Pursuing the Case for Safety

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North Sea platform. Events in the North Sea have precipitated a new safety philosophy, and waves of change are being felt all over the world.
Risk comes in many guises. Financial and political risks are old adversaries of the oil business, and as such have attracted a host of solutions. Accidents are another inherent and all-pervasive form of risk. Safety has always been a consideration in oilfield operations, albeit to differing degrees. But the past few years have seen a growing awareness that enhanced safety is not only desirable, but beneficial to the efficient running of a business.

This wider recognition that good safety practice is an essential business ingredient has flourished in a shifting regulatory climate. The legislative changes initiating this new climate were precipitated by events in the United Kingdom but are now being felt far beyond the waters of the North Sea (left).

Changing UK Safety Legislation

On the night of July 6, 1988, the Piper Alpha oil production platform in the UK sector of the North Sea exploded, claiming 167 lives. The subsequent public inquiry into the disaster, headed by Lord Cullen, is widely regarded as one of the most thorough reviews of offshore oil industry practice. It has not only had a profound impact on UK safety legislation, but is also radically changing the underlying philosophy and practical application of safety for oil exploration and production.

The Cullen Report, published in November 1990, put forward 106 recommendations, setting out comprehensive guidelines for action by the regulatory authorities and the industry.1 The UK government accepted the recommendations in full and this has resulted in major changes to UK legislation, summarized in “The Cullen Report’s Three Main Elements,” (below).

The report embodies a goal-setting approach to safety, moving away from the previous prescriptive regime that acted more as a checklist of minimum standards—perceived in retrospect as a discouragement to continuous improvement and innovation. Goal-setting demands an objective philosophy by which companies must demonstrate their safety policies, state and

The Cullen Report’s Three Main Elements

- Transfer of statutory powers, effected in April 1991, to a single regulatory body, the purposely created Offshore Safety Division of the UK’s Health & Safety Executive. In March 1992, the Offshore Safety Act came into force to provide a legal basis for the subsequent reform of the legislation.

- The introduction of new regulations, effective May 1993, requiring operators or owners of offshore installations in UK waters to prepare and have accepted a safety case for each fixed or mobile installation.

- A complementary program of reform to underpin the safety case regime, replacing existing prescriptive-based offshore legislation with more modern, goal-setting regulations. This third phase of the reform is now in mid-program and will result in offshore-specific regulations by the end of 1994.

1. Cullen, reference 1, main text.
achieve safety targets, and establish procedures for continuous review and periodic audit of their safety management systems.

The cornerstone of the new regime is the safety case, a document that is now a prerequisite for taking part in UK exploration and production. In essence, the information in the safety case must ensure that the installation will be operated safely. It must show — make a case — that management systems comply with the requirements of health and safety law; that there are arrangements for regular independent audits of the system; that hazards with the potential to cause major accidents have been identified; and that risks of major accidents have been evaluated and all reasonable measures taken to reduce risks to personnel.

A safety case is intended to be an evolving document, and must be updated and revised to reflect changes in activities or hazards, and any modifications to the structure, plant, equipment or operating procedures introduced during the installation’s life-time. An additional safety case submission is required before decommissioning and abandoning an installation.

British safety case regulations came into force in May 1993, at which time design safety cases were required for all new projects on the drawing board, a move intended as an early check on the safety design for these installations. But by far the greatest impact of the new rules lies in the requirement for safety cases that cover the operations of all existing oil and gas installations, both fixed and mobile.

By the end of November 1993, every existing offshore installation in UK waters must have a safety case submitted for acceptance by the regulatory authority — the Offshore Safety Division (OSD) of the UK Health and Safety Executive. Two years after this it will be illegal to operate in the region without a formally accepted safety case. Some 220 operational safety cases will be scrutinized by the OSD. A two-and-a-half year transitional period, ending on November 30, 1995, has been established to enable the OSD to complete its scrutiny. This will also give operators and owners time to revise their safety cases and perform any remedial work needed to bring installations up to standard.

Owners of mobile installations—particularly mobile offshore drilling units (MODU) —must submit safety cases at least three months before starting operations in British waters, and must gain acceptance before starting work. Where installations are engaged in joint operations, typically involving a MODU working alongside a fixed platform, a combined operations safety case is required.

The safety case must satisfy the interests of many different parties: the company work force, on the front line of daily operations; client operating companies, requiring closer cooperation and more open interaction than before; and the regulatory authority. But the primary purpose of the safety case is to satisfy the owner or operator that an installation is safe.

In this respect, the safety case is a prime mover within the organization’s wider system for managing health and safety. As legislation affecting the industry increases, it is necessary for management systems to respond efficiently to changes to ensure that best practice is transferred throughout its operations (see “MARS: Bringing Method to Prevention Management,” right).

The Schlumberger approach to safety management has three principal constituents:
• management of adversity
• assessment of risk and its minimization
• the minimization of the effects of an accident, if one occurs.

The latter two depend on the situation faced by the company’s different business units, while the first of these provides a common thread across the diversity of operations.

In 1989, Schlumberger laid the foundation for a risk management system, which embraces not only safety, but the interrelated issues of health and environment (HSE). The result is MARS—the management of accidental risk at Schlumberger.

The objective of the MARS program is to cost-effectively reduce the exposure of clients, employees and associated parties to HSE risks. MARS is not the means of prevention, but a systematic method for managing risk, establishing a template for information flow and the responsibilities of all parties involved in company operations. The system is dynamic, capable of evolving as risk, regulation, knowledge and personnel change. Therefore, MARS is not a “once and for all” snapshot of risk prevention.

MARS requires two fundamental commitments. First, line management must assume responsibility for safety and be able to make the required decisions to ensure safety. To fulfill this requirement, each operating region and each product

these are monitored against annual targets for each manager.

An important feature of MARS is risk identification, which gives Schlumberger employees the means to track down hazards and near-accidents, calling on their particular hands-on knowledge of how processes and facilities work. By these means individuals contribute to the effectiveness of the data base, the intelligence at the heart of the system.

The way in which employees identify risk represents a change from the traditional culture, where negative comments on operations were not encouraged. Instead, a “no-blame” culture is being established to which all employees can contribute. This idea is also the basis for periodic audits within MARS, which are not spot checks but planned in advance and designed to act as sources of intelligence for the data base. For example, a typical safety audit on a drilling rig will involve the HSE manager, the drilling superintendent and perhaps the regional HSE manager, taking a walk through the facility looking closely at housekeeping, protective equipment, training programs and record keeping, and posing “what if” questions about operational response.

By definition, accidents will never be eliminated. However, even undesirable events can be used to contribute towards risk reduction. Inquiries into accidents will determine causes and contributing factors from both technical and management viewpoints. Including this information in the MARS data base increases knowledge of risk, and is the first step in learning how to avoid the recurrence of an accident.

As an integrated and interactive management system, MARS comprises two primary feedback loops that close through a data base: a clockwise loop passing through employees, and a counterclockwise loop via technology, process and facilities (above).

A computerized accident risk data base built from the company’s operating statistics and risk profiles provides the information needed to reduce the frequency and severity of HSE incidents. The data base represents knowledge, with the two feedback loops ensuring that data are constantly updated by input from audits and assessments, risk identification reports submitted by employees, accident reports, legislative changes and improvements in technology.

HSE managers use the data base to create safety rules, procedures and emergency response plans. But responsibility for implementing these objectives lies squarely with line management. Line management implements the awareness and training programs needed to ensure that employees take part in accident prevention. This group is also responsible for the development and practice of emergency response plans to minimize losses, the maintenance and upgrading of processes and facilities, and the introduction of new technology for safer and cleaner operations. Standards of performance in achieving these objectives are monitored against annual targets for each manager.

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new safety regime, and in particular the implications of the safety case. To this end, the International Association of Drilling Contractors (IADC) commissioned the preparation of a safety case template, a unified approach that Sedco Forex tested.

On completion, the VSC was declared a highly worthwhile and successful exercise by all participants, and the IADC template proved sufficiently flexible to accommodate the philosophies of individual drilling contractors. But in the doing—amid much constructive discussion with the Offshore Safety Division—many challenges had to be faced and valuable lessons learned.

One practical difficulty was judging the size of the safety case. A stand-alone document, with no references to other works or procedures, would be unmanageable. Pleading every interest at all levels of detail could jeopardize the basic thrust of the safety case, reducing its usefulness to line management and the work force. Conversely, too little information would not constitute a working document. Sedco Forex struck a balance with a document of around 600 pages.

An important tool to produce a safety case is quantitative risk assessment (QRA). This applies numerical techniques to calculate the risks of specific hazards in terms of probable frequency of occurrence, and relative magnitude in threatening human safety and the integrity of the installation. Sedco Forex believes QRA is a useful complement to qualitative assessments that are based on its 25 years of offshore experience.

Using in-house expertise and consultants in highly specialized areas—such as predicting the overpressures from explosions and making risk calculations—Sedco Forex employed QRA to quantify the risks from hazards onboard the Sedco 704. The 12 major hazards addressed in the MODU safety case are (in alphabetical order):

- blowout
- dropped objects
- explosion
- fire
- helicopter crash
- loss of stability
- major mechanical failure
- mooring failure
- ship collision
- structural failure
- towing incidents
- toxic release.

Once a risk is quantified, the principle of reducing risk to as low as reasonably practicable (ALARP) can be applied. This approach was introduced to the industry during Lord Cullen’s inquiry, and leads to three conceptual areas of risk and remedial action: where risk is unacceptably high, where risk is so low no mitigation is required and, between these two, the ALARP region where risk is weighed against the cost of remediation (left).

After some initial misconceptions about this gray area, the application of ALARP to major hazards onboard an installation is now well understood by the industry. However, its application to smaller risks is still raising questions of how far to take the principle.

Another concern within safety case regulations was the stipulation that all installations must provide a temporary refuge (TR). The TR provides a protected area for personnel, giving time and means to control an emergency, and effect a safe evacuation. Initial interpretations of the Cullen report specified that the TR should be capable of enduring the consequences of a major hazard—notably explosion, fire and smoke—for at least one hour. The industry argued that during a fire on existing small fixed platforms with relatively high hydrocarbon inventories, such a purpose-designed bunker could well outlast the platform, defeating the primary objective of the TR. For a MODU and other floating installations, retaining personnel in a robust box could intensify risk if the installation lost stability.

Consequently, a more flexible approach has been adopted for the TR provision. The stipulated one hour now includes the time from the first command to muster until the evacuation has been completed, acknowledging that in some emergencies sitting tight in a reinforced box is not always the best action.

To evaluate TR performance, Sedco Forex used QRA to quantify the probability of a serious incident impairing the TR—called the impairment frequency. While the OSD has set a TR impairment frequency target of $1.0 \times 10^{-3}$ per year per rig, the impairment frequency for the TR onboard Sedco 704 was demonstrated to be $0.42 \times 10^{-3}$ per year—this means that there is a chance of the TR being impaired once every 2381 years.

During the VSC process, it became clear to Sedco Forex that an additional criterion is required to take fully into account risk to individuals. A further self-imposed standard relates to offshore industry historical fatality risk—calculated using worldwide statistics...
between 1972 and 1993. This stands at 0.103 fatalities per rig per year; and Sedco Forex has set its target at half this level, at 0.05, which it has already achieved. Further reductions are planned under a program of continuous improvement.

Sedco Forex has also identified average individual fatality risk as another important standard. For general British industry the average individual fatality risk ranges from $10^{-3}$ to $10^{-5}$ per year. For the Sedco 704 the average individual fatality risk is $0.30 \times 10^{-3}$—based on a crew of 80 working a two-weeks-on/two-weeks-off rotation—dispelling the common misconception of drilling being among the riskiest businesses.

**Involving the Work Force and Clients**

Involving the work force in the preparation of the safety case has emerged as a key aspect in the new UK safety regime. Sedco Forex seeks the knowledge and experience of its work force at all levels as an integral part of hazard assessment and emergency response planning. It has developed a casebook methodology for achieving this efficiently (see “Evaluating Blowout Risk,” next page). Thus, contributions from engineers, rig workers, safety committees and management are brought together. The process has also engendered an increased awareness of safety issues throughout the organization.

Training is of vital importance to a safety management system. Involvement in the formulation and review of safety cases provides an education for all. Aspects of rig operations identified by hazard analyses—for example, the response to blowouts—have been used to enhance onboard drills and exercises.

The advent of the new safety era is also bringing benefits to client-contractor relations. Historically, a drilling contractor would win a contract and then find a way to interface with the operating company. Now collaboration is needed at the outset to identify the responsibilities and duties of both parties (right).

When a rig works alongside another installation, for example in tender-assisted drilling, a combined operations safety case must be produced jointly by client and contractor (top, right). If the rig is working in stand-alone mode, there is still a need for integration of client and contractor safety management systems as the working practices of companies will vary. Sedco Forex has worked closely with Amerada Hess—another participant in the VSC exercise—to produce a client-contractor template for this interface. Soon to be endorsed by IADC and the United Kingdom Offshore Operators Association (UKOOA), this is seen as a way of resolving occasional operational friction that traditionally arises between contractor and client.

(continued on page 44)
One of the most severe hazards in offshore drilling is a blowout. Using an assessment technique that can be applied to all hazards on complex installations, Sedco Forex has developed a hazard assessment methodology for blowouts on the Sedco 704 that has since been extended to its other North Sea rigs.

The assessment helps determine if hardware and safety procedures can prevent, control or mitigate the consequences of a failure. Further analysis includes quantitative risk assessment (QRA), a remedial action plan, and if necessary a cost-benefit analysis.

The blowout hazard assessment reviews the possibility of failure of every well control component. Depending on the severity of the incident or complexity of the control response, each component failure is reviewed qualitatively at up to three levels—the reviews are referred to as the casebook, control response book and emergency response book. Some failures can be discounted at the initial phase, others require input at all three levels, while the remaining severe events are quantitatively assessed to determine the risk of impairing the integrity of the rig’s temporary refuge and the risk of incurring fatalities.

Casebook
The first task is to tabulate all possible ways that well control equipment may fail while circulating a gas influx out of the well. Four gas kick scenarios are considered: the bit is on bottom drilling; tripping out of the hole; pipe is out of the hole; undetected kicks. Sections of the well control system reviewed include piping, control and hydraulic systems and common mode failures, typically loss of power. No hazards are discounted prematurely based solely on the probability of their occurrence.

The table is built up to include all possible measures to prevent failure, and is reviewed by the rig crews to ensure all permutations have been considered and that the preventive measures are accurate. The table includes a grade for each case, its consequences and the danger to personnel. Grades are assigned by considering each case before any corrective action is taken, and may be one of three severity levels: A, no response required; B, well control stopped; C, release of well fluid occurs.

Control Response Book
For cases B and C, a well control assessment matrix sheet is completed on the rig by the crew that may have to carry out the well control response. The matrix sheets form a detailed analysis of all steps needed to overcome a problem and the complexity of the actions involved to detect the failure. By grading these steps, a final rank for each event is determined. If the response has effectively maintained control of the well and ensured personnel safety, the event is ranked for no further review. But if ranking shows that events may escalate, additional analysis is required using the emergency response book.
Emergency Response Book

Events requiring complex control action or having severe consequences are addressed at this level. Emergency response is defined as the muster of crew during a gas kick because of the danger of loss of life. A review is carried out to examine emergency response scenarios—the team doing this typically involves risk assessors, the safety management system coordinator, the rig offshore installation manager, and supervisors of drill crew and mechanical, electrical, subsea and marine activities.

Each scenario is reviewed by the team, that follows the escalation of the event from initial failure through unsuccessful control, to impairment of emergency systems and finally evacuation and abandonment of the installation (right). The resulting recommendations are outlined in the emergency response book and have a direct input into the mustering, evacuation, escape and rescue philosophy of Sedco Forex, and have led to rig modifications. For the Sedco 704, these modifications include the installation of 100% lifeboat redundancy and heat protection for the muster areas.

To ensure that risks resulting from hazards identified in the emergency response book do not exceed UK legislative criteria for impairment of the temporary refuge, and the company’s limit for fatality risk, Sedco Forex employs QRA. The total TR impairment frequency due to all potential incidents on the Sedco 704 is calculated to be $0.42 \times 10^{-3}$ per year. Out of that total, the impairment frequency for blowouts alone is predicted to be $0.24 \times 10^{-3}$ per year, or once every 4167 years. This is 24% of the official UK acceptance level of $1 \times 10^{-3}$ per year. Furthermore, QRA predicts that the risk of a fatality from a blowout is $16.1 \times 10^{-3}$ per year, well within Sedco Forex’s target for total installation fatality risk of $50 \times 10^{-3}$ fatalities per year.

The QRA performed on the C cases demonstrates that the risks associated with major hazards are within acceptance criteria. However, this acceptability does not in itself satisfy the “as low as reasonably practicable” (ALARP, see page 40) principle of risk reduction. To fulfill that commitment ALARP analysis is also applied at each stage of the hazard assessment to ensure that risks are not only below acceptance targets but as low as is practicable.
Looking Ahead

Preparing the VSC for the Sedco 704 has proved a valuable learning experience and safety cases are now being prepared for eight of the Sedco Forex semisubmersible fleet. Seven of these are MODUs already working in British waters, and the other is likely to enter the sector from Norway in 1994. A jackup working in Dutch waters is also the subject of a safety case.

The work load involved in preparing a safety case is substantial—the VSC took 12 months, some 5 man-years of effort, and almost $1 million to produce. Sedco Forex estimates that each operational safety case for rigs in the 700 series, which have a number of similarities in design, requires a full-time team of three people working for several months.

The process has also required physical modifications to the rigs, including enhancing passive fire protection, upgrading heating, ventilating and air-conditioning systems to prevent smoke ingress, adding more lifeboats and reorienting them (as mentioned above), and improving control room functions (right). For the 700-series rigs, which were built in the 1970s and 1980s, the cost of the upgrades ranges from $300,000 to $3 million each.

Changes in safety management are not confined to rig owners. They are occurring throughout the industry. For example, Schlumberger’s drilling services company Anadrill is putting in place safety management systems and believes that service procedures and equipment will soon be subject to risk assessment, first in the North Sea and then elsewhere.

Although the immediate effects of the new safety regime have been seen in the UK sector, legislation is changing all over the world. Much of the regulatory thrust is coming from the European Community, the US and Norway, with new regulations also set to come into force in The Netherlands at the beginning of 1994. Australia and Canada are now investigating new legislation.4

These changes are further fueled by international oil companies and their contractors and service companies transferring safety standards developed in mature areas to operations in other regions of the world, leading to the establishment of global standards (next page).

The move towards a single set of international safety standards will enable equipment and services to cross from one sector to another without major upgrades or operational changes. This move requires selection and adoption of the best practice or highest standards and adhering to these even if there are no regulatory requirements in the region. If successful, it should ensure that any operation anywhere in the world is being carried out to the highest possible standards.

—TK

4. The European Community (EC) “six pack”, is typical of new legislation. It is a set of six new goalsetting regulations requiring minimum standards of health and safety which came into force on January 1, 1993. These cover:

- management of health and safety at work
- provision and use of work equipment
- manual handling operations
- personal protective equipment at work
- display screen equipment
- workplace (health, safety and welfare).

These apply to all EC countries onshore. Offshore only the first five apply. In the UK sector this will be implemented as part of the forthcoming specific offshore regulations, designed to replace and update existing legislation and to support the safety case regulations.
Geco-Prakla's new GECO Topaz at work in the North Sea. Inset is the spacious back deck afforded in the new class of vessels. A sliding gantry arrangement allows sources to be deployed with a minimum of cable handling.

Over the past three years, Geco-Prakla has worked to reduce regional differences between vessels as the company moves towards an elevated single standard of safety throughout the fleet. This is complemented by a company-wide back-deck task force leading to a program of safety upgrades for its two dozen survey vessels, both old and new, which will be completed by the end of 1993.

North Sea practices are spreading worldwide. Safety cases are not just confined to platforms or rigs. At least one major operator is asking for marine safety cases to be submitted for seismic survey vessels as part of the qualification to bid. Furthermore, the North Sea practice of auditing seismic vessel safety is now being carried out before contract award by a number of operating companies working in Asian, African and other waters.