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Safety of offshore oil and gas operations: Lessons from past accident analysis

Ensuring EU hydrocarbon
supply through better
control of major hazards

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Instead of Foreword

“
Deepwater energy exploration and production, particularly at the frontiers of experience, involve risks for which neither industry nor government has been adequately prepared, but for which they can and must be prepared in the future.
...”

“
Sharing information as to what went wrong in offshore operations, regardless of location, is key to avoiding such mistakes.
...”

From “**Report to the President**”, National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, January 2011

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1. Introduction - Purpose

Following the catastrophic accident of 20 April 2010 in the Gulf of Mexico, where an explosion on drilling rig *Deepwater Horizon*, exploring oil and gas at the *Macondo* well about 60 km offshore the US coast, caused the death of 11 workers, severe injuries to many others and massive sea pollution from the release of 5 million barrels of crude oil, the European Commission responded by Communication "Facing the challenge of safety of offshore oil and gas activities" in 2010 and with a proposal for a Regulation "**on safety of offshore oil and gas prospecting, exploration and production activities.**"¹ While the articles of the proposed offshore safety legislation are being discussed within the European Parliament and the Council, there seems to be a unanimous agreement of all stakeholders that information exchange on past incidents and accidents is of paramount importance for preventing the recurrence of similar accidents in the future. In that context, Articles 22 and 23 of the proposed legislation require sharing of information and transparency in the safety performance of operators, while Annex VI foresees a common format for reporting this information.

The JRC, through a Memorandum-of-Understanding (MoU) with DG ENERGY and through its institutional work programme supports the development and implementation of the offshore safety legislation. One activity contributing to this support is the analysis of past accidents in the sector in order to identify the existing conditions related to sharing of information, transparency and lessons learning. It is also useful to get statistical information on the frequency and severity of accidents.

The purpose of the present report is threefold:

- i. To perform a preliminary survey on the **sources of information**, databases, etc. existing at national, international and open market level, and the availability of these information sources to the operators, authorities and the public;
- ii. To analyse a number of "landmark" accidents – such as the Macondo, Montara and Piper Alpha accidents – and review the **lessons learned** from these accidents, especially for the regulators and the operators and how they contribute to better control of the different phases of risk management; and
- iii. To perform an analysis of accidents collected in the WOAD database² and investigate the **accident statistics** of the sector.

After a first brief reference to the hazards related to the exploration and production activities in oil and gas rigs, the analysis goes to existing sources of information and their availability to the public. Then, some landmark accidents are reviewed in Section 4, and lessons are identified for the industry and the regulators. A more detailed accident analysis based on the records of DNV's WOAD database is included in Section 5. Finally, some general remarks and recommendations for future analysis are included in Section 6.

¹ COM(2011) 688 final, 2011/0309 (COD) of 27 October 2011

² WOAD: World Offshore Accident Databank, DNV,
<http://www.dnv.com/services/software/products/safeti/safetiqlra/woad.asp> :

2. Hazards related to offshore oil and gas operations

As it has been dramatically demonstrated not only in the Macondo accident but in a variety of cases, offshore oil rigs activities entail the hazard of a major accident with potentially severe consequences to the life and health of workers, pollution of the environment, direct and indirect economic losses, and deterioration of the security of energy supply. The main hazards include:

- fire, after ignition of released hydrocarbons;
- explosion, after gas release, formation and ignition of an explosive cloud;
- oil release on sea surface or subsea.

The consequences of accidents should be clearly distinguished from emissions and pollution during normal operation activities, even if these activities are extended through the whole life-cycle of an installation. While the latter (pollution from normal operation) results in relatively small quantities of pollutants ending in the sea during long periods, the accidental events result in release of huge quantities of hydrocarbons and pollutants discharged uncontrolled in the sea during relatively short periods. Consequently, the relevant topics (pollution from normal operation and from accidents) are regulated by different instruments and different “best technologies” and “best practices” apply. Normal operation discharges are regulated by international conventions (such as OSPAR for North-East Atlantic and the Barcelona Convention for the Mediterranean Sea), while accidental risks are regulated by national legislation or the proposed European legislation on offshore safety.

While consequences of potential accidents to life and health of the workers, pollution of the environment and especially of the neighbouring coastal areas, and direct economic damage are direct effects and can easily be assessed, indirect economic damage and effects of the accident to security of energy supply are more difficult to be assessed. The indirect economic damage may include losses from the fall in the price of the shares of the company after the accident (BP shares were reported to have fallen up to 50% in June 2010 after the Deepwater Horizon accident). The impact on security of energy supply can be understood by considering the ban of certain exploration activities in some countries (USA, Italy, etc.) in the aftermath of the Deepwater Horizon accident. Clearly, the assessment of indirect economic damage and effect of a large-scale accident on energy security is not an easy task and will not be dealt with further in the present document.

3. Availability of data sources on past offshore accidents

According to Annex VI of the forthcoming EU offshore legislation, sharing of information and transparency is necessary within the EU offshore industry.

Minimum information and data that should be recorded and shared include:

- unintended release of hydrocarbons;
- loss of well control, or failure of a well barrier;
- failure of a safety critical element;
- significant loss of structural integrity, or loss of protection against the effects of fire or explosion;
- vessels on collision course and actual vessel collisions with an offshore installation;
- helicopter accidents;
- any fatal accident; any serious injuries to 5 or more people in the same accident;
- any evacuation of non-essential personnel;
- a major accident to the environment.

Until now there is no database at European level to collect and share data on accidents and other incident events. There are many databases in different EU member states which were developed mainly due to legislative requirements and that collect usually data from accidents in the continental shelf of their country. Table 1 provides an overview of the databases and data sources identified. Some details for some of the databases are presented in the following sections.

Table 1. Sources of information and databases		
<i>Source/Database</i>	<i>Member State</i>	<i>Authority</i>
ORION	UK	HSE
HCR – Hydrocarbon Release Database	UK	HSE
Collision database	UK	HSE
MAIB - Marine Accident Investigation Branch	UK	Dept. Environment, transport and the Regions
PTIL	Norway	PSA – Petroleum Safety Authority
BLOWOUT	Norway	SINTEF
DEA/EASY	Denmark	DEA – Danish Energy Agency
WCID – Well Control Incident Database		OGP – International Association of Oil and gas Producers
Common reporting format project		NSOAF - North Sea Offshore Authorities Forum
Performance Measurement Project		IRF – International Regulators’ Forum
WOAD - Worldwide Offshore Accident Databank		DNV (owner) – Accessible with charge

3.1 Databases of Regulatory authorities

3.1.1. UK – ORION Database

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR 95) arrangement came into force on 1 April 1996 and requires that all work-related accidents, diseases and dangerous occurrences in the UK and UK Continental Shelf are to be reported to the HSE. It applies to all work activities and to defined types of incidents. The incidents are to be reported using the OIR/9B and F2508A forms. These forms are to be completed and submitted to the HSE.

The information submitted on the OIR/9A, OIR/9B and F2508A forms are recorded in a database, “ORION” (the former Sun Safety System), run by the HSE-OSD offices in Bootle, Liverpool.

The ORION database was primarily developed to record incident data reported on the OIR/9A form. Other information is however recorded on the database, including details of inspections, investigations, prosecutions and the registration and location details of Offshore Installations. The OIR/9A form was first published in October 1990, and the Sun Safety System was implemented in 1st January 1991. The Sun Safety System does however contain some data on pre 1991 incidents (imported from previous systems maintained by the Safety Directorate of the Department of Energy), though not all fields on the OIR/9A form are available for this data. The Sun Safety System was decommissioned year 2000 and all data from 1991(incl.) was transferred to ORION. ORION data are not available to public; however the HSE publishes reports and safety bulletin each year with statistics form ORION database.

Further information: HSE, Accident statistics for fixed offshore units on the UK Continental Shelf 1980-2005, Prepared by Det Norske Veritas for HSE, 2007)

3.1.2. UK – Hydrocarbon Release Database.

The Hydrocarbon Releases Database System contains supplementary information, dating from 1 October 1992, on all offshore releases of hydrocarbons reported to the HSE Offshore Division (OSD) under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR), and prior offshore legislation. The information is voluntarily submitted on the OIR/12 form and also recorded in a separate and specifically designed database which is maintained by the HSEOSD offices in Bootle, Liverpool.

Only authorised users can log on to the Hydrocarbon Releases (HCR) System to enable search and other reporting facilities, including details of the associated offshore installations, systems and equipment population currently operating on the UK Continental Shelf.

Further information: <https://www.hse.gov.uk/hcr3/index.asp>

3.1.3. UK – Collision database

A database of vessel/platform collision incidents on the United Kingdom Continental Shelf (UKCS) was originally created for the Health & Safety Executive, Offshore Safety Division

(OSD) in 1985. It has subsequently been amended and extended on several occasions. The Collision Incidents Database includes incidents that have been defined as a reported impact between a vessel and a fixed or mobile installation. Accident data or accident reports are not available to the public, but the HSE provides very comprehensive reports with accident frequencies and accident statistics from this database.

Further information: HSE, Ship/platform collision incident database (2001)

3.1.4. UK – MAIB

The Marine Accident Investigation Branch (MAIB) is a distinct and separate branch within the Department of the Environment, Transport and the Regions (DETR). Its Chief Inspector reports directly to the Secretary of State for the Environment, Transport and the Regions on marine accident investigations. The authority of the MAIB to investigate marine accidents originates from the Merchant Shipping Act 1995. MAIB's responsibility covers the investigation of accidents to or on:

- all UK registered vessels anywhere in the world
- other vessels being within the 12-mile zone of the UK coast (UK territorial waters)

For offshore floating vessels all accidents and incidents occurring in transit should be reported to MAIB according to the above.

About 2000 accidents are reported per year to MAIB of which about 500 require some sort of MAIB correspondence follow-up, for clarification purposes or investigation. Most of these are from UK waters.

MAIB maintains a database covering accidents and incidents from 1991 to date. Beside the said forms and notifications, the 'Coast Guard Morning Reports' serves as first-hand information input to the database. Today the database contains some 22.000 events covering all types of incidents and accidents, ranging from smaller low-consequence events and near-misses to major accidents with loss of life.

Further information: HSE, Accident statistics for floating offshore units on the UK Continental Shelf 1980-2005, Prepared by Det Norske Veritas for HSE, 2007 (http://www.maib.gov.uk/report_an_accident/index.cfm)

3.1.5. Norway – Petroleum Safety Authority (PSA)

According to the Management Regulations all accidents that result to death or injury should be reported to PSA through special forms. Moreover all offshore incidents should be reported to PSA by operators. The most serious incidents will be investigated by the PSA. 6-9 incidents are investigated each year. PSA publishes on its website all investigation reports for accidents that are being investigated; these reports include accident descriptions. Summarized accident descriptions are also provide in the PSA website.

Further information: (<http://www.ptil.no/investigations/category157.html>)

3.1.6. Norway - SINTEF

SINTEF is not a regulatory authority; however it is supporting the implementation of the legislation in Norway and information on the Blowout database is provided here for completeness. The SINTEF Offshore Blowout Database (BLOWOUT) is a comprehensive event database for blowout risk assessment. The database includes information on 573 offshore blowouts/well releases that have occurred worldwide since 1955.

The database includes blowout/well release descriptions worldwide and drilling and production exposure data for several areas with focus on the US Gulf of Mexico Outer Continental Shelf (US GoM OCS), Norwegian waters, and UK waters.

The blowouts/well releases are categorized in several parameters, emphasizing blowout causes. The database contains 51 different fields describing each blowout/well release. In addition, the database allows for attachment of any electronic file(s) to the blowout description. The various fields are grouped in six different groups:

- Category and location
- Well description
- Present operation
- Blowout causes
- Blowout Characteristics
- Other

ExproSoft has been contracted to operate the SINTEF Offshore Blowout Database from 1 May 2001 by SINTEF. The database and annual report are confidential and only accessible for the project sponsors. The SINTEF Offshore Blowout Database is open to new participants. Some statistics from the database are presented in the several references.

Further information: (<http://www.sintef.no/home/Technology-and-Society/Safety-Research/Projects/SINTEF-Offshore-Blowout-Database>)

3.1.7. Denmark – Danish Energy Agency

Accidents and near misses are reported to Danish Energy Agency (DEA) using the Electronic reporting system (EASY) or a special notification form.

According to section 3 of Executive Order No. 33 of 13 January 2005 on the Registration and Notification of Work-Related Injuries etc., issued in pursuance of the Act on Certain Offshore Installations, (the Notification Order), the principal employer, i.e. the company in charge of operating the offshore installation, must register the following:

- any accident or fatality occurring on the offshore installation
- any significant damage to the structure or equipment of the offshore installation and
- near-miss incidents.

In addition, the employer liable to provide protection must report the following to the Danish Energy Agency (DEA) according to section 4 of the Notification Order:

- Fatal accidents
- Any accident resulting in incapacity to work for one or more days beyond the injury date.

The employer liable to provide protection means the employer in whose business or service the accident occurred.

Moreover, the principal employer must report the following:

- Near-miss incidents involving a risk of fatality and serious personal injury.
- Any significant damage to the structure or equipment of the offshore installation or vessel.

No specific format is required for these reports. However, the information from the accident reporting form, where relevant, must be included.

The DEA compiles statistics on reportable accidents and near miss incidents every year that are published in the annual report on oil and gas production in Denmark. The DEA uses these statistics and the individual reports on injuries and near miss incidents received for the purpose of prioritizing its supervision activities. Accident reports are not directly available to the public.

Further information:

http://www.ens.dk/en-US/OilAndGas/Health_and_Safety/Work_Related_injuries%20etc/Sider/Forside.aspx

3.2 Other sources of information and projects on common formatting and exchange of data

3.2.1. OGP – Well Control Incident Database

The Wells Committee of the International Association of Oil and Gas Producers (OGP) has been created in order to identify areas for improvement and focus on these to strengthen the long-term health of the oil & gas industry across the whole cycle of well planning, construction, operation and abandonment.

The purpose of this committee is to provide a formal and active body through which its members can share good practice to contribute to OGP objectives related to well integrity matters and its mission to facilitate continuous improvements in safety and the environment. One of the primary objectives of the committee is to analyse incidents and disseminating lessons learned and good practices based on shared experience among its members. For that specific purpose a database has been developed. OGP Members report well control incidents and near misses into the OGP Well Control Incident Database. All data submitted is anonymous and confidential. Data are not available to the public, only to members of the project.

Further information: <http://www.ogp.org.uk/committees/wells>

3.2.2. IRF - Performance Measurement Project

The International Regulators' Forum has set up the Performance Measurement Project in order to measure and compare offshore safety performance among IRF participants by collecting and comparing incident data based on a common set of criteria.

Data include Fatalities, Injuries, Gas Releases, Collisions, Fires and Losses of Well Control. Data are provided from the members of the Forum which are:

- The National Offshore Petroleum Safety and Environmental Management Authority, Australia (NOPSEMA)
- The Petroleum Safety Authority, Norway, (PSA)
- The US Bureau of Safety and Environmental Enforcement (BSEE)
- The Danish Energy Agency (DEA)
- The National Hydrocarbons Commission, Mexico (CNH)
- The New Zealand Department of Labor, (DOL)
- The Canada-Newfoundland and Labrador Offshore Petroleum Board, (C-NLOPB) and the Canada-Nova Scotia Offshore Petroleum Board, (CNSOPB)
- The Brazilian National Petroleum Agency, (ANP)
- The Health and Safety Executive, Great Britain, (HSE)
- The State Supervision of Mines, the Netherlands, (SSM)

3.2.3. NSOAF – Common reporting format project

The North Sea Offshore Authorities Forum (NSOAF), where representatives from all the North Sea countries' governmental authorities in charge of supervision of offshore petroleum activities take part has launched a project in order to develop a common format for exchanging information about incidents, accidents and near-misses amongst the NSOAF members which are the following:

- Norway: Petroleum Safety Authority (PSA)
- Denmark: Danish Energy Agency
- Faroe Islands: Ministry of Petroleum
- Germany: Landesamt für Bergbau, Energie und Geologie
- Ireland: Department of Communications, Marine and Natural Resources
- The Netherlands: State Supervision of Mines
- Sweden: Svenska Geologiska Undersökning
- UK: Health and Safety Executive.

3.2.4. DNV - WOAD

One of the main sources for offshore accident information for public use is the Worldwide Offshore Accident Databank (WOAD) operated by Det Norske Veritas (DNV). WOAD contains more than 6000 events from 1975, including accidents, incidents and near misses. Data are derived mainly from public-domain sources such as Lloyds Casualty Reports, newspapers and official publications. Most of the data is from the UK and Norwegian Sectors and the US Gulf of Mexico. WOAD holds data on a number of parameters such as name, type and operation mode of the unit involved in the accident, date, geographical location, main event and chain of events, causes and consequences, as well as evacuation details.

Exposure data is also provided, allowing accident rates to be calculated for different accident and installation/rig/platform types. WOAD data are not publicly available but are accessible through a database subscription (with charge).

Further information: http://www.dnvusa.com/Binaries/flyer_WOAD_tcm153-136061.pdf

3.3 Main conclusions on information availability

Occupational related accidents and incidents are mainly notified to national Regulatory Authorities based on national legislative requirements and gathered on national level. As a result in most of the cases, focus is given on accidents resulting in fatalities, injuries or serious damage of the installation. Near misses are not always reported since this is not always a legal requirement. For most of the EU member states accident descriptions are not available to public; the regulatory authorities publish reports on accidents with statistical data and lessons learned.

Another main issue highlighted is that there is no common formatting between different countries and different organizations; that is the reason why international associations like IRF and NSOAF have launched projects in order to achieve a common formatting for the reporting of accidents and incidents between different countries and different legislations.

The overall picture of accidents reporting looks like a mosaic or a puzzle: there are many pieces available but it is very difficult to put them together in order to get the full image.

The main conclusions after the exploration of accident data sources are:

- There is a clear need for pooling of data in order to have a complete picture of the safety in offshore sector
- There is a clear need for common formatting in order to facilitate data and experience sharing
- There is a clear need for transparency of data
- The inclusion of near misses in accident databases is necessary, because important lessons can be learned from them
- Lessons learnt from accidents and incidents should be available to all stakeholders
- Obviously there is a need to protect sensitive and confidential information
- There is a need to avoid double-reporting of accidents and incidents in different organizations (i.e. regulatory authorities, international associations)

Aggregation of data is absolutely necessary for effective lessons learning and dissemination of knowledge on past accidents but also in order to obtain a clear overall picture of the risk of possible accident types. In this way risk management decisions (e.g. related with liability provisions, financial security pooling scheme, ALARP decisions, etc) would be based on more subjective and reliable data.

4. Lessons learned from landmark past accidents for the control of offshore major accident hazards

In this Section some of the landmark past accidents will be briefly described and key lessons on the control of major accident hazards related to the offshore oil and gas extraction industry will be summarised. The analysis focuses on landmark blowout accidents, but two other accidents (Piper Alpha and Alexander Kielland) are also included due to their increased death toll:

- Alexander L. Kielland
- Ixtoc I
- Piper Alpha
- Ekofisk B
- Adriatic IV
- Montara
- Macondo – Deepwater Horizon

4.1. Description of accidents

4.1.1. Alexander L. Kielland capsized (North Sea, 1980)

The semi-submersible “flotel” (floating hotel) Alexander L. Kielland capsized on 27 March 1980 while bridge connected to the steel jacket Ekofisk Edda platform. The flotel lost one of its five legs in severe gale force winds, but not an extreme storm. The accident started with one of the bracings failing due to fatigue, thereby causing a succession of failures of all bracings attached to this leg. It was discovered during the investigation that the weld of an instrument connection on the bracing had contained cracks, which had probably been in existence since the rig was built. The cracks had developed over time, and the remaining steel was less than 50%.

When the leg came loose, the rig almost immediately developed a severe listing. Within 20 minutes of the initial failure it capsized completely, floating upside down with just the bottom of the columns visible in the sea.

Both the escape and evacuation operations were far from orderly and had only limited success. Only one lifeboat was in fact launched successfully, one was totally unavailable due to the listing, and others were smashed against the platform during launching in high waves. The final death toll was 123 fatalities and 89 survivors.

This accident was the first instance in the Norwegian offshore operations where an official commission of enquiry was appointed to investigate a severe offshore accident. Attention was mainly focused on the cause of the failure, but considerable attention was also paid to the evacuation and rescue operations that had revealed extensive shortcomings.

4.1.2. Ixtoc I Blowout (Gulf of Mexico, 1979)

In 1979, the Sedco 135F was drilling the IXTOC I well for PEMEX (Petróleos Mexicanos), the state-owned Mexican petroleum company when the well suffered a blowout. The well had been drilled to 3657m with the 9-5/8" casing set at 3627m. According to reports, mud circulation was lost, so the decision was made to pull the drill string and plug the well. Without the hydrostatic pressure of the mud column, oil and gas were able to flow unrestricted to the surface, which is what happened as the crew were working on the lower part of the drill-string. The BOP was closed on the pipe but could not cut the thicker drill collars, allowing oil and gas to flow to surface where it ignited and engulfed the Sedco 135F in flames. The rig collapsed and sank onto the wellhead area on the seabed, littering the seabed with large debris such as the rig's derrick and 3000m of pipe.

The well was initially flowing at a rate of 30,000 barrels per day, which was reduced to around 10,000 bpd by attempts to plug the well. Two relief wells were drilled to relieve pressure and the well was eventually killed nine months later on 23 March 1980. Due to the massive contamination caused by the spill from the blowout (by 12 June, the oil slick measured 180km by 80km), nearly 500 aerial missions were flown, spraying dispersants over the water. Prevailing winds caused extensive damage along the US coast with the Texas coast suffering the greatest. The IXTOC I accident was the biggest single spill before the occurrence of Macondo accident, with an estimated 3.5 million barrels of oil released.

4.1.3. Piper Alpha Explosion (North Sea, 1988)

With 167 fatalities Piper Alpha is the deadliest accident in the history of the offshore oil and gas industry. The Piper field is located about 120 miles north-east of Aberdeen and the platform initially produced crude oil, while in late 1980, gas conversion equipment was installed allowing the facility to produce gas as well as oil. A sub-sea pipeline, shared with the Claymore platform, connected Piper Alpha to the Flotta oil terminal on the Orkney Islands. Piper Alpha also had gas pipelines connecting it to both the Tartan platform and to the separate MCP-O1 gas processing platform. In total, Piper Alpha had four main transport risers: an oil export riser, the Claymore gas riser, the Tartan gas riser and the MCP-O1 gas riser.

On 06 July 1988, work began on one of two condensate-injection pumps, designated A and B, which were used to compress gas on the platform prior to transport of the gas to Flotta. A pressure safety valve was removed from compressor A for recalibration and re-certification and two blind flanges were fitted onto the open pipework. The dayshift crew then finished for the day.

During the evening of 06 July, pump B tripped and the nightshift crew decided that pump A should be brought back into service. Once the pump was operational, gas condensate leaked from the two blind flanges and, at around 2200 hours, the gas ignited and exploded, causing fires and damage to other areas with the further release of gas and oil. Some twenty minutes later, the Tartan gas riser failed and a second major explosion occurred followed by widespread fire. Fifty minutes later, at around 2250 hours, the MCP-O1 gas riser failed resulting in a third major explosion. Further explosions then ensued, followed by the eventual structural collapse of a significant proportion of the installation.

167 men died as a result of the explosions and fire on board the Piper Alpha, including two operators of a Fast Rescue Craft. 62 men survived, mostly by jumping into the sea from the

high decks of the platform. The – about 100 – recommendations from the Inquiry practically re-shaped offshore safety legislation and practices.

A number of factors contributed to the severity of the incident:

- the breakdown of the chain of command and lack of any communication to the platform's crew;
- the presence of fire walls and the lack of blast walls - the fire walls predated the installation of the gas conversion equipment and were not upgraded to blast walls after the conversion;
- the continued pumping of gas and oil by the Tartan and Claymore platforms, which was not shut down due to a perceived lack of authority, even though personnel could see the Piper burning.

4.1.4. Ekofisk B Blowout (North Sea, 1977)

This accident was North Sea's biggest oil spill. The Ekofisk Bravo blowout occurred on 22 April 1977 during a workover on the B-14 production well, when about 10,000 feet of production tubing was being pulled. The production christmas tree valve stack had been removed prior to the job and the BOP had not yet been installed. The well then kicked and an incorrectly installed downhole safety valve failed. This resulted in the well blowing out with an uncontrolled release of oil and gas. The personnel were evacuated without injury via lifeboats and were picked up by a supply vessel.

The initial flow was estimated at 28,000 bpd with a calculated total release of 202,380 bbls. Up to 30 to 40% of the oil was thought to have evaporated after its initial release and the Norwegian Petroleum Directorate reported a total spill estimate between 80,000 bbls and 126,000 bbls.

The well was capped after seven days on 30 April 1977. Rough seas and higher than average air temperatures aided the break-up of much of the oil. Later investigations reported no significant environmental damage and no shoreline pollution. There was also no significant damage reported to the platform.

The official inquiry into the blowout determined that human errors were the major factor which led to the mechanical failure of the safety valve. These errors included faults in the installation documentation and equipment identification and misjudgements, improper planning and improper well control. The blowout was significant because it was the first major North Sea oil spill. Also significant was that the ignition of the oil and gas was avoided and that there were no fatalities during the evacuation.

4.1.5. Adriatic IV Blowout (Mediterranean Sea, Egypt, 2004)

On 10 August 2004, the Adriatic IV was on location over the Tamsah gas production platform, off Port Said, Egypt in the Mediterranean. The rig was drilling a natural gas well when a gas blowout occurred during drilling operations. Reports state that there was an explosion followed by fire, which was initially contained on the jack-up. For unknown reasons, the fire then spread to the Petrobel-run platform where it continued to rage for over a week before being brought under control. More than 150 workers on the jack-up and platform were evacuated with no casualties, due in part to the prior recommendation that production activities be ceased as a precautionary measure.

Global Santa Fe (GSF) reported the Adriatic IV as sunk and not salvageable. The platform, owned jointly by BP, Italy's ENI and Egypt's General Petroleum Corporation was damaged beyond repair and Egypt's petroleum minister ordered its destruction. Less than a year after the accident, production at the Tamsah field was back on-stream at full production rates.

4.1.6. Montara Blowout (Timor Sea, Australia, 2009)

This accident was the worst occurring in the offshore industrial sector in Australia and resulted in the third worst sea pollution in the Australian history. On 21 August 2009, during drilling operations at the Montara Wellhead Platform an uncontrolled release of oil and gas occurred from the H1 well. All 69 personnel at the Wellhead Platform were safely evacuated. On 1 November the leaking well was successfully intercepted, however during operations to complete the "well kill", fire broke out on the West Atlas rig and the Montara Wellhead Platform. On 3 November 2009, the fire was extinguished.

Located in the Timor Sea, the Montara Wellhead Platform is 254 kilometres north-west of the Western Australian coast and 685 kilometres from Darwin. The Montara Wellhead Platform is approximately 157 km from the Ashmore Reef National Nature Reserve & Cartier Island Marine Reserve. For a period of just over 10 weeks in fall 2009, oil and gas continued to flow unabated into the Timor Sea, and patches of sheen or weathered oil could have affected at various times an area as large as 90,000 square kilometres.

The source of the uncontrolled release (well blowout) is largely uncontested. It is clear that the cementing work to seal the well in April 2009 was not performed according to state-of-the-art practices followed in the petroleum industry, so when drilling operations restarted in August 2009 a blowout occurred. The Inquiry has determined that the most likely cause was that hydrocarbons entered the H1 Well through the 9 5/8" cemented casing shoe and flowed up inside of the 9 5/8" casing. The Inquiry in determining what caused the uncontrolled release found that the primary well control barrier of the H1 well (9 5/8" cemented casing shoe) failed. The Inquiry further noted that the initial cementing problems were compounded by the fact that only one of the two secondary well control barriers – pressure containing anti-corrosion caps – was installed.

4.1.7. Macondo Blowout (Gulf of Mexico, 2010)

On 20 April 2010, the Macondo well blew out, costing the lives of 11 men, the beginning of a catastrophe that sank the Deepwater Horizon drifting rig and spilled over 4 million barrels of crude oil into the Gulf of Mexico. The spill disrupted an entire region's economy, damaged fisheries and critical habitats, and brought vividly to light the risks of deepwater drilling oil and gas.

At approximately 9:45 p.m. CDT, on April 20, 2010, methane gas from the well, under high pressure, shot all the way up and out of the drill column, expanded onto the platform, and then ignited and exploded. Fire then engulfed the platform. Most of the workers escaped the rig by lifeboat and were subsequently evacuated by boat or airlifted by helicopter for medical treatment; however, eleven workers were never found despite a three-day Coast Guard search operation, and are believed to have died in the explosion. Efforts by multiple ships to douse the flames were unsuccessful. After burning for approximately 36 hours, the Deepwater

Horizon sank on the morning of 22 April 2010. The leak lasted for 87 days and resulted in an unprecedented environmental disaster.

The root technical cause of the blowout was that the cement that BP and Halliburton pumped to the bottom of the well did not seal off hydrocarbons in the formation. Factors that increased the risk of cement failure at Macondo include: First, drilling complications forced engineers to plan a “finesse” cement job that called for a low overall volume of cement. Second, the cement slurry itself was poorly designed and tested, while the temporary abandonment procedures, finalized only at the last minute, called for rig personnel to severely “underbalance” the well before installing any additional barriers to back up the cement job. The results of the negative pressure test conducted on April 20 and clearly showing that hydrocarbons were leaking into the well were misinterpreted by the well site leaders and Transocean personnel. Transocean and Sperry Drilling rig personnel then missed a number of further signals that hydrocarbons had entered the well and were rising to the surface during the final hour before the blowout actually occurred. By the time they recognized a blowout was occurring and activated the Blowout Preventer (BOP) it was too late for that device to prevent an explosion. Furthermore the preventer itself was inadequately designed (single blind shear ram, unable to cut through tool joints) and operating.

The underlying cause of the accident was a bad safety culture of the operator (BP) and its contractors (Transocean, Halliburton). The investigation reports (Commission Report to the President and Chief Counsel’s Report) reveal a series of organisational and safety management failures that led to the accident. Amongst them, the following can be stressed:

- Lack of adequate hazard identification – in particular addressing risks rising from the frontier conditions and from changes to well design and conditions
- Inadequate level of detail in procedures
- Lack to timely recognise and react to early warning signals
- Lack of communication
- Lack of clear leadership, especially lack of a culture of leadership responsibility
- Lack of the ability to learn lessons from other accidents and recent near-misses.
- Lack of appropriate training of personnel, especially in reacting to emergency situations.

The investigation reports contain also recommendations for regulatory reform, since the Minerals Management Service (MMS) regulatory structure in place in April 2010 was found completely inadequate to address the risks of deepwater drilling projects like Macondo. Amongst others the Report’s recommendations include:

- The need to separate leasing from safety oversight regulatory functions
- The need for a shift towards a risk-based performance approach, similar to the “safety-case” approach used in the North Sea
- The need of authorisation, review and approval of the safety case, as well as performance of inspections
- The need for improved international safety standards
- The need for increased transparency, reporting of incidents and near-misses for the purpose of lessons learning.
- The need for increased capabilities and better planning for emergency response.

4.2. Lessons learned from the accidents

In this Section we will analyse the main failures leading to accidents and will describe lessons learned for the control of the relevant risks, in other words actions necessary to be taken by the operators, the regulators and the international community in order to control these risks and keep them at an adequately low level. The description of failures will principally use the Macondo accident as example, however the findings are easily extended and valid for all of the reviewed accidents.

The following Table summarises the analysis of failures and lessons learned, and presents them according to the usual risk management chain, i.e. prevention – early warning – mitigation – preparedness – emergency response – aftermath/recovery. In general it is noted that for every failure there are recommendations for the operators, for the regulators to oversights the relevant activities and for the international offshore oil and gas community in establishing high-level standards and best practices.

Table 2. Failures and lessons learned from landmark accidents	
<i>Failures</i>	<i>Lessons learned</i>
<u>Prevention</u>	
Failure to properly identify risks and address them in risk assessment	Performance of adequate risk assessment: <ul style="list-style-type: none">- Identification of hazards under extreme conditions, during changes of procedures and boundary conditions and during all phases of the life cycle of the oil & gas exploitation activity- Existence, application and review of high level standards for hazard identification
Failure of cementing job in well (primary barrier)	Appropriate cementing of the well: <ul style="list-style-type: none">- Existence of high level well integrity standards and practices- Operator follows adequate procedures- Operator/contractor recognises early signals and reacts promptly- Operator maintains high safety culture level- Appropriate oversight by regulatory authorities; control conformity, review risk assessment, check operator's /contractor's capacity
Failure of BOP (blowout preventer) (Secondary barrier)	Installation of BOP with adequate features. Ensure performance as preventer and integrate in prevention system: <ul style="list-style-type: none">- Existence of high level technology standards (e.g. double shear ram, or able to cut through joints)- Risk assessment ensures increased reliability of the overall protection system; ensures that it works under all conditions- Operator applies state-of-the-art

	<p>technology and recognised best practices</p> <ul style="list-style-type: none"> - Regulatory authority oversees risks, reviews risk management and performs inspections
<u>Early warning</u>	
Failure to recognise and react to early warning signals of hydrocarbons entering the well	<p>Better monitoring, early detection and interpretation of early warning signals:</p> <ul style="list-style-type: none"> - Existence and application of good practices
<u>Mitigation</u>	
Failure to adequately use the diverter; too much reliance on human response under pressure	<p>Installation of diverter of appropriate design and with the adequate features. Ensure that in case of accident, it is used in the appropriate way to avoid escalation:</p> <ul style="list-style-type: none"> - Existence of high level technology standards with appropriate balance between automatic / human intervention - Risk assessment ensures increased reliability of the overall protection system and appropriate protection level - Operator applies state-of-the-art technology and recognised best practices - Regulatory authority oversees risks, reviews risk management and performs inspections
Failure to avoid ignition of released hydrocarbons	<p>Installation and functioning of gas detectors in appropriately defined hazardous areas; avoid ignition sources in these areas:</p> <ul style="list-style-type: none"> - Existence of good practices for the definition of hazardous and high technology in gas detectors - Operator installs state-of-the-art gas detectors in appropriate locations and extends the hazardous areas where necessary - Regulatory authority checks adequacy of protection measures and performs inspections
Failure to protect vulnerable areas (e.g. control room, workers' area, vulnerable compartments) from the impact of explosion	<p>Use of materials and designs that withstand increased overpressure (high-strength steel):</p> <ul style="list-style-type: none"> - Existence of best technologies and good practices for the protection of vulnerable areas - Operator installs state-of-the-art protection measures (balance with increased cost and other drawbacks) - Regulatory authority checks adequacy of protection measures
<u>Preparedness and planning</u>	
Failure to be adequately prepared	Be prepared and foresee the capacities needed to

to respond to the accident	<p>respond to the accident. Develop a plan on how to respond:</p> <ul style="list-style-type: none"> - Existence of good practices - Development of scenarios and assessment of capacities necessary to efficiently respond to these scenarios (e.g. to rescue personnel, to stop the release, to drill relief wells, to contain the spill) - Operator develops emergency plan (internal) based on commonly acceptable scenarios and good practices. He has to ensure that capacities are in place. - Regulatory authority has to review and inspect the emergency plans and to confirm the existence of capacities. It also has to ensure that other respond authorities (e.g. costal guard, civil protection, maritime pollution control) are informed - Transboundary effects
<u>Emergency response</u>	
Failure to adequately respond to the accident	<p>Application of highly sophisticated emergency response technologies and application of efficient plans, mobilising all necessary capacities of the operator and the Member States (Note: No progress in response measures has been noticed between <i>Exxon Valdez</i> and <i>Deepwater Horizon</i> oil spills):</p> <ul style="list-style-type: none"> - Existence of high level technology standards and best available technologies for emergency response - Existence of capacities - Emergency plan (external) with the involvement of various authorities from affected Member States
<u>Aftermath / Restoration</u>	
Failure to restore the environment to the status prior to the accident (hopefully, not in the Macondo accident)	<p>Take measures to restore the quality of environment:</p> <ul style="list-style-type: none"> - Existence of high level technology standards for cleanup operations - Operator applies state-of-the-art technology and recognised best practices - Regulatory authority oversees and monitors cleanup operations
<u>Safety management</u>	
Failure to manage safety of operations adequately	<p>Put in place a Safety and Environmental Management System, addressing continuously and systematically the safety challenges of the operations:</p> <ul style="list-style-type: none"> - Existence of good practices - Operator applies recognised best practices

	<ul style="list-style-type: none"> - Operator takes actions to enhance and promote safety culture, communication, targeted training and safety leadership inside his business - Regulatory authority reviews safety management systems and monitors the level of safety
<u>Lessons learning</u>	
Failure to learn from accidents and from near-misses	<p>Put in place an appropriately designed system to investigate accidents, identify key lessons and learn lessons from accidents, incidents and near-misses (note: Transocean did not learn from a similar near-miss occurred on 23 December 2009 in the North Sea). Communicate not only internally, but – for the key lessons – also externally, to the wider offshore risk management community:</p> <ul style="list-style-type: none"> - Existence of a common format for reporting accidents, incidents and near-misses - Existence of agreed taxonomies of the causes, consequences and critical issues related to them, including lessons learned. - Operator investigates accidents, incidents and near-misses, identifies lessons and disseminates them not only within the personnel, but also shares lessons with other operators, inspectors and risk management community - Regulatory authority collects data and forwards to the Commission for further analysis - Commission (or other independent body) analyses accidents and disseminates lessons

4.3. Key lessons for the regulators

In this Section the main lessons for the regulating framework are presented.

4.3.1. Regulatory regime

It is clear from Sections 4.1 and 4.2 that accidents do not happen always according to predefined sequences and scenarios. Rather, they – almost always – fail in complex ways and there is a variety of root causes leading each time to the accident. For that reason it is not possible for a prescriptive regulatory framework to address all relevant risks. It is necessary to use the principles of risk assessment and safety management to review and control the risks on a case-by-case basis.

A strong recommendation of the Commission Report to the President on Deepwater Horizon (DwH) accident was a shift in the regulatory regime:

*“... should develop a proactive, **risk-based performance approach** specific to individual facilities, operations and environments, similar to the “safety case” approach in the North Sea”*

Similar support to this regime comes from the Australian Commission’s Report on the Montara accident, while both UK and Norwegian regime are clearly of this kind.

4.3.2. Authorization / review and approval of the safety and environmental report / Compliance (inspections)

One of the main recommendations of the Commission Report to the President on DwH accident was the establishment of a new Offshore Safety Authority, whose

“..... Key responsibilities include:

- **Reviewing and approving (or denying) all permits** under exploration, development, and production plans.
- **Inspecting** all offshore operations by expert teams through scheduled and unannounced inspections.
- Auditing or otherwise requiring certification of operator health, safety, and environmental management systems.
- **Evaluating eligibility for lessees** based on safety and environmental qualifications.
- **Reviewing and approving** the safety and feasibility of any **environmental mitigation activities** prescribed by National Environmental Policy Act (NEPA) documents and other environmental consultations, authorization, or permits in addition to enforcing such requirements over the duration of an operation.
- Collecting and analyzing **leading and lagging indicators** from all active parties for full risk evaluation.
- Promulgating all structural integrity, process, and workplace safety rules and regulations in order to create a foundation of prescriptive regulations to supplement performance-based (“safety case”) regulations.
- Providing technical review and comment on the five-year leasing program and individual lease sales.
- Providing **technical review of spill response and containment plans**.
- Reviewing and approving all spill response and containment plans and advising the new safety authority on environmental considerations.

- ***Investigating all accidents and other significant events that could have potentially turned catastrophic***”.

It was one of the findings of the US Commission that these elements were lacking before the DwH accident and these are indispensable items of good risk governance.

4.3.3. Best Available Techniques, Technologies and Practices

It is necessary for the risk-based regulatory regime to supplement governance with standards and best available techniques. It is clear that certain topics need to be addressed through “state-of-the-art practices” (e.g. development of procedures, hazard identification, risk assessment), while in other cases it is necessary to rely on more strictly defined “best available technologies” (e.g. does not exclude “techniques”).

Again from the DwH Recommendations:

“ ... should supplement the risk-management program with prescriptive safety and pollution-prevention standards ... ”

It should be noted that here reference is made to **safety standards** and not to product safety standards. This means that focus should be given not only to product safety standards but also to issues such as what risk assessment methods should be used, what acceptability criteria, how safety devices should be combined to achieve acceptably low levels of risks.

4.3.4. Scope of application (include related pipework?)

This needs to be investigated properly. It seems reasonable to include the complete system, without going to sea transportation of oil and gas. It could be something like “Surface and subsurface installations necessary for the extraction, storage and transport of oil and gas to onshore installations (terminals) for further processing, excluding their transport by sea vessels”. This means: All fixed and mobile installations – including MODU’s – risers, pipelines to onshore facility, tankers loading operations. Transmission pipelines (e.g. from Norwegian platforms to UK, supplying UK with gas) may be excluded – but in that case their safety control should be ensured by other instrument (e.g. specific regulation on pipelines safety)

No lessons learned from review of accidents.

4.3.5. Directive 92/91

Clearly, 92/91 focuses on workers’ health and safety and not to the prevention of major accident. Nevertheless, general principles of accident prevention and mitigation of the consequences are applicable also for the purposes of 92/91 Directive.

4.3.6. Safety management / safety culture / performance indicators

It is clear that failures of the safety management system and a poor safety culture are almost always the underlying cause of major accidents. This is manifested either through failures in the design phase, failure to identify hazards, unsafe operations or lack of adequate response

procedures. This bad SMS and poor safety culture was clearly identified as the main underlying cause both in Macondo and in Montara accidents (and presumably in any offshore oil and gas accident).

Adopting on a mandatory basis a Safety and Environmental Management System is also recommended – and now applied – in the USA and reviewing it is one of the tasks of the new BOEMRE (Bureau of Ocean Energy Management, regulation and enforcement – USA). Collection of leading and lagging safety performance indicators is also recommended.

4.3.7. Accident reporting

Sharing of information and reporting of accidents for the purposes of lessons learning is beneficial for everybody. It is also more and more recognized that ***in prevention of major accidents everyone has to be involved***. For that reason we need to be as much as possible transparent; allow non-confidential information to be open and be analysed by everyone (industry, authorities, researchers, consultants, academia).

Moreover, information from **near-misses** can and should be shared anonymised to prevent future accidents. It should be highlighted that should Transocean have learned from the near-miss of 23 December 2009 in the North Sea, the Macondo accident wouldn't have happened. Unfortunately, information about this near-miss was not disclosed not even to Transocean employees of the installations operating in the Gulf of Mexico.

5. Accident analysis of offshore oil and gas rigs

A more detailed analysis of past accidents and events has been performed based on the database WOAD (World Offshore Accident Dataset) of DNV. This is one of the most reliable and most complete databases of failures, incidents and accidents in the offshore oil and gas sector. Still, it has to be stressed already from the beginning that although the database provides a good basis for lessons learning, it does not consist a good basis for statistical analysis. The reason is that reporting is voluntary and the content of the database is based on the information collected and compiled by DNV, i.e. it is not a completely authoritative accidents register. Yet, it is the best available source of information on offshore accidents and for that reason it is used for our accident analysis.

A first “symptom” of the voluntary character of WOAD is the different way in coverage of different geographical areas. Although the database contains worldwide data and DNV has made every reasonable effort to achieve the best and uniform coverage, it is evident that this was not possible. WOAD currently contains 6183 records, i.e. incidents, accidents and near-misses. Figure 1 shows the geographical distribution of collected accidents: 3505 in North Sea, 1685 in the Gulf of Mexico, while only 45 in the Mediterranean and 866 in all other regions of the world (Africa, South America, Australasia). Clearly, there has been more complete information and much willingness for sharing information in the North Sea countries – and USA – than in the rest of the world.

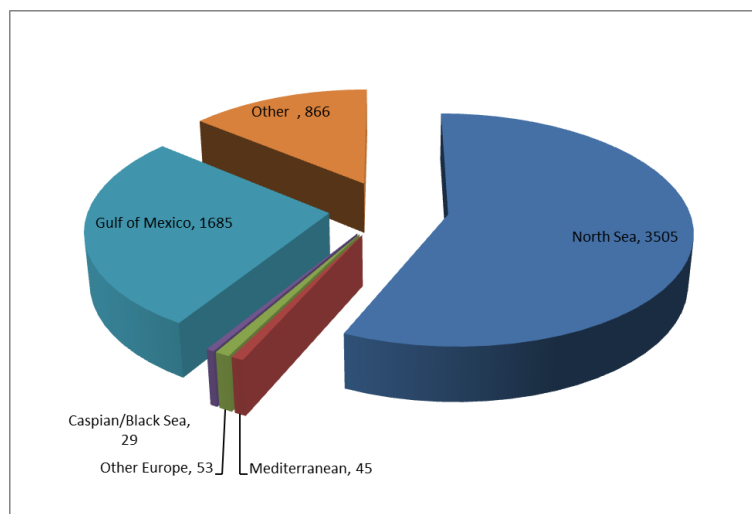


Figure 1. Geographical distribution of accidents in the WOAD database

The question of “representability” of the dataset appears more clearly in the next analysis and Figure 2. While European Mediterranean countries have a certain level of safety performance, North African countries appear to have a better performance, which is not correct. The reason why North African countries have fewer records in WOAD is simply because information about accidents in Egypt, Libya, Tunis, Algeria and Morocco has not been available.

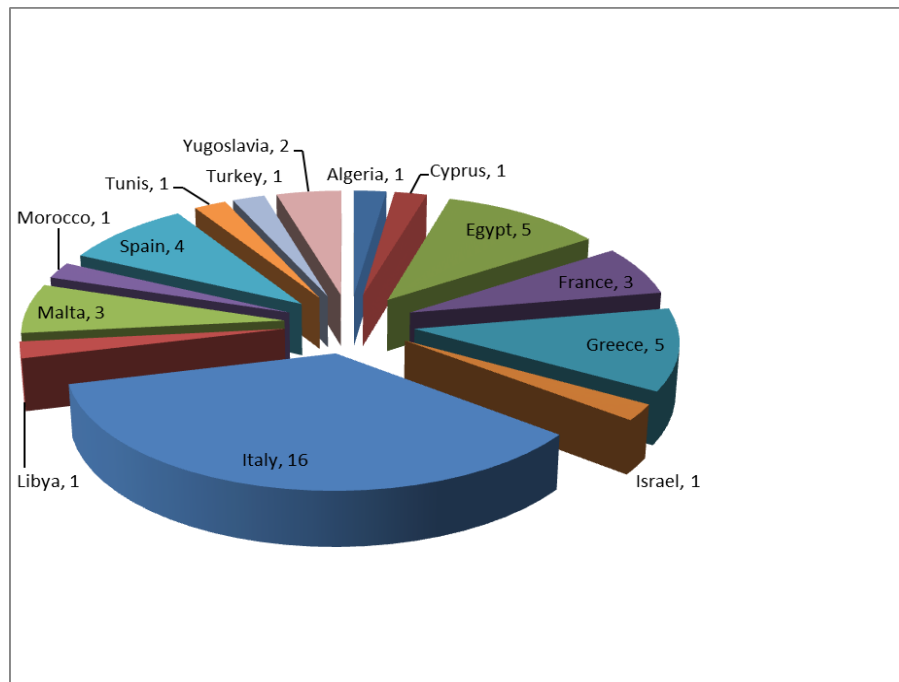


Figure 2. Accidents in the Mediterranean Sea

The chronological distribution of accidents is presented in Figure 3. Records in WOAD start from 1970 (with a smaller number of records due to limited information sources) and cover the period until 2009³. Important peaks are registered in 1999 and 2005. In 1999 a great increase has been recorded for accidents in the Norwegian Continental Shelf. This is mainly due to the fact that new regulations came into force that require reporting of all events (including near misses) and not that the actual number of incidents has increased. From the 381 events recorded only 8 were actually characterized as accidents. As the Norwegian Petroleum Directorate reports “There were no accidents in 1999 that led to serious damage to the environment, significant material loss or interruption of production” (Norwegian Petroleum Directorate Annual Report Offshore Norway 1999). Another important peak is recorded in 2005. This is the year of the hurricanes Katrina and Rita in US and as a result most of the records in this year are from the US Continental Shelf (341 records in 484 events in 2005)

The annual distribution of accidents is shown in Figure 4. Some particular findings from this diagram indicate that while incidents take place without great differences the whole year around, yet there are two peaks in the months of August and September, which are the months that most hurricanes pass from the Gulf of Mexico. Indeed almost half of events (610 out of 1344) took place in the Gulf of Mexico (either in US Continental Shelf or not) while the other large percentage is recorded in Norwegian Continental Shelf (502 incidents out of 1344). The seasonal variation of accident frequency in the North Sea indicates a slight increase during the winter months.

³ Although the WOAD database was purchased in August 2012 and was last interrogated in December 2012, the dataset contains incidents from 1970 till 2009. According to DNV, incidents are being collected and an update of the database is scheduled for the first half of 2013. Once the updated dataset becomes available, a review of the accident statistics and of the relevant findings would be necessary.

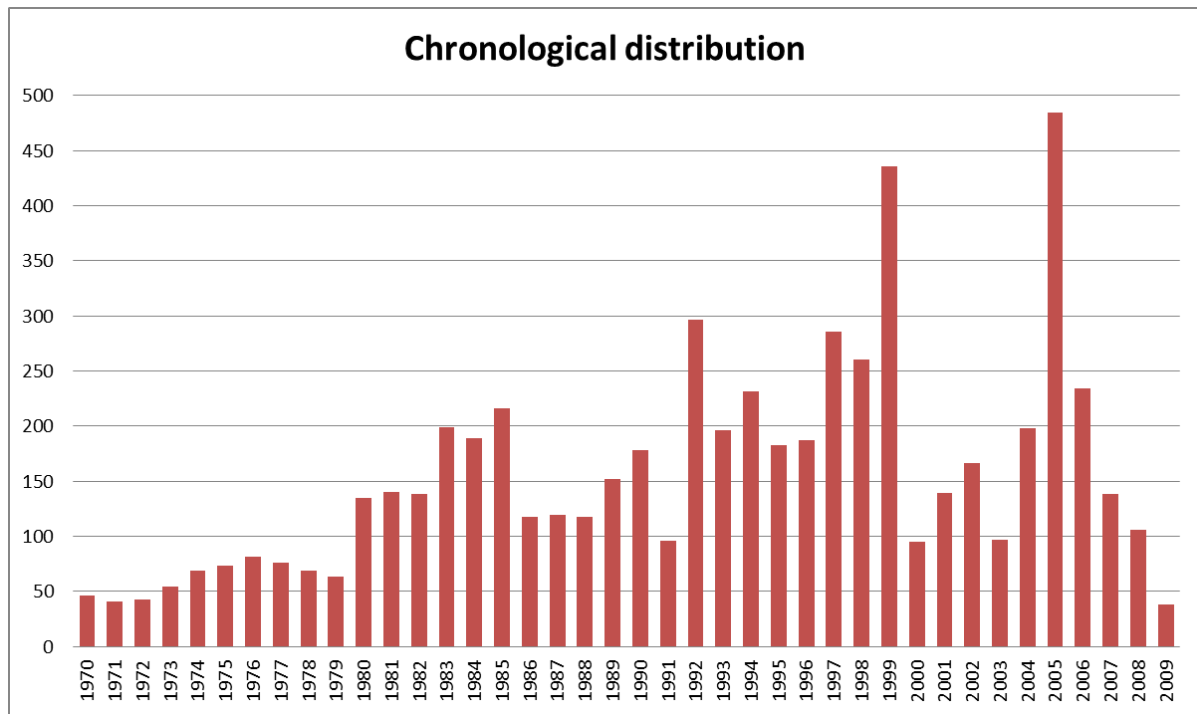


Figure 3. Chronological distribution of accidents in the WOAD database

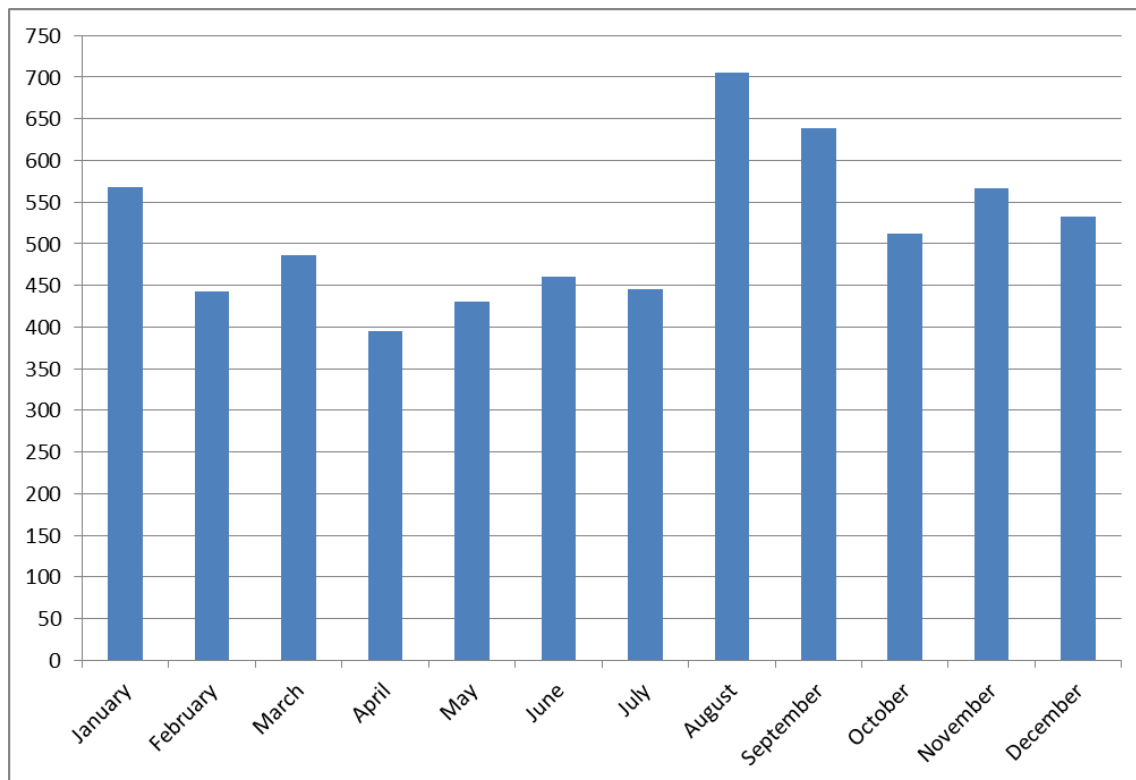


Figure 4. Annual distribution of accidents in the WOAD database

Within the WOAD database, the records are classified in 4 categories:

- Insignificant events
- Near-misses
- Incidents /Hazardous situations, and
- Accidents.

Insignificant events represent hazardous situation, with very minor consequences. In most of the cases no damages were registered and repairs were not required. Small spills of crude oil and chemicals are also included in this category. Included are also very minor personnel injuries, i.e. "lost time incidents".

Near-misses represent events that might have or could have developed into an accidental situation. No damage and no repairs were required also in these cases.

Incidents represent hazardous situation which have not developed into an accidental situation. Low degree of damage was recorded, but repairs/replacements usually were required. This type includes also events causing minor injuries to personnel or health injuries.

Accidents represent hazardous situation which have developed into an accidental situation. In addition, for all situations/events causing fatalities and severe injuries this type of event has been used.

Figure 5 presents the percentages for the different type of events while Table 3 provides the number of accidental events for the different types of Unit.

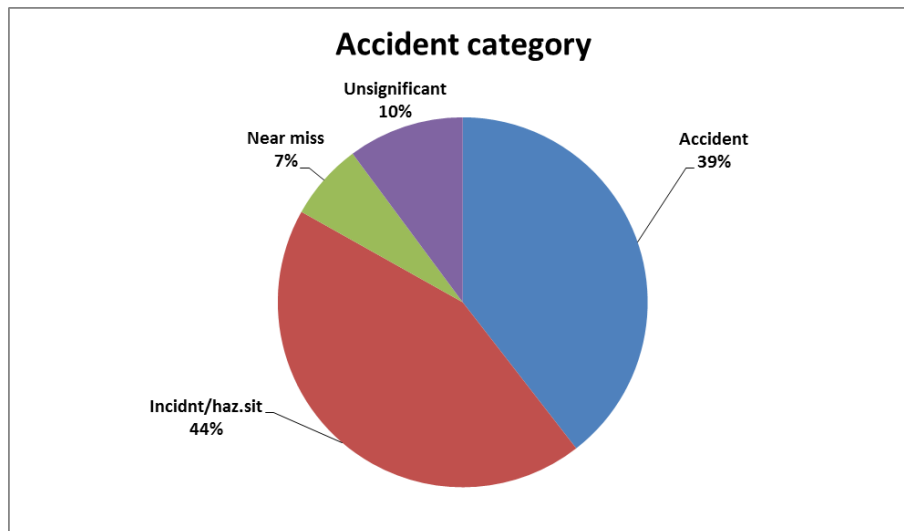


Figure 5. Distribution of accidents type for accidents in the WOAD database

It is clear that the numbers corresponding to more severe events, i.e. incidents and accidents, are more reliable than those corresponding to near-misses and Insignificant events. Near-misses are often not reported and information about them remains "hidden". As a result, for certain types of units we often have more accidents than near-misses, which is contrary to the "pyramid" of accidental events.

In Figure 6 the percentages for the overall categories of fixed and mobile units is presented. In half of the cases events were recorded in fixed units.

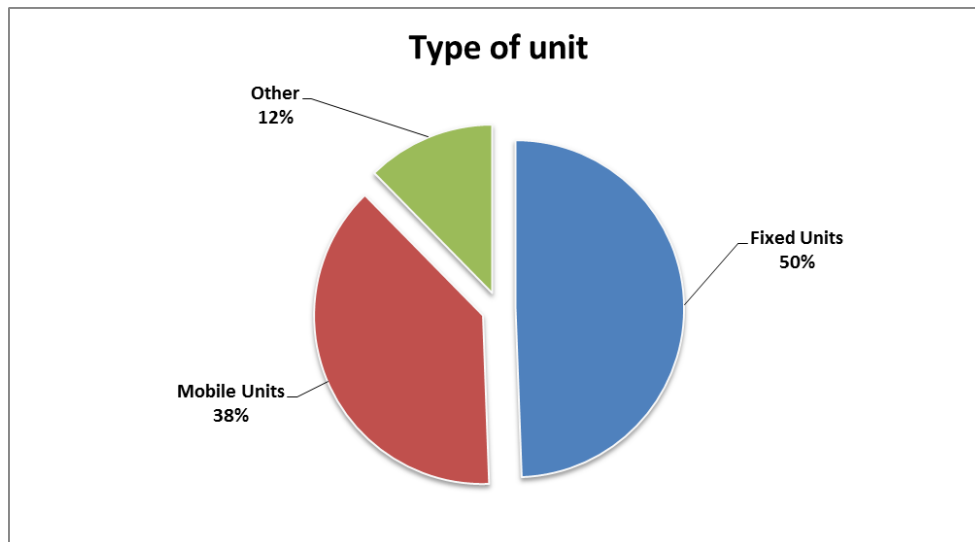


Figure 6. Distribution of accidents per type of unit for accidents in the WOAD database

Table 3. Number of accidental events for different Types of Unit				
Type Of Unit	Accidents	Incidents / Hazardous situation	Near miss	Insignificant
Barge (not drilling)	41	20	2	0
Concrete structure	81	419	74	136
Drill barge	65	22	0	2
Drill ship	91	65	3	4
Drilling tender	10	4	0	1
Flare	1	0	0	1
FPSO/FSU	10	68	8	23
Helicopter-Offshore duty	238	17	13	3
Jacket	716	889	127	252
Jackup	552	210	13	33
Lay barge	21	14	0	1
Loading buoy	13	19	2	5
Mobile unit(not drill.)	18	3	0	0
Other	0	2	0	1
Other/Unkn. fixed struct	3	3	0	1
Pipeline	139	111	1	4
Semi-submersible	277	626	147	119
Ship, not drilling or production	6	27	1	8
Submersible	19	5	0	1
Subsea install./complet.	4	6	0	2
Tension leg platform	13	132	22	29
Well support structure	122	36	2	2

Table 4. Accidental events in Chain in relation to the Function where they occurred								
Event in Chain	Construction	Drilling	Idle	Operating	Other	Production	Support	Transfer
Anchor/mooring failure	21	117	16	27	10	13	9	8
Blowout	0	228	1	86	1	43	0	0
Breakage or fatigue	32	141	7	98	23	379	9	70
Capsizing, overturn, toppling	12	44	3	18	8	156	1	43
Collision, not offshore units	17	28	14	2	26	142	1	21
Collision, offshore units	21	130	13	18	51	98	12	35
Crane accident	29	302	4	54	4	251	2	4
Explosion	11	49	0	16	13	98	1	4
Falling load / Dropped object	38	509	4	127	14	403	3	14
Fire	27	195	5	51	43	678	21	10
Grounding	11	18	4	4	5	1	1	40
Helicopter accident	1	14	1	2	1	38	2	0
Leakage into hull	11	17	4	3	8	6	4	31
List, uncontrolled inclination	10	37	2	32	6	9	1	20
Loss of buoyancy or sinking	20	36	0	18	120	27	0	45
Machinery/propulsion failure	1	9	2	0	4	0	3	14
Other	11	65	3	11	226	121	3	6
Out of position, adrift	16	87	15	16	10	4	3	103
Release of fluid or gas	11	240	7	107	22	1499	3	4
Towline failure/rupture	3	1	0	4	0	0	0	102
Well problem, no blowout	0	353	0	152	1	50	0	0

The accidental events are categorized according to two schemes: One reports the *Main event*, while the other reports all the *Events in Chain*. For example, a Blowout can lead to an explosion and then to a fire. In this case, all 3 events are coded as Events in Chain.

Table 4 presents the Events in Chain together with the Function where they occurred, i.e. construction, drilling, production, etc. It is interesting to note that accidents have occurred even in the “Idle” function. Concerning blowouts, it is noteworthy that their vast majority has happened during the drilling phase, with fewer accidents during operation and during production (228 vs. 86 vs. 43). Fatigue is also noted as an important contributor to accidents, manifesting itself especially during the production phase.

When considering causes of accidents the categories used in WOAD database include human – related and equipment – related causes. In the first category of human – related causes the following categories are used:

- 3rd party error
- Act of war/during warsit
- Sabotage
- Improper design
- Unsafe act / No procedutre
- Unsafe Procedure
- Other

In Figure 7 the distribution of events for the different human-related causes is presented. Causes that mostly contribute to events are related to procedures either as unsafe procedures (37% of events) or as absence of procedures which results in unsafe acts (44%). What should be noted here is that in a very large percentage of events (5323 events ~ 86% of the cases) no human – related causes were attributed. This does not mean that human-related causes were not present, but rather that a systematic analysis identifying underlying human/organizational failures was not performed.

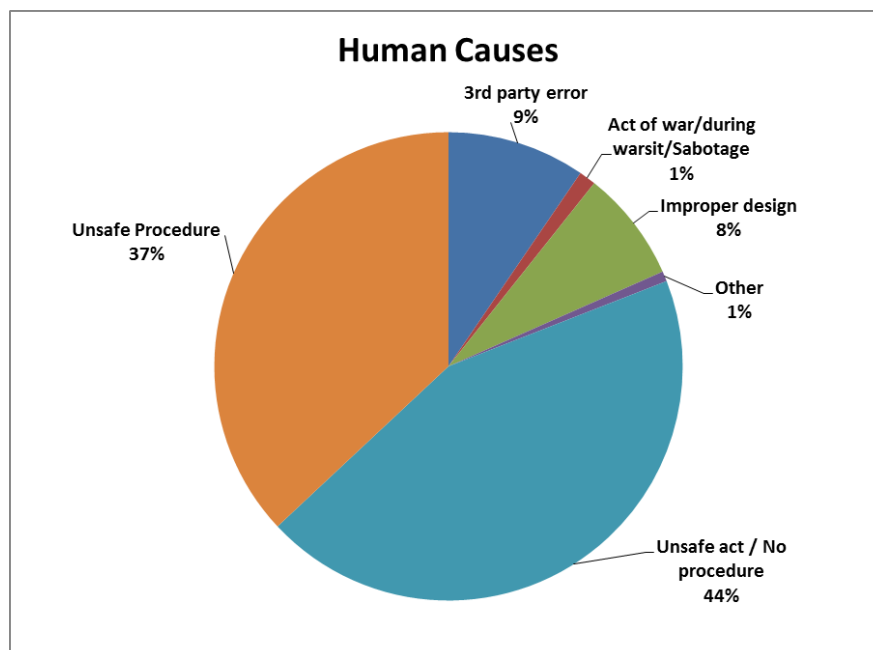


Figure 7. Distribution of accidents per type of human – related causes for accidents in the WOAD database

For equipment – related causes the following categories are used:

- 3rd party equipment failure
- Earthquake, volcanic eruption
- All equipment malfunction (electric and mechanical)
- Foundation and structural failure (including fatigue and corrosion)
- Ignition (all types of ignition included i.e. heat, open flame, cigarette/match, electrical, hand tools and sparks, lightning, weld, torch and unknown)
- Safety system malfunction
- Weather, general
- Other (including exceeding design criteria)

In Figure 8 the distribution of events per type of equipment – related causes is presented. In most of the cases equipment malfunction was the main attributed cause to the event (34%) followed by ignition (26%). Causes related to safety systems are rarely recorded (only 0,18%). The comment that was made previously for the human – related causes is valid also in this case. In almost 55% most of the cases (3355 events out of 6183) no equipment – related causes were attributed to the events.

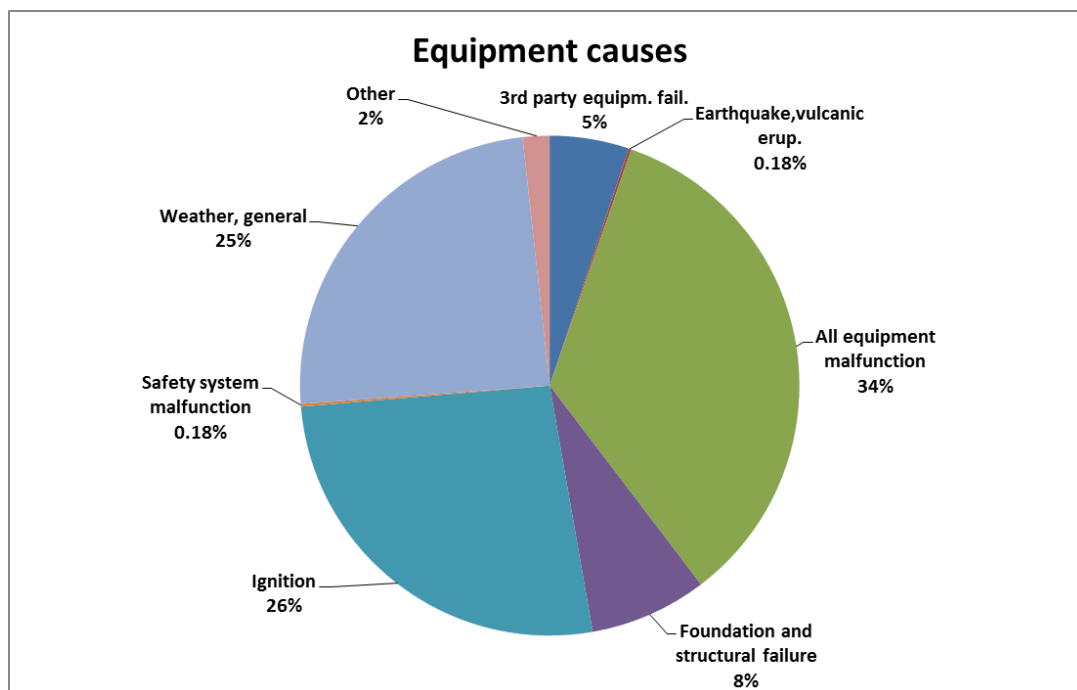


Figure 8. Distribution of accidents per type of equipment – related causes for accidents in the WOAD database

Table 5. Events in Chain for different Types of Unit			
Event in Chain	Fixed Units	Mobile Units	Other
Anchor/mooring failure	3	196	22
Blowout	159	196	4
Breakage or fatigue	233	326	200
Capsizing, overturn, toppling	164	107	14
Collision, not offshore units	111	76	64
Collision, offshore units	98	204	76
Crane accident	303	325	22
Explosion	120	58	14
Falling load / Dropped object	538	547	27
Fire	732	252	46
Grounding	0	67	17
Helicopter accident	37	18	4
Leakage into hull	7	68	9
List, uncontrolled inclination	12	101	4
Loss of buoyancy or sinking	37	97	132
Machinery/propulsion failure	0	27	6
Other	116	92	238
Out of position, adrift	1	221	32
Release of fluid or gas	1314	299	280
Towline failure/rupture	1	94	15
Well problem, no blowout	253	299	4

Table 5 gives the accidental events for Mobile and for Fixed Units. The dominant event, occurring most frequently is the release of fluid or gas, especially for fixed units, followed by fires and falling objects. For Mobile Units, the occupational incidents (falling objects, crane accidents) are dominant event, followed by fatigue and releases of liquids/gases.

Table 6. Number of accidental events for different Types of Unit

Spill Type	Small	Moderate	Significant	Large	Very Large
	1481	0	0	0	0
Chemicals	19	0	0	11	10
Crude oil & lube	154	0	1	54	70
Crude to formatn.	1	0	0	0	0
Gas;fuel gas,H2S	871	0	0	39	24
Light oil	191	1	0	61	64
No spill	2865	0	0	0	0
Oil and gas	165	0	0	24	30
Other	39	0	0	5	3

Table 6 gives the spills divided into different categories, i.e. small, moderate, significant, large and very large. It is worth noting that the spills reported are either small or large and very large, with the intermediate categories missing. This can be explained by the different accident types and failure modes. It's clear that there are lots of small incidents leading to small releases. However, it is interesting that the frequency of large spills is significant. In other words, the “tail” of the curve is not negligible. This is more clearly visible in Figure 9. This needs to be taken into consideration when estimating the probability of very severe accidents.

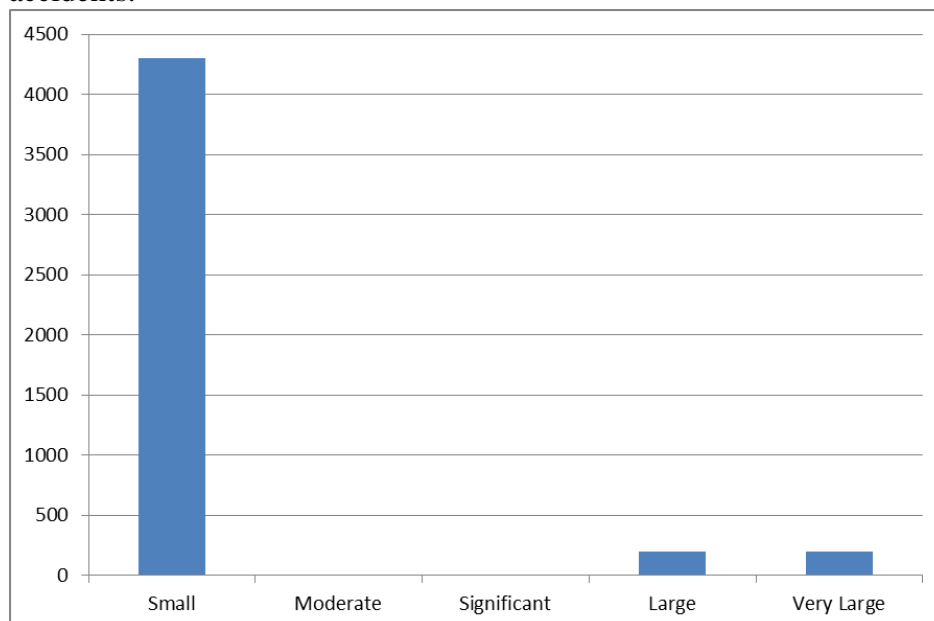


Figure 9. Size of spills for accidents in the WOAD database

Table 7. Extent of Damage in relation with the Main event					
Main Event	Insignif/no damage	Minor damage	Severe damage	Significant damage	Total loss
Anchor/mooring failure	37	45	0	37	0
Blowout	138	54	6	27	2
Breakage or fatigue	21	54	96	197	12
Capsizing, overturn, toppling	1	0	191	5	73
Collision, not offshore units	45	50	42	63	18
Collision, offshore units	61	136	26	111	15
Crane accident	67	20	0	5	0
Explosion	46	34	10	28	0
Falling load / Dropped object	876	69	14	74	1
Fire	592	132	86	100	41
Grounding	2	10	21	29	10
Helicopter accident	30	27	0	0	0
Leakage into hull	5	11	5	24	3
List, uncontrolled inclination	9	9	14	28	4
Loss of buoyancy or sinking	0	1	35	3	68
Machinery/propulsion failure	13	9	0	1	0
Other	192	36	41	13	81
Out of position, adrift	32	15	2	5	0
Release of fluid or gas	1047	132	125	40	1
Towline failure/rupture	53	1	3	2	0
Well problem, no blowout	211	14	0	8	0

Table 7 presents the extent of damage caused by the different Main events. Especially for blowouts, it is worth noting a rather “smooth” distribution: 138 blowouts had insignificant or no damage, 54 had minor damage, 27 medium, 6 blowouts led to severe damage, while 2 blowouts caused the total loss of the installation.

Table 8. Extent of Damage in relation with the Event in Chain					
Event in Chain	Insignif/no damage	Minor damage	Severe damage	Significant damage	Total loss
Anchor/mooring failure	55	67	15	79	5
Blowout	142	68	55	46	48
Breakage or fatigue	29	67	362	242	59
Capsizing, overturn, toppling	1	0	201	5	78
Collision, not offshore units	49	54	56	70	22
Collision, offshore units	62	136	34	118	28
Crane accident	502	77	9	62	0
Explosion	53	42	34	48	15
Falling load / Dropped object	907	82	29	85	9
Fire	616	149	97	112	56
Grounding	2	11	27	32	12
Helicopter accident	31	27	0	0	1
Leakage into hull	6	13	16	34	15
List, uncontrolled inclination	9	11	36	38	23
Loss of buoyancy or sinking	5	2	75	11	173
Machinery/propulsion failure	13	10	0	3	7
Other	213	41	49	20	123
Out of position, adrift	88	44	35	66	21
Release of fluid or gas	1285	239	208	139	22
Towline failure/rupture	65	6	12	13	14
Well problem, no blowout	360	71	41	47	37

Table 8 reports again the extent of damage, this time in relation with the Events in Chain. It is noteworthy that when blowouts are considered not as the Main event but as an Event in Chain – i.e. leading to fires or explosions or other events – a different shape of the distribution of the damage is observed. In more detail, the number of blowouts having insignificant or no damage increases now to 142, i.e. there are 138 blowouts as main events and 4 additional blowouts leading to other accidental events, which are reported as Main events and all have insignificant damage. These numbers are 68 blowouts leading to minor

damage, 46 leading to significant damage, and **55 and 48 blowouts leading to events that have caused severe damage and total loss, respectively**. This shows a rather persisting tail of the distribution as it is shown in Figure 10. In comparison with the data of Table 7, only 6 and 2 blowouts considered as Main event were leading to severe damage and total loss, respectively. This means that there have been reported 49 blowouts not considered as main events but which have led to other events finally causing severe damage. Similarly, 46 blowouts not considered as main events but which have led to other events finally causing total loss. This number is a significant percentage of the 359 blowouts, which have been reported as Events in Chain. It practically means that almost 30% of blowouts are not the main event, but lead to other events, which can then cause very high consequences, namely severe damage or total loss. Without doubt the uncertainty in the estimation of frequency of these low frequency – high consequences events is very high and needs to be taken into consideration in the relevant frequency calculations.

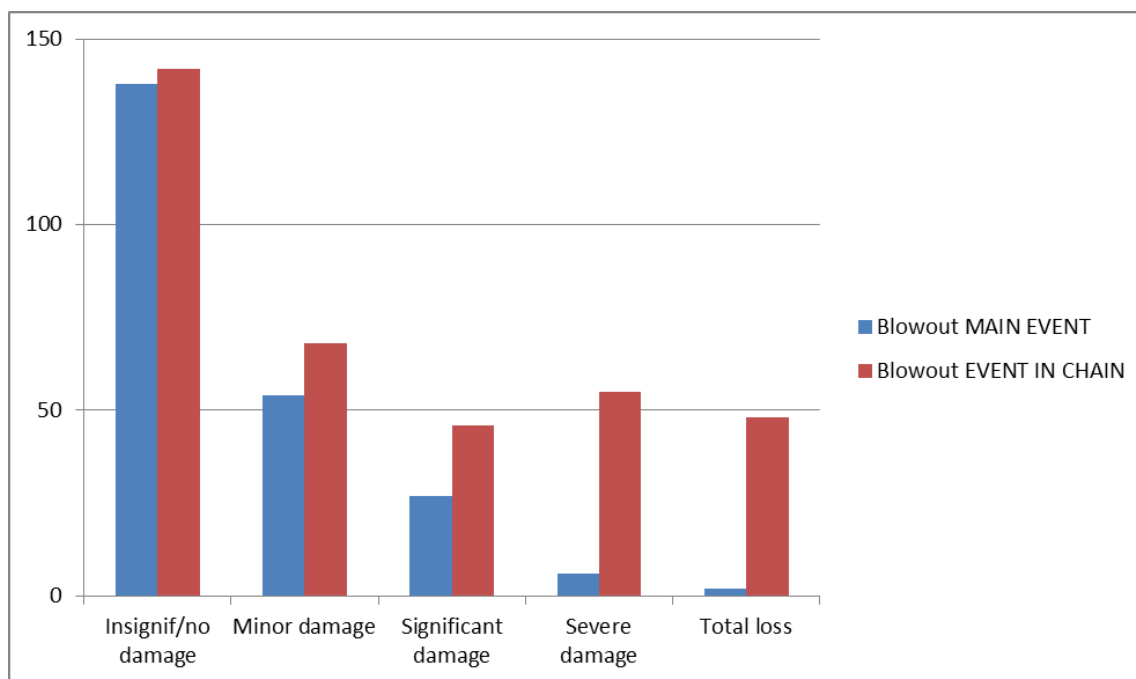


Figure 10. Extent of damage in relation to blowouts as “Main events” or “Event in Chain” for accidents in the WOAD database

Overall the accident analysis has shown the relevance of major accident hazards in the offshore oil and gas activities. Accidents do happen, and risks are present and need to be controlled. The events that require particular attention in this context, mainly fires, explosions and blowouts, have been reported to cause severe consequences. Particular attention needs to be given to low frequency – high consequences events, in other words the “tail” of the curve, whose frequency appears not to be negligible and uncertainty related to this estimation is very high. The spills of chemicals, crude oil and H₂S need also to be monitored.

6. Remarks and recommendations

The present analysis had three objectives:

- i. A preliminary survey on existing sources of information on past accidents and incidents and their availability to operators, authorities and the public;
- ii. Analysis of some “landmark” accidents and review of lessons learned, with focus to the exact lessons for each phase of the accident management cycle; and
- iii. Analysis of accidents collected in the WOAD database.

The survey on existing sources of information revealed a “mosaic” of information, which does not allow the analyst to form a clear picture. Accidents and incidents – especially occupational safety events - are being reported to national authorities according to national legislation. No common format is followed and even the definition of what constitutes a “reportable accident” varies amongst the Member States. Some Member States consider 1 or more days of absence from work following an incident as a reportable event, whereas others require the absence for at least 3 subsequent days as the necessary condition. Accessibility of information to the public is also rather weak. Most authorities and industrial associations prepare overall statistical information in their annual reports. However, the descriptions of accidents, with maybe very few exceptions, seem not to be available to the public. This does not help transparency and trust to be built between all involved stakeholders – mainly between the industry on one side and NGOs and the public on the other. Moreover, denial of accessibility to researchers, consultants and the academia, prevents from more sophisticated analyses to be performed and from lessons to be learned. It is from the public scrutiny of non-confidential information that lessons can be identified and learned.

The need for a common reporting format, allowing proper pooling and exchange of non-confidential information is of paramount importance for safer operations. This is an area, where coordination work is needed. Attempts have been made in the past to create a common format. Therefore it is important not to re-invent the wheel, but rather to take into consideration the work already done, complement with what is needed and start implementing it. The Commission (ENER and JRC) needs to collaborate closely with the industry and the authorities in order to make the necessary arrangements to provide a reliable data system, facilitating the development of a corporate memory of the sector.

“Landmark” accidents have a distinguished role in the lessons learning process. All stakeholders recognise them and are aware of their severe consequences (which is the reason for characterizing them “landmark”). It is necessary, however, to go beyond the impressive numbers, identify the underlying causes and present the lessons in a systematic and easy way for each stakeholder (operator or authority) to learn. It is important to present what each lesson means in the risk management chain.

The statistical analysis revealed important findings too. It proved that the Macondo accident was not “one of a kind” – at least to what concerns the failures, the causes and the chain of events. Other similar – or broadly similar – incidents have occurred. It is of course the magnitude of consequences what made the Macondo accident distinguishable. However, similar events are not extremely rare.

A very worrying finding is that related with some “tails” of the distribution functions. The analysis indicated that the “tails” of frequency distribution for some events – mainly blow-outs – are not smoothly decreasing for high severity. This requires a further investigation of the blowout events, which may not be considered as “low frequency – high consequences” events anymore. This needs to be taken into consideration in the estimation of overall risk and in the risk-based decision-making procedure. Indeed, the whole risk management process and the ALARP (As Low As Reasonably Practicable) principle is based on a pre-condition of a smooth tail of the distribution. The principle presupposes that most risks can be controlled, while only a small percentage of “remaining risk” needs to be tolerated – and this should be managed in a cost-efficient way. If the tail of the distribution is not reduced smoothly, this means that significant amount of risk remains uncontrolled. Given the high severity of blowout events, this finding needs to be further investigated.

In summary, the following recommendations can be made:

- There is a clear need for data pooling and exchange of information on past accidents.
- A common reporting format has to be developed and put in place without delay. JRC can have an important role in this development, taking advantage of its role as ultranational and independent character and collaborating with all stakeholders (industry, authorities, trade unions, academia)
- “Landmark” and other important accidents need to be investigated and lessons to be identified, classified and shared. Highlighting the importance of the lessons in the risk management chain can also facilitate their dissemination and use.
- Offshore accidents are not extremely rare events. In particular, blowouts with severe consequences may not be as rare as initially thought. Further investigation of these events is necessary.

References

- European Council, Directive 92/91/EEC concerning the minimum requirements for improving the safety and health protection of workers in the mineral-extracting industries through drilling, 1992.
- HSE, Accident statistics for fixed offshore units on the UK Continental Shelf 1980-2005, Prepared by Det Norske Veritas for the Health and Safety Executive, 2007.
- HSE, Accident statistics for floating offshore units on the UK Continental Shelf 1980-2005, Prepared by Det Norske Veritas for the Health and Safety Executive, 2007
- HSE, Ship/platform collision incident database 2001, Prepared by Serco Assurance for the Health and Safety Executive, 2003
- National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, "Report to the President", January 2011
- Norwegian Petroleum Directorate, Annual Report Offshore, Norway, 1999
- RIDDOR - Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, UK 1995
- Vinnem, Jan Erik (2007). Offshore Risk Assessment - Principles, Modelling and Applications of QRA Studies (2nd Edition).. Springer – Verlag, 2007.

Links to offshore accident databases

Danish Energy Agency:

http://www.ens.dk/en-US/OilAndGas/Health_and_Safety/Work_Related_injuries%20etc/Sider/Forside.aspx

HSE Hydrocarbon releases database:

<https://www.hse.gov.uk/hcr3/index.asp>

Major Accident Investigation Branch:

http://www.maib.gov.uk/report_an_accident/index.cfm

OGP – Wells Committee:

(<http://www.ogp.org.uk/committees/wells>)

Petroleum Safety Authority – Norway:

<http://www.ptil.no/investigations/category157.html>

SINTEF – Blowout Database

<http://www.sintef.no/home/Technology-and-Society/Safety-Research/Projects/SINTEF-Offshore-Blowout-Database>

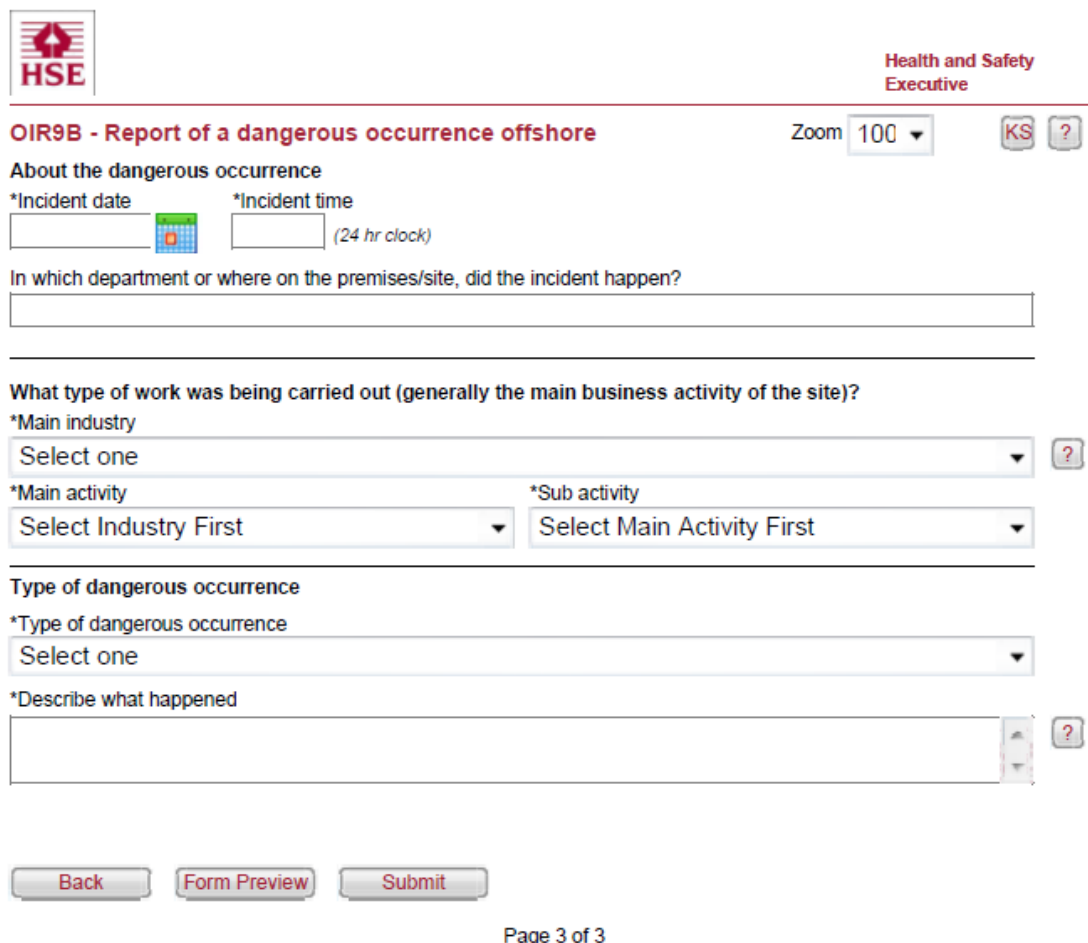
WOAD: World Offshore Accident Databank, DNV

<http://www.dnv.com/services/software/products/safeti/safetiqlra/woad.asp>

ANNEX I

Accident reporting forms from EU Regulatory Authorities

1 UK – Health and Safety Executive




The screenshot displays the HSE OIR9B form for reporting a dangerous occurrence offshore. The form is titled "OIR9B - Report of a dangerous occurrence offshore" and is part of the Health and Safety Executive's reporting system. It includes a zoom control set to 100, a keyboard shortcut "KS", and a help icon. The form is divided into several sections: "About the dangerous occurrence" with fields for incident date and time; "In which department or where on the premises/site, did the incident happen?" with a text input field; "What type of work was being carried out (generally the main business activity of the site)?" with dropdown menus for main industry, main activity, and sub activity; "Type of dangerous occurrence" with a dropdown menu for the type of occurrence and a text input field for a description. At the bottom, there are buttons for "Back", "Form Preview", and "Submit".

HSE

Health and Safety Executive

OIR9B - Report of a dangerous occurrence offshore Zoom 100 KS ?

About the dangerous occurrence

*Incident date  *Incident time (24 hr clock)

In which department or where on the premises/site, did the incident happen?

What type of work was being carried out (generally the main business activity of the site)?

*Main industry
Select one

*Main activity
Select Industry First

*Sub activity
Select Main Activity First

Type of dangerous occurrence

*Type of dangerous occurrence
Select one

*Describe what happened

Back Form Preview Submit

Page 3 of 3

Figure A.1 Extract from HSE Accident Reporting Form OIR9B – Report of a dangerous occurrence offshore.



OIR9B - Report of an injury offshore

Zoom 100

KS



About the injured person's injuries

*Injured person's injuries

*Part of the body affected

*Please check as many as apply:

- ☐ The injured person became unconscious
- ☐ The injured person needed to be resuscitated
- ☐ The injured person remained in hospital for more than 24 hours
- ☐ None of the above

*What was the severity of the injury?

- ☐ Fatality
- ☐ Major injury
- ☐ Injury preventing the injured person from working for more than 7 days
- ☐ Member of the public - taken directly to hospital

* Please refer to the help for guidance on severity of injury.

Back

Form Preview

Submit

Page 5 of 5

*Main factor involved in the incident

*Main factor involved in the incident

*Describe what happened



Back

Next

Form Preview

Page 3 of 5



[Click here for guidance](#)

RESET



Incident Serial No.
(HSE use only)

HYDROCARBON RELEASE REPORT SUPPLEMENTARY INFORMATION

This form should be used to impart supplementary information on Hydrocarbon Releases which are reported on OIR/9B forms under RIDDOR 95, Dangerous Occurrences 13, 14, 73, or 74 per ON 30 (revised) available at http://www.hse.gov.uk/offshore/notes/on_30.htm

OFFSHORE INSTALLATION DETAILS:

NAME (or other designation)

Registration No.

(for HSE use only)

DATE:

TIME:

(of incident)

(of incident) (24 hours)

Location at time of Incident:

Quadrant

Block

Latitude

Longitude

Water Depth

metres

GUIDANCE NOTES :

This form should be completed as soon as possible, but in any case within 4 weeks following the incident. Guidance on how to complete the form is contained on page 6 at the back of the form, and detailed guidance on reporting of Hydrocarbon Releases is given in booklet ref. OTO96956 available at <http://www.hse.gov.uk/research/otopdf/1996/oto96956.pdf>

Next Page

Please return completed form to:

Health and Safety Executive
Offshore Division
HCR Admin (OSD3.1)
5N.2 Redgrave Court
Merton Road
Bootle
L20 7HS

For official use only

OIR / 9B REF:

CHECKED:

DATE:

INPUT:

DATE:

INPUT
AUDIT:

DATE:

TECH
AUDIT:

DATE:

1. HYDROCARBON (HC) RELEASED: *(Tick appropriate box)*

NON PROCESS ☐ (Specify)

PROCESS: OIL ☐ CONDENSATE ☐ GAS ☐ 2-PHASE ☐

FOR GAS, DENSITY FOR LIQUIDS, GRAVITY

IF 2-PHASE, STATE GOR: (*) = Specify GOR units, e.g. scf / bbl

FOR GAS or 2-PHASE, STATE LEVEL OF H2S: p.p.m.

2. ESTIMATED QUANTITY RELEASED:

(*)

(*) = Specify units e.g. Tonnes, Kgs, m³

3. DURATION OF LEAK:

(MINS)

(Estimated time from discovery, e.g. alarm, to termination of leak)

4. LOCATION OF LEAK: *(Please complete checklist on Page 4)*

5. HAZARDOUS AREA CLASSIFICATION: *(i.e. zone at location of incident)*

(Tick appropriate box) 1 ☐ 2 ☐ UNCLASSIFIED ☐

6. EQUIVALENT HOLE DIAMETER:

(*)

(*) = Specify units e.g. inches or mm.

7. MODULE VENTILATION?

NATURAL ☐ FORCED ☐

HOW MANY SIDES ENCLOSED?

(Insert the number of walls, including floor and ceiling)

MODULE VOLUME m³

ESTIMATED No. OF AIR CHANGES (if known)

(*)

(*) = Specify hourly or daily rate

8. WEATHER CONDITIONS:

WIND: SPEED DIRECTION (*)

(*) = Specify units, e.g. mph, m/s, ft/s

(*) = Specify heading in degrees

OTHER CONDITIONS: (Describe)

9. SYSTEM PRESSURE:

MAXIMUM ALLOWABLE OPERATING ACTUAL (*)

(*) = Specify units e.g. bara, psig or other

(i.e. at time of release)

10. TOTAL HC INVENTORY IN SYSTEM

(*)

(i.e. isolatable between ESD valves)

(*) = Specify units e.g. Tonnes, Kgs, m³

11. MEANS OF DETECTION: *(Please tick type of detector or specify as appropriate)*

HEAT ☐ SMOKE ☐ FLAME ☐ GAS ☐ OTHER ☐ (specify)

12. EXTENT OF DISPERSION? *(Please describe)*

13. CAUSE OF LEAK? *(Please complete checklist on page 5)*

14. DID IGNITION OCCUR? *(Please tick appropriate box)* Yes ☐ No ☐

If Yes, was it: IMMEDIATE ☐ DELAYED ☐ DELAY TIME (secs)

Was there: (add sequence of events by numbering appropriate boxes in order of occurrence)

A FLASH FIRE ☐ AN EXPLOSION ☐
A JET FIRE ☐ A POOL FIRE ☐

15. IGNITION SOURCE *(IF KNOWN) (please describe)*

16. WHAT EMERGENCY ACTION WAS TAKEN? *(tick appropriate box(es))*

SHUTDOWN	<input type="checkbox"/>	AUTOMATIC	<input type="checkbox"/>	MANUAL	<input type="checkbox"/>
BLOWDOWN	<input type="checkbox"/>	AUTOMATIC	<input type="checkbox"/>	MANUAL	<input type="checkbox"/>
DELUGE	<input type="checkbox"/>	AUTOMATIC	<input type="checkbox"/>	MANUAL	<input type="checkbox"/>
CO2 / HALON	<input type="checkbox"/>	AUTOMATIC	<input type="checkbox"/>	MANUAL	<input type="checkbox"/>
CALL TO MUSTER	<input type="checkbox"/>	AT STATIONS	<input type="checkbox"/>	AT LIFEBOATS	<input type="checkbox"/>
OTHER	<input type="checkbox"/>	(specify)	<input type="text"/>		

17. ANY ADDITIONAL COMMENTS:

CONTACT *(In case of queries) (block capitals, please)*

NAME: POSITION:
SIGNATURE: DATE:

LOCATION CHECK LIST (SEE 'LOCATION OF LEAK' ITEM 4. ON PAGE 2)

(Please indicate those items which come nearest to pinpointing the location of the leak)

(a) MODULE/AREA NAME:

(Please state the name in common use on the installation, inc. subsea if appropriate)

(b) SYSTEM: (please tick one box per category and also tick equipment details as appropriate)

<input type="checkbox"/> DRILLING:	Well Control <input type="checkbox"/>	Exploration <input type="checkbox"/>	Appraisal <input type="checkbox"/>	Development <input type="checkbox"/>	Completion <input type="checkbox"/>
<input type="checkbox"/> WELL:	Oil production <input type="checkbox"/>	Gas Production <input type="checkbox"/>	Gas Injection <input type="checkbox"/>	Surface <input type="checkbox"/>	Subsea <input type="checkbox"/>
<input type="checkbox"/> FLOWLINES:	Oil <input type="checkbox"/>	Gas <input type="checkbox"/>	Other <input type="checkbox"/>	(specify) <input type="text"/>	
<input type="checkbox"/> MANIFOLD:	Oil <input type="checkbox"/>	Gas <input type="checkbox"/>	Other <input type="checkbox"/>	(specify) <input type="text"/>	
<input type="checkbox"/> SEPARATION:	Oil <input type="checkbox"/>	Gas <input type="checkbox"/>	Test <input type="checkbox"/>	Production <input type="checkbox"/>	Train No <input type="text"/> of <input type="text"/> Stage <input type="text"/>
<input type="checkbox"/> PROCESSING:	Oil <input type="checkbox"/>	Gas <input type="checkbox"/>	(Specify system) <input type="text"/>		
<input type="checkbox"/> UTILITIES:	Oil <input type="checkbox"/>	Gas <input type="checkbox"/>	(Specify system) <input type="text"/>		
<input type="checkbox"/> GAS COMPRESSION:					
<input type="checkbox"/> METERING:	Oil <input type="checkbox"/>	Gas <input type="checkbox"/>	Condensate <input type="checkbox"/>		
<input type="checkbox"/> EXPORT/IMPORT	Oil <input type="checkbox"/>	Gas <input type="checkbox"/>	Condensate <input type="checkbox"/>		
<input type="checkbox"/> DRAINS:	Open <input type="checkbox"/>	Closed <input type="checkbox"/>			
<input type="checkbox"/> VENT/FLARE:	HP <input type="checkbox"/>	LP <input type="checkbox"/>			
<input type="checkbox"/> BLOW-DOWN:					

(c) EQUIPMENT: (Please tick one box per category and also tick equipment details as appropriate)

<input type="checkbox"/> BOP	Wellhead <input type="checkbox"/>	Xmas Tree <input type="checkbox"/>	Surface <input type="checkbox"/>	Subsea <input type="checkbox"/>	Rating: <input type="text"/>
<input type="checkbox"/> COMPRESSOR	Centrif <input type="checkbox"/>	Recip <input type="checkbox"/>			
<input type="checkbox"/> FILTER	Drain Opening <input type="checkbox"/>	Plug <input type="checkbox"/>			
<input type="checkbox"/> EXPANDER	Recompressor <input type="checkbox"/>				
<input type="checkbox"/> FIN FAN COOLER					
<input type="checkbox"/> FLANGE:	Type <input type="text"/>	Rating <input type="text"/>	Size <input type="text"/>	(*)	
(*) Specify e.g. RTJ, RF, ANSI 900#, API nom, bore ins/mm, etc.					
<input type="checkbox"/> HEAT EXCHANGER:	HC in Shell <input type="checkbox"/>	Tube <input type="checkbox"/>	Plate <input type="checkbox"/>		
<input type="checkbox"/> INSTRUMENT (incl. piping, valves and tappings)					
<input type="checkbox"/> MUD	Shale <input type="checkbox"/>	Drilling <input type="checkbox"/>	(please specify) <input type="text"/>		
<input type="checkbox"/> PIG LAUNCHER/ RECIEVER:	Horiz/Vert, Length/Dia <input type="text"/>	(ins/mm)			
<input type="checkbox"/> PIPELINE	Riser <input type="checkbox"/>	Material <input type="text"/>	Rating <input type="text"/>	Size <input type="text"/>	(*)
<input type="checkbox"/> PIPING:	Material <input type="text"/>	Rating <input type="text"/>	Size <input type="text"/>	(*)	
(*) Specify e.g. API 5LX52, pressure in psig/barg, nom. bore in ins/mm, etc.					
<input type="checkbox"/> PRESSURE VESSEL:	Horiz/Vert Type <input type="text"/>	Length/Dia <input type="text"/>	(ins/mm)		
(*) Specify e.g. separator, contactor, length tan to tan and diameter in ins/mm					
<input type="checkbox"/> PUMP:	Centrif <input type="checkbox"/>	Recip <input type="checkbox"/>	Single <input type="checkbox"/>	Double Seal <input type="checkbox"/>	
<input type="checkbox"/> STORAGE TANK:	Capacity <input type="text"/>	(Specify units e.g. bbls, gall. m ³)			
<input type="checkbox"/> TURBINE:	Gas <input type="checkbox"/>	Dual Fuel <input type="checkbox"/>			
<input type="checkbox"/> VALVE:	Manual/Actuated Function <input type="text"/>	Type <input type="text"/>	Size <input type="text"/>	(*)	
(*) Specify e.g. Relief, ESDV, PCV, gate, ball, globe, diameter in ins/mm, etc.					

[Next Page](#)

CAUSE OF LEAK CHECK LIST (SEE "CAUSE OF LEAK". ITEM 13. ON PAGE 3)

(Please indicate those items which come nearest to identifying the cause of the leak)
(Choose one parameter from each of the following categories, and tick appropriate boxes)

(a) DESIGN:

- ☐ FAILURE RELATED TO DESIGN
☐ NO DESIGN FAILURE

(b) EQUIPMENT:

- ☐ CORROSION: INTERNAL ☐ EXTERNAL ☐
☐ MECHANICAL FAILURE FATIGUE ☐ WEAROUT ☐
☐ EROSION
☐ MATERIAL DEFECTS
☐ OTHER (Specify)
☐ NO FAILURE IN THE EQUIPMENT ITSELF

(c) OPERATION:

- ☐ INCORRECTLY FITTED
☐ IMPROPER MAINTENANCE INSPECTION ☐ TESTING ☐ OPERATION ☐
☐ DROPPED OBJECT OTHER IMPACT ☐
☐ LEFT OPEN
☐ OPENED WHEN CONTAINING HC
☐ OTHER (Specify)
☐ NO OPERATIONAL FAILURE

(d) PROCEDURAL:

- ☐ NON - COMPLIANCE WITH PROCEDURE PERMIT TO WORK ☐
☐ DEFICIENT PROCEDURE
☐ OTHER (Specify)
☐ NO PROCEDURAL FAILURE

(e) OPERATIONAL MODE IN AREA AT TIME OF RELEASE:

- ☐ DRILLING WELL OPERATION ☐ WITH TREE ☐ TREE ☐ OIL ☐ GAS ☐
(please specify actual operation e.g. wireline, well test etc.)
☐ NORMAL PRODUCTION
☐ PIGGING
☐ SHUTTING DOWN SHUTDOWN ☐ BLOW - DOWN ☐
☐ FLUSHING CLEANING ☐ INSPECTION ☐
☐ MAINTENANCE: HOT WORK ☐ OTHER (Specify)
☐ CONSTRUCTION: HOT WORK ☐ OTHER (Specify)
☐ TESTING SAMPLING ☐
☐ REINSTATEMENT START - UP ☐

Continue

Figure A.3 HSE Accident Reporting Form OIR12 Hydrocarbon Release

2 UK – Marine Accident Investigation Branch

Section A				
Date of accident (dd/mm/yyyy):*		Time of accident:*		
		UTC		
		Local time		
Name of vessel:*				
Port of registry:*		Flag of vessel:*		
Type of vessel (e.g. tanker/bulk carrier/cruise/ferry/fishing vessel etc):*				
Type of accident:*				
Location of accident (e.g. name of port, berth, or other geographic reference including lat/long):*				
In which Traffic Separation Scheme did the accident take place? (if applicable) *				
Did the accident occur within the operational limits of a port?				
Natural light:	Visibility:	Sea state:	Wind force:	Wind direction:
<p>Consequences of accident (tick as many boxes as apply):</p> <p> <input type="checkbox"/> Fatal injury <input type="checkbox"/> Non-fatal injury <input type="checkbox"/> Vessel damaged <input type="checkbox"/> Vessel lost or abandoned <input type="checkbox"/> No injury or damage </p> <p> <input type="checkbox"/> Pollution – if ticked please state quantity: * Pollution type: * </p>				

Figure A.4 Extract from MAIB Accident reporting form

3 Norway – Petroleum Safety Authority


 PETROLEUM SAFETY AUTHORITY NORWAY				Confirmation of alert/notification to Petroleum Safety Authority Norway about situation of hazard and accident																																			
				E-mail: varsling@ptil.no																																			
The incident occurred: Date: Time:		Operator/responsible: Field: Installation/onshore facility:		Reporting person: Name: Telephone: E-mail:																																			
Confirmation of alert according to Management Regulation, <input type="checkbox"/> Sct. 29, 1st paragraph situations that have led to: <input type="checkbox"/> Sct. 29, 1st paragraph situations that under slightly altered circumstances could have led to:		<input type="checkbox"/> a) death <input type="checkbox"/> b) serious and acute injury <input type="checkbox"/> c) acute life-threatening illness <input type="checkbox"/> d) serious impairment or discontinuance of safety functions or other barriers, so that the integrity of the offshore or onshore facility is threatened <input type="checkbox"/> e) acute pollution																																					
Notification according to Management Regulation, <input type="checkbox"/> Sct. 29, 3st paragraph situations as mentioned in the first subsection, litera b through e, but of a less serious or less acute nature		<input type="checkbox"/> b) serious and acute injury <input type="checkbox"/> c) acute life-threatening illness <input type="checkbox"/> d) serious impairment or discontinuance of safety functions or other barriers, so that the integrity of the offshore or onshore facility is threatened <input type="checkbox"/> e) acute pollution																																					
Description of incident/near-miss:																																							
Supplementary information: <table border="0"> <tr> <td><input type="checkbox"/> HC emission</td> <td><input type="checkbox"/> Man over bord</td> <td><input type="checkbox"/> Lifting</td> <td><input type="checkbox"/> Evacuation/unmanning</td> </tr> <tr> <td><input type="checkbox"/> Explosion</td> <td><input type="checkbox"/> Injury</td> <td><input type="checkbox"/> Diving</td> <td><input type="checkbox"/> Cessation of hazardous work</td> </tr> <tr> <td><input type="checkbox"/> Well/Blow out</td> <td><input type="checkbox"/> Illness</td> <td><input type="checkbox"/> Terror / threat / crime</td> <td><input type="checkbox"/> Transportation</td> </tr> <tr> <td><input type="checkbox"/> Fire</td> <td><input type="checkbox"/> Power failure</td> <td><input type="checkbox"/> Anchor chain / DP</td> <td><input type="checkbox"/> Electr. accident with injury</td> </tr> <tr> <td><input type="checkbox"/> Collision</td> <td><input type="checkbox"/> H₂S emission</td> <td></td> <td><input type="checkbox"/> Other</td> </tr> <tr> <td><input type="checkbox"/> Structural damage</td> <td><input type="checkbox"/> Radioactiv source</td> <td></td> <td></td> </tr> <tr> <td><input type="checkbox"/> Subsea leakage</td> <td><input type="checkbox"/> Falling object</td> <td></td> <td></td> </tr> <tr> <td><input type="checkbox"/> Helicopter</td> <td><input type="checkbox"/> Pollution</td> <td></td> <td></td> </tr> </table>								<input type="checkbox"/> HC emission	<input type="checkbox"/> Man over bord	<input type="checkbox"/> Lifting	<input type="checkbox"/> Evacuation/unmanning	<input type="checkbox"/> Explosion	<input type="checkbox"/> Injury	<input type="checkbox"/> Diving	<input type="checkbox"/> Cessation of hazardous work	<input type="checkbox"/> Well/Blow out	<input type="checkbox"/> Illness	<input type="checkbox"/> Terror / threat / crime	<input type="checkbox"/> Transportation	<input type="checkbox"/> Fire	<input type="checkbox"/> Power failure	<input type="checkbox"/> Anchor chain / DP	<input type="checkbox"/> Electr. accident with injury	<input type="checkbox"/> Collision	<input type="checkbox"/> H ₂ S emission		<input type="checkbox"/> Other	<input type="checkbox"/> Structural damage	<input type="checkbox"/> Radioactiv source			<input type="checkbox"/> Subsea leakage	<input type="checkbox"/> Falling object			<input type="checkbox"/> Helicopter	<input type="checkbox"/> Pollution		
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Number of injured or fatalities:				Other measures taken:																																			
Other institutions notified: <table border="0"> <tr> <td><input type="checkbox"/> Joint Rescue Coordination Centres</td> <td><input type="checkbox"/> Coastal Administration</td> <td><input type="checkbox"/> Radiation Protection Authority</td> <td><input type="checkbox"/> Civil Aviation Authority</td> </tr> <tr> <td><input type="checkbox"/> Police</td> <td><input type="checkbox"/> Fire brigade</td> <td><input type="checkbox"/> Maritime Directorate</td> <td><input type="checkbox"/> Others</td> </tr> </table>								<input type="checkbox"/> Joint Rescue Coordination Centres	<input type="checkbox"/> Coastal Administration	<input type="checkbox"/> Radiation Protection Authority	<input type="checkbox"/> Civil Aviation Authority	<input type="checkbox"/> Police	<input type="checkbox"/> Fire brigade	<input type="checkbox"/> Maritime Directorate	<input type="checkbox"/> Others																								
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Figure A.5 Petroleum Safety Authority Accident Reporting form

4. Denmark – Danish Energy Authority



DEA serial number

Report of an Accident Offshore

1. Injured person

Name		Civil registry number (CPR no.)	
Address	Postal code	City	
Job title at the date of the accident		Country	
First date of employment	Income in the year before the accident		

2. The injured person's employer at the date of the accident

Name of enterprise		CVR no./P no.	
Address	Postal code	City	Telephone no.
Name of offshore installation or vessel where the accident occurred			
Employer's insurance company (to be filled in when the employer reports the accident)		Policy no.	

3. Time/Place of accident

Year	Month	Day	Hour	Minute	Where precisely on the offshore installation did the accident occur?
Shift commenced at			Offshore experience/seniority		Commencement date of offshore period

4. Sequence of events

Which work was the injured person carrying out?	Which tool, machine or equipment was the injured person using?
Sequence of events (supplementary sheets may be attached)	

5. How did the accident occur (type of accident)?

<input type="checkbox"/> Contact with electricity <input type="checkbox"/> Striking against a stationary object <input type="checkbox"/> Struck by moving object <input type="checkbox"/> Excess strain on the whole body/body parts <input type="checkbox"/> Contact with sharp, pointed or abrasive object <input type="checkbox"/> Drowning or exposed to other lack of oxygen	<input type="checkbox"/> Fire and explosion <input type="checkbox"/> Falling or tripping <input type="checkbox"/> Contact with chemicals <input type="checkbox"/> Exposure to radiation <input type="checkbox"/> Excess pressure, decompression <input type="checkbox"/> Caught or crushed	<input type="checkbox"/> Other, state cause:
--	---	--

Form E. 02 (3rd edition)

6. Internal investigation of the accident

Did the accident give rise to any immediate measures to prevent similar accidents? If yes, which?

(Supplementary sheets may be attached)

7. Information about the injury

Nature of the injury (tick one box only)

- ☐ Laceration and superficial wounds
☐ Fractures
☐ Luxation, sprain or strain
☐ Concussion or internal injuries
☐ Burn, scald or frostbite
☐ Poisoning or infection
☐ Drowning or other form of asphyxiation
☐ Injuries due to noise, vibrations or pressure
☐ Injuries due to high temperatures, radiation or light
☐ Shock
☐ Acid burn
☐ Loss of one or more body parts (traumatic amputation)
☐ Hypothermia (low body temperature)
☐ Other (describe below)

Injured body part (tick one box only)

- ☐ Head
☐ Neck, including cervical vertebrae
☐ Back, including thoracic/lumbar vertebrae
☐ Trunk and internal organs
☐ Upper body limbs
☐ Lower body limbs
☐ The whole body or several body parts
☐ Other injury, describe below:

Detailed description of injury:

8. Consequences of the injury

For how long is the injured person expected to be unfit for work?

- ☐ Unfit for work for less than 1 day
☐ Unfit for work for 1-3 days
☐ Unfit for work for 4-14 days
☐ Unfit for work for 14 days-5 weeks

- ☐ Unfit for work for 5 weeks-6 months
☐ Unfit for work for 6 months or permanently
☐ Fatal injury

Indicate actual number of days of incapacity for work (if required)

--

9. Reporting pursuant to the Act on Protection against the Consequences of Industrial Injuries

Has the accident been reported as an industrial injury to the employer's insurance company/the National Board of Industrial Injuries for the purpose of an assessment pursuant to the Act on Protection against the Consequences of Industrial Injuries?

Yes ☐
No ☐

If Yes, send a copy to the insurance company.

10. Any witnesses

Name:	Name:
Address:	Address:

11. Information about the person reporting the accident

Reported by: <input type="checkbox"/> Employer <input type="checkbox"/> Doctor/dentist <input type="checkbox"/> The injured person <input type="checkbox"/> Medic <input type="checkbox"/> Other	Stamp, telephone no. and any contact person	Date (day, month, year) _____ _____ _____
		Signature of the person reporting the accident

Figure A.6 Danish Energy Authority Accident Reporting form

ANNEX 2

Example Report from DNV – Worldwide Offshore Accident Databank

Worldwide Offshore Accident Databank	
Accident ID No.: 2002-08-23/008 Date of Accident: 11/22/2001	
<u>Accident Record</u> Last Revision Date: 12/1/2002	<u>Accident</u> Time: 10:00 Duration (hrs):
<u>Installation / Unit</u> Unit ID No.: 74002 Name of Unit: BYFORD DOLPHIN Type of Unit: Semi-submersible Function: Drilling Class. Society: Det Norske Veritas Owner: DOLPHIN SERVICES A/S Contractor: DOLPHIN SERVICES A/S Operator: STATOIL	<u>Location</u> Geog. Area: Europe North Sea Shelf: Norway Field / Block: Water Depth (m): Drill Depth (km): Wind Speed (m/s): 16 Wave Height (m): 8
<u>Operating Mode</u> Main: Transfer, wet Sub: Transfer, wet <u>Accident Category:</u> Accident Cause Human: Equipment: Weather, general	<u>Main Event:</u> Out of position, adrift Event Chain 1 Towline failure/rupture 2 Out of position, adrift
<u>Consequences</u> Fatalities Crew: 0 3rd Party: 0 Injuries Crew: 0 3rd Party: 0 Degree of Damage: Insignif/no damage Cost(\$million): 0 Downtime(Days): 10 Spill Type: No spill Spill Amount(m3): 0 Repair Type: Not repaired Repair Time(Days): 0	<u>Evacuation</u> Type: Partly evacuation No. Evacuated: 17 Means of Evacuation 1 Helicopter
<u>Information Sources</u> Lloyd's List/Casualty Week/Register Ocean Industry Offshore Rig Newsletter	<u>System / Equipment</u>

Worldwide Offshore Accident Databank

Accident ID No.: 2002-08-23/008

Date of Accident: 11/22/2001

Description

The semi, with 71 people on board, was being towed towards the Mikkel Field, where it was contracted to plug a well, when the towline broke. Seventeen persons were flown ashore by helicopter as part of the regular crew change, but no new personnel flew back to the rig to replace them. The rig got adrift at a speed of 1.2 knots with only a work line between tug and platform. The weather conditions were bad with high winds (40 knots), 7-8 m waves and snow showers. Two supply vessels were close to the drifting platform, working to get another towline on board. The rig drifted southwards but did have use of its own limited engine power. The rig passed the Draugen and the Njord fields, well clear of the installations. The day after at 0615 hrs tug/supply "Northern Crusader" managed to get a tow line on the rig. The vessel awaited improvement in weather before continuing towage. The semi was towed to the Sigyn field arriving there December 1. More information is found in the WOAD archive.

Figure A.7 Accident report from DNV – Worldwide Offshore Accident Databank

European Commission

EUR 25646 – Joint Research Centre – Institute for Energy and Transport

Title: Safety of offshore oil and gas operations: Lessons from past accident analysis - Ensuring EU hydrocarbon supply through better control of major hazards

Authors: Michalis Christou and Myrto Konstantinidou

Luxembourg: Publications Office of the European Union

2012 – 58 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1018-5593 (print), ISSN 1831-9424 (online)

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doi:10.2790/71887

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Abstract

The disaster following the explosion on drilling rig *Deepwater Horizon*, in the Gulf of Mexico in 2010, dramatically demonstrated that offshore extraction and exploitation of hydrocarbons is not without risks. Accidents can occur, often with devastating consequences to human lives, expensive extraction equipment, the sea and coastal environment and ecosystem, coastal economies and interruption – or delay – of energy supply.

In order for offshore oil and gas operations to become safer, lessons from the analysis of past accidents need to be identified and shared. This report investigates sources of information on offshore accidents, identifies lessons to be learned from “landmark” accidents and how they fit in the risk management chain, and performs statistical analysis based on the content of a commercial accident database.

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

