore safety regulatory responsibilities to HSE in relation to the Health and Safety at Work Act, OIAC was set up with representatives from HSE, CAA, UKOOA, IADC and the trades unions (MSF and TGWU). Its tasks were:

to monitor and, where appropriate, advise on actions taken by industry and HSE to improve safety standards on offshore helidecks, in the light of CAA's present and future advice to HSE;

in particular, to advise on all operational aspects of helideck safety (including both normal and emergency arrangements).

The Committee's terms of reference include the safety of passengers on board helicopters in flight as well as on an installation. This includes Duty holders' related safety management systems and safety case issues. HSE provides the Secretariat for the committee.

Findings of recent enquiries into offshore safety

Aberdeen University (AUPEC) 1999 (31)

AUPEC carried out an evaluation of current guidance and practice. The researchers sought views from members of the workforce and managers employed by a range of different types of organisations working offshore in five particular areas:

- a management survey
- a survey of the financial costs and benefits of the legal requirements
- work to follow up a survey of workforce views in 1994/5
- a review of published material examining the effectiveness of the regulatory regime for offshore installations
- a review of safety data from published statistics and independent research.

The author considers the following two findings of the AUPEC report to be of particular importance in relation to the safety of helicopter landing areas offshore:

***Regulatory Interfaces* (ref 8.5.5 rec 5 & ref 8.7.1 rec 1 & ref 8.8.1 rec 1)**

The evaluation found that industry perceives the marine, offshore and aviation regulators as being insufficiently equipped to deal with interfaces between legislative jurisdictions. It is evident that liaison arrangements do exist, extending in several cases to formal Memoranda of Understanding and matrix-based models of the regulatory interfaces. These arrangements are insufficiently appreciated and understood in the industry. There should be greater transparency of these arrangements and enhanced efforts to communicate them to the industry.

***Management and Administration Regulations (MAR)* (ref 8.9.3 Rec 3) (30)**

The complexity of relationships between contractors and operators offshore has been recognised by the inclusion of a generalised duty of co-operation in MAR. The importance of regular contact between companies with different but overlapping Duty holding responsibilities under safety legislation should be emphasised.

Other findings and recommendations of the report that may the author considers be apply particularly to Installation Operators, Helicopter Operators, the regulators and others include:

Managing risks to personnel from helicopter operations offshore

The risk assessment process had enabled many companies to improve their understanding of the main risks. However, managers found the law complex, and a number expressed concern about inconsistency by HSE.

Workforce involvement was widely regarded as an area where the industry still had considerable work to do.

There were major concerns about the methodology and application of Quantified Risk Assessment.

More could be done to communicate good practice and improve understanding of the way different regulations are related.

***Safety Management Systems* (ref 8.2.1 rec 3)**

The importance of a robust, comprehensive and active safety management system is widely acknowledged in the industry. It was acknowledged that economic downturns and cost-cutting can impact offshore safety through degradation of the safety management system.

HSE has a major role to play in promoting good practice in safety management and also in ensuring through inspection that safety management systems remain robust in difficult economic conditions. HSE has improved the delivery of specialist support from its topic experts to its field inspectors through internal reorganisation in the late 1990s. However, there is scope for further enhancements of the skills of operational inspectors to identify SMS failings and apply solutions, by devolving SMS expertise further into inspection management teams.

Communicating Best Practice (ref 8.2.5 rec 13 & ref 8.9.4. rec 6)

Pending new regulations, there is considerable scope for better communication of best practice on active workforce involvement in risk analysis and related activities. This may be achieved through good practice workshops or other training environments. HSE has a key role to play in this activity.

Goalsetting Regime (ref. 8.2.4. rec 6)

The importance of Duty holders understanding their own responsibilities in a goalsetting regime needs to be reinforced. Problems have arisen with companies which may have been operating in a prescriptive environment for a long time: with small contractors who still expect to pass responsibility to clients or installation owners and with some companies who find difficulty in managing compliance in regimes which have both prescriptive and goalsetting elements.

The evidence from the evaluation is that some companies do not fully appreciate the extent of their freedom of action under the Cullen regime. Equally, they may be unaware of how much responsibility they must take on themselves if they are to make full use of that freedom of action.

Risk Assessment (ref 8.2.5 rec 12 & ref 8.9.4 rec 5)

More should be done to encourage practical workforce participation in risk analysis and Safety Case development and monitoring activities. Current workforce involvement provision by operators adopts a restrictive view of the role of workforce involvement. Future development of workforce involvement legislation should contain guidance on how active workforce involvement can be achieved.

Regulatory Complexity (ref 8.3.3 rec 3)

The complexity of the regulatory regime, both in the content of individual regulations and the inter-relationships between them, remains a problem to many in the industry. Difficulty in understanding the regulations is not helped by the fact that, with few exceptions, regulatory and guidance material is promulgated only in text form. There is scope for improving understanding of the inter-relationships between regulations and of the boundaries of individual regulatory provisions by using graphics to illustrate guidance. More emphasis should be put in the development of non-text guidance. This may be best achieved by a collaborative effort involving the regulators, the industry and training providers.

Safety Performance Indicators (ref 8.4.1 rec 1)

There is a requirement for better definition of some data and further analysis. Breakdowns could include accident rates by occupational group, by contractual status (operator, contractor or subcontractor), and by shift status. There may be value in adopting a new definition for less serious incidents than the current 3-day definition.

(ref 8.4.1 rec 2) The work done by HSE OSD on severity analysis of hydrocarbon releases should be extended to other dangerous occurrences which do not involve hydrocarbon releases.

Review of Oil Industry Accident and Incident Data (ref 8.4.3. rec 3)

Examination of the accident data of the past seven years has shown that there are many problems in the measurement and definition of accident statistics which must be overcome before accident data can be used as an objective measure of safety performance.

Future of Offshore Safety: Industry Schemes and Benchmarking (ref 8.4.3 rec 6)

A comparison across all the published studies conducted from 1993 onwards shows an informed and knowledgeable workforce, who understand where the hazards lie and are generally satisfied that there are adequate measures in place to mitigate against these. The study considers it encouraging that the future focus from the offshore industry is recognised through the Step-Change initiative and recent HSE conferences and workshops on workforce involvement in the process of safety.

Cullen Enquiry 1990 (32)

Recommendation 77 of the Cullen Report proposed that operators should adopt a flight-following system for determining at short notice the availability and capacity of helicopters in the event of an emergency. Appropriate measures were implemented along with other Cullen recommendations. Rather than a flight following system being developed, VHF rebroadcast was installed on a number of platforms to allow Air Traffic Service staff onshore to be in two-way communication with aircrew on board helicopters over most of the British sector of the North Sea.

Burgoyne Committee 1980 (33)

The committee noted (5.107) that responsibility for safety of personnel in flight was a grey area, with offshore employers having varying degrees of involvement in, for example, the provision of survival suits and ear protection and training in underwater evacuation from a ditched helicopter.

Training has now been largely standardised by Duty holders, as agreed with OPITO, at training establishments and both on- and offshore in departure lounges at heliports.

Regulations current in 1980, including considerations as to the location, design and equipment of helidecks, including SI 289/1976 Construction and Survey Regulations, Firefighting Equipment Regulations, etc have now been replaced by the new goalsetting legislation brought in after the Cullen enquiry, as described above.

5. DESIGN OF OFFSHORE HELIDECKS

An offshore helideck has to combine in one helicopter landing area a place suitable for parking, the immediate take-off and further lift-off and approach and touchdown. By comparison, an onshore heliport may have separate parking areas and a departure clearway containing a Rejected Take-off Area. The arrangement onshore allows more space to accommodate pilot mishandling errors and the effects of any adverse environmental conditions.

For economic reasons the offshore helideck has to take up the smallest possible layout area (including any parking area). The environment surrounding the helideck has to be free of permanent obstacles in the Obstacle Free Sector, and only limited obstructions in the Limited Obstacle Sector.

The focus during helideck design should be on the whole system, ie the helideck in the context of the installation management system and overall operating environment. This has not always been the case with past helideck designs and has sometimes resulted in extra operating and redesign costs.

Helicopter operations offshore

The design of the helideck on an offshore installation needs to be considered in relation to its intended operational use and to other activities on the installation, taking account of the positioning of other topsides structures.

Operational activities such as drilling, process, power generation, accommodation, diving and crane operations, and the working environment around these facilities, may have implications for the helideck design.

Vessel movements around the installation will also need to be considered (especially for FPSOs and other floating installations).

Items that need to be considered during the conceptual and detailed design include:

- the maximum size of helicopter likely to land
- the structural capacity of the helideck for the selected helicopter
- helideck height above sea level
- capability to provide a clear 210 degrees approach sector
- any limited obstructions
- the falling gradient (5:1 from the edge of the landing area over the central 180 degrees within the 210 degrees sector)
- orientation to prevailing winds
- gas and exhaust emissions
- air turbulence from nearby structures
- effects of vessel motions if applicable
- access and escape routes
- any need for a parking area
- lighting
- marking

- landing net or friction surface choice
- tiedown locations
- perimeter safety net
- refuelling facilities
- firefighting equipment
- text and references in the safety case, operations manual and other documents.

Failure to optimise the design of the helideck can result in operational restrictions in certain wind directions, reduced payload and increased operational expense, and may later lead to expensive modifications as noted above.

Nets are not often specified for new installations, as these can be inconvenient tripping hazards and make the use of wheeled trolleys almost impossible.

Environmental problems can limit helicopter operations, drilling and production operations in areas exposed to natural ventilation and affect the health and safety of personnel. Offshore helicopter operations can be seriously affected by the degree of turbulence above the helideck, the magnitude of the downward wind component and the temperature rise above ambient caused by hot exhaust gases. The degree of turbulence induced by nearby deck structures can be minimised by placing the helideck in as widely spaced and easily accessible a location as possible and in an area likely to be upwind of gas emissions from exhausts and flares. It may be difficult, though, to optimise the design for an installation which has limited space and changing process operating conditions.

Wind turbulence

The installation superstructure distorts the wind flow, causing locally increased turbulence. Potential problems can be identified if a wind-tunnel model study using flow visualisation techniques is carried out, although, increasingly, computer-generated CFD (computational fluid dynamics) models are being used instead. The results allow appropriate remedial measures to be identified, eg design changes by altering the position of the helideck or of obstructions or exhausts. As a last resort, operational modifications can be made or limits placed on operations in the higher risk conditions (for certain wind directions, for example). These tests effectively enable the designer to verify the design at an early stage.

Gas turbine exhaust plumes

Hot exhaust plumes from gas turbines on an installation can affect helicopter performance. The power output of the turbine engines on a helicopter is reduced as the air temperature at the intake increases. The helicopter payload therefore has to be reduced to compensate as the surrounding air temperature rises. Under certain wind conditions, the helideck crew themselves may be exposed to high temperatures.

Further information relevant to design and operation is given in the UKOOA Guidelines for the management of helideck operations.

Helicopter landing loads

CAP 437 (10) and current ICAO recommendations (15) are very closely related. Although both documents are produced for guidance, their recommendations are generally taken by both Helicopter Operators and Installation Duty holders to be mandatory for the design of offshore helidecks. CAA might not issue an Air Operator's Certificate to a Helicopter Operator flying to a helideck that was not broadly in line with CAP 437. This document has effectively become the standard for helideck design in the UK and in many other parts of the world. Although directed less towards helicopter operations, CAP 437 contains some useful advice in this area that has been adopted by the offshore industry.

The author is advised that CAP 437 was initially based on recommendations from the then Department of Energy (DEn). DEn used aviation consultants in drawing up the standards included in *4th Edition Guidance (Offshore Installations: Guidance on Design, Construction and Certification Fourth Edition 1990)* (34). 4th edition guidance was adopted by the Health and Safety Executive on its assuming many of the regulatory responsibilities for offshore health and safety in 1991. This document is no longer published by HSE or otherwise maintained, being largely replaced by up-to-date guidance from other sources. The provisions of CAP 437 are almost identical to the earlier HSE guidance. Further information about the history of the development of standards for helidecks offshore UK is given in chapter 1 of CAP 437.

Normal (heavy) landings

The load factor for vertical loads for normal landings of 1.5 MAUW given in CAP 437 (10) is derived from the helicopter closing vertical descent velocity at touchdown specified in JAR 29 for helicopters. (There are equivalent values for other types of aircraft in other JARs.)

Helicopters, and particularly their undercarriages, are tested in drop tests designed to allow the helicopter to reach the specified terminal velocity of 2.5 metres per second under the influence of gravity over the height of the drop.

The concept of a *heavy normal landing* given in CAP 437 is not recognised in ICAO Annex 14 (24) or in the design codes of countries other than the UK. In any event, the normal condition does not govern the design of any helideck structural members.

Emergency landings

Emergency helicopter landings may be considered as Design Accidental Events that the installation is designed to resist using the criteria from ICAO or national standards.

Whereas the American code API RP 2L (25) gives a load factor of 1.5 for the vertical dynamic load from emergency landings, ICAO and CAP 437 use a factor of 2.5. The Norwegian regulations (35) specify a factor of 3.0. These values are based on engineering judgement and tried and tested in service. Historically, no helideck designed to either the 1.5 or 2.5 load factor has ever failed under the load applied by a helicopter in service, even under the few emergency conditions recorded.

API RP 2L has no lateral design load requirement. Again somewhat arbitrary, the load factor of 0.5 MAUW specified for the applied horizontal load on offshore helidecks in CAP 437 is derived from the JAR OPS 3 ((4) requirement to consider run-on landings and can be related back to a particular value of the horizontal component of aircraft velocity at landing.

Helicopter crash on an installation

In contrast to emergency landings, crash landings are Residual Accidental Events, ie events that can not readily be designed against. Instead, the probability of occurrence must be demonstrated to be very low indeed. This may be done by reference to previous accident data or by synthesis, through projection and assessment of information for a particular installation by experienced and competent personnel.

After an incident

The response planned by the Helicopter Operator and Installation Duty holder after an accident should be coordinated in the Emergency Response Plan for the installation and referred to in the installation Safety Case. It may be possible to move a crashed helicopter away from the landing area on to a parking area or off the helideck completely to allow other helicopters to land if necessary, those assisting in an evacuation for example. Generally, if a damaged helicopter can not readily be returned to a condition suitable for flying, it will be lowered by crane onto a work vessel for transport to shore.

Existing design methods

Helideck structures are designed in much the same way as other offshore structures using national standards such as AISC (36), BS5950 (37), NS3472 (38) and, when published, the ISO code (6). (The standards body for the European Union has an agreement that the existence of an ISO standard obviates the need for a comparable EC standard.) The designer is normally a design contractor, a company such as Wood Group, Kvaerner or Brown and Root that is contracted to the company managing the construction of the installation as part of a field development plan. The design and construction of the helideck is sometimes subcontracted to a specialist contractor, especially if an aluminium helideck is specified in the client's Basis of Design.

The structural strength of the helideck must be designed to resist the dynamic loads from an emergency landing, together with imposed area loads from snow and possible equipment left on the deck. The helideck and its supports should be designed to resist these applied loads. The vertical and horizontal dynamic loads are applied as patch loads at the wheels of the landing gear. These dynamic loads are applied as pseudo-static loads calculated by applying suitable load factors to the maximum weight of the helicopter (MTOW or MAUW).

The dynamic Emergency Landing load case normally governs the design. A check is also recommended for the static load case of a helicopter and its associated area loads (the latter are higher than for the emergency landing case).

Plastic design methods may be used for the design of the deck plate and stiffeners, assuming that a permanent deformation after a design case emergency landing is acceptable (ie a permanent set develops). This consideration from CAP 437 may not be clearly understood, as design engineers rarely make use of this relaxation. Elastic considerations are normally applied to the design of the main support structure underneath the deck *pancake*, ie the steel trusses, beams, columns and braces of which it is composed.

Although a survey of the design methods used by design contractors was not carried out as part of the current study, a study carried out by Paul Frieze Associates for HSE

in 1994 (39) showed that a variety of empirical methods are stated in Classification Society rules for checking helideck designs.

Verification

An offshore installation helideck is a collection of systems, some of which are safety-critical or have safety-critical subsystems or components. A failure of even part of their operation could cause or contribute to a major accident. All Installation Duty holders include the loadbearing deck structure in the list of safety critical elements required by PFEER (29) (often extended to cover the structural integrity requirements of DCR (8)). Helideck safety systems, such as foam monitors, are also included where these are necessary to limit the effects of a helicopter accident on the helideck.

The international requirements of classification must be followed for mobile installations that are classed as vessels. There is close correlation between the fundamentals of classification and those of verification and compliance with CAP 437 is usually assumed to be mandatory. However, mere compliance by itself may not be sufficient to meet the overall requirement to be demonstrated in the safety case to reduce risks to ALARP or the requirements of the Offshore Installations (Design and Construction) Regulations (9) to develop and maintain a safe installation.

Installation Duty holders must identify safety-critical elements, have them subjected to independent review by an Independent Competent Person (ICP) and develop a scheme to verify their performance throughout the life cycle of the installation. Such a review and confirmation that performance standards are being met is intended to verify the integrity of the helideck structure, systems and equipment and measure suitability and effectiveness.

The ICP should conduct a design appraisal and fabrication survey to verify that the helideck and its systems meet the performance standards that have been set. Appropriate design documents, including drawings, wind tunnel test reports, etc should be reviewed and verified as part of the verification process.

At the conclusion of helideck design and fabrication, a set of 'as built' documents including construction drawings, wind tunnel test reports, etc. should be passed to BHAB for review. BHAB should be notified on satisfactory completion of the helideck hook-up and commissioning so that they can carry out an initial inspection of the helideck and its systems before helicopter operations begin.

UKOOA Guidelines for the Management of Safety-critical Elements (40) give further information.

A reliability approach to design: risk-based loads and resistance

As mentioned above, current designs may be over strong for the load cases considered in current codes and standards. There is a balance between the desirable cushioning effect of a helideck crumpling on helicopter impact and retaining a sufficiently strong structure to allow emergency landings. An over-hard, over-stiff and undersprung surface may lead to the same kind of damage as a helicopter crashing on impact into a concrete runway. The risk of a helicopter crash on the helideck is considered in section 3 above. The risk is very low as a result of the very low frequency of occurrence rather than by consideration of the serious consequences if it does.

Mode of failure

There is no explicit consideration of the likely mode of failure of the helideck structural system at present. The mode of failure experienced for any particular helicopter crash scenario will depend on a number of factors:

- orientation to prevailing winds
- dynamic considerations as to the relative approach velocity of the helicopter and the helideck from heave, roll and pitch for a floating structure (this will determine the kinetic energy of the mass of the helicopter as it hits the helideck)
- stiffnesses of the helicopter undercarriage and helideck structure
- damping characteristics of the undercarriage and to a lesser extent the helideck
- natural frequencies of the two systems.

The design assumption implicit in existing international and national design standards is that for the governing emergency landing condition the helicopter will land on the deck in an emergency and immediately transfer a pseudo-static load factored from the helicopter maximum take-off weight (MTOW). A load factor of 2.5 is used in ICAO (24) and CAP 437 (10), 1.5 in API RP2L (25), and 3.0 in Norwegian standards (35).

In reality, the most likely situation, given the high strength of existing helidecks, is that the undercarriage will collapse in any greater-than-emergency landing. In such an event, the helicopter would close on the helideck at high speed, with a negative hover/thrust margin. The fuselage would then crumple as it hits the deck, deforming over a progressively larger area until all the energy of impact has been absorbed.

A scenario involving a crash either onto the helideck or other parts of an offshore structure can be shown from historical data to be highly improbable. However, such an eventuality could have high consequences for the personnel on board the helicopter, even though there might be little damage to the helideck, depending partly on the physical characteristics of the helicopter such as the quality of the seats and harnesses provided and the emergency evacuation arrangements.

It may be too restrictive to assume that a helicopter about to crash will always hit a suitably loadbearing area of the helideck, rather than the edge, say, or even a nearby topsides structure. More likely scenarios, though still highly improbable (extrapolating from historical data), include collisions with topsides structures such as the flare, cranes or drilling derrick or the helideck perimeter netting and its supports.

Current design methods based on load factors seem to give satisfactorily strong helidecks. Current designs will therefore continue to cater to an unquantified extent for any more severe helicopter crash landing scenarios that could occur.

6. HELICOPTER OPERATING ENVIRONMENT

Effective control of risks from helicopter operations offshore requires identification of all credible hazards, including environmental hazards. The position of the helideck on an offshore installation is an important safety concern to reduce environmental effects as much as possible. If the arrangement is less than optimal, the consequent operational limitations placed on helicopter flights may cause difficulties for the Installation Duty holder by restricting certain necessary activities, such as drilling or flaring.

Crew changes need to be carried out as far as possible on schedule or operational efficiency may be reduced. Personnel can become upset and angry, too, if they feel imprisoned on an installation in fog or bad weather, or for logistical reasons. However, the whole point of having an Adverse Weather Policy is (occasionally) to delay flights where necessary so as to avoid risks from helicopter operations.

Human factors

Skill of pilots

The competence of professional pilots flying to offshore installations is ensured by qualifications, training and experience and is monitored by the aviation regulators. Pilots fly in sometimes very arduous conditions of bad weather from wind, rain and low visibility at night or in fog to land on a relatively small landing area offshore. The helideck may be moving significantly as on an FPSO, for example, particularly during an emergency evacuation.

All pilots flying in Europe are required to be highly trained. Many have been flying offshore for years and are highly experienced. Several Installation Duty holders specify high levels of experience in their service contracts with the Helicopter Operators.

Pilot error

Historically, pilot error has been as common a cause of helicopter accidents offshore as mechanical failure. CAP 491 *Report of the Helicopter Airworthiness Review Panel* (HARP) 1984 (41) notes:

The causes of the fatal accidents were split equally between mechanical failures and human error, but most of the latter were operational in character, eg flying into obstructions, flying in meteorological conditions for which the pilot was not qualified or pilot disorientation.

Following the introduction of HUMS in the 1980s, and its widespread adoption since then throughout the industry, the risk of mechanical failure is now much reduced. (New helicopters destined for offshore use in Western Europe may be specified with HUMS fitted in the factory.) With the increasing reliability of aircraft mechanical and systems, human factors affecting pilot performance and judgement are probably now the major hazard to offshore flights. Steps have meanwhile been taken to improve pilot training, especially in the area of crew cooperation. All Helicopter Operators now give Crew Resource Management Training.

CAP 491 also examined duty times achieved in North Sea helicopter operations. The report of the HARP panel noted that a 20% reduction in the limits on annual, 28 day and daily flying hours would produce no significant change in times on duty. Stress and fatigue were endemic to the pilots' way of life. The report further concluded:

It seems unlikely that the main cause of, or remedy to, any current disquiet of North Sea helicopter pilots will be found in CAP 371. The disquiet which does exist amongst crews is due largely to fatigue and the prospect of continuing at the same high level of stress into the foreseeable future. Some effort is necessary to resolve this problem.

This study also concluded that pilots felt under increasing pressure to fly for commercial reasons even in difficult conditions.

There is a high pilot workload associated with the take-off and landing phases of the hundreds of offshore flights that take place every week. This workload is particularly high in conditions of low visibility and adverse weather.

Pilots are trained to fly on instruments from early on in their training courses. Aircraft procedures require the pilot to use instruments when necessary.

AAIB Bulletin No. 9/98 (42) notes:

Disorientation is very uncommon when the pilot has well-defined external visual clues; but when he attempts to fly when sight of the horizon is degraded by cloud, fog, snow, rain, smoke, dust or darkness he quickly becomes disorientated unless he transfers his attention to the aircraft instruments. The ability to maintain control of an aircraft without adequate visual clues is quite short, typically about 60 seconds, even when the aircraft is in straight and level flight at the time vision is lost, and shorter still if the aircraft is in a turn. In such circumstances, loss of control occurs because the non-visual receptors give either inadequate or erroneous information about the position, altitude and motion of the aircraft.

Other human factor errors that may be associated with helicopter operations offshore relate to:

- communications between the pilot and co-pilot in the cockpit
- boredom - the ability to generate the necessary level of professionalism and awareness on a regular and repeated basis on a succession of uneventful flights across empty sea
- lack of appreciation by the staff of the Installation Operator of the exacting requirements placed on the pilots to preserve safety
- communications between the pilot and the HLO
- understanding landing and take-off procedures
- training of helideck crew
- survival training of passengers.

Not all the points made in CAP 491 apply to offshore helicopter operations offshore. It would be interesting to know which of the recommended improvement measures have been implemented since the study was published in 1987.

Noise and vibration

There is little published information available relating to the uncomfortable levels of noise and whole-body vibration to which aircrew and passengers are exposed and any effect this may have on their performance and long-term health. There is some evidence that helicopter pilots suffer a higher than average level of back problems.

IVLLs (Installation/Vessel Limitation Lists)

It is important when helicopters are taking off and landing in wind that a headwind component is provided. This is particularly necessary in the stronger wind speeds usually encountered at sea. To ensure that some headwind component can be provided, take-off climbs and approaches need to be made available over an arc of at least 210 degrees.

Helicopter approaches may be limited by topsides structures and equipment, such as the flare, gas turbine exhausts and funnels in the case of an FPSO from certain directions. Procedures also cover crane operations and the cold venting of process equipment during helicopter operations. About half of all installations have limitations restricting helicopter landing and take-off when the wind is in certain directions, and for floating installations when roll, pitch and heave exceed specified values.

Operational information to pilots about flights to a particular installation is provided in AERAD plates and IVLLs. This information is made available to air crew for pre-flight and in-flight planning. These documents not only show aspects which will affect operations to a helideck, but also set out the reasons for any restrictions imposed.

BHAB initial inspection of an offshore helideck and appraisal of the relevant design documents is intended to note any non-compliances with CAP 437 (10) and allow them to determine any operational limitations that should be applied. An inspection of the helideck, its markings, associated equipment, physical obstructions (essentially hardware) and the peripheral operating environment (turbulence and thermal effects) should be carried out before it is put in to service. In-service inspection is an auditing requirement of the regulations made under the Health and Safety at Work Act (7).

Firefighting and rescue

Protecting the helideck and nearby structures and modules can also help to protect people from an incident that might otherwise escalate out of control. Providing the means of dealing with a helicopter accident or incident near the helideck is important. This is where there is the greatest opportunity to mitigate the consequences of any hazardous event. The need to extinguish a fire could occur immediately following a helicopter incident or during rescue operations.

The most important factors in making an effective rescue in a survivable helicopter accident (or indeed for many other types of accident) are:

- the training received
- the effectiveness of equipment
- the speed at which firefighting and rescue personnel and equipment are brought into use.

Making properly equipped firefighting and rescue teams available offshore is more difficult than onshore because of the restricted space available on a typical offshore helideck. Limitations on the positioning of foam monitors so as to avoid obstructing helicopter approach paths may also make it more difficult to achieve effective coverage of the landing area.

Although a quantitative risk assessment based on historical data for helideck fires might show that the frequency of occurrence is very low, the consequences of a fire could be very serious. No Installation Operator in the UK has proposed a reduction in the current measures taken to provide fire cover on a normally-staffed installation.

Further information about firefighting requirements and rescue requirements can be found in the Heliport Manual (15), CAP 437 (10) and in installation safety cases.

Control of crane movements

The ICAO Heliport Manual (15) notes (1.4.5.1):

It is particularly important that all crane movements on the installation and in the immediate environment are controlled efficiently. The 210 degree obstacle-free sector of the helideck must not be infringed upon by any cranes or parts thereof during helicopter movements. All cranes in the vicinity of the FATO which may, during their operation, encroach into the 210 degree sector or the 150 degree limited obstacle sector must cease movement during helicopter operations. Not only can the physical presence of cranes in the sensitive areas constitute decided hazards to operating helicopters, but crane movement, even in a safe location, can distract a pilot's attention at a critical stage of an operation. It is desirable, therefore, that all cranes, both on the installation and on any attendant installations or vessels be stationary and, if practical, be lowered and stowed clear of the obstacle-free and limited obstacle sectors during all helicopter movements at the installation.

Turbulence and heat effects

Although there were no loss of life or injuries resulting from poor air conditions around installations from 1976 to October 1999, several incidents were reported where the effects of wind turbulence or hot gases caused heavy landings and temporary loss of control of the aircraft by the pilot. The most serious report was that of a very heavy landing on an accommodation platform adjoining a production platform in 1995.

Principal sources of environmental hazard are the vertical components of wind such as downdraughts, wind turbulence and local increases in air temperature. Wind turbulence, turbine exhausts and venting of gases near an installation can affect the performance of a helicopter, leading to handling problems for the pilot. The degradation in helicopter performance can be quantified in terms of a reduction in the hover/thrust margin available to allow recovery by the pilot from a dangerous situation.

CAP 9900 (3) proposes the following issues for a helideck management system should be addressed in the safety case for an installation:

- the maintenance of an unobstructed airflow over and under the helideck
- the operation of gas turbine and diesel units in situations where hot exhaust may be emitted into the path of a helicopter
- flaring of gas and venting of flammable gas
- the location, operation and maintenance of wind recording equipment
- combined operations involving another unit in the vicinity of the installation with the potential to disturb the airflow or to emit hot exhaust into the flight path
- a system of audit and control which monitors compliance with a set of established operational requirements designed to minimise environmental hazards.

7. CONCLUSIONS

Accident history

The accident rate for helicopter accidents offshore has fallen during the thirty years of offshore oil and gas activity in Europe in common with that for other forms of air transport.

The CAA tables and graphs of operating statistics for the UKCS in Appendix 1 show that the number of accidents leading to fatalities has declined from a maximum five-year moving average of 0.8 per 100,000 hours flown in the period before 1985 to 0.4 from 1985 to 1989, and has since declined to less than 0.2.

For the UK, the 5-year moving average of reported occurrences (fatal accidents, serious injuries, dangerous occurrences and other incidents that may have safety implications) has declined from 3.8 incidents per hundred thousand flight stages in 1988 to less than 1.2 in 1998 although there was an increase in 1999.

The most recent accident involving fatalities was in 1997 in the Norwegian sector of the North Sea when 12 passengers and crew were killed. There have been no fatalities in UK waters since 1992. The most serious accident was the Chinook crash into the sea off Shetland in 1986 that killed 44 people.

Risks to passengers and aircrew on board helicopters flying offshore are similar to those from scheduled flights in comparably-sized fixed-wing aircraft. The main risk to people already on an installation is to helideck crew.

The risks associated with helicopter travel have come to be accepted by many workers as part of the occupational risk of working offshore. The risks involved in transfers using the only alternative, ships, would likely be much greater and involve greatly increased costs and inconvenience.

Causes of accidents

Mechanical reliability

There has been a reduction in the number of mechanical failures and the reliability of aircraft systems has increased greatly over the last ten years. The Chinook accident in 1986 was the driver for the voluntary introduction by the oil companies of HUMS (health and usage monitoring systems) in helicopters travelling to offshore installations in the UK sector. This measure is considered by many experts to have been the most significant advance in aviation safety in recent years.

Human factors

A larger proportion of more recent aircraft accidents have been due to pilot error. While the Air Accident Investigation Board reports prepared after each helicopter accident in the British sector may categorise the cause of an accident as pilot error, more detailed reasons are not given. As a result, it is often difficult to pinpoint the causes more exactly. (In Scotland, the legal requirement to hold a Fatal Accident Inquiry in public may make more information available.) Earlier studies suggest that pilot error is related to the conditions under which aircrew operate and the complex physical and operational environment offshore.

As well as the problem of piloting an aircraft in difficult weather conditions and manoeuvring to land and take off in a confined air space that may be subject to hazards from installation operations, commercial pressures to fly and a pilot's determination to complete their task may also play a part in influencing their judgement.

Significant risk factors

Categories of personnel at risk

In the air, aircrew are at greatest risk (not surprisingly) in terms of the time they spend flying and the nature of the activities, including training flights, to which they are exposed. 'On the ground', risks are greatest to helideck crew at an installation.

Countries in which accidents have occurred

By inspection of the data, accidents have occurred roughly in proportion to the numbers of flights from each of the countries involved in offshore oil and gas activity.

Flight phase

Eleven fatal accidents were a result of incidents occurring during the cruise phase of the flight. One accident involving two fatalities happened onshore at a heliport. Seven incidents took place at an installation or within the 500 metre zone surrounding it. Of these, four affected personnel on board the helicopters. There have been three deaths to aircrew and none to passengers at or near heliports onshore.

Layout and design

Two fatal accidents may have been related to the design of the installations at which these occurred.

Commercial factors

Helicopter Operators may claim that the rates currently paid by Installation Operators are hardly sufficient to cover their costs, and they are operating at a loss. However, there is no evidence of any statistical connection between economic viability and safety.

Aviation culture

There is some evidence of a culture within the aviation industry of aircrew and other active personnel reporting incidents that might possibly have serious consequences. Reporting is seen as allowing any necessary corrective action to be taken, *preventing accidents before they happen*. CAP 87007 *Report of the Helicopter Human Factors Working Group* (19) notes, though, that only limited data, such as a brief description of an incident, is available from Mandatory Occurrence Reports:

Lack of detail in the data precluded the possibility of an analysis in depth of the causes of the occurrences...

Furthermore, anecdotal evidence suggests that the *blame culture* may not be entirely missing within the aviation industry, possibly hindering the reporting of incidents.

Adequacy of current regulations on helicopter safety

Regulations governing aviation (and marine) transport are prescriptive (and the level of detail set out in aviation standards is much greater than for marine.) Standards are generic and tend to change only slowly and incrementally as a result of experience gained over the years. By comparison, the regulations applying to risks to personnel on offshore installations are installation-specific and adopt a goalsetting approach, rather

than trying to prescribe exactly what should be done in all cases, though the operating circumstances might differ.

These goalsetting regulations applicable to offshore installations may appear at first sight to be at odds with the highly prescriptive regime applicable to aviation safety. In practice, the two approaches may be combined to take account of the operating environment affecting helicopter operations at a particular installation.

As far as the current situation offshore UK is concerned, responsibility for demonstrating that a particular type of helicopter can safely be operated to a helideck for a particular installation rests with the Installation Duty holder (the operator, or owner in the case of floating installations). The Helicopter Operator has duties as a contractor to this principal duty holder, as well as having other duties while the helicopter is in the air during a flight. The goalsetting regulations applicable to offshore installations may appear at first sight to be somewhat at odds with the prescriptive regime applied to aviation, although aviation safety is more and more turning towards a similar kind of 'objective-based' legislation.

Provided these are followed, current regulations relating to the design and construction of helicopters and helidecks are generally considered by the responsible regulatory authorities to be suitable and sufficient to ensure the health and safety of passengers and crew flying to offshore installations.

The recent study by Aberdeen University (AUPEC, 1999) (31) confirms this view. However, this study also showed that misunderstandings still occur. The responsibilities of the organisations and individuals taking part need to be better explained so that all the people involved in helicopter operations offshore clearly understands their respective roles.

Helicopter operating limitations for support vessels

Although helicopter operating limitations apply via IVLLs (Installation/vessel limitation lists) to offshore installations and by SHOLs (ship/helicopter operating limits) to naval vessels, no such control measures apply to merchant ships with helidecks that are in use offshore. Such vessels include survey and heavy lift vessels and diving and ROV spreads. Any extension of the current system for naval vessels, limiting helicopter operations in certain weather conditions, for example, to other vessels would require to be debated by the IMO and shipping regulatory bodies.

Responsibilities of installation operators and owners

As far as the current situation offshore UK is concerned, there are responsibilities on both the Installation Duty holder and the Helicopter Operator to ensure that the type of helicopter used can safely be operated to the helideck on any particular installation. The Installation Duty holder is required to demonstrate in the safety case for the installation that risks to personnel are being controlled. The Helicopter Operator has a legal duty to satisfy himself that the landing area is fit-for-purpose. As well as having the principal aviation duties while a helicopter is in flight to and from the installation, he also has duties as a contractor to the Installation Duty holder.

The Installation Duty holder is required by the Offshore Installations (Safety Case) Regulations of 1992 to identify credible routes to a major accident (including for example the possibility of the collision of a helicopter with the installation), to assess the

resulting risks to personnel, and to control risks so as to reduce these to as low as reasonably practicable.

It is important that duty holders and staff understand their responsibilities in a goalsetting environment, especially in a regime like helicopter safety offshore with both prescriptive and goalsetting elements.

The author believes that more could reasonably be done by the Installation Duty holders, Helicopter Operators, helicopter manufacturers, regulatory authorities and others involved in helicopter safety offshore to inform staff of their responsibilities and to communicate and cooperate to manage hazardous conditions during helicopter operations. More publicity would assist all of those involved in offshore helicopter operations to understand better their own roles as organisations and as individuals, and where they interface with others.

Existing designs of helideck

There is no evidence that existing designs of helideck are not safe. Indeed, existing designs may have a margin of over-design through being designed for unnecessarily high emergency landing loads in Europe compared with America, and not taking advantage of the scope for limit state rather than working stress design.

There have been two fatal accidents where helicopters have collided with parts of an installation - Brent Spar in 1990, where the rotor of the aircraft hit part of a crane during a crew-change flight, and Ekofisk in 1991, where the main rotor struck the flare while lifting an underslung load as part of engineering modification work on the platform. In neither case was any serious damage caused to the installation.

The causes of both accidents were attributed by the official enquiries to pilot error. There has been no suggestion in official reports that the design of the helideck or the layout of the installation as a whole played a significant part. However, in the Brent Spar case, the use of an undersized helideck compared with that recommended in CAP 437 and the obstruction created by the nearby crane are thought by some observers to have been material factors.

Risk assessment approach to the structural design of helidecks

The starting point for the study was to consider the adequacy of existing helidecks. An examination of current design standards shows that offshore helidecks are more than adequate for the emergency landing load cases normally considered. As a result, an additional safety margin is available to allow to an unquantified extent for any more serious and highly improbable incidents that might occur, such as a helicopter crash onto the deck. Possibly, the use of a lighter helideck structure might be justified in some cases.

The load factors used in design are derived from aviation regulatory requirements. In normal day-to-day conditions, pilots pride themselves on making a landing where they gradually squeeze the tyres onto the deck surface, and the passengers will scarcely detect their arrival. Helicopter landing loads used for design are currently based on somewhat arbitrary criteria related to specified drop-heights that are intended to produce aircraft velocities at touchdown of 1.8 and 3.6 metres per second for the defined normal and emergency landing cases, respectively. These values compare with usual operational landing velocities that can be measured in centimetres per second.

It may not be enough simply to consider the prescriptive requirements of any one landing condition, even though this may be the limiting condition identified in current guidance on helideck construction and should therefore be given due weighting. It is possible that other credible major accident scenarios could be identified by the Duty holder for the installation, and the safety case should therefore consider these.

However, it may be very difficult for Installation Duty holders to define other installation-specific cases of emergency landings or helicopter crashes that have a reasonably foreseeable probability of occurrence and might lead to greater risks, compared with the emergency landing case already identified in ICAO guidance and based on many years of aviation experience. It seems likely therefore that the emergency landing cases currently defined in aviation guidance will continue to be the ones considered in the design of offshore helidecks, at least for the next few years.

Current design codes assume maximum relative closing vertical velocities as indicated above. These velocities, and the resulting load factors on the helicopter maximum all-up weight, apply to both fixed and moving installations. The load factors given in both European and American codes have been found to be satisfactory in service. During harmonisation of codes as part of the ISO process, some rationalisation of design methods may be possible to demonstrate continued safety using lighter and more economical structures.

In order to demonstrate the validity of the loading requirements it will be necessary for Duty holders to reduce as far as possible the effects of environmental and other factors that can increase the risk of heavy landings. Detailed risk assessment for a particular combination of type of helicopter and offshore helideck might show that load factors for the structural design of helidecks other than those currently given in guidance material would be more appropriate. Rationalisation of current design methods could be useful in demonstrating continued safety while allowing greater economy of construction.

As far as the design of the helideck structure is concerned, critical factors are those that affect performance in the closing gap between the landing decision point where helicopters are in the air but must then land, until they are supported by the helideck. This also applies to take-off when a re-land is necessary in the event of a power unit failure before the take-off decision point.

Helicopter landing is a complex dynamic issue not always readily susceptible to a deterministic evaluation of landing loads and response. Future developments in design methods may benefit from taking a reliability approach, based on the probability of achieving an agreed safety margin for a range of possible landing conditions. This is not simply a technical matter, but one with real implications for understanding how engineering can help in ensuring safety at the critical interface between a helicopter and an offshore installation.

European aviation legislation now being implemented will insist on improved helicopter performance. No exemptions will be given, as at present, to allow older designs of twin-engine helicopters to retain a reduced one-engine inoperative classification. This measure will help to ensure that helicopters used offshore will have a very high probability of surviving a single engine failure, thus reducing the risk of serious impact with the installation.

Analysis shows that major injuries occur less often than death in major accidents from helicopter crashes. This may not be surprising given that the occupants are subjected

to violent external forces when a helicopter ditches or lands out of control. (The recent introduction of 4-point seat harnesses should help to increase the chances of survival.)

Effects of platform physical environment

Seven accidents have occurred within the 500 metre zone around an offshore installation, of which four were in the air, leading to multiple fatalities, and three on the helideck, each leading to the death of a member of the helideck crew.

The environmental research study recently completed for CAA with HSE support (3) emphasises the importance of the physical environment at a helideck in maintaining air of good quality suitable for helicopter operations. Helicopters coming in to land or taking off operate in air that may be affected by gas from processing and utilities equipment and wind turbulence from topsides structures.

The environment around an installation may also be affected by physical obstructions such as cranes, drilling derricks, flares and other protruding parts of the topsides structure. Hot gas from flares and turbine exhausts can adversely affect helicopter performance on the critical final approach and at take-off. The ability to make a safe landing in these conditions can affect the type and magnitude of landing load, depending on the response of the helideck structure. Venting of unburned gas is particularly hazardous to helicopters if ingested into engine intakes. Operating procedures are necessary to keep helicopters clear when hot or cold gas is being vented, to prevent thermal effects or the risk of engine malfunction.

The report suggests that changes in the way installations are designed and operated may help to reduce these risks and should be investigated.

Communication

Probably the most important factor in the conduct of helicopter installation operations is good communication between helicopter operator and installation Duty holder staff, particularly between the HLO and radio operator on an installation and helicopter pilots.

Adverse weather policy

The use of an adverse weather policy may well have contributed to reducing the accident rate in recent years.

The whole point of having an Adverse Weather Policy is (occasionally) to delay flights where necessary so as to avoid the risk of helicopters operating in the corners of the flight envelope. Presumably, partners and families would rather see their loved ones a few hours or even days late, rather than be involved in an accident.

Further risk reduction measures

Helideck structural design

The absence of any history of damage to helideck structures tends to indicate that current design guidance is conservative. For example, CAP 437 load factors seem excessive compared to the JAR 29 undercarriage collapse loads used for aircraft design.

Any changes to guidance will have to show that an equivalent level of safety is maintained. It can be argued that current design methods based on load factors give satisfactorily strong helidecks. Current designs cater to an unquantified extent for more severe helicopter crash landing scenarios that might occur.

The author considers it would be helpful in reducing the risks from helicopter operations at offshore helidecks if helicopter manufacturers worked with the Helicopter Operators and Installation Duty holders, the regulatory authorities and others to carry out research to try to better define the envelope of landing loads that could occur within reasonable limits of probability for a range of offshore landing conditions. This risk-based approach could provide a more rational basis for the future design of helidecks than the current arrangements based on factors of helicopter Maximum Take-off Weights (MTOWs).

Installation layout

A significant finding of the Environmental Research report, CAP 99004 (3) is that the safety case regulations do not require an Installation Duty holder to consider the risks from hazards that may be produced by the installation, such as turbulence and exhaust gases, on people in helicopters once they are in the air, while approaching and taking off.

It may be worth considering ways in which the regulations administered by HSE and by CAA might be better linked, so as to ensure that the Installation Duty holder is required to exercise more control in the design and operation of the installation over operations that could affect flying within the 500 metre zone.

Effects of noise and vibration

There is little published information available relating to risks to health from the uncomfortable levels of noise and whole-body vibration to which aircrew and passengers in helicopters and helideck crew on installations are exposed and any resulting effects on their health over time. This may be an area requiring further research.

Role of HSE

Risks to personnel must be demonstrated in the safety case for an installation presented to HSE to be so low that these can be accepted. Adequate safety management is at the heart of measures to control risks. The recent Aberdeen University (AUPEC) study (31) notes:

HSE has a major role to play in promoting good practice in safety management and also in ensuring through inspection that safety management systems remain robust in difficult economic conditions. HSE has improved the delivery of specialist support from its topic experts to its field inspectors through internal reorganisation in the late 1990s. However, there is scope for further enhancements of the skills of operational inspectors to identify SMS failings and apply solutions, by devolving SMS expertise further into inspection management teams.

Use of MORT analysis after a serious accident

Evaluation by MORT (Management Oversight and Risk Tree) analysis of any future helicopter accidents that occur offshore could be useful in identifying possible links in the chain of cause and effect that may lead to these. Such an analysis would put in context the management systems in place at the time, including policies and procedures, the actions of individuals and the possible effects of the installation layout and hardware.

New designs of helicopter

The helicopter fleet operating offshore has an average age of 15 years. Age by itself is not important as helicopters are maintained in a 'nearly new' condition. However, the

new technology introduced to more recent models has not yet been made available offshore. In deciding when to invest in new models, the possible benefits new technology could bring in terms of improved health, safety and welfare standards, as well as reduced operating costs, should be considered by the operators and owners of offshore installations.

Welfare

Finally, in the author's experience from trips made offshore, and from talking to people at heliports and on board installations, helicopter travel is still perceived by many offshore workers as one of the most hazardous and stressful parts of their job. Anything that can reasonably be done to reduce travel risks and to improve the welfare and comfort of passengers, including using new and quieter types of helicopter with more reliable control and operating systems and lower noise and vibration levels, seems likely to reduce risks and improve the morale of the workforce and their perception of the risks of working offshore.

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DEFINITIONS AND ABBREVIATIONS

Definitions (and see JAA and other publications)

AERAD plates Diagrams held by a pilot giving physical details of a destination installation

Dangerous occurrence An incident in which a hazard is realised, not causing fatalities or injuries.

FATO (Final approach and take-off area) A defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. Where the FATO is to be used by performance class 1 helicopters, the defined area includes the rejected take-off area available. The FATO may be any shape, but must include the dimension specified in ICAO Annex 14 (for offshore helidecks the 'd' value defined by the overall length of the helicopter).

Helicopter Operator The term used in this report for the primary Duty holder that is the company statutorily responsible for flying helicopters commercially to one or a number of offshore installations.

Helideck An area located on a floating or fixed structure offshore designated for the use of helicopters.

Installation Duty holder The term used in this report for the company that is the primary Duty holder statutorily responsible for the control of risks to health and safety on one or a number of offshore installations - the installation operator (or owner in the case of a floating installation).

TLOF (Touchdown and lift-off area) A loadbearing area on the FATO or in a separate discrete location on which a helicopter may touch down or lift off.

Abbreviations (refer to organisations in the UK unless noted otherwise)

AAIB Air Accident Investigation Branch (This is a government body separate from CAA and reporting directly to the Secretary of State)

BMT British Maritime Technology Limited

CAA Civil Aviation Authority

CAA-N Civil Aviation Administration, Norway (Luftfartsverket)

CRM Crew resource management

CVR Cockpit voice recording

DCR Offshore Installations and Wells (Design and Construction) Regulations 1996 SI 1996/913

DETTR Department of the Environment, Transport and the Regions

DEn Department of Energy (no longer in existence - responsibilities transferred to other government bodies)

DERA Defence Executive Research Agency

DTI Department of Trade and Industry

EA Environment Agency (of England and Wales)

FADEC Fuel analysis digital electronic control

FATO Final approach and take-off area

FPSO Floating production, storage and offloading unit

HLO Helicopter Landing Officer

HSW Act Health and Safety at Work, etc Act 1974

HSE Health and Safety Executive

HUMS Health and Usage Monitoring System

ICAO International Civil Aviation Organisation

IMO International Maritime Organisation

IVLL Installation/vessel limitation list

JAA Joint Aviation Authority (Europe: EU + EFTA + other states)

JAR Joint Aviation Requirements (of JAA)

LDP Landing decision point

MAUW Maximum all up weight (of a helicopter)

MODU Mobile drilling unit

MSF Manufacturing, Science and Finance Union

MTOW Maximum take-off weight (another term for MAUW)

NCAA Norwegian Civil Aviation Authority (Luftfartstilsynet) (see also CAA-N)

NPD Norwegian Petroleum Directorate (Oljedirektoratet)

OIAC Offshore Industry Advisory Committee

OILC Offshore Industry Liaison Committee (registered trade union)

OPITO Offshore Petroleum Industry Training Organisation

PFEER Offshore Installations (Prevention of Fires and Explosions, and Emergency Response) Regulations 1995

ROV Remotely operated vehicle

SAR Search and rescue

SBV Standby vessel

SEPA Scottish Environmental Protection Agency

SHOL Ship/helicopter operating limits

SINTEF SINTEF Industrial Management Safety and Reliability A/S, Norway

TDP Take-off decision point

TGWU Transport and General Workers Union

TLOF Touchdown and lift-off area

VHF Very high frequency

VFR Visual flight regulations

APPENDIX 1: Incident data

John Burt Associates
UKCS helicopter incident analysis

CAA

UK Offshore Helicopter Operations Statistical Report for 1999 CAA Safety Data Department June 2000, including:

Operating statistics for UK registered multi-engined helicopters in offshore operation – 1999

Accidents and incidents to UK registered multi-engined helicopters in offshore operations – 1999

UK registered multi-engined helicopters in offshore operations, operating statistics, accident and passenger fatality rates 1990 – 1999

UK registered multi-engined helicopters in offshore operations, five year moving average based on number of accidents per 100,000 hours flown '86-90 to '95-99

HSE

Offshore injury, ill health and incidents statistics report 1999/2000 OTO 2000 111

Table 1: Summary of injuries and dangerous occurrences
April 1992 - March 2000 (Provisional)

UKCS OFFSHORE HELICOPTER INCIDENT ANALYSIS

SUMMARY

There are 84 UKCS offshore helicopter accidents and serious incidents recorded in the JBAL database specifically relating to UKCS offshore helicopter operations.

Accidents	66
Serious Incidents	18

These occurrence reports cover a period from 1968 to 1999 and as far as is known they are a complete record [sources used are CAA-SDD and AAIB]. Several other reports in the database have been excluded from the analysis. These relate to UKCS SAR operations, training, etc, and overseas incidents.

The classification of Serious Incidents, by AAIB, is a relatively recent introduction.

There are numerous Mandatory Occurrence Reports [MORs] but these are not included in this analysis. Suffice it to say that normally, in the first instance, an MOR would be raised for a reportable occurrence. If the MOR is then deemed to be a 'UK Reportable Accident' it will be subject to further investigation by the AAIB.

DETAILED ACCIDENT ANALYSIS

The accident reports have been broken down into:

En-Route over Land/On Airfield
En-Route over Sea
On Helideck/Within 500 m Zone

This simple breakdown provides a better appreciation of the accident events by flight phase, when an incident has occurred. For example, En-Route over Sea will normally mean that the helicopter is established in the cruise. Whereas, the 'so called' critical flight phases [take-off, climb, approach and landing] are generally encountered when En-Route over Land/On Airfield and On Helideck/ Within 500 m Zone.

1. En-Route Over Land/On Airfield

Total Accidents	20
Fatalities	0
Injuries	4
POB Exposed	230

End Event

Crash on Runway	1
Crash on Land	1
Emergency Landing	1
Forced Landing	2
Heavy Landing	5
Personal Injury or Death	1
Roll over on Apron	2
Aircraft Damage Only	7

2. En-Route over Sea

Total Accidents	23
Fatalities	58
Injuries	0
POB Exposed	332

End Event

Crash in Sea	3
Ditching	16
Offshore Diversion/RTB	3
Offshore Diversion	1

3. On Helideck/Within 500 m Zone

Total Accidents	23
Fatalities	22 [including 2 x HLOs]
Injuries	2
POB Exposed	236
Accidents on Helideck	14
Accidents elsewhere in 500 m Zone	9

End Event

Crash in Sea	2
Crash on Helideck	1
Crash on Installation	1
Ditching	1
Helideck Incident	9
Heavy Landing	3
Normal Landing	1
Personal Injury or Death	3
Aircraft Damage Only	2

SERIOUS INCIDENT ANALYSIS

18 serious incidents are recorded in the JBAL database. 17 are detailed as follows but one serious incident report [involving an S76] has insufficient detail to assign.

4. En-Route over Land/On Airfield

Total Serious Incidents	8
POB Exposed	71

Incident Location

En-Route over Land	1
Airport Apron	5
On Airfield	2

5. En-Route Over Sea

Total Serious Incidents	5
POB Exposed	124

End Event

Offshore Diversion	3
Offshore Diversion/RTB	1
Aircraft Damage Only	1

6. On Helideck/Within 500 m Zone

Total Serious Incidents	4
POB Exposed	71

Incident Location

On Helideck	3
Elsewhere within 500 m Zone	1

HELICOPTER TYPES INVOLVED

The following list of helicopter types gives the total number of accidents and serious incidents encountered by each type. The years given are the period during which the recorded accidents and serious incidents occurred. It should be noted that some of these aircraft have been withdrawn from UKCS offshore service [denoted *].

Bell 212	6	1977-94
Bell 214 ST	4	1985-94
Boeing BV 234*	3	1983-86
Eurocopter AS 330*	2	1978
Eurocopter AS 332	20	1982-98
Eurocopter AS 365	2	1986-92
Eurocopter Bo 105	8	1976-93
Sikorsky S61	26	1968-95
Sikorsky S76	7	1980-99
Sikorsky S58*	2	1976-78
Westland Wessex	2	1976-81



UK OFFSHORE HELICOPTER OPERATIONS STATISTICAL REPORT FOR 1999

Safety Data Department
June 2000



UK OCCURRENCE REPORTING SYSTEM - CONTENT OF RECORDS

The records include information reported to the CAA, information obtained from CAA investigations, and deductions by CAA staff based on the available information. The authenticity of the contents or the absence of errors and omissions cannot be guaranteed. Records in this system commenced on 1 January 1976 coincident with the introduction of mandatory occurrence reporting in the UK, but occurrences reported voluntarily are also included, and no distinction is made between them. The records contain:

- (i) Reportable occurrences to aircraft operating under the control of a UK operator.
- (ii) Reportable occurrences to other aircraft when UK ground facilities or services (e.g. air traffic, aerodrome facilities, maintenance, repair or overhaul facilities) are a significant element in the occurrence.
- (iii) UK reportable accidents (not normally to gliders or balloons).
- (iv) A significant number of accidents, worldwide, to : fixed wing aircraft over approx 5700 kgs and rotorcraft over approx 4500 kgs.
- (v) A small number of particularly significant occurrences to foreign-operated aircraft selected on the basis of their relevance to UK operations and CAA interest.

Any data obtained from the system will therefore include items (i) to (v) unless specifically noted to the contrary. The inclusion of occurrences to non-UK operators should be taken into account if deriving rates based on UK operating statistics.

ANY DATA PROVIDED FROM THESE RECORDS IS MADE
AVAILABLE ON THE UNDERSTANDING THAT IT IS ONLY
TO BE USED FOR PURPOSES OF FLIGHT SAFETY AND
MUST NOT BE USED FOR ANY OTHER PURPOSES.

CIVIL AVIATION AUTHORITY
SAFETY DATA DEPARTMENT
AVIATION HOUSE
SOUTH AREA
GATWICK AIRPORT
GATWICK
WEST SUSSEX
RH6 0YR

TELEPHONE 01293 573220
TELEX 878753
FAX 01293 573972

OPERATING STATISTICS FOR UK REGISTERED MULTI-ENGINED HELICOPTERS IN OFFSHORE OPERATIONS - 1999

Details at end of stated period	TYPE OF HELICOPTER						TOTAL	
	BELL 212	BELL 214	BOLKOW 105	SA332S PUMA	SA365 DAUP	SIKY S61	SIKY S76	
No. in service	3	2	14	42	7	18	16	102
Hours	124	697	9142	40303	8272	8416	15303	82257
Flight stages	1002	1392	30111	44370	45485	16319	52853	191542

ACCIDENTS AND INCIDENTS TO UK REGISTERED MULTI-ENGINED HELICOPTERS IN OFFSHORE OPERATIONS - 1999

	TYPE OF HELICOPTER						TOTAL	
	BELL 212	BELL 214	BOLKOW 105	SA332S PUMA	SA365 DAUP	SIKY S61	SIKY S76	
a) Fatal Accidents:	0	0	0	0	0	0	0	0
a1) Crew fatalities	0	0	0	0	0	0	0	0
a2) Pax fatalities	0	0	0	0	0	0	0	0
b) All Accidents:	1	0	0	1	0	0	1	3
b1) Aircraft destroyed	0	0	0	0	0	0	0	0
b2) Aircraft damage substantial	1	0	0	1	0	0	1	3
b3) Aircraft damage minor or none	0	0	0	0	0	0	0	0
c) Return to base or diversion	0	0	7	20	6	4	5	42
d) Ditching or forced landing	0	0	0	0	0	0	0	0
e) Airprox	0	0	0	1	0	1	1	3
f) In-flight engine shut-down	0	0	5	7	1	2	0	15
g) Severe vibration	0	0	1	1	2	2	1	7
h) Runaway or total failure of AFCS	0	0	0	2	0	0	0	2
i) Emergency declared or procedures used	0	0	2	13	2	3	4	24
j) Separation of a major component	0	0	0	0	1	0	2	3
k) Total loss of all channels of any system	0	0	0	0	0	0	0	0

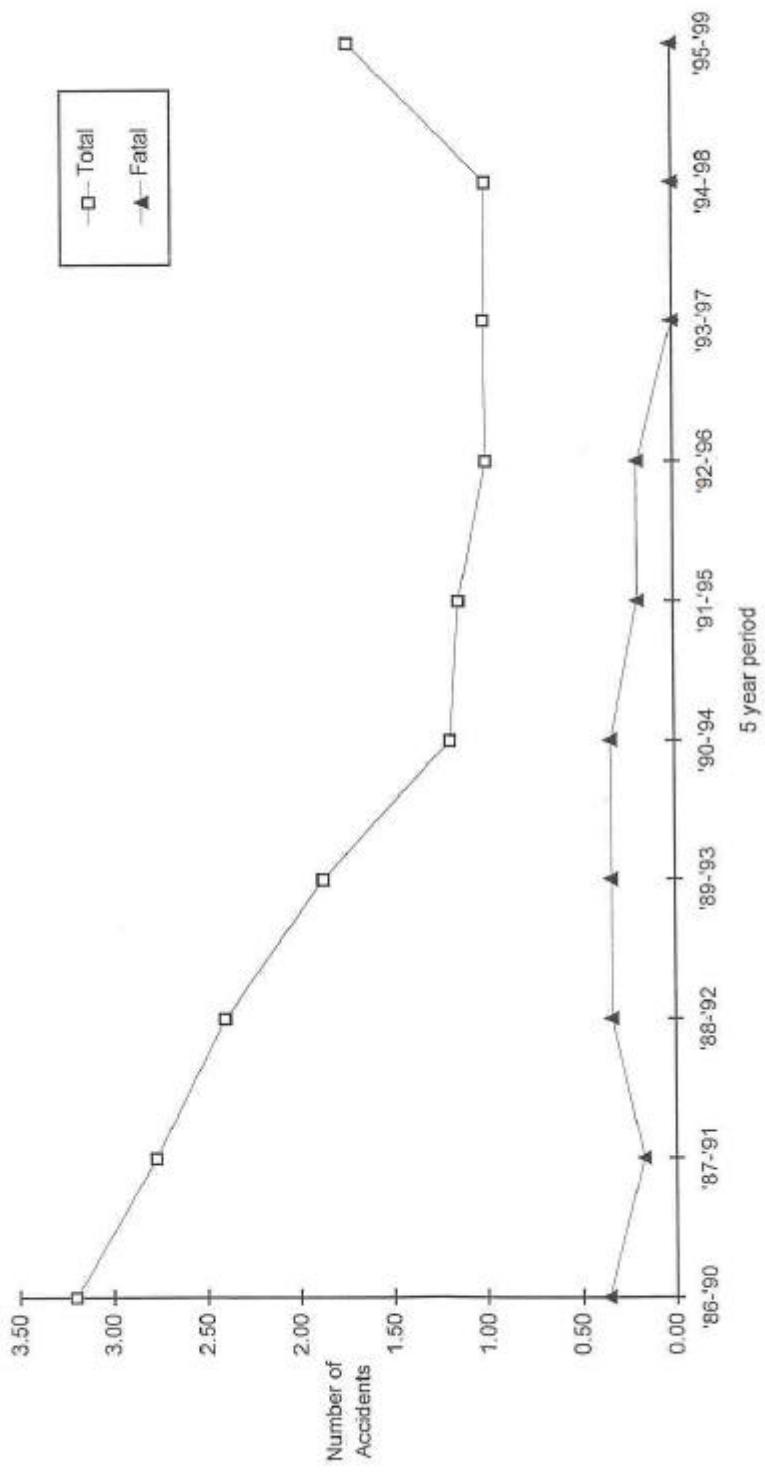
SUMMARY OF ACCIDENTS TO UK REGISTERED MULTI-ENGINED HELICOPTERS IN OFFSHORE OPERATIONS IN 1999

Date	Aircraft Type	Registration	Location	Fatalities			Circumstances	CAA Ref
				Crew	Pax	Other		
23.07.99	SA332S Puma	G - PUMH	Kirkwall	-	-	-	Nose landing gear retracted shortly after touch down. Fault traced to NLG 'centre extended' proximity sensor.	9904878
21.09.99	Bell 212	G - BALZ	Oil Rig	-	-	-	Main rotor blade struck tailboom on shutdown during final stages of blade rotation - attributed to sudden gust of wind.	9906431
17.11.99	Sikorsky S76	G - BHBF	North Sea	-	-	-	Lightning strike followed by burning smell in cockpit. Mayday call, a/c returned & landed safely. Significant damage to two main rotor blades & LH horizontal stabiliser.	9907917

UK REGISTERED MULTI-ENGINED HELICOPTERS IN OFFSHORE OPERATIONS
OPERATING STATISTICS, ACCIDENT AND PASSENGER FATALITY RATES 1990 - 1999

Year	Hours Flown (000's)	Flight Stages (000's)	Reportable Accidents		Rate per 100,000 hours flown Total/ Fatal/	Rate per 100,000 flight stages Total/ Fatal/	5 year moving average (per 100,000 hours)	
			Total	Fatal			Total	Fatal
1990	134.3	354.5	3	1	4	2.23	0.74	0.85
1991	117.9	305.5	2	0	0	1.70	-	0.65
1992	104.8	256.0	1	1	10	0.95	0.95	0.39
1993	93.6	219.5	1	0	0	1.07	-	0.46
1994	94.2	217.1	0	0	0	-	-	-
1995	102.1	234.3	2	0	0	1.96	-	0.85
1996	102.0	226.6	1	0	0	0.98	-	0.44
1997	101.0	209.7	1	0	0	0.99	-	0.48
1998	96.7	205.7	1	0	0	1.03	-	0.49
1999	82.3	191.5	3	0	0	3.65	-	1.57
							-	1.72

UK REGISTERED MULTI-ENGINED HELICOPTERS IN OFFSHORE OPERATIONS
FIVE YEAR MOVING AVERAGE BASED ON NUMBER OF ACCIDENTS PER 100,000 HOURS FLOWN



EXTRACT FROM HSE Offshore Technology Report OTO 2000 111 Offshore Injury, Ill Health and Incident Statistics Report 1999/2000 [Provisional Data], p13

SUMMARY OF INJURIES AND DANGEROUS OCCURRENCES
APRIL 1992-MARCH 2000 [p]

	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000
FATALITIES	5	1	1	5	2	3	1	2
MAJOR	111	87	68	67	44	74	74	52
COMBINED FATALITIES AND MAJOR INJURIES	116	88	69	72	46	77	75	54
OVER 3-DAY DANGEROUS OCCURRENCES	480	377	239	348	302	291	245	192
	525	633	594	523	569	649	693	633

Table 1

APPENDIX 2: HSE NOTICES

Operations Notice 24: Health and Safety at Work etc Act 1974 (Application outside Great Britain) Order 1995 [SI 1995/263]

Safety Notice 4/99: Offshore Helideck Design and Operation [September 1999]

Operations Notice 47: Offshore Helidecks – Advice to Industry [December 1999]

Press Release: Maintenance accidents through human error increasing, warns HSE [3rd August 2000]



Health and Safety at Work etc Act 1974 (Application outside Great Britain) Order 1995 (SI 1995/263)

Introduction

1 This Notice announces that a revised Health and Safety at Work etc Act 1974 (Application outside Great Britain) Order 1995 (SI 1995/263) comes into effect on 15 March 1995. The purpose of the Order is to apply the Health and Safety at Work etc Act 1974 (HSW Act) outside the mainland of Great Britain. The revised Order replaces the earlier 1989 Order and modifies the application of the HSW Act. The main changes are set out in paragraph 4.

Background

2 The Order has been revised following the extension of the HSW Act's purposes offshore by the Offshore Safety Act 1992. Various definitions have been modified in line with prospective changes to offshore health and safety legislation. As a result the revised Order applies the HSW Act offshore to installations, pipelines, wells and certain associated activities; and to mines and other activities in territorial waters.

3 The revised Order contains a new definition of 'offshore installation' which will be consistent with that in other new offshore health and safety legislation. Detailed interpretative guidance on the new definition of an installation will be published as part of the guidance on the forthcoming Offshore Installations and Pipeline Works (Management and Administration) Regulations (MAR). A further Operations Notice will be issued shortly to give details of when that guidance will be available and where it can be obtained.

Main changes

4 The revised Order continues application of the HSW Act to offshore installations, pipeline works and connected activities. The main provisions are summarised in Annex A. The main changes from the 1989 Order are:

- a new definition of 'offshore installation'. Flotels and other vessels which provide accommodation for people working on or from an installation are included, but only if providing accommodation is their main use. The definition excludes 'stacked' installations although they are covered by the HSW Act as a place of work (Article 8). Wells and pipelines are covered as separate categories, but can be deemed to be part of an installation in specific offshore health and safety regulations (Article 4(2));

- wells whether linked to an installation or not (eg suspended wells) and activities in connection with those wells (eg well servicing, inspection, testing, diving etc) (Article 5) are included as a separate category;
- pipelines are included. The definition of 'pipeline works' is extended to include incidental activities, primarily to ensure it covers all occupational risks affecting pipelaying (Article 6);
- all activities carried out by vessels in connection with an installation are covered except the transporting, towing or navigating of the installation and any activity on or from a vessel which is being used as a stand-by vessel. This includes, as now, construction, repair, dismantling, loading, unloading and diving. It will also include vessels providing accommodation for people who work on or from an installation (where the provision of accommodation is not the main use of the vessel) (Article 4(1)(b)). Activities preparatory to these activities are also included. Connected activities include providing stand-by vessels where appropriate to comply with statutory duties (eg under the forthcoming Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations), but not activities undertaken by stand-by vessels. This means that the HSW Act covers the adequacy of stand-by arrangements to ensure the safety of installation workers in an emergency, but does not cover the health and safety of stand-by vessel crews, which is provided for by marine legislation;
- non-diving aspects of the survey and preparation of the sea bed for an offshore installation are no longer included (Article 4(1)(c)).

Application of regulations offshore

5 HSW Act regulations apply offshore only if they contain a clause which says so explicitly. Each set of new regulations made under the HSW Act will detail the extent of their application offshore by reference to the relevant Articles of the Order. They are not bound to follow the Order's divisions between categories (eg parts of pipelines and wells can be deemed to be parts of offshore installations), but cannot exceed the overall scope of the Order. Existing regulations which refer to the 1989 (or previous) Orders will be construed as referring to appropriate parts of the new one.

Further Information

6 Copies of the revised Order (ISBN 0 11 052413 6) can be obtained from HMSO, price £1.55 (Tel: 0171 873 9090). Any queries on this notice should be addressed to the Health and Safety Executive, Offshore Safety Division, Fraser Place, Aberdeen AB9 1UB. Tel: 01224 252500.

Annex A

The main provisions of the Health and Safety at Work etc Act 1974 (Application outside Great Britain) Order 1995

The Application outside Great Britain Order 1995 applies the HSW Act in UK territorial waters adjacent to Great Britain and in designated areas of the UK Continental Shelf to:

Article 4

- offshore installations (as defined). This definition includes six fixed towers which have no connection with offshore oil and gas activities;
- activities in connection with offshore installations (other than transporting, towing or navigating the installation and any activity on or from a vessel which is being used as a stand-by vessel) and activities immediately preparatory to those activities;
- diving operations connected with the survey and preparation of the sea bed for an offshore installation.

Article 5

- wells and connected activities (including station keeping, but not other activities connected with navigation); and activities immediately preparatory to any of the connected activities.

Article 6

- pipelines (as defined);
- pipeline works (as defined);
- certain activities in connection with pipeline works, eg loading, unloading, fuelling or provisioning of a vessel engaged in pipeline works.

Article 7

- the working of a mine extending under the sea bed and connected activities.

Article 8

This applies the HSW Act in territorial waters only to the following additional activities:

- the construction, reconstruction, alteration, repair, maintenance, cleaning, demolition and dismantling (or any preparatory activities) of any building or other structure (other than a vessel);
- loading, unloading, fuelling or provisioning of a vessel (which includes a 'stacked' installation, ie one which is not in use or intended for use at that time);
- the construction, reconstruction, finishing, refitting, repair, maintenance, cleaning or breaking up of a vessel (including a 'stacked' installation) except when carried out by the master or any officer or member of the crew of that vessel;
- diving operations;
- maintaining a 'stacked' installation on station.

Article 8 does not apply to vessels registered outside the UK on passage through territorial waters.

Offshore helideck design and operation

Introduction

1 The purpose of this safety notice is to advise industry of recent research which has clearly shown the need for improvement in particular aspects of the design and operation of helidecks on offshore installations for the safety of offshore helicopter flight operations. New designs and existing installation helidecks need to take this research into account.

Background

2 In December 1995 a Sikorsky S61 helicopter, on final approach to the Claymore 'A' Accommodation Platform (CAP), became engulfed in hot plumes from gas turbine exhausts on an adjacent production platform (CPP). As a consequence, the pilot was unable to sufficiently arrest the helicopter's rate of descent for a safe landing, and the aircraft heavily impacted the CAP helideck, sustaining major damage.

3 This offshore helideck incident exposed the 2 flight crew and 14 passengers to extreme danger. However, on this occasion, the personnel on board the helicopter were all unharmed.

4 Air Accident Investigation Branch (AAIB) investigated the incident and published their report (Ref: EW/C95/8/4) which included a number of recommendations. One of these was that CAA, HSE and industry consider jointly commissioning research into the effects that wind, turbine exhaust and flare exhaust emissions have on helidecks of installations that are positioned adjacent and near to one another.

5 A research project was subsequently commissioned which has concluded some important improvements are required in the design and operation of offshore helidecks.

6 The main areas of concern are: the helideck location in relation to plant and equipment which can cause localised environmental anomalies near the helideck, and on available flight paths; and the provision of sufficient and accurate operational information to helicopter operators.

7 A number of recommendations have been made as a result of this research project (Ref CAA paper 99004 *Research on offshore helideck environmental issues*). These include:

- (a) The need for duty holders to recognise and fully address, during installation design and modifications, the probable effects on helicopter flight operations caused by adverse operating environments created on and around offshore installations. Where appropriate, relevant information should be included in safety cases.

These adverse effects result mainly from production processes and structures on the installation, or from adjacent installations and vessels. When combined with ambient weather conditions, the resultant effects can place helicopters in jeopardy, particularly during critical flight phases. Careful and critical consideration of these factors during design or modification can reduce such problems.

- (b) The need for further work into defining acceptable turbulence criteria with respect to safe helicopter performance and handling.
- (c) The need for a detailed design guide to supplement CAA guidance for offshore helidecks as set out in CAP 437 *Offshore helicopter landing areas: guidance on standards* (3rd edition, October 1998).
- (d) The need to resolve the present lack of suitable and sufficient operational information being provided to helicopter operators, for flight planning purposes. There is a pressing need to improve the quality of information being provided to flight crews about the potential for, and the probable extent of adverse environmental conditions on and around installations.

Safety requires co-operation between everyone who has a contribution to make to ensuring health and safety on an offshore installation or the activities involving the installation. The scope of regulation 8 of the Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995 (MAR) is therefore very wide and includes operators, owners, concession owners, employers, employees, managers and people in charge of visiting vessels or aircraft.

Action required by duty holders

- 8 Duty holders should:
 - (a) consider fully the subject of adverse environmental effects that may have the potential for affecting the safety of helicopter flight operations on and around an installation, eg combined operations, maintenance of air gap under helideck, modifications to topside layout;
 - (b) ensure that sufficient information is provided to the BHAB Helideck Sub-Committee about installation and helideck design, and the potential adverse helicopter operating environments on and around installations. This information will be used by BHAB for determining the extent of any flight restrictions and for providing advice to flight crews;
 - (c) include sufficient and appropriate levels of information on helideck design and operation in the safety management system and safety cases, and ensure these matters are addressed in the safety management systems.

Relevant legal requirements

9 The relevant legal requirements are:

- (a) regulation 11 (Helicopter landing area) of the Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 (DCR) (SI 1996/913);
- (b) regulation 8(1) (Co-operation) of the Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995 (MAR) (SI 1995/738).

Further information

10 Any queries relating to this safety notice should be addressed to the Health and Safety Executive, Offshore Safety Division, Lord Cullen House, Fraser Place, Aberdeen AB25 3UB. Tel No: 01224 252500.

References

11 The main references are:

- (a) AAIB bulletin number 3/96 (Report EW/C95/8/4);
- (b) CAP 437 *Offshore helicopter landing areas: guidance on standards*.

This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.



Offshore helidecks - advice to industry

Introduction

1 This operations notice has been issued to draw the attention of industry to the following:

- (a) the publication of Civil Aviation Authority CAP 437 3rd edition;
- (b) new arrangements for offshore helideck authorisations.

Civil Aviation Authority (CAA) CAP 437

2 CAP 437 *Offshore helicopter landing areas: guidance on standards*, 3rd edition (October 1998) has been issued by the CAA following major amendments.

3 The amendments incorporated in this most recent edition have been made as a result of the valuable experience gained by CAA staff during their four years of offshore helideck inspection with the Health and Safety Executive (HSE), and from co-operation with the British Helicopter Advisory Board (BHAB). The changes made reflect the analysis of results of the offshore helideck inspection regime, completed in 1995 (*HSE/CAA inspection project offshore helidecks 1991 - 1995*, OTO 98088), and knowledge gained from accidents, incidents, occurrences and research projects.

4 CAP 437 gives guidance on the criteria used by the CAA in assessing the minimum standards of helicopter offshore landing areas for worldwide use by helicopters registered in the United Kingdom. These landing areas may be located on:

- (a) fixed offshore installations;
- (b) mobile offshore installations;
- (c) vessels supporting offshore mineral exploitation;
- (d) other vessels.

5 Copies of CAP 437 can be obtained from Westward Digital Limited, 37 Windsor Street, Cheltenham, Gloucestershire GL52 2DG (Tel: 01242 235151 or 01242 250066).

Revised procedures for authorising helidecks

6 With effect from 1 December 1998 the BHAB Helideck Sub-Committee has taken over responsibility for the co-ordination of authorisations for offshore helidecks from the CAA. This procedural change has resulted from the joint development by Industry and the authorities, of a new helideck review, survey and verification process.

7 The process is designed to enable helicopter operators to satisfy themselves, in accordance with their responsibilities under the Air Navigation (No 2) Order 1995, Article 30, that offshore helidecks are suitable for their purpose. These responsibilities are amplified in the future Joint Aviation Requirements (JAR) OPS 3 requirement which demands that each landing site be specifically authorised for use by the helicopter operator.

8 A key element of this process is the timely notification and provision of relevant information to BHAB concerning 'new builds', new arrivals or proposed modifications to existing helidecks, for them to assess compliance with the criteria.

9 Furnished with this information, BHAB can then develop or amend, as appropriate, the information contained in the Installation/Vessel Limitations List (IVLL), to provide the primary means for supplying up-to-date information on offshore helidecks to flight crews. This enables the helicopter operators to discharge their duties, in a manner acceptable to the CAA, in a relation to the Air Navigation Order and JAR OPS 3.

10 The IVLL contains details of all offshore helidecks on the United Kingdom Continental Shelf (UKCS) together with any operator-agreed limitations applied to specific helidecks in order to compensate for any failings or deficiencies in meeting CAP 437 criteria; so that the safety of flights is not compromised.

11 This new procedure and its requirements form a functional part of the installation/vessel safety management system and as such, installation duty holders and vessel owners should refer to CAP 437 for further details and guidance.

12 Further information and assistance with the new procedure can be obtained from BHAB (Administrator: John Monaghan, c/o Bond Helicopters, Aberdeen Airport East, Dyce, Aberdeen AB21 7DU. Tel: 01224 846339. Fax: 01224 846347).

Action required by installation duty holders and vessel owners

13 Duty holders and vessel owners are advised to:

- (a) obtain and review, as soon as practicable, the revised text of CAP 437 3rd edition;
- (b) take note of the revised procedure, introduced on 1 December 1998, for helideck authorisations by the BHAB Helideck Sub-Committee and to ensure that the appropriate arrangements are maintained for providing the necessary information to the BHAB.

Relevant legal requirements

14 The main legal requirements are:

- (a) regulation 11 of the Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 (DCR) (SI 1996/913);
- (b) regulation 8(1) of the Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995 (MAR) (SI 1995/738).

Further information

Any queries relating to this operations notice should be addressed to the Health and Safety Executive, Offshore Safety Division, Lord Cullen House, Fraser Place, Aberdeen AB25 3UB. Tel No: 01224 252500.

This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

Press Release E140:00 - 3 August 2000

Maintenance accidents through human error increasing, warns HSE

Major accidents resulting from human error in industrial maintenance operations are on the increase, says the Health and Safety Executive (HSE), but new guidance published today can reduce such incidents significantly.

Overall, the general accident trend in Britain is downwards but the role of maintenance error as a root or contributory cause of major accidents has increased. There have been many high-profile examples, both in Britain and elsewhere, e.g. Clapham Junction, Bhopal, Piper Alpha and a number of aviation accidents.

Recent near-misses resulting from errors during maintenance include a large release of natural gas from an offshore production platform and a spillage of 17 tonnes of highly flammable liquid at an onshore refinery. Fortunately, in both cases there was no ignition.

Dr Paul Davies, HSE's Chief Scientist and Head of Hazardous Installations Directorate, said:

"Traditional approaches to safety have focused on engineering and process risks, and sought hardware solutions to them. However, studies show that 'human factors' contribute to up to 80% of workplace accidents and incidents. HSE is actively tackling this area by developing its own human factors guidance and expertise, and applying it directly in its inspection and enforcement activities."

Dr Davies' comments coincide with HSE's publication of new guidance providing practical step-by-step methods, which if applied, can help industry reduce error significantly by identifying and assessing issues that impact on the performance of maintenance staff.

The guidance, which is aimed at all industries - chemical, nuclear, railway, aviation etc. - and all sizes of business, was developed by a specialist Maintenance Sub-group from the Human Factors in Reliability Group (HFRG), a long-standing forum for individuals from industry, regulatory bodies and academia with an interest and expertise in 'human factors'. HSE contributed to, and sponsored the project.

The guidance gives an overview of the importance of human factors and lists the main issues that management control. It goes on to provide a method, based on readily collectable information, for identifying the key issues adversely affecting maintenance in any particular organisation. Useful questionnaires and guidelines on ranking the relative importance of issues from information on underlying incident causes are included.

"The key message from the guidance is that human error in maintenance is largely predictable and therefore can be identified and managed", said Dr Davies. "HSE expects to see industry tackle maintenance risks in a structured and proactive way, making it part of every company's safety management system. HSE is committed to pursuing the continued reduction of accidents resulting from maintenance activities through advice and, where necessary, enforcement."

Copies of '*Improving maintenance - a guide to reducing human error*' can be ordered online at <http://www.hsebooks.co.uk> or are available from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA (Tel: 01787-881165/Fax: 01787-313995). HSE priced publications are also available from all good book shops. ISBN 0 7176 1818 8, price £16.00.

Notes to Editors

1. The new guidance follows on logically from a 1995 HFRG publication, '*Improving compliance with safety procedures: Reducing industrial violations*' (also published by HSE) and from HSE's recently-revised core human factors guidance, '*Reducing error and influencing behaviour*'
2. HFRG is a forum for individuals who have an interest and expertise in human factors, associated with reliability. It was inaugurated in 1981 to foster collaboration between organisations with a direct interest in optimising and assessing human reliability in human-machine systems and to support research and dissemination of information in these areas.
3. HFRG has a very broad hazardous industries' representation including the chemical, nuclear, aviation and offshore sectors. Further information on HFRG can be obtained from the Secretary, Elaine Ridsdale, at the Safety and Reliability Directorate (SRD) Association (Tel: 01925 254621). For further information on this guidance contact: Steve Mason, Health, Safety and Engineering Consultants Ltd (Tel: 01530 412777/Fax: 01530 415592/e-mail: steve.mason@hsec.co.uk); or John Wilkinson, Hazardous Installations Directorate, HSE (Tel: 0151 951 4031/e-mail: john.HID.wilkinson@hse.gsi.gov.uk)
4. The term 'human factors' refers to "environmental, organisational and job factors, and human and individual characteristics which influence behaviour at work in a way which can affect health and safety" (from HSE guidance '*Reducing error and influencing behaviour*' - see below).
5. The two near-misses referred to both resulted in HSE prosecutions. BG Exploration and Production Ltd were fined £300,000 at Kingston-upon-Hull Crown Court on 10 February 2000 following a gas release from a leaking pipework joint on the company's Rough 47/3B offshore platform in February 1998 (see press notice [E022:00](#)). Exxon Chemical Ltd were fined a total of £75,000 at Southampton Crown Court on May 12 2000, following an incident at the company's refinery at Fawley, Hants, when three workers were exposed to hazardous substances during a maintenance operation in March 1998.

References

1. *Improving compliance with safety procedures: reducing industrial violations* HSE Books 1995, ISBN 0-7176-0970-7.
2. *Reducing error and influencing behaviour* (HSG48 Revised) HSE Books 1999, ISBN 0-7176-2452-8.

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Call HSE's InfoLine, tel: 08701-545500
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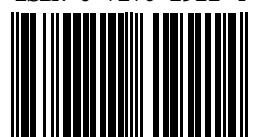


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