Title	OTO 1999 011: CFD Calculation of Impinging Gas jet flames
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Executive Summary	Passive fire protection material (PFP) is used to place an insulating barrier between the heat loading from a fire and vulnerable objects such as vessels and supporting structures. Traditionally, such materials have been tested using heat loading from a furnace operating under time-temperature conditions defined by a fire curve. However, furnace tests are unable to replicate the severe erosive forces, thermal shock or the balance between convective and radiative heat loading resulting h m a impinging jet fire from a high pressure gas leak. Therefore, a working group was formed from interested industry parties and regulatory authorities, with the objective of defining and validating a jet fire resistance test that could be performed in a reproducible manner at a number of test laboratories, and that replicated the key conditions of large-scale jet fires. This report describes computational fluid dynamics (CFD) calculations carried out by Shell as part of the validation process, under commission from the Health and Safety Executive. The objective of the numerical modelling was to provide information about difficult-to-measure properties such as flame temperatures, velocities, dynamic pressures and convective and radiative heat transfer to flame-impinged surfaces. Calculations have been performed for two free, and three impinging natural gas and propane gas jet flames. Sub-models have been developed to simulate the initial expansion of the high-pressure gas jet, turbulent gas-phase combustion, soot evolution and radiative and convective heat transfer. Numerical solutions were obtained using the CFX software from AEA Technology, Validation of the calculations where possible was made against experimental measurements made by BG Technology plc, SINTEF Energy and South West Research Institute. The following conclusions can be drawn from the work. 1. The 0.3 kg/s propane gas jet flame used in the jet fire test does replicate the convective and radiative heat loading typical of a large-scale natural gas jet flame when it is fired into the test arrangement for planar and structural specimens. This supports the results found with PFP coated specimens tested at both scales. 2. Premixed flamelet modelling is required in order to obtain an accurate prediction of the combustion behaviour of the lift-of region of the 0.3 kgls propane gas jet flame. However, the diffusion flamelet model for natural gas combustion provides sufficiently accurate predictions of flame properties in the bulk of the flame to enable comparison of difficult to measure properties. 3. The Jet Fire Test for Tubular Specimens also appears to reproduce the convective and radiative heat loading that would be found inside a large-scale flame. However, although the peak dynamic pressures on the tubular are equivalent to those found in a large-scale flame, the region of high dynamic pressures is quite small and corresponds to a region of relatively low flame gas temperatures, 4. The work has also demonstrated that CFD is a useful tool for the analysis of the behaviour of impacting flames in complex geometries.

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