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# Gas Explosion Effects on Offshore Structures

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**Abstract**

Gas explosion is a rare but severe event on offshore production facilities. Its impact is a severe load on the structure. This paper identifies the key characteristics of these forces and factors governing the severity of an explosion, and examines the effects of the direct over-pressure loading generated by an offshore explosion on walls, floors and ceilings. The gases venting from the explosion can also generate high drag loads on equipment, pipe work , structural elements etc. sited in the vent areas. Two cases are considered, a module where the dominant loading effects are due to the direct over-pressure and an FPSO where the drag load has a considerable effect on equipment on the deck.

This paper discusses the two types of loading mechanism, also the range of analysis methods available to the designer is considered from a simple quasi-static approach to a sophisticated finite element model.

Finally, the structural response implications of the variability of the pressure-time histories obtained from both CFD simulations and full scale tests is discussed with a view to setting a design value for blast over-pressures.

**Key Words:** Structures, Offshore, Gas Explosions, Loading, Response, Modules

## Introduction

Structural design to limit the consequences of offshore hydrocarbon explosions prior to the Piper Alpha incident in 1988 was mainly confined to blast walls around the well bay . Some platforms did have blast walls installed but these were limited in numbers and the design over-pressures were low compared to present values.

The Piper Alpha accident and the subsequent introduction of the Safety Case approach to both new projects and existing installations in the UK sector of the North Sea placed requirements on operators to consider the possible consequences of a possible hydrocarbon explosion and to provide some degree of mitigation.

Quantification of over-pressures immediately post Piper Alpha were largely based on empirical models many of which were not appropriate. For example, a number were variants of the work carried out in the sixties by Cubbage and Simmonds (Ref. 1) who produced a methodology to predict and relieve pressures generated by blasts in small paint drying ovens. This empirical approach was adequate for its intended purpose, but is too simplistic and did not give reliable results for the complex geometry of an offshore module. A discussion on the merits of explosion models can be found in Tam and Simmonds (Ref. 2 and 3).

In the late seventies and early eighties development started on a number of new approaches ranging from phenomenological models to a full Computational Fluid dynamics (CFD) explosion code. As over-pressure prediction models were developed, model testing was also carried out in parallel and mainly in small to medium scale (<1/5). This culminated in the full scale tests carried out at Spadeadam between 1995 and 1997 by Phase II of a joint industry Blast and Fire Engineering for Top Side Structures Project

Although the accuracy of over-pressure predictions has improved considerably since the early empirical methods were introduced, very little work has been done related to the specific characteristics of gas explosions (in congested and confined process environments) and their effects on structural response.

## Hydrocarbon Gas Explosions

The design of structures to resist explosion loads has been an area of interest for military applications for many years. However, most of the data has been based on results from TNT type of explosions..

Hydrocarbon gas explosions differ from explosions created by TNT. Although the peak over-pressure generated may be substantially lower, the duration of a hydrocarbon gas explosion is considerably longer than