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TRANSACTIONS (TM)

SAFETY ENGINEERING REQUIREMEN S ON OFFSHORE PRODUCTION PLATFORMS

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Safety Engineering Requirements on Offshore Production Platforms

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SYNOPSIS

The paper shows the magnitude of the project required for the designing and building of an offshore production platform for operation in the North Sea. The all-encompassing role of safety is developed, starting with legislation, codes of practice and standards and leading to the involvement of all engineering disciplines in the development of safe designs and installation procedures. Orientation, hazardous areas, fire and gas detection, the prevention of explosions and fire protection are particularly emphasized.

INTRODUCTION

Safety for any offshore project can be divided into two separate functions for each project phase:

- Safety of personnel within an office building or on a fabrication or construction site.
- Safety in the engineering design of the installation.

Within the UK, legislation has been established to define the responsibilities of both employer and employee with respect to safety.

Probably the most familiar is the Health and Safety at Work Act 1974.[1] This legislation does not make provisions for safety or responsibilities but does empower the Secretary of State for Employment, acting through the Health and Safety Commission, to draw up detailed regulations and codes of practice on specific health and safety matters.

The existing Offices, Shops and Railway Premises Act 1963,[2] the Factories Act and the Mines and Quarries Act, which were in force long before the Health and Safety at Work Act, continue to remain effective until replaced by new legislation. These documents, however, are predominantly for onshore installations.

The Mineral Workings (Offshore Installation) Act 1971[3] was enacted by parliament to provide for the safety, health and welfare of those involved in the exploration for and exploitation of underwater mineral resources in the waters in or surrounding the UK. The Secretary of State was thus empowered to draw up detailed regulations under the Act, as under the provisions of Ref. 2. In fact in 1974, 1975 and 1977, Statutory Instruments to the Health and Safety at Work Act 1974 (Commencement Orders Nos 1, 2, 3 and 4) were issued, implementing various sections of the Act for offshore installations.

The Oil and Gas (Enterprise) Act 1982[4] further extended the powers of the Secretary of State concerning the provision and supply of gas through pipes by persons other than the British Gas Corporation. This paper outlines the effects that this legislation and the even higher standards of safety demanded by operators have had on the design of offshore installations.

After twenty seven years in the Royal Navy and six years in design contracting for the oil industry, B. A. Montgomery joined Shell Exploration and Production as Safety Adviser. He is currently Fire and Safety Engineer on the Eider Project, and is responsible for ensuring that the design, fabrication, construction and commissioning of the installation meet all statutory and Shell fire and safety requirements.

CONCEPTUAL AND DETAIL DESIGN PHASES

Personnel safety

The first stage in personnel safety is to ensure a clean and safe working environment for the design team. This includes adequate space per person with proper allowance for desks, filing cabinets, drawing boards, computers etc. The correct lighting must be provided for the work to be done (eg at drawing boards or VDUs), with glare or reflection from lamps and windows being avoided.

Escape routes must be sufficiently wide for the number of persons present. The lighting on the escape routes must function after a mains power failure.

The second stage is to provide proper training, not only for specialist equipment but also for emergency procedures such as fire and bomb alerts. The first aiders should hold 'industrial' certificates and their names and whereabouts should be published so that all personnel are familiar with the procedure in the event of an accident. Accurate and up-to-date records are required of courses and drills carried out by individuals or the building's occupants as a whole.

Having ensured that the building in which the design work is to be developed is safe and has a good working environment, the design can commence. For the purposes of this paper, it is assumed that the petroleum engineers, geologists and financial experts have proven the feasibility of the project and that the necessary funds have been allocated for the design to commence.

Safety in design

One advantage of operating in UK waters is that the legislation has been well thought out. Furthermore, a method of monitoring the proper use of the codes of practice and standards required by that legislation has been introduced.

The introduction of the Mineral Workings (Offshore Installations) Act 1971 led to the production of the following regulations for specific functions: Offshore Installations (Construction and Survey) Regulations 1974, Statutory Instrument 289;[5] Offshore Installations (Operational Safety, Health and Welfare) Regulations 1976, Statutory Instrument 1019;[6]

Offshore Installations (Life Saving Appliances) Regulations 1977, Statutory Instrument 486;[7] and Offshore Installations (Fire Fighting Equipment) Regulations 1978, Statutory Instrument 611.[8]

The Secretary of State, exercising his powers under Section 3 of the Mineral Workings (Offshore Installations) Act 1971, made the Offshore Installations (Construction and Survey) Regulations 1974, SI 289, requiring all offshore installations established or maintained in waters around the UK to be certified as fit for the purposes intended. This certification is carried out by the Department of Energy for the overall design and construction; assisted by the Department of Transport, who have special responsibility for fire-fighting equipment and life-saving appliances. The practice long followed by responsible engineers in this country, namely ensuring that all aspects of the design and construction process are subjected to critical scrutiny by an independent professional eye, is maintained by having this scrutiny carried out by the Certifying Authorities. The Certifying Authorities were selected because of their established and international expertise in maritime, and other, classification and inspection techniques.

One of the most valuable assets of the legislation is that 'Guidance Notes' have been issued to assist in the interpretation of the Regulations. In these notes, reference is made to alternative codes and standards, eg 'Equipment which complies with national standards and is approved by a National Administration (or equivalent body) for the purpose intended and meets the requirements of the Regulations will normally be considered'.

Safety, however, is everybody's responsibility, and the Health and Safety at Work Act 1974, Section 6 'places duties on anyone who designs, manufactures, imports or supplies an article or substance for use at work to ensure, so far as it is under his control, that the article or substance is safe when used in accordance with information supplied by him. The duty extends to the provision of necessary testing, inspection and research. Those who install plant are also to have a duty to ensure that it is safely installed'.

However, in the major oil and gas production companies and associated design houses, these duties are more carefully delineated and each discipline has a philosophy to work to. This obviously needs interdisciplinary liaison in order to avoid incompatibility of ideas and equipment, but the most important requirement is safety.

Design

Conventional engineering disciplines are also involved in the design of an offshore installation and, because of the very large requirements of such a design, experienced contract design engineering companies are often used. 'Discipline' engineers supervise these companies, approve the design work and ensure that the programme schedule is met.

The responsibilities can be broadly outlined as follows.

Petroleum engineers

The geophysical data and core samples from the proposed installation site are reviewed constantly, in order to assure the operator that the investment will reap adequate dividends. Confirmation that drilling is taking place in the right place is always reassuring!

Process engineers

The appropriate process systems must be selected and designed for cleansing the hydrocarbons and transporting them to the onshore facilities or tankers.

Mechanical engineers

This group often includes engineers, who liaise with process engineers to select the pressure vessels and rotating machinery. They also specify the prime movers for power generation, cranes and heavy machinery.

Electrical engineers

The high- and low-power electrical generation and distribution requirements for normal operational and emergency equipment must be specified and then designed to meet these specifications.

Structural engineers

The jacket, which supports the heavy machinery and equipment necessary for hydrocarbon recovery, has to be capable of withstanding all the might of a hostile North Sea and vagaries of the sea bed.

Architectural engineers

The environment that the operators and maintenance engineers live in must also be well designed, and delicate and sophisticated equipment needs to be protected against the saliferous environment.

HV and AC engineers

Heating, ventilating and air-conditioning systems are required for both personnel and electronic systems in order to provide the best working conditions. Pressurization, for protection, will be necessary in hazardous areas.

Instrumentation engineers

This group often includes telecommunciation engineers and designs the control and monitoring systems for the process and mechanical equipment throughout the platform. Also needed is a fire- and gas-detection system and an emergency shutdown system for the process, with interfaces between them. The telephone, public address and general alarm, intercom and microwave systems throughout the platform, between platforms and to the shore must meet the Safety of Life at Sea (SOLAS) requirements.

Fire and safety engineer

Sometimes called the 'loss prevention engineer' this may be a management function with certain responsibilities for fire and safety delegated to engineers within some of the disciplines referred to earlier. However, as a general rule the role assumes a number of specific responsibilities, including the following.

Hazardous areas

Internationally there are a number of recognized codes for the identification of hazardous areas and the specification of suitable equipment for use in those areas, including: Institute of Petroleum Model Code of Safe Practice Parts 1 and 8,[9] American Petroleum Institute Recommended Code of Safe Practice API RP500,[10] and Det norske Veritas Technical Note 302.[11]

These codes provide a valuable tool for selecting the safest orientation of the platform and the equipment on it. The general rule of thumb is to install the equipment such that hazardous and non-hazardous equipment is segregated and that hazardous areas are located down wind of non-hazardous areas.

Information used to establish the hazardous area classification includes:

- The hazardous equipment schedule, which details the explosion and fire risks of the materials to be handled, processed or stored.
- The volume and arrangement of the hazardous materials and vessels.
- An assessment of the possibilities of leakage of these materials, ie quality of vessel, glands and seals etc.
- The construction details of the plant with particular reference to natural and mechanical ventilation, below-grade locations (where heavier-than-air gases can accumulate) and inverted pockets (where lighter-than-air gases may become trapped).

Orientation

Hazardous-area classification, with the ensuing benefits of the prevailing wind, is only one consideration when calculating the orientation of the platform. The wind itself is never constant and the wind rose gives a complicated picture, but this and tidal movements are studied when deciding the location of mooring positions for the supply vessels.

Lifeboats, or totally enclosed motor-propelled survival craft (TEMPSC) as they are known, must be positioned with care, be unaffected by a supply boat moored alongside, and the wind must, as far as can be predicted, assist rather than inhibit passage away from the platform.

However, it must always be remembered that the seabed on which the platform legs are to be established will sometimes dictate how much flexibility there is in selecting the location of the jacket.

Noise

All the heavy machinery on an offshore installation creates noise, and space allowing the equipment to be spread out to reduce noise is at a premium. Noise is a recognized hazard, and all equipment suppliers are obliged to provide sound maps of their machinery.

When the proposed installation layout is assessed for overall noise, arrangements can be made for sound insulation or areas may be designated as 'noisy', with the appropriate warning signs and provision of ear defenders.

Heat

Heat can also be a serious problem, both a lack and an excess of it. Some North Sea platforms are many miles North of Moscow and so much nearer the North Pole. This means that the effects of wind and its 'chill factor' on man and machine have to be considered.

The chill factor or wind chill effect is the phenomenon which lowers the temperature of an object or human body in proportion to wind speed across its surface. There are well established tables showing the wind/temperature relationships.

For example, at a wind speed of 5 m/s, which can be identified as smoke rising from a chimney being blown gently away, the risk of frostbite at −35 °C is considered to be 'an increased or high risk'. At a wind speed of 10 m/s, at which speed thin tree branches would break, the same 'increased risk' would exist at −15 °C. Thus in these very-low-temperature conditions an increase in wind speed of 5 m/s could have the equivalent effect of a 20 °C drop in temperature.

Man's normal internal temperature is 37 °C, but should this drop to 34 °C he comes apathetic and requires assistance to survive. At 32 °C he will lose consciousness and at 30 °C heart problems and convulsions will be experienced. Below 30 °C and by 20 °C survival is limited.

Thermal insulation is provided to prevent the process temperature being reduced below the operating temperature, and also to protect personnel against process machinery and pipework at high temperatures. Walls or enclosures also may be fitted with insulation to provide an improved working environment.

Gas extracted from the oil or direct from the wells is used to power the generator prime movers. It is also used in the vent system as a purge gas to reduce the possibility of flash back or explosion within the equipment or pipework.

The hydrocarbon purge gas is fed, at a controlled pressure and rate of flow, to the process equipment in order to maintain an air-free, and thus inert, atmosphere. The constantly flowing purge gas is collected within the low-pressure vent or flare system and either discharged to atmosphere or burned off through a low-pressure flare.

The radiated heat from the flare in everyday use and in an emergency 'blow-down' situation, when the whole process system is depressurized quickly for safety purposes, is calculated and a 'polar' diagram produced. This is necessary to ensure that the flare boom is long enough to prevent personnel and equipment from being at risk should a blow down occur. With the wind in an unfavourable direction, the situation could be injurious to personnel in exposed positions such as the drill derrick, crane cabs etc.

Hazards and protection

In the hostile environment of the North Sea there is no 'dial 999' facility and so no highly professional fire brigade on call. Furthermore, the offshore worker cannot walk away from the incident and watch the spectacle from a safe distance.

Thus fixed and often fully automatic fire protection systems should be included in the design. These protection systems are supplemented and/or actuated by the fire- and gas-detection systems.

Fire detection

Fire could occur at any location on a platform in varying degrees of magnitude and from a variety of fuel sources. The generally accepted fire-protection philosophy is to cater for one major incident at any one time. Thus the systems are designed to:

1. Detect fires or potential fires quickly.
2. Eliminate the fuel source, eg by shutting down the appropriate process train.
3. Control or extinguish the fire, using manually or automatically activated fire-fighting systems, depending upon the location.

The types of risk on the platform are identified and then checked against legislative guidelines and company policy before flame, smoke or heat detectors are allocated to given areas.

Gas detection

Throughout the platform the potential risk of the accidental accumulation of flammable or toxic gas is assessed from process information, hazardous-area drawings and plant layouts. From this information and suppliers' data, suitably tempered with experience and checked against legislative guidelines and company policy, the locations of gas detectors and the number and type required are identified. The system is designed to:

1. Detect gas accumulations/leaks well before they reach a potentially hazardous level.
2. Isolate and bleed down residual pressures to minimize accumulation of gas.

Fire protection

The systems provided offshore generally include:

- Carbon dioxide.
- Sprinkler systems.
- Halon 1301 systems.
- Helideck foam systems.
- Deluge systems and monitors.
- Firewater ring main and hydrants.

The offshore industry has learned or inherited a lot of knowledge from its forebearers in the marine world. The firewater ring main, fed by multiple pumps to allow for redundancy and segregation of sections, is used for the fixed water-spray systems.

Sprinkler systems, similar to those used in hotels, cinemas and modern superstores, are fitted in accommodation and certain workshop areas. Multiple-spray-head deluge systems, which are capable of providing many cubic metres of water per hour, are situated over all equipment used for processing, storing or transporting hydrocarbon fluids, other than fuel for prime movers. The ability to add foam to the water systems enables specific risks, eg on the Helideck, to be catered for.

Since the development and use of fixed carbon dioxide systems in the marine industry, halon extinguishers have been produced and refined. In compartments where electrical and electronic equipment is installed, a dry and gaseous extinguisher is preferable to water, particularly salt water. The halon extinguishers are less toxic and, in the amount required to extinguish a fire, do not have the asphyxiating properties of carbon dioxide. This has led to their increasing use by industry as a whole.

Fully automatic fire protection

Sprinkler systems, which use their 'frangible bulbs' for detection and actuation simultaneously, are fully automatic and have no manual operation facility. Deluge and Halon 1301 systems are normally fully automatic in that they are activated by detectors through the fire and gas control system on a voting network. Each system is provided with a local and manual remote operation facility and an inhibit facility. The Halon 1301 system normally has the automatic actuation selected in the protected area.

As the improving technology inevitably reduces the need for the presence of operators in the vicinity of running machinery and the trend towards unmanned installations gathers impetus, the detection of an incident and the execution of remedial action cannot be left to human responses in a remote control room. By providing fully automatic systems, the lost time between 'detection' and the control of an incident is considerably reduced.

The fire and safety engineer identifies the risk, selects the most suitable method of protection and, within the project safety philosophy, determines the method of system actuation. He is responsible for monitoring the specifications and the engineering necessary to achieve the optimum design.

Safety of personnel

Within the design, the safety and survival of the individual in the event of a major incident is of paramount importance. A number of different areas have to be considered, and items can be missed when safety is first discussed.

The provision of an adequate number of life-saving appliances is fairly straightforward.[7] The number and type of lifeboats, lifebuoys, lifejackets etc. are specified, and the location and distribution of these items around the installation, to ensure rapid accessibility in an emergency, is fundamental to good design. They must still be accessible if a major incident (fire or explosion) occurs, and personnel must be able to reach the lifeboats after they have been launched.

High-pressure relief valves are fitted in certain process equipment and thermal relief is provided in the event of a fire. The relieved pressure should vent safely and not impede a primary or secondary escape route. There are many such valves on a platform and, along with other equipment, they require regular maintenance and possibly removal and replacement. It must be possible to reach this equipment easily and safely, and lifting facilities are required for heavy items. Furthermore, escape routes must not be impeded when this work is being carried out.

Operational procedures have to be considered when the design process and instrument diagrams (PIDs) are studied. Safety can be improved by both interlock systems and operational procedures, and usually a combination of the two is selected. It should always be remembered that simplicity can often lead to safety, while complexity can lead to confusion.

Monitoring

So far, the principles, tenets and legislation have been discussed, together with some of the individual responsibilities of engineers. The fire and safety engineer, outwith his discipline engineering responsibilities, acts as a catalyst, guide, mentor and sounding board for the other engineers.

If good rapport and mutual respect is reached early in a project, then safety will self-propagate. The effectiveness of safety within the design is monitored by a number of tools, which both measure and record the standard of safety achieved.

Hazard and operability studies (HAZOP)

A hazard and operability study is a systematic review of the process and utility systems and engineering design in an effort to identify potential problems and their possible consequences. The studies cover, in particular, the hazards arising from deviations in operating conditions and identifies the causes and consequences of potential hazards and any remedial action that can be taken.

By identifying these problems at an early stage in design, changes can be incorporated quickly and with the minimum impact on the schedule and cost. In practice, more than one HAZOP is usually conducted:

- Coarse HAZOP: very early, when the preliminary layouts

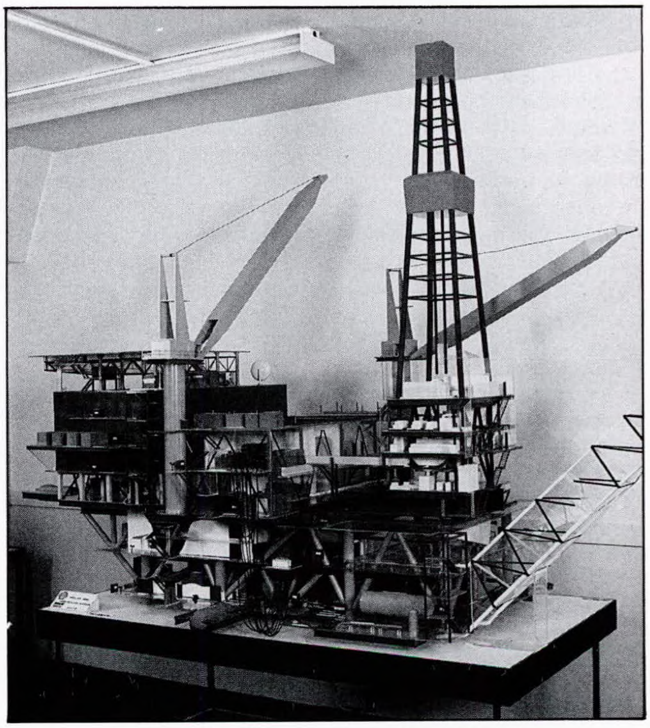

FIG. 1: Model of a production platform

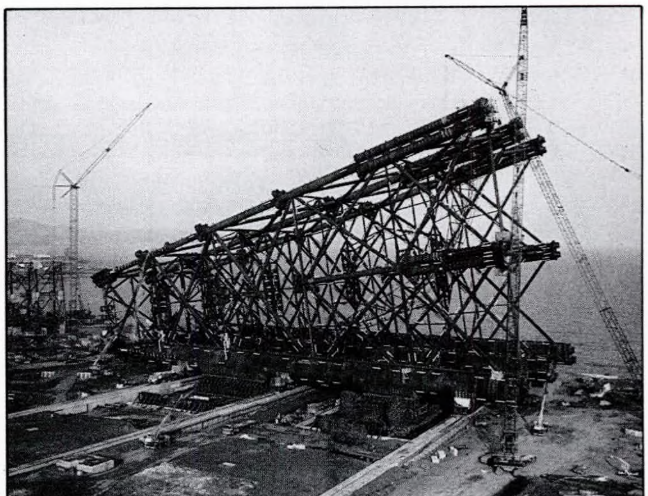

FIG. 2: Jacket under construction

the process flow diagram and limited PIDs (for primary systems) are available.

- Primary HAZOP: usually toward the end of the conceptual design stage, to build on the findings of the coarse HAZOP and to check that its recommendations have been incorporated; also provides additional recommendations for inclusion in the detail design stage.
- Final HAZOP: during the detail design stage, as a final check that all problems identified during the preceding studies have been adequately catered for and that the design meets the optimum standard of safety.

Hazard analysis (HAZAN)

There are basically two types of HAZAN:

- Minor HAZAN: studies to allow analysis of the risks of various designs and to aid decision making, with assessment of the interaction between proposed new plant and any existing plant.
- Major HAZAN: may be part of onshore or offshore plant planning applications or approval or to satisfy the 'Seveso Directive' from the EEC.

The need for HAZAN studies will be identified within the HAZOP studies. They are usually required where a system design is new or the design team is unfamiliar with its operation or it interfaces with other systems.

Hazard analysis is the technique of analysing the frequency and consequences of failures of equipment, within a given system, and include risk, consequence and fatigue analyses. The quality of such analyses is dependent upon the historic data available and is steadily improving as more operators and suppliers gather, collate and make available equipment and material information.

Safety reviews and audits

Having carried out in-depth studies of the equipment and systems, the design needs to be examined from the point of view of the operators who will live and work on the platform. This is usually achieved by the fire and safety engineer compiling the documentation, which will ultimately be presented to the Department of Transport (Marine Directorate) for formal approval, and inviting an independent team to conduct an impartial review of the contents. In principle, this is a HAZOP of everything not already covered by a HAZOP!

These reviews are similarly carried out during both the conceptual and detail design stages, with a documented follow-up procedure, to verify that the recommendations have been incorporated into the design.

FABRICATION AND CONSTRUCTION

The considerations discussed thus far have been purely paper exercises. The design (see Fig. 1), with all its massive collection of 'Approved for Construction Drawings', philosophies, specifications and operating procedures, has been submitted to the Department of Transport and the Certifying Authority, acting on behalf of the Department of Energy, and obtained approval in principle. Now all that is needed is to turn the mass of paper into a production platform.

Each item of equipment, purchased as an individual component or as an integral part of a system, is specified to the last detail and the supplier must provide authentication of its suitability for the purpose intended.

The thousands of tonnes of equipment, and associated documentation, begins to arrive at the specified yards and offices. The equipment is to be of the highest quality, which means that the fabricator must also be of a similar standard.

When drawing up the design, the best engineers had been installed in ideal working conditions and then had every idea and design they came up with subjected to the most stringent audits and reviews. The fabricator who is to build the multi-

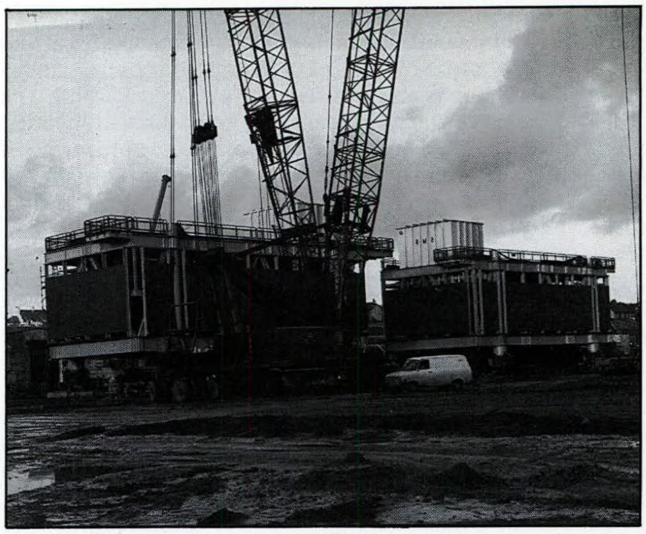

FIG. 3: Topside modules in the fabrication yard

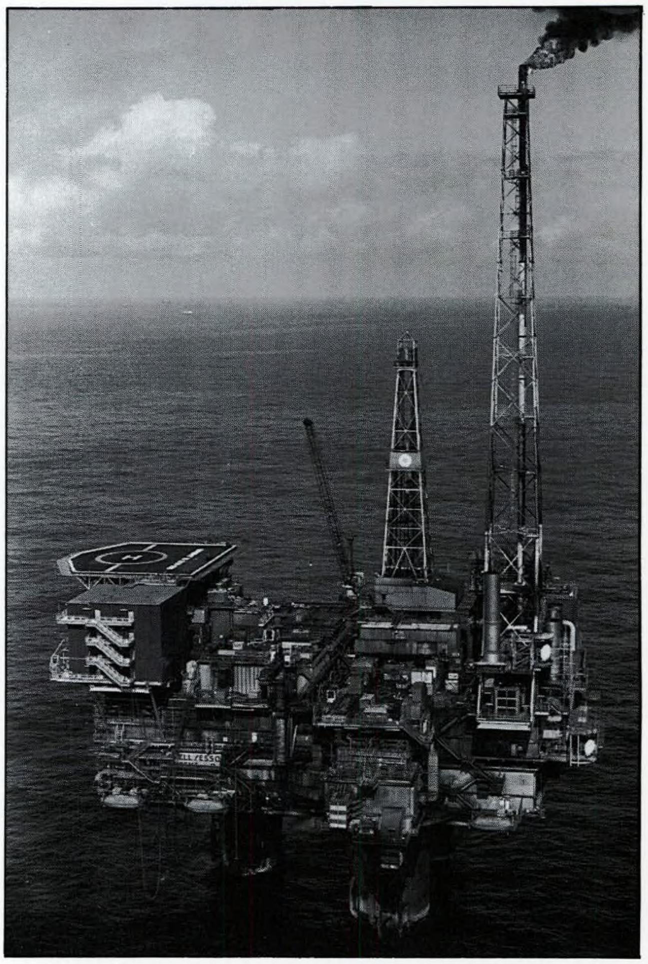

FIG. 4: Production platform operating in the North Sea

million pound structure must also be tested for suitability, and when tendering is asked to provide the following:

- Details of the safety organization.
- Corporate statement on health and safety at work.
- Accident and incident reporting procedures and investigative methods.
- Method by which sub-contractors are incorporated into the safety policy.

- Details of staff training for specialist skills and operationial practices for hazardous work.
- Track record, year by year, of their accidents and incidents, itemizing fatalities and lost-time incidents.

Furthermore, at the shortlisting stage site visits are carried out by the fire and safety engineer, suitably supported from the central office, to compare facts with the printed word.

The same standards of safety which were applied during design must be maintained throughout the varying stages of fabrication and construction. The only thing that changes is the size of the building block: from component to skid, from skid to system or module and finally assembly, module by module, into the whole (see Figs 2 and 3).

This final assembly will, in most cases, take place offshore and the components will be the largest sections that can safely be shipped, lifted and assembled by the transport and lifting barges available. The jacket on which these sections are to be supported may be floated out with added flotation units or on a barge, and each method has its own peculiar difficulties to overcome.

The planning of the tow-out and installation, and the execution thereof, has its own nightmares. It is a very complex subject and would need a separate paper to do it justice, as do the operations involved in setting to work and commissioning platform before handover to the operator (see Fig. 4).

CONCLUSIONS

There are many similarities between the safety aspects of designing an offshore oil or gas production platform, and the roles of the participants, and what is required for a ship which is to handle hazardous cargoes. It is not all engineering, neither is it all hard hats and steel toecaps. Rather, it is the fusing together of both, with a lot of help from experience and common sense. Much has been learned by the two industries, and as long as the good relationship continues there will be many safer and more prosperous years ahead.

ACKNOWLEDGEMENTS

Shell (UK) Photographic Services are thanked for providing the illustrations.

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Discussion

P. S. LEGGOTT (Matthew Hall Engineering): My question concerns Shell's discussions with the Authorities regarding fire areas in naturally ventilated open areas of a platform.

Statutory Instrument 611 Guidance Notes on offshore fire-fighting equipment require areas of the platform protected by deluge systems to be surrounded by A class walls or the platform extremities. Would Mr Montgomery please explain what general concessions have been agreed by the Authorities for large open areas protected by several smaller deluge systems and whether these concessions would also apply to a 'normally manned' installation.

C. W. OLIVER (Darchem Engineering): I should like to ask Mr Montgomery if there is any danger from process or wellhead explosions (blast) to adjacent areas in 'open deck' concept platforms such as the Shell Eider platform, which has only minimum walls of partitions unlike the more conventional module construction such as Brae A?

J. CRAWFORD: The arrangements of the process plant and adjacent areas gives me some cause for concern. Assuming that the process area is dealt with on the basis of an open deck, naturally ventilated area (ie open deck zone 2 area), I believe that such an arrangement should include an auxiliary ventilation system in order to prevent the formation of static pockets in way of equipment or semi-enclosed corners of the structure which would otherwise retain hazardous gases/vapours.

Furthermore it is considered that in order for the area to be dealt with on the above basis as an adequately ventilated area, a minimum of 12 air changes per hour should be available at all times. It would appear from the arrangements as proposed that direct access is made between the hazardous (process) area and the adjacent safe area and it is submitted these access arrangements would in themselves constitute a hazard.

Author's reply

The 'concessions' mentioned in Mr Leggott's question are certainly not 'general' and must not be considered as such. Where the 'open' concept is envisaged and smaller deluge areas, separated by spaces or 'fire breaks', are intended for use, it is essential to maintain a dialogue with the Department of Transport. Certain criteria will be established according to the circumstances of the design, including the use of the additional pumps. Whilst the principle has been applied on a 'normally manned' installation it is not possible to tabulate the criteria or the details of any concessions. Each proposal must be considered separately, on its merits.

In reply to Mr Oliver, the principle of an open concept with 'adequate' natural ventilation (DnV TN 302B) is the avoidance of areas where 'flammable gas may accidentally accumulate'. Additionally an 'explosion' requires confinement and other than the wellhead, pipework and vessels, the open design by its very nature severely limits the possibility of an 'explosion' occurring.

A rapidly escalating fire with a fast moving flame front would normally be diverted by a fire wall constructed to an A60 standard and structurally suitable for the North Sea environmental conditions. Similarly a fire wall of this construction will act as a reasonable protection against missiles generated by an explosion within pipework or vessels.

This 'open' concept has been in use in 'onshore' sites to a very large extent without any major problems. However, it is conceded that space is not usually a problem!

Mr Crawford's concern is noted and indeed has been taken into account during the design of the Eider platform. All the calculations and the practical wind tunnel tests were carried out, without the effects of moving machinery or thermal currents generated by equipment. It is generally accepted that these would in fact assist in air movement.

The studies show quite conclusively that all the necessary criteria are met and that additional mechanical, auxiliary ventilation would be unnecessary, expensive to install and require additional power and maintenance without any practical advantage. This is not to infer that the point can be ignored, nor that on another design layout auxiliary ventilation would not be necessary.

As with the point on auxiliary mechanical ventilation, the wind studies show that there are no additional hazards created by having direct access between hazardous area Zone 2 and non-hazardous areas. With onshore facilities where the open concept is employed, hazardous areas will be shown bordering on non-hazardous areas. How else can it be shown?

By definition a Zone 2 area is one in which, in normal working conditions, an explosive gas/air mixture is unlikely to occur. The only possible alternative, if the point is accepted, would be to put up walls and this would defeat the whole object of the exercise.

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