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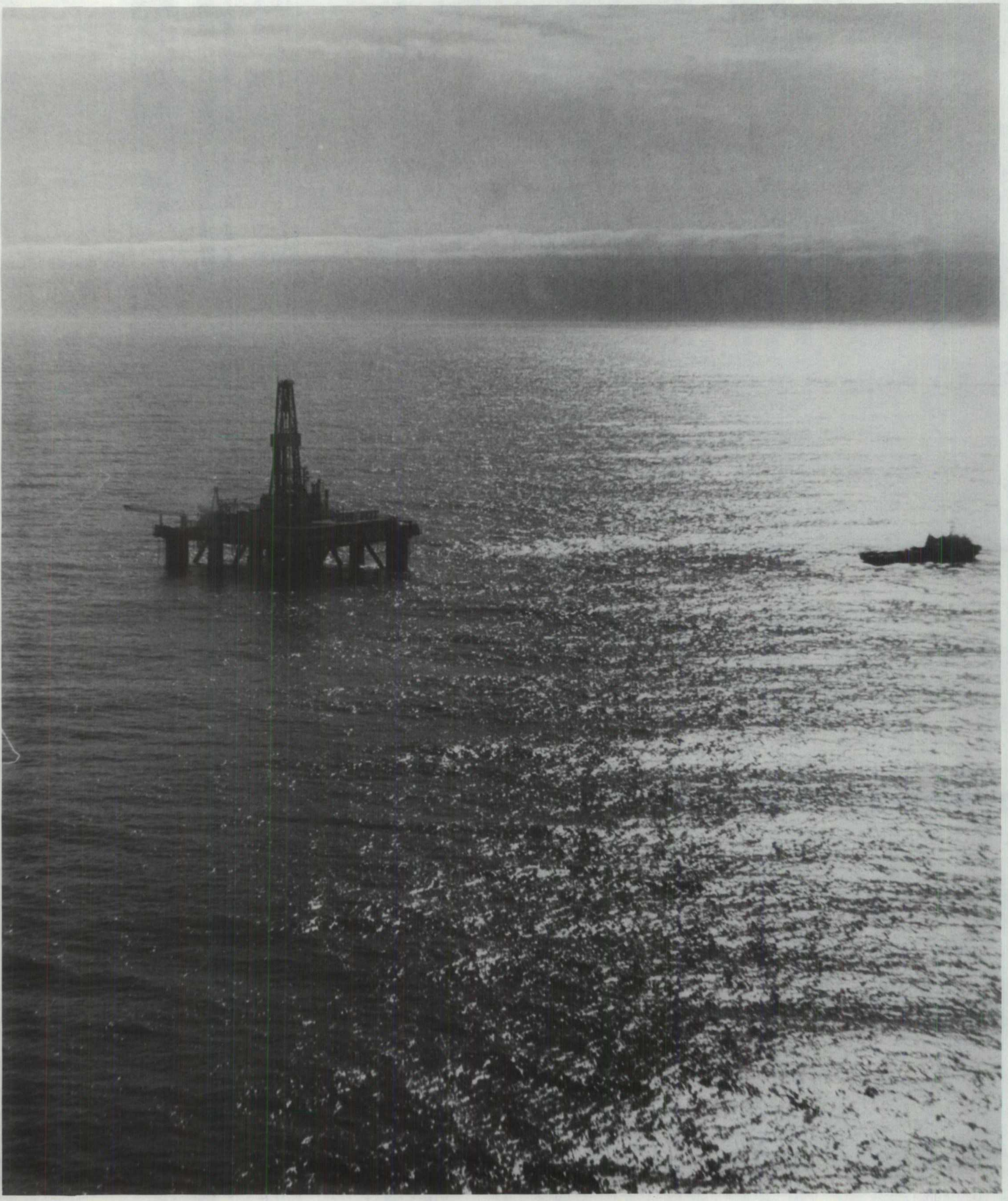
DESIGN



DESIGN

MOBILE OFFSHORE DRILLING UNIT DESIGN EVOLUTION

(1) *An Essay on the Design of Mobile Offshore Drilling Units*
(2) *Report on Mobile Offshore Drilling Unit Design Evolution*
Earl & Wright Consulting Engineers
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MODU design has evolved from the use of land-based drilling equipment on shallow water barges in the late 1940s to the present day when world-class drilling units are capable of operating for extended periods in water depths of 100 to 460 metres and under very extreme environmental conditions. The factors that governed the design of early MODUs still dictate the concepts and techniques being applied today; essentially a MODU must provide a stable, highly mobile platform for drilling in deep water offshore, under a prescribed set of operating conditions. To cope with new conditions, designers either modify existing designs until a limit of extrapolation is reached or develop alternative concepts. The principal mechanism for evolution of MODU designs has been the change in configuration brought about by increased functional requirements and environmental limits.

MODUs can be separated into two general groups, bottom-supported and floating. Bottom-supported units include submersibles and jack-ups, while drill ships, drill barges, and semisubmersible units make up the floating group. Floating MODUs maintain position at the drilling location either with catenary mooring or dynamic-positioning systems or some combination of both. In evolving the design of MODUs there were some overlaps between these broad groups, for example, a number of early semisubmersible designs were capable of operating as submersible units in very shallow water.

The first true offshore drilling units were inland drill barges which consisted of land rigs mounted on barges that operated in swampy areas with less than three metres of water. The drilling equipment was installed on a deck raised above the barge hull and supported by posts or piles. The barge was moved on location and submerged, leaving the drilling equipment above the waterline. The instability encountered during the process of submerging led to design refinements which produced the first true submersibles.

The first submersible was the Barnsdall-Hayward design *Breton Rig 20* built in 1949. This rig incorporated design features which provided increased stability while the barge was being submerged. Once the barge was on the bottom, its pontoons were flooded and sunk to minimize the effects of wave forces. Further refinements to this initial concept led to the introduction of the "bottle-type" submersible, the first of which was *Rig 46* now owned by Trans World Drilling Company. This unit, built in 1956, was capable of drilling in 21 metres of water. It featured large diameter columns that provided stability during towing as well as during the lowering procedure. The largest submersible rig, *Rig 54*, also owned by Trans World Drilling Company, was built in 1962 and operated in water depths up to 53 metres, which proved to be the economic limit for the submersible type MODU.

Self-elevating or jack-up type drilling units were first developed in the mid-1950s, in response to the limitations of submersible rigs. Developed to provide a means of keeping the drilling platform above the wave crests for depths exceeding the capabilities of submersibles, jack-ups derived many of their features from earlier marine construction platforms which were floated to a particular site and raised above the water on steel piles or legs. Due to the limited capacity of the jacking devices employed on early jack-up units, some had as many as 10 or 12 legs. Advances in jack-up design reduced the number of legs, leading to the development of a triangular, barge-type hull with 3 tubular or lattice truss legs. Jack-ups were initially developed for shallow water sites in the Gulf of Mexico and the Middle East. These units operated in water depths of less than 30 metres and in areas where environmental conditions (with the exception of hurricanes) were relatively mild. With the movement of exploratory drilling operations into more severe climates, however, continued improvements in jacking equipment, leg-to-hull connections, and the legs themselves were necessitated. Excessive leg penetration into the seabed was also a problem encountered with early jack-up designs; this led to the development of spud cans to increase the leg's bearing area. The development of the mat-supported type jack-up was another solution to the penetration problem.

As drilling locations extended to more remote areas and increasing water depths, designers were forced to abandon the bottom support concept and turned to the development of floating drilling units. The initial designs involved the conversion of conventional ship-shaped vessels to carry a complete drilling system. Purpose-built drill ships appeared in the 1960s and although contemporary designs have increased stability by providing wider hulls, bilge keels, and roll suppression systems, drill ships are still limited in their operation by relatively poor motion response. With the exception of the introduction of dynamic-positioning systems which allow the vessel to "weathervane" with the prevailing wind and sea state and thus minimize motions, the basic design concept of the drill ship has not changed in a significant manner since its introduction.

From the experience gained in developing the submersible and recognizing the inherent limitations of ship-shaped drilling units, designers developed the semisubmersible concept. In general, semisubmersibles exhibited improved motion characteristics when compared with drill ships. Consequently, these units have evolved as the most common MODU used for operations in deep water and severe environments. Early semisubmersible designs had multiple lower hulls and stability columns, ranging from 4 or more lower hulls and up to 20 columns. Major buoyancy members were located below the water line because the effect of wave action is reduced with increased water depth thus improving the unit's motion characteristics. The early designs had inherent stability, strength, and maintenance problems due to the overall structural complexity. The desire to provide a simplified structural framing arrangement, increased transit speed, and mobility led to the development of the modern twin hull semisubmersible configuration.

■ *MODU DESIGN* The design of MODUs is an iterative and evolutionary process of incredible complexity. The constraints of operating performance and regulatory requirements coupled with economic, technical, and human factors force designers to seek an optimum engineering solution through the application of new and existing principles, materials, and technology. The extent to which the design process interacts with a unit's construction and subsequent operation varies considerably. In some cases, a designer may monitor the rig throughout its working life, while in other circumstances his involvement ceases before construction begins. Throughout the design process, professional judgement is exercised to establish the MODU's level of safety, especially in those areas where analytical methods are questionable. The final product, a drilling unit optimized for a specific range of operating conditions, is typically the result of four stages: the development of a conceptual design; the preparation of a design basis; a preliminary design; and a final design.

The conceptual design stage involves developing and defining the MODU's capabilities and is a good starting point from which to develop a unit that satisfies the needs of a client or project. If a client is involved during the conceptual design phase, his requirements are an important consideration. Conceptual designs are, however, also prepared either on speculation or in anticipation of the development of a potential project.

To decide the size and capability of the MODU, basic operating parameters must be defined, including: anticipated geographic area of operation, environmental forces, motion limitations, required payload, mooring system and dynamic positioning system, transit requirements, crew size, and applicable regulations. Based on these parameters the conceptual design studies should result in sizing a unit within about ten percent of its final size. When the initial sizing has been completed, a gross expected lightship weight is developed using the designer's past experience with the weights of drilling equipment, ship's service equipment, and structural components. An analysis of the stability and motions of the conceptual design is performed and the results are compared with the characteristics of existing MODUs.

At the end of the conceptual design phase, a concise report of the findings is produced and the results are reviewed against the required parameters and discussed with the client, when one is involved. It is often possible to establish a cost estimate for the conceptual unit to help develop an operating day rate. If the proposed unit's configuration departs sharply from the norm, an "approval in concept" may be discussed with a classification society to forestall future problems.

Following the approval of the conceptual design, the designer integrates the operating parameters and criteria developed during that phase with more detailed design aspects to ensure that the final product will truly meet the needs of the client. Detailed operating requirements are developed including basic criteria for ship's service and drilling systems as well as structural aspects such as the required fatigue life. A decision regarding the classification society to be used and the country of registry is made, in order to allow the design to meet the appropriate requirements. In addition, the regulatory agencies governing the anticipated geographic areas of operation are identified so that the design incorporates a proper and economical approach to their various regulations. The design basis phase results in a formal design procedure document which also incorporates the technical approach for the structural, mechanical, electrical, and other design disciplines.

Once the conceptual design is complete and the design basis has been defined and accepted, the preliminary design phase begins. The basic arrangements of the deck are developed to confirm or modify the space allocations determined during the conceptual design phase. The structural framing scheme and weight estimates for the structure are developed using mathematical analysis in combination with past experience. Emphasis is placed on developing a simple, straightforward framing system with inherent redundancy in case of damage. Engineering drawings indicating the basic structural scheme and sizing are produced. Using the conceptual design configuration and sizing as a starting point, the designers' naval architect estimates the unit's lightship weight and vertical centre of gravity, and analyses the stability and compartmentation required. A mathematical analysis is performed to determine the motions of the unit; many iterations of the initial design and configuration may be made to optimize the motions.

When the foregoing steps have been completed, a drilling efficiency or "downtime" analysis may be required by the leasing client or the owner.

A great deal of the basic mechanical and electrical design is also performed during the preliminary design stage. The requirements for the bilge, ballast, and cooling water systems are determined and schematic drawings of the systems are made. To verify space requirements and allocation, basic layouts are done for the mechanical equipment, including the pump rooms. An initial power and electrical load analysis is performed to determine the required generator capacity and to produce a simple, one line power distribution drawing. An estimate of equipment weights is made for inclusion in the lightship weight estimate. Some consideration for model testing is often given at this stage, particularly where a new configuration, which differs significantly from other designs, is undertaken. Model basin and wind tunnel tests are used to verify motion response, wave passing, towing and propulsion requirements, and the effects of environmental forces. At this point, a decision is made as to the need or value of submitting the preliminary design package to regulatory agencies for "approval in principle". A submission of this nature can settle basic questions and clear the way for the final design.

In the final design stage a set of drawings and construction specifications are developed for approval by a classification society and applicable regulatory agencies. These drawings and specifications define the unit as it is to be built and form the basis for shipyard bids. The final design will incorporate detailed arrangements for the layout of the unit, a detailed structural design and analysis, the naval architectural analysis for stability and mooring, a detailed mechanical and electrical design, and a construction specification which defines the material, equipment, and workmanship required for the completed unit.

When the final design is submitted for classification/regulatory approval, many different groups within each society or agency review the plans of the unit. The approval process can therefore be quite lengthy and is very seldom complete before construction bids are requested. Therefore, during the construction period, the approval process goes on, not only of the construction documents, but also of design aspects. To minimize possible changes at the shipyard, particularly after steel is ordered, an effort is made during design to submit the job in segments to the agencies.

■ *DESIGN TRENDS* The design concepts for the three major types of MODUs employed in East Coast Canadian waters – jack-ups, drill ships, and semisubmersibles – have developed to a point where current and future trends are primarily directed toward refining individual systems, reducing cost, and improving speed of construction. Major developments have occurred in the areas of stability and watertight integrity, mooring and dynamic-positioning systems, ballast systems and marine service systems. Advances in the understanding of metal fatigue have led to changes in welding procedures for MODU fabrication. Improvements in the operational aspects of rigs working in harsh environments have also been attempted.

In most early MODU designs, stability considerations were limited to providing a sufficient metacentric height (GM) and waterplane area to resist the effects of 35 to 50 metre-per-second storm winds. Gradually other considerations were addressed and accidental flooding criteria were adopted to enable MODUs to survive damage resulting from collisions. Early designers had essentially no guidance on stability for MODUs, as the majority of the stability regulations were developed for conventional ship-shaped vessels. Stability was provided by following basic principles of naval architecture. For intact stability, the primary requirement was to maintain a positive GM at all drafts and to provide sufficient GM at operating draft to facilitate the drilling operation. For units with an off-centre drilling derrick, this could be a serious problem due to trim induced by large variable drilling loads on the hook and derrick. Intact stability for semisubmersibles posed no particular problem once operational requirements were met. The same situation existed for jack-ups and drill ships, however, in these cases freeboard was an important factor influencing intact stability. The relatively high casualty record for jack-ups under tow can be attributed in part to a less seaworthy hull form with a small amount of freeboard and the very high position of the elevated legs which often causes synchronous roll with the seas.

The contemporary intact stability rules for MODUs are intended to ensure that a unit possesses sufficient righting energy to offset the overturning energy due to wind. All of the factors in these rules are attempts to account for dynamic effects by applying empirical analysis; although the rules have proven satisfactory, considerable research is under way to provide a more thorough understanding of environmental effects on intact stability.

To provide some measure of damage stability the early barge type MODUs had some internal watertight bulkheads or other subdivision, but in the majority of cases there were no explicit criteria defining the extent to which flooding would be tolerated. Typically designers allowed for one compartment to be flooded and applied some constraint either on freeboard or angle of inclination after flooding. The first formally published rules for MODU design issued in 1968 by the American Bureau of Shipping called for a one-compartment standard with positive freeboard after damage, including the static effect of a 50-knot wind. There was some confusion as to whether the standard applied to any one compartment or only compartments near the waterline. This was, however, clarified in the 1973 edition of the rules to cover single or multiple compartment damage only near the waterline.

The contemporary damage stability rules of classification societies either apply a one-compartment damage requirement or a more stringent one. The static effect of a 50-knot wind is included, but there is no allowance for waves and motions in terms of freeboard to downflooding openings. Many flooding casualties can be traced to wave entry through multiple openings above the static intact waterline. To allow for ballasting or other operational errors as well as inadvertent flooding, many designers feel that a one-compartment flooding standard without reference to the waterline is necessary.

The consideration given to a MODU's stability has progressed from the "rule-of-thumb" methods employed in early units to the highly regulated considerations which are in effect today. Although there is a continuing desire to adopt more rational intact stability criteria, there is no compelling argument that the existing rules are inadequate. There remains some question, however, regarding the applicability of existing rules for harsh environment areas.

A MODU's mooring or dynamic-positioning system must provide precise control of the vessel above the wellhead and produce sufficient resistance to hold the vessel on location under normal operating conditions. These considerations have led to the development of more complex systems than are usually employed for ships. Conventionally moored MODUs are presently limited to operations in water depths of approximately 460 metres. Beyond this limit, the weight of the mooring system components reduces the MODU's payload capacity. In addition, as water depth increases, the positioning capability of catenary mooring systems becomes less effective and the MODU cannot be maintained over the wellhead in rough seas.

Dynamic-positioning systems first evolved as part of thruster assisted conventional mooring systems. Control systems were developed to regulate both thrust and direction of the individual thrusters thus allowing full dynamic-positioning systems to become a feasible option. While contemporary dynamic-positioning systems make it possible to dispense with anchors as a backup, this is not economical in moderate water depths and not possible in very shallow water. In eastern Canadian waters MODUs equipped with dynamic-positioning systems also use conventional mooring systems.

Recent developments in dynamic-positioning systems include improvements to position sensing and control equipment and advances in thruster design. Conventional mooring systems have improved through the use of high strength chain, emergency release systems, automatic tension monitoring and load sharing, and chain chaser lines. In addition, onboard computers are making it possible for personnel to carry out evaluations of vessel motions and anchor line dynamics to optimize anchor patterns, predict tensions, and analyze the effect of operational changes.

Early MODUs, especially jack-ups, did not have dedicated ballast systems until submersibles and semisubmersibles were developed. At best, most units had some type of bilge pump or draining arrangement as required by classification rules developed for ships. A new set of ballast system requirements were developed for semisubmersibles. In early semisubmersibles, ballasting was accomplished by gravity flooding into the pontoon tanks, while deballasting required pumping the bottom ballast tank empty. If other tanks were to be deballasted or ballasted they were connected to a central tank which communicated with a bottom ballast tank. Although operators could control such systems safely, there was a general desire to have somewhat more positive and direct control of each ballast tank. This need resulted in the centralized ballast manifold which allowed valves to be more accessible and each tank to be controlled individually. In systems with common manifolds, block valves have been introduced to divide the manifold to prevent the accidental transfer of ballast between tanks at the extreme ends of the pontoons. In general, ballast system arrangements have evolved towards more centralized and accessible equipment.

For jack-up units several approaches are used to trim the unit while afloat. When the hull is jacked out of the water a short distance, jack-ups must use a preload system to transfer sufficient weight to the legs to ensure proper seabed penetration. After the required penetration has been achieved the tanks are deballasted and no further ballasting is required. For "mat type" jack-ups, the mat may be filled with water to provide the necessary bearing pressure when on location. Prior to a long move, the mat is sometimes deballasted using air pressure.

Semisubmersible ballast systems have gradually increased in complexity. To sustain more severe damage conditions, the number of ballast tanks has increased. Additional pumps and pump rooms have been added in some cases to provide for safe operation at large angles of inclination and to provide for some level of redundancy in the system. As these systems become more complex, the trend will to be toward more sophisticated control systems. If safety is to be increased, or at least maintained, design for reliability and simplicity in these systems must be encouraged.

Classification rules, in this area, apply mainly to hardware requirements for ballast system components and to bilge systems. A need has been recognized for the development of operating criteria for ballast systems, and considerable effort is being focussed on this area by both regulators and owners.

As MODUs have evolved, their marine service systems have become increasingly complex. System requirements for cooling, fuel, compressed air and liquid, and dry mud as well as generator capacity have all increased significantly. Advances in computer technology have permitted an increase in the use of remote control and monitoring systems. The most significant design trend has been the attention placed on system redundancy and the use of systems during emergencies.

Exploratory drilling in areas exhibiting low temperatures and the presence of ice and icebergs has led to the incorporation of special design features. Many contemporary world-class drilling units, particularly those intended for cold-weather operation, incorporate heat traced piping and substantially enclosed working areas, including the drill floor. Formalized operating procedures have been developed for dealing with ice and snow loads, iceberg and pack ice contingencies, and the parting of anchor chains in emergencies. The most recent designs for world-class MODUs operating in arctic environments incorporate advances in materials technology, including the use of high tensile steel developed for use in cold temperatures.

At present, classification society rules address only limited ice strengthening of MODUs. The extent of this protection is confined to waterline areas at normal transit drafts and the strengthening is intended only to protect the hull from broken ice during transit in mostly open water. Very few MODUs have incorporated ice protection beyond basic classification society requirements, although several ice-strengthened semisubmersibles have been built for operation in areas with partial ice cover.

CONTINUITY FROM DESIGN TO OPERATION

Information Flow Report
Noble, Denton & Associates, Inc.
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Each party involved in the design, construction, and operation of a MODU has basic responsibilities for the unit's safety. The owner is responsible for the safe and efficient operation of the MODU and is therefore responsible for ensuring that the unit has been designed and built for the environment in which it is intended to operate, that it is maintained adequately and that it meets the regulatory requirements for the area of operation. The designer is responsible for designing the unit to operate safely under specified environmental criteria, payload capacities, drilling capabilities, and operational limitations. The design must also satisfy the necessary classification rules and regulatory requirements. The builder is responsible for constructing the unit in accordance with the contract specifications, classification rules, regulatory requirements, and the specifications and drawings provided by the designer. The operator is responsible for contracting a unit that is capable of withstanding the environmental conditions within an acceptable risk level, and for ensuring that the unit meets all applicable regulations. The operator is also responsible for drilling operations including blowout and oil spill prevention measures.

A classification society performs an independent third party assessment of the MODU design, construction, and maintenance during operations for compliance with its rules to the extent that the unit is designed, built, and maintained in class. To a certain extent their design assessment will be on the basis of criteria specified by the designer and accepted by the owner. The roles of coastal state agencies and regulatory bodies are varied and requirements differ from jurisdiction to jurisdiction. Where government agencies have assumed a role in regulating the safety of MODUs, the operator is required to demonstrate that the unit is capable of operating safely. The regulatory body may also regulate safety equipment requirements and may require certain levels of crew qualifications and training. In some cases a marine surveyor may be employed by the owner or operator in order to meet the requirements of insurance underwriters. The marine surveyor's responsibility is to provide an independent assessment of the risks involved in moving and operating the unit.

A closer review of each party's role during the design, construction, and operation of a MODU is, however, required to highlight possible information flow failures. The roles of the various parties can never be exactly defined as they vary for each MODU project and are dependent on the perception of each individual group concerning their roles and responsibilities.

■ *THE OWNER* When a company decides to have a MODU constructed they will investigate the designs or design concepts which are available and capable of meeting the requirements for an area of operation. If suitable designs or concepts are not available, they may either engage a designer to develop or modify a unit or engage their in-house design group to do so.

A combination of requirements must be met to ensure that the unit will be suitable. The environmental conditions must be established for the area of operations, particularly the wind, wave, and current forces during a storm with a 50- or 100-year recurrence period. The effect of environmental conditions on the design is considerable. The determination of maximum environmental conditions is not, however, an exact science and different consultants may provide data with a great deal of variance for the same area. Also, the estimated environmental extremes tend to increase as an operating area matures and a larger meteorological data base becomes available. These data, though sometimes of questionable accuracy, constitute one of the most important considerations during the design process and will often be the basis on which a design is accepted or rejected.

Classification societies approve designs for the environmental conditions specified by the designer; they do not judge if these conditions are acceptable for the intended area of operation. The owner, therefore, may have to assume additional responsibilities and establish more realistic operating, transit, and survival limitations for the area in question. Classification societies offer many optional coverages which must be specified by the owner in the construction contract. The selection of the classification society is often based on economic considerations; if the owner wants a different society than the one specified by the designer and/or builder, the contract price may be increased to cover the estimated costs for compliance. In reality the owner is not completely free to choose the society unless he specifies it very early in the design stage, or is willing to pay an additional charge to change. The owner will also select the home port of the unit and thus its country of registry; this in turn will determine which government regulations will be met. If the unit is to operate in areas such as the North Sea and offshore Canada, its classification and other certification is often not sufficient, since governments require an independent review of the design for compliance with their regulations. It is extremely important for the owner to specify the area of operation at an early stage of design to avoid the high cost of modifications.

It is common practice for the owner to supply most of the drilling equipment for the unit and often to supply mooring equipment, safety equipment, and general service equipment as well. If this is the case, the owner must work closely with the designer and the builder to ensure that all equipment information is provided in a timely fashion and that the equipment complies with applicable regulations. The owner, in effect, shoulders a certain amount of responsibility during the design. It is acknowledged that some designers have limited experience in drilling and marine operations; consequently the quality of the design may depend, to a large extent, on input provided by the owner. The owner must follow the design process very closely, using all his available knowledge and experience to ensure that operational assumptions are realistic. If the owner has knowledgeable and experienced staff working with the designer and builder, many gaps left by the design, classification, and certification processes can be eliminated. The fact that many designs are sold and constructed before an owner has been established may limit or eliminate the owner's involvement at this stage.

To minimize changes during construction it is in the builder's interest to limit the flow of information to the owner. This may be done by proclaiming most drawings to be of a proprietary nature and restricting the owner's access. The contractual obligations of the designer and builder are considered to be met when the classification society and regulatory agencies approve and certify the unit. However, the unit's classification may not cover all aspects of the design and consequently there may be major items not surveyed or tested adequately. Although the owner's representatives will inspect the construction of the unit in parallel with a classification society's surveyors, in the case of disagreement regarding the quality of construction, the opinion of the classification surveyor will normally prevail.

Operating manuals generally do not become available until either late in the construction phase or at the actual delivery, thus limiting the owner's capability to familiarize himself with the unit's operations and making it almost impossible for the owner to instigate changes if procedures are found to be impractical. In many cases, operating manuals are inadequate and leave unanswered many questions that will occur during operation. The operating restrictions in the manual may be unnecessarily limiting and the owner may soon determine that the restrictions must be partially or wholly ignored. The owner will be fully responsible for all his actions beyond the manual's limitations, and the experience, knowledge, and judgement of his key personnel will determine if this will endanger the unit and its crew. Owners may decide to rewrite portions of the manual or expand it to cover operations that are not sufficiently addressed. If an owner decides to do this, he may be required to resubmit the manual for approval to the authorities that approved it originally. Whether this is actually done and whether all government authorities have procedures to deal with proposed changes, is not known.

■ *THE DESIGNER* A designer's role can vary from project to project and is contingent upon contractual relationships with an owner and his own view of his function. In cases where a designer is fully independent, criteria including the unit's operating environment will be defined. Then a suitable design is developed and marketed to prospective clients. Most jack-ups have been, and still are, designed by independent designers. In other circumstances, a designer may be instructed to develop or adapt a concept in close cooperation with the owner. It is obvious that in the first case the possibilities of information gaps are greatest, especially between designer and eventual owner.

To be successful, a designer must develop a commercially competitive design. This means that his efforts are directed towards developing a design that is cheaper to build than similar designs meeting the same criteria. Consequently, a designer will often try to minimize all systems and equipment that are a significant part of the unit's construction costs. To achieve this, a designer may employ the latest and most complex methods of analysis to show that environmental loads can be reduced and that the resulting lighter structures are capable of withstanding these reduced loads. It is possible that in some of these more efficient designs, the level of built-in structural redundancy is reduced and operational restrictions are imposed. Ideally, a designer should find a balance between commercial pressures and the safe and effective operation of the unit.

The extent to which a design is completed before sale is largely dependent on the designer's financial support, his commitment to the concept, and MODU market conditions. Several years ago when a building slot for a MODU was hard to find, many designs were sold before approval was obtained from a classification society. As the rig building market is currently depressed, potential owners require proof of adequate design development before contract negotiations occur. Consequently, the extent to which information is exchanged between designers and classification societies, regulatory bodies, and marine surveyors in the early design stages can vary considerably.

If a design has not been fully developed at the time of sale, the designer and builder tend to provide a limited amount of detail in the contract specifications. The favoured method is to describe the design criteria in rather general terms, and then make as much as possible subject to classification and regulatory approval, thus giving the owner little control over the design process.

Although classification rules and regulatory requirements may not have been intended to be a strict design and building code, they will, in effect, become one unless the owner specifies in the contract adequate control of the design process. The minimum requirements in the classification rules and regulatory requirements may become the unit's maximum capabilities, while the poorly defined areas in those rules and regulations may become the unit's weaknesses. This process, however, is dependent on market conditions, and on the owner's experience, engineering capabilities, and negotiating skills when the contract specifications are established.

Apart from commercial and technical considerations, the delivery time for a MODU is important, since the unit may have to be built for a specific drilling contract. In many cases, the designer may have to issue unapproved drawings to the builder so that the planning and the ordering of materials may begin. Changes required during or after construction are costly.

The designer and builder will often approve amendments required by classification societies or regulatory bodies. These pressures may lead to a more literal interpretation of the contract, the specifications, and the contract drawings by the designer and builder in an effort to limit their responsibilities, while the owner will try to support a more liberal interpretation to receive a unit with minimal limitations.

Short delivery schedules can affect the orderly development and evaluation of a design. To expedite construction, the designer and builder may try to limit the owner's involvement in the approval process. The obvious method to reduce the pressures imposed by delivery time is to use or modify an existing design for the project. A considerable design effort may still be required because many designs must be adapted to suit a specific owner's requirements. In almost every case, all information must be submitted to classification and regulatory bodies for each MODU. Only in the case of genuine sister rigs being built at the same yard is the information submitted for one unit considered to be applicable for the others also.

As much of the design work may still be in progress during construction, most designers provide continuous support to the builder. A designer may either make all detailed workshop drawings, or be responsible for approved design drawings while the builder develops workshop drawings. The contract between the designer and builder may specify that the builder must either submit drawings to the designer for review or inform the designer of any significant changes. Changes may have to be discussed, the effect of different tolerances evaluated, and the effect of equipment and material substitution determined. Late information from the owner concerning owner-furnished equipment may delay the design of various systems and their submission for the approval of classification societies and regulatory authorities.

Unless the designer is part of the owner's organization, it is unlikely that he will receive any significant feedback concerning the unit's operational performance. To develop designs with improved operating characteristics, many designers would like to be more involved in the operation of their designs and rigs.

■ *THE BUILDER* The delineation of responsibilities between the builder and the designer is often hard to establish accurately. Where the builder obtains a licence from an independent designer to construct a certain design, he generally receives approved design drawings, examples of schedules, specifications, procedures, and available information from other units of identical design. Certain independent designers provide detailed information while others may provide general drawings and specifications that may not adequately address interferences between structures, systems, and equipment. The quality of the design information to be provided is hard to specify in contracts between a designer and a builder. In some cases, however, the design group is part of the builder's organization and the exchange of information will be less problematic. It is certainly in the builder's interest to investigate the quality of information and support that the independent designer can and will provide before committing to build. Many costly changes have been made in designs during the early phases of construction. Due to the designer's often limited financial resources, the builder is often forced to absorb any extra costs.

When evaluating a design, a builder considers the quality of his own engineering/design group and construction capabilities. Many designs require construction tolerances, welding qualifications, material processing, and erection procedures that only an experienced builder can provide. It is not uncommon that certain designs require tolerances and procedures that conventional shipyards may not be able to provide.

The builder will generally be responsible for detailing the design, translating imperial measurements into metric and finding equivalent materials. The builder may then need to obtain approval from a classification society for these more detailed drawings, specifications, and procedures. It would be prudent in all cases to have the designer review detailed drawings prior to fabrication. This is seldom done, due to schedule, economic, and manpower limitations. Without a designer's involvement, a builder and a classification society's surveyor may not be fully aware of the importance of specific design details.

The builder clearly carries the major responsibility during the construction phase but relies on the designer's input to ensure successful performance. If large quantities of owner-furnished equipment are involved, the builder depends on the owner's information and support. Due to tight delivery schedules and extensive construction preparations, it is in the builder's interest to minimize last minute changes. Since meeting classification and regulation review has priority, the design and drawing review by the owner will be minimized. Although the builder's and owner's representative may realize that some changes will significantly enhance the MODU, they may never be implemented due to their effect on price and delivery time.

The builder will normally assign construction quality to a separate in-house quality control department. Although most builders have excellent quality control departments, some yards are limited in their ability to implement quality control standards. Although the builder will be responsible for the tests and trials required for the acceptance of the rig, many drilling system tests require the owner's involvement. Some necessary testing may not take place at all since it is not a classification requirement and was not specifically itemized in the construction contract.

As part of the acceptance process the builder is often responsible for producing as-built drawings, final equipment and systems' manuals, and various certificates required by the contract. Some designers enforce a very strict policy regarding the proprietary nature of their designs and do not provide the owner with certain structural drawings, despite the fact that various regulations require that a full set of drawings be on board the unit at all times.

As is the case with the designer, the builder may not get any significant feedback from the owner unless they have a close relationship or significant problems evolve. The builder's involvement may be limited to warranty claims, assistance with the MODU's mobilization and the supply of spare parts for the first years of operation.

■ *THE OPERATOR* The operator's direct involvement in the design phase is limited unless the unit is being designed for a specific drilling program. In such cases the operator's requirements are provided to the designer through the owner. For frontier areas where no proven MODU concepts exist, many operators become involved in the development of designs by commissioning conceptual design studies or by actively supporting owners with design development. Therefore, an operator may carry a certain responsibility for the overall quality of a MODU design.

The operator is responsible for specifying the environmental conditions under which the MODU must operate, and must make certain that a contracted unit can meet these criteria. The survival criteria may be obtained from independent sources or may be specified by regulatory agencies. If the survival criteria are not directly comparable with the unit's design criteria, the operator may have to obtain independent studies that prove the unit is capable of surviving the maximum environmental conditions. In some instances operators require full safety audits and extensive non-destructive testing programs.

Since most MODU operating manuals address only the marine aspect of the survival preparations, the operator should be responsible for ensuring that the procedures for shutting down the drilling operation interface with marine survival preparations. Many of these procedures may be developed in close cooperation with the owner and must be well understood by both parties. This requires that the operator's onboard representative has a good understanding of both the marine and environmental factors and the unit's design limitations.

■ *THE CLASSIFICATION SOCIETY* During the design phase the classification society performs an independent evaluation of the MODU design which covers structural design, stability, critical systems, and any additional equipment or systems that the owner may wish to be classed under the society's rules. The limits of a classification society's involvement are not always understood by the owner. The unit's structural evaluation is either passed strictly on criteria specified in the construction contract or on the basis of criteria specified in the society's rules. Design approval does not mean that the unit is capable of operating in every geographic location for which it is approved.

All classification societies carry out independent analyses of a MODU's stability. The structural design review is approached somewhat differently by different societies. For example, one society will review the designer's calculations and the assumptions used in the calculations, whereas another will perform a fully independent analysis using their own assumptions, based on the service limitations specified by the designer.

In recent years, classification societies have extended their involvement in MODU evaluation through memoranda of understanding with several national and international regulatory agencies. In such cases, the society will review the design for such certification concurrently with their review for classification. They will then extend their review as required by the regulations and perform any additional analyses required. The operating manual may then be reviewed by the classification society for compliance with the applicable regulations.

The classification society's surveyors will be at the builder's yard to ensure that the MODU is built in accordance with their rules and in accordance with the approved drawings. It is seldom possible for the limited number of surveyors to monitor all phases of the construction on a continuous basis. Their effectiveness will therefore depend on the builder's quality control department and the surveyor's relationship with that department. Many owners have their own quality control team at the builder's yard. Their effectiveness may, however, be limited unless the construction contract clearly specifies that their approval is also required. During construction, there will normally be regular contact between the owner's representative and the surveyors even though no direct contractual relationship exists between the owner and the classification society.

■ *REGULATORY AGENCIES* Since many coastal states require certification of MODUs before they are allowed to operate, MODU design is affected significantly by government regulations. If such regulations are close to the accepted norm for MODU design, there will be few changes required. If, however, the regulations are more stringent, the design may have to be completely modified or costly changes made to existing units. Since government regulations are applicable to specific geographic areas, two design standards may develop since not every owner is willing to pay the price of complying with higher standards. Designers have no practical problems with most regulations, provided that they are clearly defined and are not subject to regular changes or personal interpretations by inspectors. Unfortunately, this is not always the case and since many construction contracts will simply specify that the designer and builder are fully responsible for compliance with certain regulations they may, in effect, take on a responsiblity that is not clearly defined.

After a unit has received the necessary certification, regular inspections are carried out by the coastal state to check the unit's compliance. Inspections may be concentrated on the safety aspects of the unit such as its stability, lifesaving system, firefighting system, and may include its blowout prevention and pollution control systems.

■ *THE MARINE SURVEYOR* The insurance industry has provided MODU operation insurance since the inception of mobile drilling operations in the United States. As the industry developed internationally, insurance coverage for international ocean towages was also offered. As a condition of the insurance, such marine ventures are carried out subject to the recommendations and approval of a recognized independent marine surveyor or consultant.

During the design phase, the marine surveyor's role is rather limited and entirely at the owner's, designer's, and builder's discretion; however, a well-known independent marine surveyor's recommendations for ocean and field tows have often been included in construction contracts. Owners have requested that the same marine surveyors carry out feasibility studies at the design stage to ensure that the unit can operate and move safely in the intended area of operation. Designers have also employed similar studies to show potential owners that the marine aspects of the design have been considered, and that the marine surveyor endorses the unit's capabilities. During construction the marine surveyor may be employed by the owner to evaluate design changes and to assist in preparing for the unit's first ocean tow.

Prior to beginning offshore operations, the marine surveyor may carry out feasibility studies if the conditions in the area of operations are not directly comparable with the unit's design criteria. These studies may be carried out on behalf of the owner or the operator. The surveyor may also carry out studies for the long distance transport or ocean tow of the unit. The surveyor may then inspect preparation for transit, attend load outs and offloadings, and provide a certificate of approval. The surveyor may also be on board during transit to ascertain that the feasibility study recommendations are followed.

Most marine surveyors also become involved in damage evaluation and in handling damage claims. As a result, their organizations have gained considerable experience with MODU marine problems. The marine surveyor's effectiveness is largely dependent on the industry's view of his role, his review and approval policies, and the knowledge and experience of his staff.

■ *GAPS IN INFORMATION FLOW* The various parties involved in the design, construction, and operation of MODUs participate in a complex interaction that is dependent on the qualifications of those parties, their understanding of the information provided, their own views of their roles, their willingness to collaborate and, to a certain extent, MODU market conditions.

Some potential concerns regarding the continuity of information flow have been identified. The extent of the basic classification design review and construction survey may be too limited. Obviously, the regulatory agencies can influence the extent of this coverage and in fact are beginning to do so. Construction contracts and specifications often leave large gaps in the description of the unit's capabilities and characteristics, and errors have been made in the translation of the design information into detailed construction information. Once the unit is constructed and in operation, the record of its performance could be used as input to improve future design decisions. There is, however, a lack of any significant feedback to the designer and builder concerning design flaws discovered during operations, and no defined forum for the distribution of important information learned from casualties.

The potential for significant information flow gaps and problems in the interaction between parties involved certainly does exist, and can result in design flaws and increased risk levels. To what extent these gaps and problems result in serious hazards will depend largely on the commitment and knowledge of the parties involved. If their commitment, experience, and knowledge is of a high order, the MODU will likely be a safe and efficient unit.

Even if all precautions are taken, all regulations complied with, and all personnel well qualified, the possibilities of serious accidents can never be completely eliminated. MODU design is not an exact science and human judgement and human error will always remain a contributing factor to accidents. There is no doubt that the information flow process between the various parties involved can, in many cases, be improved.

JACK-UP RIG DESIGN

Jack-ups with Reference to the East Coast of Canada
Noble, Denton & Associates, Inc.
Houston, Texas, USA
November 1984

Self-elevating mobile drilling units (jack-ups) were first used for offshore oil exploration in the early 1950s, primarily in the Gulf of Mexico. The jack-up rig consists of a barge-hulled structure and a number of tubular or open lattice-type legs equipped with a jacking system which enables the barge to be lifted from the water to a sufficient height to provide wave clearance. To work in the shallow water around the U.S. Gulf Coast, early jack-up rigs were typically designed for 7- to 10-metre waves and 70-knot winds.

Even though the Gulf Coast is subjected to hurricanes which exceed these design values, the rigs' close proximity to shore provides sufficient working time to evacuate crews and sometimes even to bring the rigs into sheltered waters. Consequently, despite the loss of several rigs, the loss of life was small. This reliance on evacuation as a method of dealing with extreme environmental conditions has continued, and the jack-up rigs operating in the Gulf of Mexico today are often built to withstand only a 10-year return period hurricane. New designs of cantilevered units capable of withstanding a 50- or 100-year storm have been developed because jack-ups often work over fixed platforms which are designed to withstand a 100-year return period hurricane. The collapse of the jack-up under such environmental conditions could mean the collapse of the fixed platform and the production facility.

In more hostile areas of the world, such as the North Sea, Alaska, Australia, and offshore eastern Canada, storms are generally more frequent and storm warnings allow insufficient time for evacuation. Consequently, jack-ups operating in these areas need to be built to a more stringent 50- or 100-year storm level.

The level of risk involved in operating a jack-up at a particular location will vary subject to the local wind, wave, current, and soil conditions. Drilling contractors and operators may wish to work to different risk levels, depending on several factors such as previous knowledge of the site, the length of time the unit will be on location, and the consequences of structural damage. In certain areas, government authorities may dictate the risk level.

■ *CLASSIFICATION AND CERTIFICATION* Jack-up rigs are normally designed and built according to rules specified by a classification society. The classification society will approve a design for the storm criteria specified by the designer, survey the construction, and make regular surveys during the life of the unit to ensure the rig maintains its class. The classification society will normally not determine whether the design criteria are adequate for certain areas of operation, unless it is acting on behalf of the government authority whose certification must also be obtained and, even then, will only do so if this authority specifies certain criteria or storm return periods.

In many cases, insurance underwriters require a separate certificate of approval to be obtained from a Warranty Survey House. The warranty surveyor ensures that the unit will stand up at the specific location and can be towed safely between locations whether the rig has its certificates or not. To assure the underwriters that the rig is adequate, it is necessary to obtain site specific meteorological and seabed data, check this against the design specification and generally make sure the unit can operate at the location with a sufficient margin of safety. It should be kept in mind that a jack-up rig's primary function is to operate in an elevated mode with the platform above all wave action. In a floating condition, with the legs sticking high up in the air, there will be sufficient seaworthiness for the intended purpose of moving the unit; however, no great seaworthiness should be expected from a jack-up rig afloat without extensive preparations. Most jack-up casualties happen when the rig is in transit, moving between locations or under tow. Some 70 percent of all accidents may be directly attributable to the marine environment and not to the drilling operation. Because of this, and because many rigs' crews are not mariners, it is often a requirement of the underwriter that a marine surveyor be in attendance during jacking-down, towing, jacking-up, and preloading.

■ *METEOROLOGICAL DATA* Jack-up rigs are designed to withstand the stresses associated with the maximum environmental conditions which can be expected to occur in a given period of time. Several different methods are used by meteorologists and oceanographers to predict extreme storm wave heights, wind speeds, and currents. For many areas, the lack of adequate historical data reduces the level of confidence which can be given to these estimates. Even in areas like the Gulf of Mexico, the variation in expert opinion is significant for particular water depths. Since the forces are approximately proportional to the square of the wind speed, current, and amplitude of the wave, these differences are quite significant. Once "generalized data" have been determined, it may be necessary to obtain a detailed "spot location report" that accounts for local variations, particularly if the unit is working near its survival capability. It is important that the appropriate regulatory authority, using the best available data, establish a set of maps showing the contours of extremes for the area under consideration.

The utilization of jack-ups in areas subject to sea ice, icebergs, and ice accretion requires special consideration because jack-up rigs built to date would not be able to withstand the force of an iceberg impact. It is necessary, therefore, to consider the weather conditions for the unit to jack down and get out of the way of an approaching iceberg. A period must be available where wave heights do not exceed approximately 1.5 metres, although some jack-ups are capable of jacking operations in waves up to 3 metres. Some areas offshore eastern Canada are subject to icing conditions from freezing rain, sea spray, and snow fall. Accumulated ice and snow add to the weight of the rig, in addition to causing operational problems. Ice loading on the helideck of one jack-up unit was a contributing cause to losing the helideck while under tow. Designing critical systems and components to ensure reliable operation in cold climates is essential for units that work offshore eastern Canada.

■ *LOCATION DATA* It is prudent to obtain full knowledge of the sea floor and shallow subseabed conditions prior to the emplacement of any bottom-supported unit. The operator should make a firm designation of the proposed location prior to the surveys and should not make last-minute changes to the location once the survey has been completed. Some casualties have been caused by a last minute change in location to one "close by" for which data had not been developed and which turned out to be significantly different. High quality navigational equipment is necessary to ensure that the jack-up is placed exactly on the location that was surveyed.

A number of methods are used to survey the proposed site. A close grid bathymetric survey must be performed, typically covering a square area having sides of one kilometre centred on the location. In addition, a diver survey is performed over an area of at least 30 metres beyond the extreme parameter of the footings in order to ensure the absence of wrecks or other submarine hazards. In the event that the area cannot be surveyed by divers, it should be effectively dragged by a line suspended between two towing vessels or surveyed using side-scan sonar.

To ascertain the underlying lithology of the location, a high resolution seismic survey should be carried out to a depth of at least 60 metres, encompassing the same area as the bathymetric survey. Such high resolution acoustic profiling can alert operators to the presence of shallow gas, which constitutes a significant safety hazard during drilling. This data can also provide useful, although indirect, information on foundation conditions by providing a basis for extrapolating available soil bearing data, by identifying three dimensional sedimentary features over a large area which cannot be defined by conventional geotechnical borings and by identifying faults and changes in lithology associated with crusts and gas pockets. A coring, or *in-situ* pressuremeter test, is desirable to ascertain the soil type and shear values at various levels below seabed. These results, correlated with the shallow seismic survey, are useful in defining anticipated penetrations and anticipating areas where punch-through can occur.

■ *METHODS OF ANALYSIS* The equations used to determine the static and dynamic stresses which will be encountered by a jack-up rig have been experimentally verified for only a few simplified cases and could be different when considering a complex braced structure in a wave train: The methods are particularly at variance in calculating extreme forces from breaking waves. In addition, difficulties arise in calculating the drag coefficients of jack-up legs and in predicting wind forces on the legs when the unit is afloat. Even though there are still discrepancies between expert opinions on these matters and in the matter of evaluating the safety of a rig, or the comparative safety of one rig over another, it is imperative to use a consistent method of calculation. Comparing rigs on the basis of advertised criteria means little if the designers used different methods of calculation.

The actual and effective penetrations anticipated on site can also affect the results. In general, designers of the independent-leg rig have assumed that the legs are pinned three metres below the bottom and no fixity accrues from the penetration into the seabed. In areas where penetration is high, this may indeed be conservative, but in areas of shallow penetration, it can be dangerous to assume a fixity at the seabed unless a sufficiently detailed study of the particular location shows it to be a reasonable assumption. Further difficulties may arise where the jack holding capacity is not capable of withstanding the required preloading weight necessary to ensure that the rig will not punch through during storm conditions. For such units, it would be necessary to examine the soil information with great care to assure no significant further penetration would ensue.

One frequent difficulty with specifying a rig which only states maximum water depth conditions, without some qualifying statement about shallower conditions in the same area, is that the rig may not be as capable in shallower conditions. Some designs incorporate scantlings which are adequate for the specified loadings at the top of the legs and also relatively strong at the bottom to withstand towage loadings. In the centre is an area of lighter scantlings which may give a performance discontinuity. This could mean the unit is capable of operating in deep water but cannot operate at a shallower location in the same area.

■ *TRANSPORT CONSIDERATIONS* Moving a jack-up rig is a major activity requiring experience which has to be gained in marine disciplines, and skills which are often alien to the drilling industry. Ocean transports require considerable study, planning, effort, and cooperation between the owner, marine surveyor, and transport contractor to ensure a safe arrival. For many years, the only method available was the wet ocean tow where the rig is towed, floating on its own hull, by one or more ocean-going tugs. Due to the short, blunt shape of jack-up hulls and their limited seaworthiness, wet tows are slow and fraught with difficulties. The causes of accidents during wet tows can be generally classified under two headings: human errors and bad weather. Bad weather, in itself, seldom causes major jack-up accidents; when coupled with human errors, it can and has produced serious damage.

In 1973, the first dry tow of a jack-up was made from Italy, around the Cape of Good Hope, to Dar es Salaam over a distance of 15,932 kilometres. In a dry tow, the complete rig is loaded on a special submersible transport barge and towed by an ocean-going tug. Due to the better shape of the barge, towing speeds are higher and the seaworthiness of the combination is better. A recent improvement in dry rig transport has been the development of special self-propelled submersible transport vessels, providing an even faster and safer method of transport.

A field or location move is a move from one drilling site to another within a local area of operation. The tow must be completed within a reliably forecasted good weather period; normally, the rig can make its field moves with the legs either fully raised or partially lowered. The towing route must be planned carefully with sufficient water depth available at low water, especially if the rig is towed with the legs partially lowered.

Good preparation of a jack-up rig for a field move covers many aspects. The legs, the tie down of equipment, cantilevers, substructure, drill structures, deck cargo, drill pipe, and casing must be able to withstand the unit's roll and pitch during tow. As a lack of watertight integrity has been a significant contributing factor in many jack-up accidents, the platform must be thoroughly prepared to prevent the ingress of water into void, preloaded, or other compartments. Since the jack-up unit spends only a small percentage of its operating life afloat, special attention must be paid to all closures. Of paramount importance in any move is the selection of crew with appropriate towing experience. Ideally, the tug should place one or two experienced seamen on the jack-up, so that there is adequate communication and experienced personnel are available in case a reconnection of the tow line is necessary.

In the Gulf of Mexico, the risks encountered during field moves are much lower than those in Canadian waters because the towing contractor can often call an additional tug for assistance or fly out spare tow lines and parts in the event of problems. Operating in Canadian waters is much more akin to operating in the North Sea, where these facilities are generally less available at short notice.

■ *STORM PREPARATIONS* All jack-up rigs are designed for certain survival criteria involving a combination of a maximum wind speed, wave height, and current. Sometimes the rig can only withstand the storm after various special preparations have been made. To avoid overstressing the legs, it is usually required that the longitudinal centre of gravity and transverse centre of gravity of the platform, drilling structure, and variable loads are near the centroid of the legs. This assures that each leg will carry an equal amount of platform weight and that the safety factor against overturning is optimal in all directions. In some cases of extreme loading, it may be necessary to add ballast water to the platform to increase the safety factor. In some designs, the operations manual may require that the cantilever is retracted when a severe storm approaches. The extent of the effort required for retracting the cantilever and its possible effect on the drilling operation and well control must be taken into account. Some designs may need to limit the variable loads on board so as to avoid overstressing the legs during storm conditions; this means that liquid consumables such as drill water and mud may have to be dumped every time the unit is prepared for survival conditions.

In areas where storms are frequent, it is often very difficult to make these preparations within a reasonable time, especially when the severity of the storm may not be known in detail until a few hours before it reaches the rig. It may be prudent not to allow rigs to work at these locations unless they are designed to weather the storms with their cantilevers extended.

■ *ACCIDENTS* Of all types of MODUs, jack-ups are the most vulnerable to damage and destruction and account for about 68 percent of all accidents. A large number of the accidents involving either jacking up or down or being towed from one location to another have been sustained during fair weather. In fact, more towing accidents have occurred during fair weather than in rough weather. The majority of accidents during jacking are due to punch-through which is rapid, uneven penetration of one leg during initial jacking up of the platform and preloading. Between 1980 and 1984, there were at least ten severe incidents involving punch-through of jack-up rigs; very likely, the actual number is higher since not all incidents have been publicized. Punch-through is usually caused by irregular soil layering or unusual soil features. A thorough and careful inspection of the site significantly reduces the likelihood of punch-through.

■ *CONCLUSIONS* Jack-up platforms are exceedingly useful tools for exploration in the eastern Canadian offshore. Unlike floating units, the integrity of the structure is very dependent on the specific location at which the unit is operating. An accurate assessment of the oceanographic environment for the location is essential. Designs are currently being produced for the extreme conditions encountered in Canadian waters. It is essential for safe operations that independent assessments are made to establish the safety of the units for specific sites and environments. It is the task of both the designer and the builder to produce a jack-up which is suitable for the rigors of operation and transit, but it is the responsibility of the owner to operate the unit within the stated limitations of the design. The barge engineer and the other responsible personnel will have to be fully aware of the stated and implied limitations and must demonstrate sound understanding and marine judgement in order to prevent accidents. The best safety feature for any platform is skilled and knowledgeable rig management.

Summary of Model Testing Seminar

The Royal Commission undertook a series of model tests of the semisubmersible *Ocean Ranger* during the process of completing its Part I mandate. The tests, carried out by hydraulic laboratories in Canada and Norway, proved to be of significant value in determining the reaction of the rig to the environmental forces and operational loads which existed on the night of the accident. On December 14, 1983, the Royal Commission convened a one-day seminar to investigate the potential value of hydraulic and aerodynamic modelling as a means of assessing the safety of MODU designs. The participants were chosen to provide a range of views on the subject, and included theoreticians, practitioners, and users of model testing techniques.

The participants took two distinct approaches to the subject of model testing in MODU design. To the designer, model testing is a tool used together with numerical and other methods as a means of evaluating specific designs; the cost and accuracy of numerical modelling has improved substantially in recent years with advances in computer technology, making widespread use of hydrodynamic and aerodynamic model testing relatively prohibitive. To the theoretician and physical modeller the same data processing developments have allowed more detailed analyses of test results and improved accuracy in wind and wave modelling and in real-time data measurement. In short, the field of model testing has been advanced by the same technology which has threatened to limit its use.

It was noted several times that there are many instances of disagreement between the results obtained from numerical and physical techniques, ranging from discrepancies in predicting the air gap in semisubmersibles to the difficulty of establishing the wind forces encountered by floating offshore structures. Further problems were seen when comparisons were made with full-scale measurements, and it was generally acknowledged that very little full-scale information returns to the modeller or the designer. One participant suggested that the iterative nature of the design process demands a totally integrated approach, consisting of theoretical work, experimental modelling, numerical simulation, and full-scale measurements. By understanding the relative strengths and weaknesses of each method the designer can benefit from the results.

A major point of discussion was the application of model testing in the development of regulatory design criteria, particularly with respect to stability. The fact that existing criteria are based on empirical methods and do not have a rational theoretical basis seemed to be of less concern to the designers than to those who actually carry out the testing. It was suggested that, although, satisfactory, theoretically-based stability criteria for semisubmersibles would probably not be available in the foreseeable future, every effort should be made to achieve a better understanding of the dynamic principles involved. This area of discussion highlighted the major thrust of physical modelling programs, that of dealing with dynamic factors in situations where only static or quasi-static numerical methods exist. Model testing in MODU design finds its greatest application in examining vessel motions, mooring forces, and towing resistance.

The *Ocean Ranger* model tests provided a challenge to state-of-the-art techniques and encouraged the development of refinements to those techniques. For instance, the simulation of wind loading, with allowance for gusting, was based on a series of aerodynamic tests carried out by the National Research Council (NRC) in Ottawa. The NRC Hydraulic Laboratory modelled the resultant wind forces by using elastic braided filaments connected to the model so as to exert varying loads dependent on the rig's instantaneous position and attitude, the air gap, and the mean wind speed and gustiness. The Norwegian Hydrodynamic Laboratories (NHL) in Trondheim used computer-controlled fans to achieve the simulation. Representatives from both laboratories gained significant experience in the application of these techniques, and, although neither group was prepared to suggest which method might be preferable, the resulting data do provide a basis for analysis. The testing program also pointed out areas for improvement in techniques and measurement. Those participants involved in the testing program carried out for the Royal Commission noted that the tests and the large body of data which entered the public domain at the completion of the Part I report, provide a basis upon which further analyses should be undertaken.

It was evident from the comments of all participants that model testing will continue to be an integral verification process in MODU design, and that the exchange of information between all parties involved would be of significant value.

4

SAFETY MANAGEMENT


Husky/Bow Valley
NATION

SAFETY MANAGEMENT

INDUSTRY SAFETY MANAGEMENT

An Evaluation of Industry Safety Management in Eastern Canada Offshore Drilling Operations
Manadrill Drilling Management Inc.
Calgary, Alberta
June 1984

There has been a significant degree of improvement in the safety of offshore operations in Canadian waters over the past few years. Industry and government are working together in several key areas and new ideas, equipment, and training programs have been implemented. The most significant development has been the marked improvement in safety awareness on the part of employees, supervisory staff, and senior management.

The Canada Oil and Gas Lands Administration (COGLA) has matured significantly since its inception. Industry has grown to accept that COGLA can be an effective control mechanism and is working with the regional and head offices. Regulations, guidelines, and requirements issued between 1982 and 1985 are being observed by industry to the satisfaction of government agencies. The operators have made significant progress in developing an effective voice through the amalgamation of the Canadian Petroleum Association and the East Coast Petroleum Operators Association to form the Canadian Petroleum Association Offshore Operators Division, an effective operations-oriented group that has the support of industry management and the respect of the government agencies. There has also been a definite relaxation of some of the controversial issues, for example, local employment and goods and services, that had earlier undermined the working relationships between government and industry.

The areas that still require attention and that give rise to varying degrees of concern are generally marine oriented or non-drilling issues. These range from a general or overall concern about the administration of marine operations on Canada's Continental Shelf, outside the 12 mile limit, to some very specific concerns around basic offshore industry practices and procedures. Many of the concerns are common to both industry and government.

The lack of a consistent approach to the administration of activities in Canada's Continental Shelf waters is one of the main concerns facing industry and government agencies. There will continue to be a significant amount of confusion, duplication of effort, inconsistent interpretation of regulations, and the possibility of an oversight leading to a serious accident, until this basic legal question is answered. A strong working relationship between the drilling contractors, the owners and builders of the drilling units, the Canadian Coast Guard (CCG), and COGLA is essential to the administration of a strong safety regime. That relationship cannot be expected to develop without a basic definition of the Coast Guard's responsibilities and roles which are in turn directly related to the country's overall administration of its waters.

■ *EQUIPMENT AND SERVICES* The philosophy and the technology related to lifesaving equipment systems and procedures are not as advanced as those regarding drilling and well control. The systems in use for the evacuation of personnel from a MODU in rough weather conditions are inadequate. There is a significant amount of work being done to improve the industry's capability in this area, but this work has been left to the conventional marine equipment manufacturers. Industry and government should take more active roles in the development of systems tailored to the unique needs of the offshore drilling industry.

One specific type of safety equipment that needs reconsideration is the helicopter immersion suit. These suits are less bulky than the survival suits generally provided on drilling units because they are worn on a daily basis and because they provide the manoeuvrability needed if a person is to escape from the cabin of a downed aircraft. The suits do not provide the same degree of thermal protection as regular survival suits, and this is seen as a problem since helicopter accidents are considerably more frequent than abandon-rig situations.

The risk of collisions between supply vessels and MODUs should be lessened as design improvements are made in supply vessel mooring and propulsion control systems. Emphasis is being placed on the need for supply vessels which are designed and built as MODU support craft rather than modified to this use from diving or construction support applications. Concern was also expressed about the adequacy of the qualifications required for the senior command positions on board supply vessels operating in Canadian waters. Personnel from the merchant marine and the fishing industries require special training and a significant amount of on-the-job experience before they are qualified to operate these sophisticated and specialized vessels alongside MODUs.

Concerns were expressed on the part of some of the contractors with respect to the deployment and dedication of supply vessels in the standby role. Supply vessels double as standby vessels in most East Coast operations. Contractors feel that the standby role may be compromised from time to time when vessels are changing functions at the rig. Should an emergency occur while the supply boat is offloading, for example, it may not be in a position to respond immediately in its standby role.

A second area of concern with respect to the use of supply vessels in the standby role has to do with the effectiveness of their recovery equipment and techniques. Industry has adopted the latest, state-of-the-art equipment but industry and government agencies both expressed concerns that the level of training and development of the support vessel crews is not in keeping with the stage of evolution of the equipment. Training requirements should be established and facilities provided to ensure that these crews are well versed in the use of the equipment. The industry should also investigate the development of a set of standards that would guide the support vessel crews in rescue exercises.

■ *SAFETY PROCEDURES* There currently exists a basic disagreement between industry and government on the philosophy of conducting emergency lifesaving drills and exercises on board drilling units. One school of thought advocates some form of regulatory control forcing the contractor to hold these drills on a random basis to eliminate the complacency theoretically created when drills are conducted on a scheduled basis. The opposite school of thought, which includes all of the drilling contractors and most of the operators, believes that random drills do not remove the tendency to complacency and, in fact, can create unnecessary hazards to onboard personnel. It is essential that industry reach a consensus on this very basic element of safety training before unacceptable systems are either adopted or regulated by operators or government.

The philosophy of planned evacuation of MODUs prior to impending bad weather requires serious review on the part of both industry and government. The policies and procedures currently in effect were adopted by industry as the result of political and public pressures. The procedures are inconsistent and the basic philosophy is not universally accepted by either the contractors or the operators.

■ *TRAINING AND DEVELOPMENT* An area of concern that is shared across industry and within government, relates to the onboard command hierarchy in effect on MODUs. COGLA issued a set of guidelines in late 1983 which specified that floating drilling units require an individual responsible for the safety of the unit, qualified in marine matters, who possesses a recognized Master Mariner's Certificate. Although industry has complied with this guideline there is a great deal of controversy over the issue.

Many contractors and some operators' personnel find it difficult to imagine that the forced introduction of a Master Mariner into an organizational hierarchy based on the drilling-oriented management style in use in the Gulf of Mexico, will necessarily improve safety. In fact, this type of action could create enough confusion and misunderstanding to jeopardize the safety of the unit. This issue requires an in-depth evaluation to arrive at a rational solution as soon as possible.

The training and development of offshore personnel has been an area of particular concern to operators, contractors, and government. The most controversial aspect of this issue has been the pressure placed on the industry by government to employ local residents. These pressures are applied directly through the operators in the exploration agreement process. The operators in turn, pass the issue on to their contractors who, in fact, employ most offshore workers. It is generally recognized that industry and government have made considerable progress in adopting the best equipment, systems, and procedures available for use in exploration activities. Equipment and systems, however, are only as good as the people who operate them. If the people are poorly qualified, if they are unfamiliar with their company's procedures and philosophies and if they are not highly performance- and team-oriented, the best equipment available is of little benefit. Interference in the proven, logical, and acceptable industry training practice by manpower agencies whose objectives have been at best somewhat myopic and at worst highly political, may create situations that are hazardous or even catastrophic.

Government manpower and employment agencies require a thorough understanding of the basic employment issues that characterize the drilling industry in order to ensure that the guidelines and regulations they develop are realistic. These issues include the fact that it is the production phase of offshore development that is labour intensive, not the exploratory phase; drilling contractors have proven over the past decade that they will recruit local personnel through the simple rules of supply and demand, and basic economic reality, without political pressure.

The development of a marine emergency training process tailored for the Canadian industry and its operating environment has been a particularly trying experience for all parties involved. The need for a basic universal procedure that prepares personnel for offshore assignments is common to government and industry. After a number of false starts by government agencies, an understanding has been reached with industry, and a commitment made that should lead to the establishment of a program that is tailored to the specific Canadian environment and to the equipment, systems, and emergency safety procedures in use by the offshore drilling industry.

■ *OVERALL EFFECTIVENESS* Many of these individual concerns can be traced to the overall control system and the degree of isolation that system has created for the drilling contractors. The weaknesses in the system are generally in the marine equipment and operations area, in the employment and development area, and in the safety aspects of both areas. These issues lie within the realm of responsibility of the contractors who own and operate the marine equipment and who employ and develop the personnel. Both areas are highly specialized and to a large extent peculiar to the offshore drilling industry, in general, and to the drilling contractors specifically.

The problem facing industry and government is that the drilling contractors are officially isolated from those agencies in the control regime who are responsible for marine and personnel issues. The regulatory control hierarchy places two major components, COGLA and the operator (the contractor's client), between the drilling contractor and the Canadian Coast Guard on marine issues, and the Canada Employment and Immigration Commission (CEIC) on manpower and training issues. Neither COGLA nor the operator have the necessary expertise to deal with these highly specialized issues, but because of the one window, one-voice-control philosophy, they are put in a position where they are making decisions and developing control mechanisms without formal effective input from the contractors.

These problems can be solved without affecting the basic structure of the control regime. The prime requirement is an effective direct communication link between the drilling contractor and those agencies specializing in marine and employment issues. The development of a system that clearly defines the roles and responsibilities of these secondary agencies will eliminate much of the confusion that exists on the part of industry and many of the agencies themselves. This step would provide the control framework and the communication loop necessary to directly connect all principal players in the control regime while maintaining the primary contact between COGLA and the operator.

Industry and government should also investigate the possibilities for the exchange of personnel in hands-on work assignments of one- or two-years' duration to give employees a strong working knowledge of the opposite side of the control regime. This arrangement could form an integral part of employee development schemes for both government and industry.

COMMAND STRUCTURES

Assessment of the Normal and Emergency Command Structures Relating to Drilling Systems for Eastern Canada Offshore Drilling Operations
Currie, Coopers & Lybrand
Calgary, Alberta and Halifax, Nova Scotia
July 1984

Command structures vary in response to regulatory demands and also to the requirements of the different rig types and their modes of operation. On a jack-up rig, a senior toolpusher (or a rig superintendent) commands the unit while it is drilling, while the barge master on board is responsible to the toolpusher for safety, logistics, and lifeboat operations. The command of the jack-up is formally signed over to a certified rig mover when the rig is being moved or under tow. All drill ships, whether anchored or dynamically positioned, are required to have a Master Mariner on board and in full command, although on an anchored drill ship, the senior drilling person may be in command during drilling operations.

Semisubmersibles always have a marine captain on board except in the United States where an accepted equivalent is a person with a Limited (Column-Stabilized) Master's ticket. The command structure, however, is not always clear as it depends on whether the rig is drilling or in transit, and on the regulatory regime under which it is operating. As with jack-ups, where the captain does not have full command at all times, the captain of a semisubmersible, in most instances, has full command only while the rig is being moved and during an emergency situation. When a semisubmersible is in the drilling mode, it is usually the senior drilling person who is in command. This is not true for Norway, however, where the Marine Captain, who also has drilling qualifications, is in overall command at all times.

■ *COMMAND QUALIFICATIONS* Although many improvements have been made in recognizing the importance of command structure to the offshore drilling industry, there are a number of areas where confusion still exists or where changes need to be made. A shared or divided command system could lead to potential confusion and a weakened emergency response. A strong, unified command with a blend of marine and managerial skills, attitudes and experience would seem to be most suitable in the Canadian context, but there is a serious shortage in the supply of people qualified and available for such command positions. This situation could be improved by establishing offshore drilling as a specialty section of Canadian marine training with specific theoretical and practical subject matter related to drill ships and semisubmersible drill rigs. Industry has already commenced discussions with the Coast Guard to see if drilling personnel can be trained in marine operations aboard Coast Guard vessels and if Coast Guard captains can be trained on board drilling rigs in drilling operations. This type of interchange would assist in improving the skills available to the industry. In addition, it would greatly enhance the Canadian Coast Guard's understanding of rig operations and design principles.

As part of this recognition of the qualifications required to assume a MODU command position, industry-wide standards and a certification process should be developed. Training and certification programs should also be required for other key positions including senior drilling staff, first mates, captains, ballast control operators, and lifeboat captains.

Until there is agreement on the qualifications and standards required for semisubmersible and drill ship commander positions, and until certification programs are developed and the supply of qualified rig commanders is adequate, command structures which are not completely unified will continue to exist. In the interim, command structure documentation should recognize clearly those aspects which will be delegated by one individual to others in the chain of command and the limitations of authority involved in each instance.

■ *EMERGENCY SITUATIONS* It is also important that the command structure for normal operations support the structure which will be required in emergency situations. Even though the captain may have delegated substantial responsibilities to the drilling supervisor while drilling operations are being carried out, he must remain active in terms of coordinating the overall safety program, supervising support functions such as maintenance, and conducting emergency drills. In this way he will be seen as the ultimate "safety commander" and authority in marine and overall rig safety matters. Emergency response plans should indicate clearly the alert conditions which trigger the assumption of full active command by the captain. Guidelines for the development of clear organization charts should be developed by industry for different command structures. The adoption of common documentation practices and methods of showing lines of authority, functional relationships, and advisory relationships between elements in the drilling system would be beneficial to a uniform understanding of emergency response plan and command structure documentation.

Further work should be carried out in identifying the specific conditions which trigger alert stages, and in defining activities to be undertaken at each stage by the command structure. The alert stages of current industry emergency response plans are not adequately defined for onshore personnel, nor are the heavy weather conditions for an onboard alert clearly stated. Also, the conditions under which government Search and Rescue becomes actively involved are not indicated. Decision-making by industry in response to a particular emergency is most effectively made at the site of the emergency. This should be clearly stated in company emergency response plans which currently imply that key decisions are to be made by shore-based managers. While industry has developed a formal "mutual aid" system which significantly enhances any rescue operation, it remains necessary to ensure that Canadian marine and air search and rescue services are fully aware of the industry's emergency response plan and that onboard drills are carried out regularly and effectively.

Industry sources indicated that safety drills on board most rigs provide adequate training for individuals to carry out their normal duties in an emergency situation. These exercises should be conducted periodically, however, to ensure that back-ups for key positions also understand how to carry out the duties of their superiors should they be injured or otherwise unavailable during an emergency. This requirement is particularly important considering earlier findings that the overall level of training and experience among those in back-up positions is significantly less than that of those in charge.

Exercises involving Search and Rescue, the Coast Guard, and other government regulatory agencies have been carried out. It is particularly important to test the procedures and communication systems involved in these exercises as close logistical support among independent units will be required during emergency situations. In this regard it might be useful to implement regular interval drills at all levels in the command structure, and to require that simulated emergency exercises involving Search and Rescue, the Rescue Co-ordination Centre and Coast Guard, be carried out by each rig at least once per year. Exercises aimed at testing the effectiveness of the joint operator alert response plan should also be carried out on an agreed frequency basis. These exercises would be designed to test inter-operator communication systems, emergency response readiness of designated helicopters, emergency response readiness of other operator supply boats, as well as other elements of the system such as the functioning of Sable Island as an emergency base.

COMMUNICATIONS

Assessment of the Means of Communications in Relation to Eastern Canada Offshore Exploratory Drilling
NORDCO Limited
St. John's, Newfoundland
July 1984

A drilling unit needs to maintain long and frequent communications contact with its shore base. The type of communications services needed and provided on a drilling unit include voice, telex, or teletype, telecopier or facsimile, and data. Both the drilling unit and its shore base also need to be capable of voice communications with transport helicopters and support vessels. The ship, shore, and helicopter stations are required to meet a fairly comprehensive and detailed set of regulations under international, Canadian, and other flag state conventions. These include the *International Telecommunications Regulations* (ITR), the *Canadian Radio Act* (Department of Communications), *SOLAS Convention*, the *Canada Shipping Act* and its component regulations, the *Canadian Aeronautics Act*, and relevant sections of the *Canada Oil and Gas Drilling Regulations*.

■ *REGULATORY STANDARDS* A question exists as to whether communications systems on drilling units should adhere to regulations pertaining to passenger or to cargo vessels. Standards are now being prepared by the Canadian Coast Guard to address this problem and to determine whether Canadian regulations apply to vessels or MODUS operating outside the 12-mile coastal limit but within the 200-mile territorial limit.

Pertinent regulations of the *SOLAS Convention* must be adhered to by the vessels whose flag state is a signatory to the convention. For vessels and MODUs operating in Canadian waters offshore, a request must be received from the country of registry before an inspection takes place and radio certificates can be issued under the *Canada Shipping Act*. Ships registered in countries that are not signatories of the *SOLAS Convention* must be inspected under the *SOLAS Convention* and the *Canada Shipping Act* for customs clearance purposes but radio certificates are not issued. The *Canada Shipping Act* applies to all ships operating in Canadian waters and its regulations are more stringent than those practised under the *SOLAS Convention*. The specific equipment requirements under the *Canada Shipping Act* are determined by the frequency zone in which the vessel is operating.

■ *DESCRIPTION OF PRESENT SYSTEMS* Helicopter communications are covered under the *Canadian Aeronautics Act* which states that two-way voice communications must be maintained with control central throughout the flight. The aircraft is also required to carry an emergency locator transmitter and, under instrument flight rules (IFR), a radio direction finder. Equipment specifications, however, are not included.

Most drilling units operating off eastern Canada in 1984 have satellite communications terminals (mostly linked to INMARSAT), which provide voice, telex, facsimile, and data communication services. Satellite communications facilities are being used even though there are no regulations which make them mandatory. These terminals, through geostationary satellites, provide a highly reliable link to the shore base. The satellite terminals are equipped with an emergency override channel which provides immediate and automatic access to shore when activated. As with most communication links, (except cable links), the size, positioning, and stabilization of antennas are important features in maintaining communication reliability. Stabilization of the ship or drilling unit antenna in relation to satellite position must be maintained regardless of the pitch or roll of the vessel.

Because of high satellite user costs, the prime communications among the components of a "drilling system" are basically provided by MF/HF and/or VHF links. Of the two links, the VHF link is more reliable but is effective only within line-of-sight (up to approximately 80 kilometres). This primary link is used in the coastal exploration zone including Sable Island and the Scotian Shelf. The MF/HF links utilize ground- and/or sky-wave mode of propagation. The effective range of the more reliable ground-wave mode is approximately 350 kilometres. The ground-wave mode is prevalent for drilling operations in the middle exploration zone including Hibernia while the longer range, but less reliable sky-wave MF/HF mode is used in more distant locations such as offshore Labrador.

The range and quality of communications by means of the above links may be degraded due to environmental phenomena such as lightning, rain, snow, wind, and sea ice. The VHF links suffer the least while the MF ground-wave propagation links may be severely affected during storm conditions. The reliability of HF sky-wave links is affected by variations in ionospheric conditions which may introduce significant noise during the night.

The communications link with helicopters is primarily provided by the VHF aeronautic band while the prime link with support vessels is provided through the VHF marine band. Both helicopters and support vessels carry MF/HF equipment as well. These links are somewhat weaker than those between the drilling unit and the shore base because the latter are reinforced by the satellite link. All the above links have multichannel capability, thus providing transmission/reception frequency redundancy. In particular, on drilling units and shore bases, multiple antennas and receivers and spare transmitters are provided, with automatic selection and switchover capability. Adequate back-up or emergency power is provided through lead acid batteries.

Although any two components of two nearby networks may not share a common private frequency, communication is possible through a number of frequencies provided on the VHF, MF, and HF bands for public correspondence. Special call frequencies may be used to establish a common working link for temporary use through an intermediary Coast Guard station. These stations are required to maintain a continuous listening watch on international distress and calling frequencies (500 kHz – telegraph under the *SOLAS Convention*, 2182 kHz, and 156.8 mHz). Most ship stations are also required to maintain this watch.

■ *RESEARCH AND DEVELOPMENT* Research aimed at improving satellite and other methods of communication is ongoing. Meteor-burst propagation systems in which VHF and Ultra High Frequencies (UHF) are propagated by reflection from columns of ionization are being examined. One-way communication of voice and facsimile has been tested, as have two-way telegraph circuits which operate over distances of 800 to 2,000 kilometres. Other developments are the radio telephone with automatic channel evaluation (RACE), which utilizes switched telephone systems, and the mobile satellite systems (M-SAT) which allow transmission of text messages over vast distances. RACE does not appear to be capable of providing high quality voice or data circuits, while the M-SAT system is still in the feasibility and design stage with anticipated demonstration service available between 1986 and 1994.

■ *CONCLUSIONS* The communications systems presently used offshore are reliable and appear to be adequate to meet the needs of exploration companies. It would enhance safey considerations, however, particularly in emergencies to equip helicopters with VHF marine band radio equipment and/or standby vessels with VHF aeronautic band equipment thus permitting immediate communication between the two support services. Drilling units, particularly those operating at distances greater than approximately 80 kilometres offshore (which may be outside the VHF coverage area of the Coast Guard Station), should be equipped with satellite communication terminals. The costs of establishing these links might be borne by a pooling of operator resources to provide the best possible antenna facilities for a particular area. General reliability of communications systems can be enhanced by following a regular preventive maintenance schedule and having spare parts and a qualified technician capable of repairing communications equipment on board each MODU. A communications contingency plan should be prepared and made available to radio operators outlining the procedures for using communications equipment in the event of a link breakdown. The applicability of Canadian regulations to offshore drilling units, particularly those that are foreign-owned, should be clarified.

Long-term benefits would accrue from the compilation of a communication reliability data base for the study area, and from research into enhancing MF/HF and VHF communications reliability through improved antenna designs and employment of space, path, frequency, and polarization diversity.

Summary of Safety Management Seminar

The safety management practices employed by corporations to monitor and improve worker and workplace safety vary according to the management philosophy of individual corporations and the degree to which industries are regulated. On September 17, 1984, the Royal Commission sponsored a seminar which examined the topic of Safety Management. Speakers from operating companies, drilling contractors, and supply vessel owners were invited to present papers on the safety management practices used within their respective companies. To stimulate discussion and provide a different perspective, representatives from Du Pont Canada Inc. participated in the seminar. With an outstanding record of safety performance in a hazardous industry, this company is acknowledged to be a leader in safety management.

Du Pont's safety management programs have proven effective in other industries such as mining. Workers are represented on the majority of Du Pont's committees and management selects the members of the safety committees with the objective of getting the best people involved regardless of their affiliation. Some plants' safety management programs have been developed by groups of workers with the assistance of a supervisor. This gives the workers a sense of ownership and commitment to the program, and this in turn has a significant effect on program results. Du Pont has not found it necessary to establish a policy on refusal to work because management deals with the workers' perceived risks as well as the actual hazards identified.

The operators and drilling contractors indicated that all levels of management are responsible and accountable for safety performance. While the chief executive officer is considered ultimately accountable for a company's safety performance, the individual workers are also responsible to perform their duties in a manner which is safe to themselves and to their fellow workers.

With the primary emphasis being placed on the prevention of accidental occurrences, the industry gives safety a high profile in a number of ways:

- Making it an integral part of each operation through regular safety meetings;
- Providing a safe working environment;
- Ensuring that appropriate work standards are established and followed;
- Providing funding for improved equipment;
- Providing continued safety training of personnel;
- Developing joint emergency response plans and exercises.

Most companies utilize formalized safety audit programs to verify the success of safety efforts in their operations. Successful safety management requires demonstration of commitment to safety by top management. Worker involvement in safety management programs including safety committee meetings and safety award programs appear to be standard practice in the industry. Safety meetings involving all employees provide a forum for hazard identification by workers, and for review of actions taken in response to previously identified hazards.

The regulatory authorities hold the operator responsible for the safe completion of the approved drilling program, and consequently, operators require their contractors to meet and maintain specified safety standards. Operators take the initiative to monitor the safety programs of their contractors. A government representative suggested that the safety management programs of operators and drilling contractors are the keys to accident prevention and effective emergency response. It was unanimously recognized that government regulations at best represent minimum standards.

A drilling contractor suggested that the regulatory agencies should assume the role of a certification board for training courses which are necessary for the safe and efficient operation of MODUs. The curricula and examinations for training courses should be primarily developed by the industry; the regulatory agencies should ensure that the curricula are appropriate, that the examinations are rigorous enough to ensure student proficiency, and that training institutions are accredited. The Canadian Petroleum Association (CPA) stated that of the 34 positions outlined in the report *Guidelines for Minimum Training Qualifications/Standards (Floating Units Only) MODU Crew Personnel for Operation on Canada's East Coast*, those which overlap the marine and drilling disciplines should be certified by industry. The certification of marine qualifications by the Canadian Coast Guard is a well established and accepted practice. The operators recognized the need for periodic recertification for certain qualifications to ensure that workers maintain a high level of competency. It was suggested that industry would, without excessive regulation, continue to develop training courses by means of industry certification and recertification.

Both industry and government representatives agreed that the collection and analysis of accident statistics need to be improved. CPA has undertaken a data collection effort for the East Coast drilling operations and COGLA's Medical Advisory Committee has initiated a study to determine appropriate parameters for a data collection system. At present, COGLA provides feedback to industry after a government analysis of accidents if it is judged appropriate and provided confidentiality of an operation can be maintained.

Representatives of Du Pont, which has operations in over 30 countries, reported that regulations have had no impact on the company's safety practices as it maintains a safety standard which exceeds regulatory requirements. A representative of Du Pont suggested that governments should redirect their efforts to improve occupational safety by developing and clearly expressing specific objectives and demands for performance, and by developing a consistent statistical base to measure performance. Du Pont suggested that merit ratings for companies, based on safety performance, should be considered in workers' compensation assessments.

It was recognized that operators' health and safety departments perform complementary functions yet safety departments are well established compared to occupational health departments which have only recently been given broad management guidelines and scope. Drug and alcohol abuse have been recognized by industry as potentially significant problems in the offshore industry. Preemployment screening and intensive security clearance systems, for screening personnel prior to departure for offshore rigs, are used to control drug abuse. Some operators have established assistance programs for personnel with chronic drug or alcohol abuse problems, and the CPA conducts ongoing reviews of drug and alcohol problems through its various committees.

A standby vessel contractor suggested that fast rescue craft training is a primary means of improving safety performance. An operator suggested that there is a need to assess the performance of safety equipment prior to requiring its installation by law.

5

TRAINING

TRAINING

MARINE AND SAFETY TRAINING

Marine and Safety Training in the Eastern Canadian Offshore Petroleum Industry
College of Fisheries, Navigation, Marine Engineering & Electronics
St. John's, Newfoundland
May 1984

The operating efficiency and performance record of any industrial activity depends on an appropriately designed system and properly trained personnel. Unless an activity is totally automated, it is necessary to have personnel who have either acquired specific job skills or have the potential to acquire the necessary skills through training and experience. The offshore drilling industry is a rather unique industrial activity simply because it takes place in a marine environment. Consequently, the industrial system on a MODU is designed to cope with operating constraints which do not occur in typical onshore industrial activities. Similarly, persons working offshore must possess job skills that in some instances require knowledge, training, and experience in two distinct areas: marine operations and drilling operations. Since offshore drilling is a relatively new industrial activity the workers who possess the optimal blend of marine and industrial skills are limited. There should, therefore, be a concerted effort made by the industry and government to develop training programs which will ensure that personnel will be able to perform their duties safely and effectively.

Differing attitudes towards offshore training in the United States, the United Kingdom, Norway, and Canada, result in a diversity of approaches and funding practices. The Norwegian model is based on the belief that society must accept responsibility. Therefore, in Norway the government plays an active role in regulating not only marine and industrial training for MODU crew members, but also safety training. Generally the funding of these programs is provided by the government. In the United States, however, the amount of government control is very limited. Certain regulatory requirements exist for senior marine and industrial personnel. The mode of training and funding are entirely the responsibility of industry. In the United Kingdom, the administration and funding of offshore training have changed over time. Initially the government set up and supported training boards whose role it was to organize and administer programs for the industry. Funding for these boards and their training programs was received from levies imposed on industry. Industry associations have now taken over control of the training boards and programs are arranged as requested by members of the various industry associations. Several commercial training institutions provide a wide range of specialty courses, notably in safety and survival training.

In Canada, regulatory requirements governing offshore training have tended to be general in their application. Before the loss of the *Ocean Ranger*, there were specific well-control training requirements for senior drilling personnel, but marine related requirements and specialty training programs (survival and safety related) were not mandatory. Since 1982, regulators and the industry have focussed specifically on the training needs of offshore workers. Industrial training programs, funded by industry, have been developed for offshore workers by the Petroleum Industry Training Service (PITS). Specialty training programs have also been developed by both public educational establishments and by commercial training institutions. These programs cover basic emergency and survival training and are funded by fees levied on participants. There is no mandatory government standard for these safety training programs.

To ensure safe and efficient operations in the offshore industry, standards should be developed by government in consultation with the industry and training institutions. These standards should apply to personnel who are employed on MODUs, marine support vessels, and aircraft. Some attempt should be made to ensure that these standards are recognized internationally.

■ *BASIC EMERGENCY TRAINING* In the performance of their assigned duties, individuals participating in an offshore operation are responsible for acting so as to prevent hazards arising, making a correct initial response to a situation which does arise, assisting others to survive, and acting to ensure personal survival. Basic safety training endeavours to prepare personnel to meet these responsibilities, although the content and provision of such training vary widely between the United Kingdom, Norway, the United States, and Canada.

In the United Kingdom, the Department of Energy requires all persons working on a MODU on the U.K. Continental Shelf to have suitable training for their own safety. While the requirements are stated in the *Mineral Workings (Offshore Installations) Act* 1971 and the *Health and Safety at Work Act* 1974, these Acts do not specify standards. Guidelines to meet the legislated requirements have been prepared by the U.K. Offshore Operators Association (UKOOA) with the Offshore Petroleum Industry Training Board (OPITB) and recommend varying levels of safety training for different categories of personnel. The training is provided by institutions within the United Kingdom, but, because these guidelines have no legal status, operators have found them difficult to enforce on their contractors.

In Norway, all offshore workers are required to undergo basic safety training based on standards agreed to in the LEIRO II syllabus. The course requires comprehensive onshore training for two weeks supplemented by one week of on-the-job training arranged by the employer. Because this formalized training schedule is applied to all offshore workers in Norway, concern has been expressed that insufficient facilities are available to meet the training needs of the large work force. Consequently, Norway has approved at least one United Kingdom training institution to offer LEIRO training since the standards required by the United Kingdom are very similar to those required by Norway.

Attitudes in the United States towards basic safety training are different from those in the United Kingdom and Norway. There are no statutory requirements for basic safety training for personnel on U.S. registered MODUs. Indeed, most U.S. companies feel that offshore survival training is not necessary for all persons working on a unit and prefer to provide their own on-the-job training and drills to achieve a satisfactory level of competence. One factor affecting this attitude is the relatively high turnover among drilling personnel.

Although in Canada the regulations require all persons employed offshore to have some degree of basic safety training from an approved course, there are not yet any nationally-accepted standards for achieving these requirements. The Marine Emergency Duties (MED) certificate offered by the Ministry of Transport is an accepted start, but the industry considers this program lacking in specific MODU content since it was designed for shipping operations. To fill this void, the industry has proposed the five-day Basic Offshore Training (BOT) course, which offers four levels of training for the various classes of occasional visitors and for regular offshore workers. The Newfoundland and Labrador Basic Offshore Survival Training (BOST) course which is similar to courses offered in the United Kingdom and Norway, is two weeks long, and also takes into account regular and occasional workers.

The course contents of BOT and BOST have much in common; industry and government are working towards agreement on a single national standard. They agreed that standards should include two core components: offshore hazards – fire prevention and control; and rig abandonment – rescue and survival. These standards should be offered at varying levels to established categories of persons spending different amounts of time offshore, with selected persons being provided with supplementary training in such specific areas as, for example, helicopter procedures and radio operations.

■ *SPECIALIST EMERGENCY TRAINING* The main response to various emergencies on MODUs is handled by personnel with specialist training with assistance from those with basic safety training. This approach makes it unnecessary to train everyone to a high level of proficiency in dealing with a specific situation. Also, some responses are better carried out, or can only be carried out, by a team practiced in coordinated working. Nevertheless, no country has sufficiently addressed the subject of specialist emergency training, and there are few formal requirements for personnel so trained, although in Norway and the United Kingdom, numerous courses are available and are used by the industry. Some typical examples of specialist emergency training include: damage control team, firefighting, man-overboard boat crew, survival craft coxswain, and first aid.

Specialized damage control training is required only in Canada by directive from COGLA who observe damage control teams in action to verify their capability. In the United States and Norway, senior marine personnel on MODUs receive training in basic damage control for ships as part of their marine training. In addition, in Norway, the LEIRO basic safety training course includes some instruction in damage control.

Firefighting teams and leaders generally follow the traditional marine pattern, although on MODUs selected drilling personnel may be included on a team. Norway and the United Kingdom offer advanced fire training at a number of schools, while in the United States, where fire training over and above that included in regular marine training is not required by law, some courses are available at schools usually associated with universities. Canada has no specialist courses available for MODU fire teams, and personnel are sent to the United States or overseas for such training. All regulatory bodies do, however, require helicopter firefighting training. Such courses are offered in the United Kingdom and the Netherlands.

All MODUs designate a man-overboard team to operate the Zodiac-type inflatables or fast rescue craft (FRCs) used in a man-overboard emergency. Man-overboard training is generally confined to onboard drills, since no specialized courses are available, other than those aimed at FRC teams serving on standby vessels. While in the United Kingdom the man-overboard drills for standby vessels are included in the UKOOA guidelines, neither the United States nor Canada has regulations on how the drills are to be conducted, and companies are left to devise their own standards in this area.

Personnel with special survival craft coxswain training are required in the United States and Canada, and such a requirement is also standard practice in the North Sea offshore industry. Lifeboatman courses usually take one or two days over and above basic safety training, although in the United States the course for a Lifeboatman's Certificate is five to eight days. Emphasis in these courses is on practical training in all phases of survival craft operation.

Specialist medical teams, to assist the rig medic in coping with emergencies, are required by the contingency plans in effect off eastern Canada. Training of these personnel is generally limited to first aid.

General safety training does not sufficiently address specialist needs, especially given the isolated, distant nature of the industry off eastern Canada. Specialist facilities need to be developed in Canada, preferably at existing institutions that offer basic safety training. Since formal requirements for specialist training are few, those developed should incorporate the need for specialist personnel to participate in regular drills and to undergo periodic refresher training.

The composition and structure of the crew on a MODU varies with the type of MODU, its activity (whether it is drilling or whether it is moving on/off or to/from a drilling site), its flag of registry, and its owner's operating policies. Generally crews can be divided into three major groups: marine, industrial or drilling, and domestic support. Marine crew structures on MODUs show considerably more variance than do the drilling crews. The structure of a drilling crew is similar on all MODU types regardless of flag. The marine crew component depends upon the MODU's flag and its type.

■ *MARINE CREW* The marine crew standards on drill ships tend to be similar, regardless of registry. They have fully certified officers and trained seamen. Jack-ups usually have a skeleton marine crew on board while the rig is operating, but, when it is being moved to a new location, a special marine crew prepares the rig for ocean transit and takes it to its new drilling location. Semisubmersibles exhibit the greatest variation in marine crew. For units registered in Norway, the United Kingdom, and Canada, certified officers and seamen are required to be on board at all times, whereas for units registered in the United States, a certified marine crew is required only for long voyages, and then, only if the rig is self-propelled.

The training and certification of marine crews on MODUs also exhibit significant differences among the various jurisdictions. These differences reflect not only different regulatory philosophies but also result in different command structures. Norway, Canada, and the United Kingdom tend to regard MODUs as vessels engaged in industrial activities and consequently require certificated officers and crew. The United States, however, tends to view a MODU as an industrial site, thus they allow marine crew members to hold "industrial" licences rather than traditional "marine" certificates.

In Norway, the person in charge must always be a Ship's Master with one or two years' previous MODU experience in a senior position. The master is required to complete the six-week platform manager's course in such subjects as drilling technology and rig manoeuvring. This course provides most of the additional knowledge required by a mariner to manage a MODU. The master does, however, have a statutory duty to consult both the Drilling Section Leader and the Stability Section Leader in any circumstances which endanger the drilling installation.

For Canadian and British registered MODUs, the person in charge must hold a Master Mariner's Certificate. In the United Kingdom, Master Mariners must attend a two- or three-day Offshore Installation Manager's course, which is designed to provide information on legal obligations, rather than insight into operational aspects of MODUs. In Canada, since September 1983, Masters of MODUs are required to attend the five-day MED III course which emphasizes leadership in various emergencies. Operators of foreign-registered MODUs working on either the Canadian or United Kingdom Continental Shelf are required to nominate a person in charge, but the responsibility for ensuring that a suitable person is nominated rests with the owner and there are no specific training requirements.

The U.S. requirement for a Master Mariner, for drill ships and self-propelled semisubmersibles in passage, involves no additional MODU-specific training. For units where a qualified Master Mariner is not required, a special Industrial Master's License is mandatory. Typically candidates for Industrial Master should have four years' service on a drilling unit including two years in a responsible position in either the marine or drilling crew, or a Bachelor of Science degree and three years' service, including one year in a supervisory position. In addition, the master must possess an approved radar training course certificate and an approved well-control certificate. The special Industrial Master's License can be obtained after only 15 to 20 days of formal training. While this type of licence is apparently appropriate for operations in the Gulf of Mexico, it does not ensure sufficient depth of knowledge for safe operations offshore eastern Canada.

The person in charge must fully appreciate the relationship between drilling activities and the marine operation as well as the capabilities and limitations of the unit. Neither a master nor a toolpusher without special training in the operations of a specific MODU type can be assumed to have all the knowledge needed to command a MODU. Canada has, at present, no system for conducting, approving, or certifying either MODU-related training for masters or marine training for toolpushers. Consideration should be given to establishing a course which would familiarize licensed masters with drilling operations and the special characteristics of MODUs and provide them with a "MODU Master" endorsement. For a jack-up unit on station, the toolpusher could be the person in charge provided he has completed a course which familiarizes him with eastern Canadian offshore conditions and marine emergency duties.

The first mate on a MODU is generally required to have an appropriate marine certificate. Norway is the only country which requires a mate to receive additional training in stability and MODU operations. On U.S. registered MODUs persons with an "industrial" licence are acceptable under most circumstances. Canada does not require additional training for mates other than that obtained during their traditional marine certification program. Although the mate's standard training is a good foundation, it does not address the special features of MODUs. Advanced training should be required in stability, MODU operations, firefighting, damage control, man overboard, and the deployment of survival craft.

There are as yet no widely accepted standards for training ballast control operators (watchstanders). Internationally there has been a great deal of activity in developing new courses. Many focus on the stability of semisubmersibles, which in itself is not sufficient. In the United States there are no legal requirements for training ballast control operators, although one training institution does offer an intensive course using a simulator and self-instruction workbooks. There are also no specific requirements in the United Kingdom for their training and certification. The owners are expected to provide suitably competent persons to ensure safe operations.

Norway has the only formalized training program for ballast control operators. Areas covered in their training include control room operations and ballasting as well as basic marine or technical training. The Canada Oil and Gas Lands Administration (COGLA) requires that ballast control operators on units operating off eastern Canada must have attended an approved course in ballast control for floating units. There are no published standards, however, for their training. The minimum qualifications vary as do the training programs offered by drilling contractors. Their training should include stability of multihull MODUs both intact and damaged, ballasting procedures in the event of damage or loss of the main control system, and an appreciation of the effects of anchor tension on stability and trim. Some instruction on the actual unit's system should also be included. The Watchkeeping Mate Certificate would be a good basis on which to develop these courses.

In Norway, the Chief Engineer is known as Technical Section Leader. In addition to holding a Certificate of Competency, Marine Engineer Officer Class 1 (Machinery or Electro Automation) or Chief Engineer's Certificate, and having at least one year's experience as Technical Assistant on a MODU, he must undergo an approved course of training for Technical Section Leaders. On U.K. registered vessels, engineers are not required to have specialized training in order to work on a MODU. The level of training required to ensure competency is left to the owner to determine.

MODUs generally have a Chief Engineer on board at all times who is responsible for the operation and maintenance of electrical, mechanical, and lifting equipment. The U.S. Coast Guard issues certificates for Chief Engineers of "column-stabilized or self-elevating mobile self-propelled motor drilling vessels of any horsepower." Candidates for Chief Engineer require four years' service in the operation, construction, or maintenance of diesel engines, and at least two of them should be as oiler, engineer, mechanic, electrician or similar on a suitable MODU. In the United States, most companies train engineers in-house, using on-the-job videos, slide and tape presentations, and packaged courses. Some companies have candidates take a variety of short courses, either in-house or externally.

MODUs of Canadian registry carry engineers who hold conventional merchant vessel First and Second Class Engineering Certificates. There is a general shortage of persons holding a First Class Engineer's Certificate in Canada. There are no special requirements for training and certification of engineers for MODUs. Consideration needs to be given to setting up a course which provides suitably qualified engineers (not necessarily marine) with an understanding of all the requirements of MODU machinery and systems. This could be used as the basis for a MODU Engineer certificate. Current Canadian examination standards for normal First or Second Class marine certificate levels, or their equivalent, appear adequate. The U.S. Coast Guard MODU Engineers examination is of a lower standard, and may not be appropriate in eastern Canada.

In the United States, Norway, and the United Kingdom a Radio Operator Second Class Certificate is the generally accepted qualification for radio operators on MODUs fitted with radio telegraphy and engaged in foreign voyages. It is not unusual, however, for an exemption to be granted since trans-ocean voyages are fairly infrequent for most semisubmersible and jack-up MODUs, and they are usually accompanied by other vessels. Norwegian MODUs must carry two radio operators with Marine Second Class certificates. Training courses for all certificates except the Restricted Radiotelephone are generally between six months and two years long and cover major radio technologies (MF, HF, VHF); most courses are weak in the newer telex, telemetry, and satellite transmission systems. The present Restricted Radiotelephone Operator's Certificate issued in Canada does not indicate a sufficient level of competency to qualify radio operators to work on a MODU unless the employer has provided adequate supplementary training in the operation of specially installed equipment and in emergency procedures. Radio operators with certificates higher than the Restricted Radiotelephone Operator's Certificate are adequately trained to work on MODUs. The earth station endorsement proposed by a Department of Communication/Canadian Coast Guard task force would be beneficial if a MODU is equipped with a satellite communications system.

There is no formal requirement in the United States or the United Kingdom for crane operator training. Industry practice is either to send crane operators to an onshore school, or more commonly to provide on-the-job training under supervision. In Norway, the regulations require that a crane operator must have served on a MODU or platform for six months as a roughneck or roustabout, have completed a training course approved by the Maritime Directorate, and have experience in operating cranes on a MODU under the supervision of a licensed crane operator. Onshore crane operator licences are accepted, but additional training may be required. In Canada, there are no regulations requiring training or certification of offshore crane operators, nor are there any specifically organized courses for crane operators; Canadian owners of MODUs currently make use of schools in the United States. Consideration should be given to establishing a facility for realistic offshore crane operator training in eastern Canada.

In the United Kingdom, there are no specific requirements for Helicopter Landing Officer (HLO) training, but most companies use the special two-day course offered by Petroleum Training Association North Sea (PETANS) and Scottish Offshore Training Association (SCOTA). The course has been developed as a result of cooperation between all parties concerned and although it has no official status, it is effectively an "approved course". The training requirements on mobile drilling units in Norwegian waters are essentially the same as those in the United Kingdom. The position of helicopter landing officer is not officially recognized on most units operating off Canada, and is not filled by any particular class of crew member. There are no established courses in the United States or Canada for this position; specific training takes place on the job. In a complex and potentially hazardous situation, the presence of a trained person, able to understand the sequence of events and react to any incident is essential. A committee, comprised of helicopter operators, MODU owners, and government should be set up to consider existing European training courses with a view to requiring similar training in Canada.

Only Norway has the formal requirement of a First Mate's Certificate for Dynamic Positioning (DP) Operators. Additional training is usually provided on the job. Manufacturers offer basic operation courses which are generally attended by DP personnel from new units, who then train their successors on the job. The U.K. Nautical Institute has made a proposal which is under consideration, to the U.K. Department of Transport for formalization of DP Operator training. In Canada, the establishment of a suitable DP Operator course and the provision of simulator facilities should be taken under advisement. This may not be necessary if DP equipment suppliers can provide adequate training. Simulator training is the only practical way to practise emergency actions.

Canada has the only formal requirement for the training of ice and weather observers. They must pass the aeronautical and maritime weather observation examinations of the Atmospheric Environment Service (AES). Companies can arrange their own training with AES approved instructors. Examinations for the Supplementary Aeronautical Weather Observer's qualification are administered by AES staff. Most new observers require eight to ten days to become familiar with meteorological equipment, observation, and standard recording formats. In addition, companies provide about two days' training on company procedures, oceanographic equipment, and observation. For observers on units where icebergs may be expected, the companies arrange additional in-house training on ice plotting. Training in radar observation is provided in-house or through a local training institution. The training of observers appears to be adequate for their tasks, especially where the policy of having new observers accompany experienced personnel for a time is practised.

■ *DRILLING CREW* The composition of the drilling crew is similar for all MODU types regardless of flag. The drilling crew is divided into two "tours", each working twelve-hour shifts. They are supported by various specialist service personnel who are usually directed by a representative of the operator. Only Norway has a comprehensive training scheme for drilling personnel, which is oriented towards offshore operations. Canada and the United Kingdom require blow-out prevention (well-control) training for key drilling personnel; the United States requires it for all drilling personnel. Well-control training is necessary for all key personnel and should include instruction on the subsea blowout preventer (BOP) unless, as in the case of a jack-up, a subsea BOP is not used. Subsea engineers, in particular, need to be well trained in the use and maintenance of these devices. There are adequate facilities for drilling training in Canada, but there is a need for consultation between government, industry, and the educational sector to make the best use of these facilities to provide specialized offshore training. Reciprocal acceptance of Canadian well-control certification with other countries should be sought. Because of the nomadic nature of the industry, it is a great advantage if drilling personnel can operate in other countries without recertification.

■ *SUPPORT SERVICE CREWS* An offshore drilling program receives logistic, supply, and transportation support from both vessels and aircraft. Offshore support vessels perform a number of specific tasks: they carry supplies and diving support systems, perform anchor handling duties, and tow icebergs. They may also act as the MODU's dedicated standby vessel and are, therefore, fitted with fast rescue craft (FRC) and other basic rescue and emergency equipment. The normal marine training of officers and seamen, while adequate for general performance of their duties, does not cover certain aspects of marine support, particularly the transfer of cargo at sea. To bring confidence to the crews, additional training needs to be provided. For vessels fulfilling a standby role, crew members must have considerable experience at sea but they must also receive rescue and emergency training. Deck hands on vessels performing standby duties are currently inadequately trained in using specialized rescue equipment, new recovery techniques, or handling large numbers of casualties. A course, therefore, needs to be developed which will provide them with a thorough grounding in standby and rescue duties. The FRC crews need specialized training and regular practice, but all crew members must be trained to launch and recover fast rescue craft, to recover survivors from the water, and to give initial treatment for hypothermia. All standby vessel crew members regularly employed on support vessels should have the same level of training in basic safety and survival as MODU crews, including training in the use of specialized lifesaving appliances not covered by MED II. Regular drills and refresher training would be required to ensure they maintain their skills.

Government control of aircraft operation in Canada is extremely stringent with respect to equipment, personnel, and operations. Local offshore helicopters are equipped to carry hoists and other rescue equipment which is held on shore, but crews specially trained in the operation of this rescue equipment are not employed by the helicopter operators. Canadian commercial helicopters could, at least under daylight visual flight rule conditions, conduct SAR operations, if the crew were properly trained. Helicopter underwater escape training (HUET), in-flight cabin firefighting, and first aid need to be considered for flight crew training. Survival and first aid training for flight crew members would also enable them to deal with emergencies while awaiting assistance. HUET as a requirement for passengers should be also considered. At present no formal helicopter rescue training courses exist outside those conducted by the Department of National Defence, although some companies provide their own programs. Consideration needs to be given to the provision of search and rescue technician (SARTECH) training for civilian personnel, if the military SAR capability cannot be developed.

Summary of Offshore Training Seminar

The loss of the *Ocean Ranger* in February 1982, revealed that serious deficiencies existed in the quality of training given to workers employed in Canada's offshore drilling industry. Since that time the industry, government, and training institutions have taken steps to develop and implement a number of programs aimed at improving the level of basic emergency and survival training received by persons working offshore. Similarily, specialized training programs have been developed for persons holding key positions on MODUs. On September 24, 1984, the Royal Commission sponsored a seminar to update its data base on the training programs provided to offshore workers. Representatives from the industry, government, and training institutions participated in the general discussion.

While there was general consensus that basic emergency and survival training is necessary and valuable in preparing workers to cope with emergency conditions and abandonment of MODUs, there was considerable discussion on the timing and amount of training being provided. The operators and the Canadian Petroleum Association (CPA) felt strongly that basic emergency and survival training should not become a prerequisite to offshore employment given that industry is committed to training all offshore workers on a rotation basis and approximately 90 percent of the workers have already completed the training. COGLA supported CPA's suggestion but indicated that the issue of the amount of training required for service personnel and for those working offshore for brief periods of time, has not been resolved. There was general agreement that basic emergency and survival training should be revalidated at appropriate intervals such as every two or three years.

The industry is aiming to achieve a national standard for basic emergency and survival training through and certified by the Petroleum Industry Training Service (PITS). COGLA supports the idea of a national training standard to facilitate the transfer of Canadians within the oil industry in Canada but has reserved decision on its own role in certifying training. COGLA expressed concern about the need for more rigorous blowout control training in light of the recent well-control problems experienced on the *Vinland* and *Zapata Scotian* rigs.

A philosophical difference exists between industry and regulatory agencies as to the level of emergency training required for offshore rig workers. The industry strongly advocates the specialist team training approach to cope with incidents such as fire, well control, and medical emergencies. While COGLA and the Canadian Coast Guard seem to concur with industry, the Newfoundland and Labrador Petroleum Directorate has supported a higher level of training in particular areas for all offshore workers.

The industry indicated that the content of refresher training courses may need to be expanded beyond the scope of current certificate courses for basic emergency and survival training and specialist team training. This concern is under review by the PITS Examination Certification Committee.

A helicopter pilot suggested that aircrews on offshore routes require survival training, and that procedures should be established for rig emergencies occurring during helicopter shut down. The representatives from training institutions indicated that helicopter underwater escape training (HUET) will soon be available to the aircrews. The operators suggested that helideck crew training be made formal through PITS in order to gain recognition and develop standards. A helicopter pilot expressed concern that aircrews are not well trained in search techniques and that the industry search and rescue capabilities could be tasked to assist other industries and the public. The regulatory agencies unanimously indicated that any assistance rendered to the public using the industry's search and rescue capability would be entirely at the discretion of the helicopter contractors.

The operators feel that they have reached an acceptable level of self-help rescue capability given the available level of search and rescue (SAR) assistance. Independent companies are developing search and rescue training courses and government search and rescue has offered assistance to train civilians. A Newfoundland Government representative expressed the opinion that the current level of air rescue support is inadequate for the offshore and that until additional public resources are made available it is incumbent upon the industry to provide the service.

The Canadian Petroleum Association has recognized the concern of supply/standby vessel masters about emergency and rescue capabilities and has initiated a Senior Officer Marine Emergency Management Forum through PITS. The representatives from training institutions indicated that there is a problem with the current selection method for crews of fast rescue craft (FRC); crews are hand picked by the master of the standby vessel. It was suggested that masters' attendance at FRC courses may improve their crew selection procedures, their understanding of the operational requirements of the FRC, and their enthusiasm for conducting FRC drills. One representative of a training institution suggested that FRC courses should place greater emphasis on transferring casualties to the standby vessel than on recovering the FRC. Another expressed the opinion that a team approach be fostered for FRC crews to include the master's and mate's responsibilities to manoeuvre the standby vessel to pick up the FRC and its occupants. A representative of PITS expressed the opinion that the team approach is best developed at sea during drills. The FRC course was developed in consultation with Coast Guard and other government agencies but is certified by PITS.

There was a general consensus that the MODU marine master requires some knowledge of drilling, and that the toolpusher requires some knowledge of marine matters. The operators and drilling contractors felt strongly that decision-making during an emergency should be carried out as a result of consultation between the master and the toolpusher. Representatives from COGLA and the Coast Guard indicated that the master is always in charge on a semisubmersible.

The Canadian Petroleum Association strongly expressed its desire to maintain the certification processes for drilling activities within the industry where the requisite expertise lies and indicated that only some marine and drilling positions should be certified. The operators indicated that training for dynamic-positioning operators should not be the focus of a regulation due to the relatively low number of these operators worldwide. The operators and drilling contractors have developed a proposal for a Ballast Control Operators' course which is under review by a joint government and industry training committee. The Coast Guard may certify the course content and delivery agencies.

According to training institutions, the present informal mechanism for feedback on equipment performance in training, from the institutions to the designers and manufacturers, is adequate.

The training institutions expressed concern about the lack of a mechanism allowing them input to the identification of training needs and training program development. PITS maintained that industry is responsible for initiating the development of training programs based upon assessments of its training needs and that PITS would seek input from government agencies and the training institutions. The Canadian Petroleum Association perceives standards for safety training to be a concern of government but job skills training as the responsibility of industry. There were indications that feedback to the training institutions, from industry experiences such as actual abandonment of MODUs has not been adequate, however, industry seemed aware of this deficiency and stated intentions to rectify it.

There appeared to be a consensus that the greatest deficiency in the present organization of training is the lack of time allowed by regulatory agencies for industry to develop, organize, and implement training programs. The drilling contractors stated that the industry had failed to convey effectively the great improvements it has made in training offshore workers. The operators perceive the next step in training to be to refine existing training programs such as FRC courses.

6

HEALTH

HEALTH

OCCUPATIONAL HEALTH AND SAFETY

Occupational Health Study
Centre for Offshore & Remote Medicine (MEDICOR)
St. John's, Newfoundland
February 1984

At present, offshore health and safety jurisdictional and legal matters are more complex in Canada than in the United States, United Kingdom, or Norway. By Acts and Royal Decrees, Norway has developed an extensive and detailed list of regulations covering almost all aspects of health and safety, and involving many government departments and directorates. The regulations specify the right to inspect installations without notice and give inspectors priority rights to the helicopter services of the operator.

In the United States a number of government agencies deal with the offshore oil industry, but the overall responsibility for health care and safety is generally assumed by the operating oil companies. This is particularly true with respect to education, training, and certification of health and safety personnel. There are no common standards or guidelines applicable to the education and training of health and safety personnel or to health care across the petroleum industry. Consequently each company, using its own resources, or those of private medical organizations, provides the level of care it considers appropriate.

The United States, like Norway, spreads responsibility (with significant overlaps) for health and safety matters over more than a half dozen relatively autonomous federal agencies. Furthermore there are differences in health and safety codes between states, and state and federal regulations sometimes conflict. Generally there is much less regulation in the United States than in Norway and the United Kingdom.

In the United Kingdom, responsibility for health, safety, and welfare has been delegated to the operators. Government implements guidelines rather than detailed regulations, and inspection of rigs and installations is arranged at times convenient to the company. There is no requirement to register health professionals working offshore and their education, training, and qualifications are the responsibility of industry. The United Kingdom Offshore Operators Association (UKOOA) has developed standards for health and safety that exceed those suggested by government. The Department of Energy has the prime regulatory responsibility.

Canadian regulatory requirements exist at federal and provincial levels. Enforcement of regulations dealing with health and safety is hindered by the fact that many of the vessels in the offshore operation are foreign registered and standards of health care, training of personnel, equipment, and supplies are based on the regulations of the country of registration. Licensing of all MODUs to a minimum Canadian standard would vastly improve contingency planning and facilitate health care. Legislation would be required at both federal and provincial government levels to enforce a minimum Canadian standard; alternatively, compliance could be effected under the present licensing system, in which the operating company's medical director would be required to assume full responsibility to meet regulatory standards of health and safety for all workers on the rig including the personnel of contractors and subcontractors.

The emergence of the Canada Oil and Gas Lands Administration (COGLA) as the primary federal regulatory agency could have the advantage of furnishing a "single window", provided that ambiguities and overlapping responsibilities with other federal agencies are resolved. To this end COGLA has initiated consultations at the provincial level, and with the federal Department of Health and Welfare.

In Newfoundland, occupational health and safety matters, in general, fall under the jurisdiction of the Department of Labour and Manpower (Health and Safety Division), the Department of Health, and the Workers' Compensation Board. The Newfoundland and Labrador Petroleum Directorate (NLPD) has responsibility for offshore health and safety. In Nova Scotia, control and regulation are vested in the federal government, while the Workers' Compensation Board, on behalf of government, conducts health and safety inspections and accident prevention training for the offshore and for other industries.

Although registration and licensing of health professionals is an accepted practice, this form of enforcement is hindered by limited jurisdiction offshore. Physicians and nurses working outside the 12-mile limit are not covered by the malpractice insurance policies of their respective professional organizations. They have had to obtain malpractice coverage through private plans because, in attending a patient on a foreign registered installation, they are at risk of suit for malpractice under the laws of the flag country. Non-registered nurses and medics such as the Canadian Armed Forces classification TQ6B medics are not eligible for registration or licensing under current provincial legislation. Therefore, licensing and registration for offshore health personnel should be rationalized. There are practical difficulties in granting recognition to the qualifications of retired TQ6B medics.

In the Canadian oil industry, the executive management roles of physicians have been limited in comparison to those of their counterparts in Norway and the United Kingdom. The rig's medic, who is administratively responsible to the rig manager, may be clinically responsible to doctors from two different companies, the operator and the contractor. Guidelines are required to establish the role of the physician within the company and the relationship between medics and physicians. The operator's medical director should have the final responsibility for all matters affecting health care in an offshore drilling program.

To achieve uniformity of health care and unambiguous regulatory structures, federal and provincial government agencies must develop coordinated approaches. Until recently, there has been relatively little communication between physicians in government and industry. As more expertise in offshore medicine is developed and identified, this deficiency should be corrected and should result in an improved health care system in the offshore.

■ *PREEMPLOYMENT MEDICAL ASSESSMENT* The preemployment medical assessment should establish a worker's medical fitness to perform satisfactorily on the job and in an emergency without risk to himself or his co-workers. It must take into account his capacity to adapt to the harsh environment, the long work schedules, the psychological stresses, and the uncertainty of medical evacuation, or the availability of medical personnel from on shore. A physician, who is familiar with the demands placed on the offshore work force, should conduct preemployment assessments, prior to the worker receiving offshore training courses, since certain parts of these courses are stressful.

In the United Kingdom, the industry (UKOOA) has developed guidelines for medical standards of fitness for offshore workers. In Norway there are comprehensive preemployment criteria, designated by legislation, for fixed rigs. The medical assessment of workers on MODUs, however, is covered by less stringent regulations. There is also a mechanism whereby a worker can appeal the examining physician's decision regarding medical fitness. In Canada preemployment medical examinations are not standardized. Each operator and contractor develops separate criteria which may vary significantly among companies. The regulatory agencies should be responsible for determining minimal acceptable preemployment criteria for all offshore workers which clearly set out contraindications to employment but leave room for clinical judgement.

There is a growing consensus in the North Sea, as well as in Canada, that a set of common guidelines should be developed to cover regional and national areas. These guidelines will help to facilitate an international standard for medical fitness which can be applied across the industry. While the concept of a medical passport has been examined, particularly in Norway, it has not received much support.

Medical examinations should be conducted with increasing regularity as workers pass 40 years of age and special examinations and assessments are necessary for workers in certain categories, such as diving.

■ *LABOUR FORCE AND WORK ENVIRONMENT* The eastern Canada offshore labour force comprises mainly young, single, or separated males with post-secondary education. Persons within the work force are exposed to a number of health hazards, some unique and others common to industrial workplace environments. A drilling unit's 24-hour work schedule results in a continuous exposure to noise. Noise can be a safety hazard, preventing workers from hearing operating instructions, or causing irritability or inattentiveness which may lead to a higher incidence of accidents. Excessive exposure to high noise levels can lead to industrial deafness. Hydrogen sulphide gas poses a significant health hazard and exposure to drilling fluids may result in skin and eye irritation.

Although major psychiatric disorders and significant neurotic illnesses have been reported on the Canadian East Coast, there are no reliable data from which to assess whether the incidence of these conditions is higher among workers in the offshore than among comparable groups in conventional settings. A worker's personal instability or over-reaction to stress is a matter of both health and safety. The expectation is that someone with difficulties in coping with stress in everyday situations will be unable to respond to super-added stress and may become a liability due to impaired efficiency. As in the North Sea, alcoholism is the predominant major psychiatric disorder observed in offshore workers on the Canadian East Coast. The data on the incidence of sleep disorders are inconclusive.

The preemployment medical assessment should identify those workers who have demonstrated adverse reactions to stress or who have suffered from psychiatric disorders. Reliable data are required on the adverse effects of noise, exposure to hydrocarbons, and stress associated with the offshore environment.

■ *INCIDENCE OF ILLNESSES* Because of the nature of the work force employed offshore eastern Canada and screening by preemployment assessment, the number of cases of serious illness is likely to be low. The majority of illnesses offshore can be diagnosed and treated by the medic on the drill unit without supervision by a shore-based physician. For the less frequent, severe disorders, individuals are evacuated to onshore medical facilities.

An analysis of a medical log from a MODU operating on the Canadian East Coast showed that illnesses were four times more frequent than accidents but were usually less severe and did not require evacuation or consultation with the onshore supervisory physician. The majority of illnesses were mild upper respiratory tract infections, headaches, and mild skin disorders. These types of illnesses are similar to those reported in other offshore jurisdictions.

■ *ACCIDENT DATA COLLECTION* The collection of personal injury data is essential to determine the health status and safety performance of offshore workers. The use of available accident data is, however, limited. Different criteria are used to define serious and minor injuries and the reporting of incidents is unreliable. Unreliability in accident data can occur when a "safety-bonus" system operates. Accepting the limitations of the data collection methods, statistics should be collected to determine the incidence and also the cause of all offshore accidents.

Accidents arise not only from deficiencies in equipment and facilities but from characteristics of the worker: lack of experience, lack of knowledge of the correct procedures, carelessness, clumsiness, or failure to wear protective clothing. The coordinated efforts of a team are required in most procedures on the drill units. The team may be composed of individuals who differ greatly in their levels of skill and experience and accidents may arise when the team's coordination is lost. An employee must, in the final analysis, be motivated to take responsibility for his own safety.

Many studies have been conducted on the time relationships of accidents to shift and hitch, but the evidence is inconclusive. Approximately 20 percent of the work force will be unable to tolerate rotating shifts but these individuals will be self-screening. The incidence of accidents is highest among employees new to the job. In some offshore operations, the turnover of junior drilling crew positions is 100 percent. This situation entails new learning experiences and a new period of vulnerability to accidents.

An analysis of accident rates on drilling units operating off Newfoundland and Labrador indicated that minor accidents were 12 times more frequent than major accidents. Hand and wrist injuries were the most common, resulting from "being struck". Major accidents affected roustabouts, roughnecks, and drillers, and the most commonly reported nature of these was contusion. These findings agree with reports from other jurisdictions.

A more detailed profile of the health of offshore workers is required and a properly designed system of data collection should be instituted which will permit meaningful comparisons with foreign petroleum offshore operations and with onshore Canadian industries.

■ *HEALTH CARE RESOURCES OFFSHORE* Although individual medics and physicians will have personal preferences, the medical equipment and supplies for the sick bay on the MODU should be standardized to aid contingency planning. The equipment should be clearly identified for use by the medic, the physician, or the medical emergency response team. Regulatory agencies should assume the responsibility for framing minimum standards for medical equipment and supplies on board any unit licensed to operate on the Canadian East Coast. This standard should be based upon the number and type of reasonably anticipated casualties, even though these numbers are difficult to estimate.

Medical input is required in determining the design, layout, and equipment of health facilities on drill rigs. The safety and efficacy of X-ray machines offshore is highly dependent on the training of those who will use them and there is currently no concensus as to their need. An ECG monitor and a defibrillator may be provided if the medic is trained to use them properly.

Major factors affecting survival in lifeboats are injuries sustained during abandonment: trauma, hypothermia, thirst, motion sickness, exhaustion, and hunger, as well as general morale. Current Canadian Coast Guard requirements for medical supplies and equipment for lifeboats and life rafts need to be modernized. A motion sickness prophylaxis should be added to the medical supplies in lifeboats and life rafts. Further, drug dosages should be expressed in milligrams rather than grains. Current scales of provisions such as water and food on lifeboats appear to be satisfactory. Improvements are required in the design of survival suits.

■ *HEALTH PERSONNEL QUALIFICATIONS* The rig medic may work in lieu of a physician or as an extension of a shore-based company doctor. The duties range from conducting a routine sick parade to handling multiple casualties. Under certain circumstances, a patient may have to be cared for over a long period. In emergencies, the rig medic should be supported by a competent team trained in advanced first aid. A wide range of knowledge and skill is required for the medic including:

- Basic knowledge of anatomy, physiology, pharmacology and pathology;
- Thorough competence in the basic skills of history-taking and physical examination of all body systems;
- Diagnosis and communication of findings in a rational, problem-oriented manner to a physician;
- A broad working knowledge of pharmacology;
- Resuscitation of the seriously ill or injured casualty involving competence in cardiac life support, airway management, hemorrhage, and shock;
- Thorough understanding of the pathophysiology of drowning and hypothermia and their management;
- Understanding the concepts of public health and industrial hygiene and the control of infectious diseases;
- Some surgical skills;
- The ability to faciliate communication between the diving team and a shore-based physician and to advise the diving supervisor intelligently;
- Counselling skills and psychiatric knowledge.

While the medic may be given other duties, these should not conflict with medical duties. Because of the organizational structure within the company and its contractors, conflicts of responsibility may arise.

The obligation of confidentiality and privilege in the patient/physician relationship similarly applies to the medic/patient relationship and may result in a conflict for medics as they are employees of the drilling contractor. Medics' conflicts may be enhanced by the dichotomy in their responsibilities to the toolpusher or master for administrative matters and the supervising physician for clinical, professional matters.

A breach in patient's confidence through the disclosure of medical records should be precluded by maintaining them as confidential between the medic and the patient. If an employee discloses a medical problem which casts doubt on his fitness for employment or which entails a danger to himself and others, the medic's duty is clearly to counsel the employee to resign. If the employee refuses to resign, the medic must report the matter to the employer who may terminate the employment. It requires maturity of judgement gained through experience to successfully manage the dichotomy in professional and administrative responsibilities. This need for maturity of judgement, as well as the technical requirements of broad experience in the practical management of medical problems, may make newly qualified physicians less suitable for the post of rig medic than experienced nurses or TQ6Bs.

The qualifications of rig medics vary in different areas of the world. In the United States, they vary from company to company. The most common categories of personnel hired as medics are ex-military medics (paramedics), emergency medical technicians (who will have undertaken training programs of varying length, up to two years), and persons with first aid qualifications. Since the drilling units in the United States are closer to shore than in other offshore areas and regular helicopter transport is available, there are indications that these qualifications are adequate.

In the United Kingdom, legislation is being enacted which allows only ex-military, independent-duty Medical Assistant I's or State Registered Nurses to be employed as offshore medics. At present, in Canada, retired Canadian military TQ6A and TQ6B medics, registered nurses, retired U.S. Armed Forces military technicans, and emergency medical technicians are employed as rig medics on offshore drilling units. Federal and provincial regulations would allow a provincially certified first aid person to be hired as a rig medic. There is, however, also a federal guideline which requires that the rig medic be able to perform a number of specific functions which are beyond the skills of such a person. This conflict within offical regulations and guidelines illustrates the need for expert medical input into such regulations. The registered nurse and the Canadian military TQ6B are highly suitable for employment as rig medics on the basis of the requisite training for their qualifications. The emergency medical technician's training is considered to provide an inadequate background for the performance of the offshore rig medic's duties. If possible, a mechanism should be found to allow professional recognition for the position of ex-military medics (TQ6B). The lack of such a mechanism causes medico-legal difficulties which do not affect the registered nurse. All offshore health personnel including physicians and medics will require some training before taking up duties. For physicians, some 80 hours of instruction would be required and a 6-month course would be required for medics. This period of time would be reduced by instituting a modular course in which the training could be tailored to the needs of the individual nurse or ex-military medic. Continuing education courses should be conducted at regular intervals by appropriate educational institutions to ensure that infrequently used skills are updated.

■ *FIRST AID TRAINING FOR WORKERS* Basic first aid training is advocated for all offshore workers. First aid courses for all workers should include instruction in safety-oriented first aid, with expanded modules on hypothermia and near-drowning. Cardiopulmonary resuscitation and hydrogen sulphide courses should also be taken. As sections of conventional first aid courses may not be suitable, regulatory agencies should assume responsibility for approving course content, monitoring the examination procedures and certifying the adequacy of the instruction to be offered. To avoid decline or loss of skills, refresher courses should be taken regularly.

Each drilling unit should have an advanced first aid team to provide first aid coverage in the lifeboats during evacuation, assist the medic in triage and care of patients with multiple injuries, and escort patients to shore.

The medic should be responsible for conducting first aid drills and providing instruction to the team on topics such as transportation of the patient, resuscitation, and the use of the sick bay equipment. A record of drills should be maintained. The members of the advance first aid team should not have conflicting emergency duties.

■ *COMMUNICATIONS AND TRANSPORTATION* Because of the crucial importance of communications in a medical emergency, reliable systems must be devised and tested. Communication with other parts of the rig and with onshore bases should be possible from the sick bay. In addition, an exclusive line should be available for the sick bay telephone.

Early results of a pilot project by Memorial University of Newfoundland, federal Department of Communications, Newfoundland Telephone Company, and Mobil Oil using the 14 and 12 gHz Anik B satellite system indicate that telemedicine techniques, (transmission of slow scan pictures and electrocardiograms), can enhance significantly the ability of an onshore physician to advise the medic. Satellite technology may provide cost-effective alternatives to existing communications systems.

Despite noise and vibration, cramped conditions, the effects of high altitude on a patient, and weather restrictions, medical evacuation by helicopter is preferable to evacuation by sea. Evacuating a patient by air requires an escort, and planning is required to accommodate support equipment.

■ *DIVING* The Canadian Standards Association (CSA) and COGLA have recently produced a standard and draft regulations, respectively, which reflect modern diving practice. In a few areas there are inconsistencies between the standard and the draft regulations. While they compare favourably with those of other countries, the COGLA draft regulations do not address surface decompression diving and the training of life support technicians is addressed only briefly.

Company contingency plans should cover evacuation of divers who are in saturation, in the event of abandonment of the MODU, and they should ensure that rescue operations can be undertaken from a diving bell trapped on the sea bottom.

Communications required for diving operations are vital in an emergency. When treatment is conducted in a compression chamber, it is desirable that the person making the decisions be outside the chamber with clear communication links to the person inside conducting the procedures. The diving station should also have direct reliable communications to shore, preferably using a satellite link.

Diving accidents have occurred when diving was undertaken from dynamically-positioned vessels. This mode of diving should be the subject of ongoing scrutiny. Research into and development of techniques is required to extend the diver's survival time if the surface gas supply should fail, particularly in deep diving.

Treating a sick or injured diver can be a complex operation. Days may be required to bring a diver in saturation to surface pressure and hours to compress an attendant to enter the chamber to render aid. All divers should be trained to a high standard of first aid, including training in the first aid of diving emergencies. Neither the rig medic nor the diving superintendent can attend the patient in the chamber, therefore diving teams should include divers who have been trained as diver/medical technicans to render immediate medical care.

In an offshore diving accident the priorities are to recover the diver into the on-site recompression chamber and then to initiate treatment through consultation with medical expertise on shore. In some instances, the diving specialist physician may travel offshore, possibly with members of the Medical Emergency Response Team, taking necessary monitoring supplies and other equipment. If transfer of the diver-patient to a shore-based facility is contemplated, the patient should first be stabilized in the offshore chamber and a rescue system involving a "fly-away" chamber could be utilized.

Evacuating an installation because of weather or danger of iceberg collision presents problems for divers in saturation. Possible methods include transfer to a support vessel, using a "fly-away" hyperbaric chamber or a hyperbaric lifeboat. Neither a "fly-away" hyperbaric chamber nor a hyperbaric lifeboat is available in eastern Canada. There is a need for an adequate onshore hyperbaric medical facility in Newfoundland. Technical problems of using these systems individually or in combination have to be solved.

Special training in hyperbaric medicine is advocated for diver medical technicians, life support technicians, diving supervisors, medics, and physicians. Because diver medical technicians are not recognized in Canada, there can be medico-legal problems. Recognition could be granted if training were given under the Canadian Medical Association's (CMA) Emergency Medical Attendant program.

Diving supervisors should be familiar with the concepts of diving medicine and physiology in addition to their knowledge of operational diving procedures. Physicians should be specially trained to conduct medical examinations for fitness to dive and some should be trained as specialists in diving medicine. Such courses are not readily available in Canada. Refresher courses could be held for specialists already trained.

Research needs identified in diving medicine and physiology include the development of improved "bail-out" gas supply systems for deep diving, the physiology and pathophysiology of decompression sickness, thermal protection, and oxygen toxicity.

■ *ONSHORE MEDICAL RESOURCES* The oil companies and drilling contractors operating on the Canadian East Coast have contracted groups of local physicians to provide medical advice or assistance to offshore medics on a 24-hour basis. In a medical emergency offshore Newfoundland, the physician may choose to attend himself or to call upon the General Hospital's Medical Emergency Response Team, comprised of specialist physicians, nurses, and support technicians. This team takes along specialized medical equipment which allows them to provide initial resuscitation under adverse conditions. The team will return the patient to a hospital designated by the team leader based upon the type of speciality service required by the patient. Formal designation of a Medical Emergency Response Team to respond to offshore and onshore emergencies should be considered in Nova Scotia and a formal procedure for air evacuations should be established for the Venture field.

Public health physicians should be trained in offshore health care and involved at all levels of offshore operations to ensure that the interests of workers, industry, and government are served by a cooperative approach between the appropriate federal and provincial government departments.

■ *CONTINGENCY PLANNING* When an emergency occurs, there must be a contingency plan in place to ensure that the patient is provided with the best care at every stage of management, from immediate first aid to eventual treatment in a land-based facility such as an intensive care unit. The operator can cope with the majority of problems using his own resources, but on occasion will require assistance from other sources. The contingency plans generally do not delineate clearly the lines of responsibility and relationships between rig medics, physicians, and administrators.

COGLA delegates the responsibility for emergency health care to the provincial agencies and has developed standards for the contingency plans submitted by companies, which require that the roles of key personnel be defined. The Newfoundland and Labrador Petroleum Directorate assumes the coordinating role in an emergency, but clarification of the relationships with other agencies is needed.

As a result of meetings between representatives of the various agencies involved in offshore emergency health services, consensus was reached about the general procedures to be followed. Some uncertainties exist about the roles of certain agencies. To reduce these uncertainties and to provide continuity, a standing liaison committee is proposed with a range of functions from reviewing collectively the emergency response capability of each organization to facilitating disaster exercises.

[Editor's Note: The Canada Oil and Gas Lands Administration Drilling Guidelines and Procedures *(September, 1984) indicate that the requirements for rig medic qualifications are under review but for the present the operator must present a statement by a qualified physician that he has reviewed the qualifications of each medic and found them to be satisfactory. The minimum standards are: registered nurse with a minimum of two years' experience with emphasis in intensive care or emergency; or formal paramedical training at the college level with three years' clinical experience; or a recent military paramedic qualification to Grade VIB. Potential medics must hold a current registration with an appropriate professional licensing authority.]*

Summary of Occupational Health Seminar

In February 1984, the Centre for Offshore Remote Medicine (MEDICOR) of the Faculty of Medicine, Memorial University of Newfoundland, submitted a report on Occupational Health and Safety to the Royal Commission. The Commissioners encouraged the establishment of a seminar at which the content of the report could be discussed by a number of invited experts. On June 26 and 27, 1984, participants from industry, government, training organizations, and health institutions attended this seminar.

At the outset, Dr. A.M. House, Director of MEDICOR, identified some of the current occupational health issues affecting the organization and operations of the Canadian East Coast offshore industry. The lines of responsibility from the operator's Medical Director to the contractor, diving companies and other subcontractors, and to standby and supply vessels, need to be identified and carefully considered to ensure that the operator's responsibility for health services is being properly discharged. For example, the current practice of hiring rig medics through subcontractors impedes clear and efficient lines of administrative and clinical authority between the operator's Medical Director, who is ultimately responsible for provision of health services, and the medic, who provides daily on-site health care services. In addition, some categories of medics such as retired Canadian Armed Forces Medics (TQ6B) lack professional status as they are not registered or licensed by a recognized health association. This has serious implications for physicians' professional relationships with these medics.

In general, it was agreed that onshore medical resources in Newfoundland and Nova Scotia are adequate to cope with the emergency health problems which develop offshore and that contingency plans are being improved; there is a need, however, for regular exercises to test the effectiveness of these plans. The Telemedicine Project at Memorial University of Newfoundland has demonstrated that the use of satellite voice communication links and slow scan T.V. can enhance the shore-based medical support available to rig medics and improve communications for general purposes.

Increasing attention is being focussed on educational and training programs for contract physicians and rig medics as a result of improved communications between various government agencies and the medical profession through Advisory Committees. Recent trends in industry recruitment practices reflect acceptance of the recommendation of the *Occupational Health Study* that the registered nurse qualification is the most appropriate for the position of rig medic. There was agreement that the work experience of the registered nurse would influence the length and type of additional training required to perform competently in that position. Furthermore, there was a consensus that primary physicians providing service to the offshore should, besides having Advanced Cardiac Life Support and Advanced Trauma Life Support training and an orientation to the offshore working environment and job tasks, have some expertise in occupational health or have a background in emergency medicine. Further, hospital-based specialists and newly graduated physicians are not suitably qualified for this position.

There was a consensus that the sick bays of some MODUs, operating on the Canadian East Coast, are not optimally positioned to facilitate easy access by stretcher cases or access to the helideck. There is a need to identify a mechanism which allows medical professionals to advise rig designers on the location and layout of sick bay facilities.

Discussion followed on the psychological stress of working and living on a MODU. Although stress factors in the offshore have received a lot of attention, they are not as significant as is generally perceived. The assertion was made that several individuals with a medical history of major psychiatric disorders have gained employment on MODUs. A preemployment assessment for psychiatric illness is important, and it was suggested that training for supervisory personnel should emphasize the necessity of identifying individuals displaying abnormal behaviour for the safety and protection of that individual and the crew, although the difficulty of making this identification was recognized. It was further agreed that major psychiatric disorders be considered contraindications for offshore employment. There were indications of inadequate preemployment screening of subcontractor's personnel resulting in medevacs that could have been avoided.

Although there is a lack of comprehensive accident data for the Canadian East Coast offshore operations, it was agreed that the injury and illness data analysis presented in the *Occupational Health Study* provided valuable information for industry health professionals. A government health professional recognized that the lack of appropriate occupational health data is not peculiar to the offshore oil industry but rather is characteristic of the field of Occupational Medicine. There was a consensus that reliable data are required, preferably in a form allowing comparison with accident data from other jurisdictions. There was a tacit assumption that a standardized data collection system would be undertaken by government or some central agency involving all the companies, with due consideration given to the issue of confidentiality. Industry representatives emphatically stated that, to elicit their full cooperation in a central data collection system, it must be demonstrated that the system's objectives are clearly defined and the resulting data will be reliable and valid. Drawing upon the experience of other occupational health data collection projects, a government representative suggested that there is a need to develop a uniform job dictionary and to collect data on near misses. It was suggested that to ensure the credibility of a data collection pilot project, a two- or three-year life span would be required. One participant suggested that the Loss Management Information System (LOMIS) already collects the occupational health and safety data being discussed.

It was unanimously accepted that the operator is responsible for the health and safety of all personnel on a MODU. The rig medic, however, is either an employee of the drilling contractor or a subcontractor who may report to the contractor's or subcontractor's physician rather than to the operator's physician. This creates a confusing and potentially hazardous situation. The operator may not be able to discharge his responsibility for the health services provided offshore, as they may not be conducted in accordance with the operator's policy or through the physician delegated the authority to act on the operator's behalf. In addition to requiring contractors to meet the specified health and safety standards, the operator must exercise "due diligence" by monitoring and auditing the contractor's performance in order to discharge reasonably his responsibility for the health and safety of all personnel.

It has been noted that problems also arise between the corporate and operations occupational health and safety groups because the corporate group sets company policy and procedures, and also monitors and audits the operations group's activities. Although management organizations differ, it is common for the communication and coordination between separate safety and health departments to be inadequate. It was suggested that ideally health and safety should be integrated. The roles of industrial hygienists and safety engineers in offshore operations were discussed. One safety representative indicated that in current practice the term "safety" is being replaced by "risk management" which is concerned with identifying the most efficient and correct method for performing a task. Company management should be committed to identifying and, where possible, eliminating or mitigating risks to employees by developing standards of design, construction, operation, and training which are applicable to all circumstances.

There was general consensus that methods of dry evacuation from MODUs are preferable to evacuation by sea and that research should be conducted in this area. The industry's use of state-of-the-art rescue equipment was discussed. A lengthy debate ensued regarding rapid versus slow rewarming of hypothermia victims. This issue was not resolved, but it was emphasized that standby vessel crews could only be expected to practice first aid and not medicine.