Title	Research Report 402: Natural ventilation of offshore modules
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Executive Summary	**Background** Natural ventilation is a common method for mitigating the hazard posed by gas and vapour leaks on offshore platforms. Openings in wind walls and doors allow the wind to blow through a module and hence the ventilation is not generally dependent on the operation of any devices such as mechanical fans. Information on how to optimise natural ventilation of offshore platforms is available in a number of documents. Guidance aimed specifically at the offshore industry can be found in the International Standard IS 15138 and is also discussed as a topic, usually within a dedicated chapter, in most other ‘Area classification’ documents. The one most relevant to the UK offshore industry is the ‘Area classification for Petroleum Industries. Part 15’ (IP 15) published by the Institute of Petroleum. This guidance is based on the European Standard BS EN60079-10. IP 15 describes the assessment of areas based upon different levels of ventilation, which range from ‘open’, ‘sheltered’ to ‘enclosed’. The level of ventilation within an area, which is described by either air velocities or air change rates, greatly affects area assessment. This report investigates the effectiveness of natural ventilation of offshore platforms, focusing on the non-uniformity of the ventilation within a module and its dependence on the wind conditions. This has been achieved by making detailed experimental measurements on three typical offshore platforms and applying Computational Fluid Dynamics (CFD) to one of these. The completion of this project has led to the production of two additional reports that describe the experimental measurements in detail on the two platforms where CFD was not used. **Objectives** The main objectives of this project are: (1) To gain an improved understanding of the extent of the problem of poorly ventilated regions on naturally ventilated offshore modules. (2) To correlate localised velocity / ventilation rate measurements and CFD predictions against wind conditions. (3) To assess the feasibility of using tracer gas techniques to measure ventilation rates in naturally ventilated offshore modules. (4) To assess and validate the use of CFD as a technique for predicting the effectiveness of natural ventilation by comparison against detailed on-site measurement. (5) To use CFD to investigate the effectiveness of ventilation under different weather conditions for diluting and dispersing flammable gases produced from realistic gas releases. (6) To evaluate the effectiveness of remedial measures to mitigate local poorly ventilated areas. (7) To assess the practicality of complying with guidance for natural ventilation and assessing the likelihood of this leading to effective ventilation. **Main Findings** (1) Velocity measurements on three separate offshore platforms and a detailed CFD study on one platform have shown that the effectiveness of natural

ventilation is highly dependent on the external wind conditions and is unlikely to be uniform throughout the module.

(2) The flow paths through a naturally ventilated module have been found to be very complex and often non-intuitive. It is therefore imperative that ventilation assessments are based on a detailed programme of local velocity measurements carried out over a range of wind conditions, preferably in conjunction with CFD predictions, to provide a clear picture of the effectiveness of the ventilation.

(3) Measurements made on the three offshore platforms have shown that natural ventilation of a deck is affected by the arrangement and amount of equipment on a deck and also by the number of openings and their position at the perimeter of the deck. A further influence on the natural ventilation within a module is the sheltering offered by adjoining platforms.

(4) The air movement on the three platforms studied displayed different flow regimes:

a) Under certain wind conditions, air flow patterns on the cellar deck of Installation A, which was the most open of the three platforms, could loosely be described as ‘plug flow’ . This was where the air entered the module via one fully open face and was swept across the deck before leaving via the opposite open face. This type of ventilation would be described as ‘desirable’. When the wind direction was parallel to the open sides the air flow patterns on the deck were complex and highly three dimensional, illustrating the effect of wind direction on flow patterns within modules. Even though this is a relatively open platform, all measured air velocities were found to be less than the prevailing wind speed.

c) Measurements on the cellar deck of Installation B, which had partial wind walls fitted to all four sides, highlighted a degree of short circuiting. Also the sheltering effect of an adjoining platform was thought likely to reduce the ventilation rate through the deck.

d) Installation C, which was the most enclosed of the three platforms studied, was surrounded on three sides by adjoining platforms. This platform displayed complex flow patterns which were highly variable and dependent on the wind speed and direction. This was the platform where CFD was applied.

(5) CFD has been shown to be a powerful tool for the prediction of the effectiveness of natural ventilation on offshore platforms. The present CFD model has been validated against a detailed set of offshore measurements and the predictions have been shown to be in good agreement for a range of wind conditions. We can expect that, with the increases in computer power and availability of CAD data for platforms, the use of CFD modelling in ventilation assessments will increase.

(6) CFD predictions have shown that the rate of gas build-up from realistic gas leaks on an offshore platform is highly dependent on the wind conditions and hence the effectiveness of the ventilation. The rate at which gas leaks are diluted and dispersed following a leak is also strongly dependent on the wind conditions.

(7) It has been found that, even for a platform that was well ventilated, large gas leak rates will lead to the formation of large explosive gas clouds. However, once the leak has stopped, good ventilation can remove the flammable gas from the platform efficiently. For smaller releases poor ventilation will allow significant gas clouds to form above the lower flammability limit. Therefore effective ventilation can be expected to remove large volumes of flammable gas after a large leak or limit the build-up of flammable gas clouds for smaller

leaks.

(8) It should be possible to measure ventilation rates on offshore platforms, for certain platform configurations/geometries and under certain weather conditions using either velocity measurements or tracer gas techniques. However, where the ventilation openings are positioned so as to create complex flow patterns inside modules, it is unlikely that accurate measurements would be possible.

(9) Whilst tracer gas measurements are difficult to carry out offshore, CFD modelling of tracer gas tests has proved to be useful and has helped to identify the least well ventilated areas. These predictions have been used to calculate purge times. These have proved to be useful for comparing the level of ventilation in different areas under arbitrary, or all, wind conditions.

(10) If local poorly ventilated areas are identified on a module it should be possible to improve the ventilation by a number of means: introduction of fans, nozzles, air movers, removal of wind walls or replacement of floor areas with open grating. However, these measures need to be designed and assessed in each case to ensure that they will actually lead to an improvement in the ventilation.

(11) Local areas of poor ventilation can often be found on a platform even where the remainder of the platform is well ventilated. This therefore suggests that determining an air change rate for a module is not a clear indication of whether or not the ventilation within a module is effective.

(12) Complying with guidance on natural ventilation that requires a minimum air change rate is not straightforward due to the difficulties in measuring the ventilation rate in modules. It has also become apparent that even if these conditions are adhered to, that this does not necessarily lead to effective ventilation.

(13) The combination of offshore velocity measurements and CFD modelling has proven to be an invaluable and practical tool for evaluating the effectiveness of ventilation on offshore modules.

Main Recommendations

(1) The current guidance is difficult to implement and its usefulness is questioned. HSE should consider influencing improvements to current guidance. Possible improvements could include the replacement of air change rates with volumetric flow rates that are dependent on the size of the potential leak, not the size of the deck in which it may occur. Alternatively ventilation rates could be completely removed from guidance and replaced with acceptable geometries/open areas which give acceptable ventilation. A further possibility is to evaluate the effectiveness of the ventilation by its ability to dilute and disperse a given range of gas leak rates.

(2) One question in particular needs to be addressed before any guidance is amended. That is, “For what range of gas leak sizes can natural ventilation be expected to provide mitigation against gas build up?” This is not clear in the current guidance.

(3) Assessing an area as ‘open’ based on the measurement of air velocities is not ideal. However, this is the approach adopted in IP 15. Offshore velocity measurements have shown that if guidance is followed, areas with no wind walls present on Installation A should be classified as ‘sheltered’. As any equipment will cause an obstruction to the flow, it is possible that there are few areas on offshore modules that could be classified as ‘open’.

(4) CFD modelling has been shown to be a powerful tool that can be used in ventilation assessments. However, it is important that CFD results are interpreted with caution and the models should be validated against offshore

velocity measurements to establish confidence in the predictions. Ventilation assessments based on CFD predictions alone must therefore be treated with caution.

(5) It has been shown that due to complex geometries and the influence of adjoining platforms that flow paths through modules and thus ventilation effectiveness is difficult to anticipate and can be counter-intuitive. Offshore measurements, ideally supported by CFD modelling, should be undertaken in order to demonstrate the adequacy of the ventilation.

(6) Ventilation assessments could usefully be used to optimise the positioning of gas detectors.

(7) Further work is needed to assess the relative effectiveness of different methods for improving the ventilation in local poorly ventilated areas. Possible methods include the installation of air movers, fans and nozzles, removal of wind walls and replacing sections of floor areas with open grating. A cost-benefit analysis is needed.

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