

Figure 238.2 Example Response Surface

A number of probability distributions have been published for particular modules giving the probability of occurrence of a particular level of peak overpressure⁽⁷⁾. These probability distributions are based on an appreciation of release rates, ventilation conditions, pressure versus gas concentration curves and ignition probability. These probability distributions of various resistance variables are known, for example the distribution of yield stress is available to the HSE from a previous project performed by SLP.

A knowledge of the probability distributions of the load (pressure) and resistance variables enables probabilities to be associated with each cell of the response surface table. The probability of failure of the component may then be calculated for the particular load and resistance probability distribution. This enables the 'Reliability' and 'Reliability Index' to be calculated for the component under the given load probability distribution, for the acceptance criterion chosen.

Other sources of uncertainty exist, such as statistical and modelling uncertainties. Statistical uncertainty usually manifests itself as an error in the assumed mean value. The statistical measures of spread used are chosen to take this into account. Modelling uncertainties may be taken into account by applying an artificial probability distribution to the response itself assuming that the resistance or load variable is fixed or known. Modelling uncertainties would only normally be considered in combination with other random variables.

Conventional reliability theory⁽⁸⁾ deals with the identification of the 'design point' which corresponds (roughly) to the most probable point on the boundary between the fail and safe cases. This boundary is referred to as the failure function. The 'Reliability Index' is a measure of the distance between this design point and the point corresponding to the mean values of the load and resistance

variables. In Figure 238.3 the axes have been normalised so that the origin corresponds to the mean values of the resistance and load variables and a unit distance corresponds to the standard deviation.

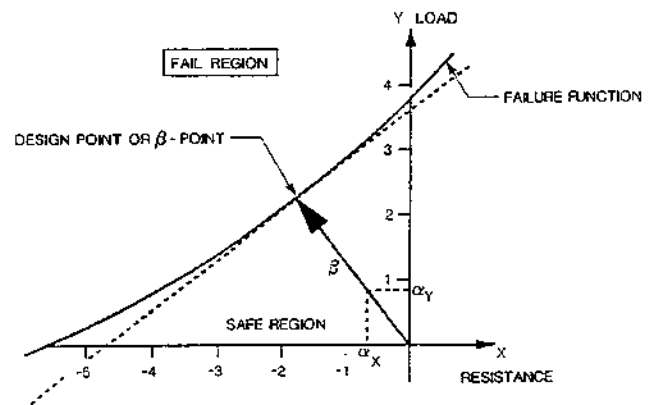


Figure 238.3 The Reliability Index β and Sensitivity Factors α

Comparisons of predicted probabilities of failure and reliability indices with conventional reliability theory give almost identical results for the variables and a unit distance corresponds to the standard deviation.

Comparisons of predicted probabilities of failure and reliability indices with conventional reliability theory give almost identical results for the variables considered so far, which have had almost linear failure boundaries near the design point.

The slope of the response surface in the X (resistance) or Y (load) directions gives a measure of the relative sensitivity of the response at a particular combination of load and resistance values. What is required, however, is an absolute measure of the sensitivity of the response associated with a particular resistance variable. This is discussed in the following section.

Meaningful Sensitivity Parameters

Conventional reliability theory shows that the sensitivity to failure by variation of a particular variable may be characterised by the slope of the failure function at the design point. This is indicated in Figure 238.3 by the relative magnitudes of the components α_x and α_y which are the (normalised) components of the line joining the origin to the design point. These conventional measures of sensitivity have been derived numerically and have been found to agree with the theoretical values derived using reliability theory.

The choice of the design point is sensible but arbitrary and does not characterise the behaviour of the failure function away from the design point. The totally numerical approach to the problem adopted by the project enables other (averaged) measures of sensitivity to be derived from consideration of the slope of the failure function and indeed the whole response surface to be calculated so long as the probabilities associated with each cell of the surface are

taken into account.

The sensitivity of the response to other resistance variables may thus be compared in a meaningful way, allowing prioritisation of the resistance (and load) variables examined.

Conventional reliability theory is able to deal with the simultaneous variation of a number of variables which may be correlated. This aspect is currently under investigation using the totally numerical approach presented here. This approach differs from the Monte-Carlo technique in that the whole response surface is mapped out in a regular fashion on a region where load and resistance probabilities are not negligible.

The project will continue into phase 2 with an investigation into module response and containment capacity to bound the range of loads and to evaluate load transfer effects between module walls and ceilings. The first two phases of the project will be complete by July 1996.

The project would welcome further involvement and funding from industry sponsors with the scope extended to suit further participants, leading possibly to an investigation into escalation and the impact of fires and explosions on total offshore installations (level 3 structures).

References

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