How safe are platforms in the face of storms?

Structural Reliability Assessment
Shell Technology Brief

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Structural Reliability Assessment

Cost Leadership and a continued commitment to Health, Safety & Environment (HSE) are critical factors for sustained success in the EP business. Recent technological developments in the structural integrity of offshore installations have contributed directly to both these factors. They achieve cost reductions in capital/operating expenditure and improve safety. These technological achievements have been accomplished by Shell’s research engineers working with Shell companies around the world.

Shell is the largest offshore operator, with a total of about 800 oil + gas platforms around the world, including the major offshore provinces of the North Sea, Gulf of Mexico and South China Sea.

What is the function of an oil platform?
Offshore structures support the hydrocarbon producing lines (conductors and risers) and the surface equipment which processes the oil or gas. They have to be able to withstand the forces of nature such as waves, winds, currents and sometimes earthquakes. The loadings from these forces are often so severe that they dominate the design.

Response to nature
How safe are offshore platforms in resisting the forces of nature? How do
waves, winds and currents combine to lead to extreme loads? How do the hurricanes in the Gulf of Mexico differ from winter storm depressions in the North Sea or the monsoons of the South China Sea? How do structures respond to these loads? How well do we understand the strength and endurance of our structures? Does it make sense to maintain the same stringent standards for unmanned satellite platforms as for permanently manned installations?

Shell has looked at all these questions systematically and developed a new methodology which rationalises structural safety across different geographical areas, different manning levels and different structure types. This method addresses: (i) the magnitude of the forces of nature which a structure has to withstand and (ii) the ultimate strength of the structural system. By bringing these two aspects together the probability of structural collapse due to extreme storms is calculated and a decision-making framework is developed.

An analytical approach
A key feature of the new approach is that approximations due to lack of knowledge are reduced to a minimum. To achieve this, information on weather patterns, including long term records of waves, winds and currents, is analysed to obtain extreme values when the forces combine. It is no longer necessary to assume that extreme waves, winds and currents will all occur at the same time and act in the same direction. Differences in the natural characteristics of hurricanes, monsoons, swells and winter storms, are also recorded and studied.

The forces resulting from waves, winds and currents pushing against the platform are evaluated using numerical models. These have been tested using unique full-scale data gathered by instruments on the Tern platform in the North Sea. The Shell team gathered data from this platform for four years. Analysis and interpretation of these data enabled the team to virtually eliminate the modelling uncertainty in this part of the process. In a parallel development, the uncertainty on the strength of the structure was considerably reduced by using state-of-the-art analysis tools which have been validated using laboratory tests.

Reduced uncertainties
Because uncertainties due to lack of knowledge have now been considerably reduced, it is possible to estimate the probability of failure with reasonable accuracy. The method treats the natural uncertainty of
waves, winds and currents probabilistically. The chance of a platform collapse due to extreme storms is quantified and can be compared with other risks to personnel offshore.

SRA in action:
The Structural Reliability Assessment (SRA) methodology was developed, tested and then “packaged” in 1996 into a recipe for the design or reassessment of offshore platforms. This design recipe ensures that the risk of collapse due to extreme storms remains small compared to the overall risk to personnel offshore. For unmanned structures, where loss of life is not a concern, the design criteria ensure adequate asset protection but are more relaxed compared with manned installations, thereby leading to cost savings.

SRA has been applied to many Shell platforms world-wide, including those in the North Sea, South China Sea, North Western Australia, Gulf of Guinea and the Gulf of Mexico. Applying the methodology to existing about US$18 million. During 1997-1998, application of the methodology by Brunei Shell led to more efficient use of existing structures with savings in excess of US$60 million.

Shell Sarawak has implemented SRA for the design of new structures, better use of existing platforms and for the utilisation of jack up units (self-elevating, drilling platforms). Cost savings already realised are in excess of US$20 million. Assessments of the Forcados Crude Loading Platform offshore Nigeria led to improved knowledge about risk levels and net cost savings of an additional US$5 million.

SRA methodology has resulted in better knowledge of offshore risk levels, real improvements in safety where needed and significant cost savings (over US$100 million) for Shell and its Partners.

Cost benefits
Application of the methodology to the design of new installations in the North Sea since 1996 (Shearwater and ETAP) has led to cost reductions of