EXPLOSION MITIGATION BY WATER MIST

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The internal explosion of an anti-ship missile or stored ammunition is a potentially catastrophic threat for a warship. These events generally cause heavy blast loading and fragments to perforate the ship structure. As a solution to reduce the blast loading, the compartment can be filled with water mist prior to the explosion. TNO Defence, Security and Safety and Fluid Gravity Engineering (FGE) have teamed up to perform a combined theoretical analysis and experimental validation programme. The cooperation is part of the British and Netherlands MoD exchange programme BNCP/N/R24. During development of the trial programme, FGE provided TNO with the required test design parameters through a one dimensional hydrodynamic analysis of the droplet distribution. It showed that the expected mitigating effect is largely independent of the initial droplet size. After that, TNO performed the trials and FGE simultaneously conducted 2D and 3D simulations in their codes EDEN and PIC3D without any access to the experimental data. Results of the experiments and numerics were compared afterwards.

In total seven blast mitigation trials were performed on a realistic scale, the amount of water mist being varied between 0, 80 and 100 litres in the 250 m³ bunker. The trials have shown that the quasi static pressure from an explosion can be reduced by almost 50% when the water mist system is designed properly. Peak pressure of the blast wave was reduced only marginally and the value varies from shot to shot. Measured impulse of the blast wave in the water mist filled bunker was 30% lower compared to the dry reference trial. Note that the quasi static pressure is one of the main design drivers for the strength of blast resistant bulkheads and doors. Results from modelling by FGE are in fair agreement with experimental data. Such models can thus be used for further development and optimisation of system design for specific compartments.

Because of the mitigating effect of the water mist, the ship can be constructed using less material (bulkhead thickness) to withstand an internal explosion, or the current bulkhead designs can provide protection against larger anti-ship missiles. Alternatively, such a system can be applied in high risk compartments like ammunition storage rooms.

Future work includes the challenge of timing: having the right amount of water in the compartment will require very fast triggering and release systems if it is used as last resort, or will require different thinking of the ship crew and commander when used pre-emptively.