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WATER MIST AS A HALON ALTERNATIVE: ITS STATUS AND DEVELOPMENT

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INTRODUCTION

The production of Halon1301, one of the most effective chemical fire suppressants ever developed, was banned at the beginning of 1994 by the Montreal Protocol, because of its effects on the earth's ozone layer. Research to develop effective and environmentally-friendly alternatives for halon is being carried out. Water-based systems are environmentally friendly, non-toxic, have low cost and are effective in suppressing certain fires. As a result, the use of water mist, as a potential halon replacement, has received considerable attention. Over the last few years, there have been a number of investigations to evaluate the capabilities of water mist systems as a halon alternative for various applications[1].

This paper provides a review of the development of water mist fire suppression systems. Fundamental research and full-scale fire suppression tests in shipboard machinery spaces conducted by the National Research Council of Canada (NRC) and other research facilities are analyzed to determine the capabilities of the present water mist technology for this application. Also, the progress made in the application of water mist technology to protect electrical and electronic equipment is discussed. Some measures required to improve the effectiveness of water mist fire suppression systems, such as computer modelling, are also identified.

REVIEW OF WATER MIST TECHNOLOGY

The concept of using water mist to extinguish liquid and solid fuel fires is relatively old[2]. However, the application of water mist in fire suppression was not considered practical until recently. The phase-out of halon has produced a renewed interest in water mist technology.

The early studies[2-3] identified flame cooling and oxygen displacement as the dominant mechanisms in water mist fire suppression. Recent investigations, however, suggest that there are additional mechanisms in water mist fire suppression[4-5]. One such mechanism is the radiation attenuation provided by water mist which can stop the fire from spreading to an unignited fuel surface and reduce the vaporization or pyrolysis rate at the fuel surface[5]. Tests conducted at NRC[5] showed that the radiant heat flux to the walls of the test compartment was reduced by more than 70 percent by the water mist. Other extinguishing mechanisms, considered as secondary, include dilution of flammable vapours, and direct impingement wetting and cooling of the combustibles[4-5].

Fire suppression by water mist is mainly by a physical mechanism and no significant chemical effects are involved. Although all mechanisms of water mist contribute to fire extinguishment to some degree, only one or two mechanisms play a predominant role in most cases[5]. Which spaces. The Canadian, UK and US military and Coast Guard are continuing with tests to develop design criteria for typical machinery space applications.

ELECTRICAL AND ELECTRONIC EQUIPMENT

Another area where water mist has a potential as an effective halon alternative is the protection of electronic equipment. However, the telecommunications and utilities industries have traditionally been reluctant to use water as a fire suppressant on electrical and electronic equipment because of concerns about potential water damage. For this reason, gaseous fire suppression agents are considered as the primary halon replacement for electronic applications.

Preliminary studies[12-13] to determine the feasibility of using water mist to suppress in-cabinet electronic fires showed that the fine water mist was effective in extinguishing fires without causing short circuit or other damage to electrical and electronic components. However, the preliminary study was confined to one particular type of telecommunication cabinet. Other electronic system hardware, with different functions and geometry, may require a more complex delivery system. It was recognized that further study is required to develop and evaluate sophisticated water mist systems which will work on different types of electronic equipment before a 'universal' protection system can be produced.

Recently, NRC conducted the IntelMist™ project to study the feasibility of using water mist as an alternative to halon to protect facilities with substantial amounts of electronic equipment. The basic principle of IntelMist is the use of state-of-the-art fire-detection technology to control a zoned water-mist fire suppression system, so that water can be applied to the minimum possible area directly associated with a fire. The IntelMist project involved three related tasks with the following objectives: to determine the water-mist characteristics required to extinguish a fire in electronic equipment using a minimum amount of water mist; to define the detection-system characteristics needed to accurately locate a fire in a large compartment and continuously monitor it during suppression; and to describe a signal-processing logic for making correct decisions about which valves to activate the related zone in the suppression-system piping.

As a part of the IntelMist project, NRC conducted a series of full-scale fire suppression tests using water mist in electronic cabinets, underfloor cable plenums and overhead cable trays[6,14-15]. Various water mist systems with different arrangements, including conical and linear sprays in cabinets and a single-point discharge nozzle with superheated water, were evaluated in these tests. The experimental investigations demonstrated that the traditional total-flooding approach (used for Halon 1301), whether in a single cabinet, an under-floor plenum or a large space with many cable trays, was unreliable when applied to water mist. On the other hand, reliable fire suppression was achieved with water mist by exercising rigorous control over spray direction to the hazard. This was accomplished by laying out the nozzles to suit the physical arrangement of the obstructions or structural elements. The studies also showed that coarser sprays ($200<D_{v0.9}<400$ microns) which produced wetting of surfaces and water dripping down into recessed places, had better performance than very fine sprays ($D_{v0.9}<90$ microns) against fires in electronic equipment. Very fine mists tended to drift beyond the intended area of application, increasing humidity throughout the cabinet. The investigation showed that a water mist system can be used to suppress fires in electrical and electronic equipment with minimum water damage.

A potential advantage of water mist is that the damage to the electronic equipment by water mist could be far less than the damage caused by thermal decomposition products of gaseous halon replacement agents. Recent studies[16] with replacement gases for Halon1301 indicated that, when they are applied to a fire, the gaseous agents can decompose and produce high concentrations of corrosive gases such as HF. Also with gaseous agents, the compartment has to be evacuated completely during the agent discharge, disabling the operation of the room. However, with water mist, the evacuation of the compartment may not be necessary, especially if a zoned water mist system is used. This may allow a continuation of limited operations in the compartment.

The IntelMist project established the feasibility of using water mist to suppress electronic equipment fires. With suitable spray characteristics and an intelligent detection system and signal-processing logic, water mist is a viable option to replace halon in electronic and telecommunication equipment rooms. Further work is needed to develop a prototype system that incorporates the suppression and detection/logic elements described in the study. Also, an evaluation of the system, based on a specific set of electronic equipment, is required to establish the cost effectiveness and overall reliability of such a system.

COMPUTER MODELLING

Recent studies of water mist technology have shown that the relationship between a fire scenario and the characteristics of a water mist system is not well enough understood to apply a "first principles" approach to the design of the water mist systems. Until now, the evaluation of the performance of a water mist system for an application was based on full-scale tests. This results in delays and high costs in the development of water mist technology. Further experimental and theoretical studies are needed to investigate the physical and chemical interaction between the water mist and the flame.

A computational fluid dynamics (CFD) model can be used to provide detailed information on fluid dynamics, heat transfer, as well as the interaction between water mist and the flame. Computer modelling was used to study liquid pool fire extinguishment by water mist at NRC[17]. Results obtained from the computer model showed that the fire created a strong upward plume directly over the fire pan which did not allow a low-momentum water spray to penetrate the fire plume and reach the region near the fuel surface. However, water mist cooled the fire plume rapidly and introduced the flow of cool gases over pans.

The current CFD models require significant computer power. This requirement increases the costs and time for the development of water mist systems. In addition, in order to improve the accuracy of the models, a more comprehensive knowledge of the spray characteristics than currently available is required. Also, further improvement is required in the currently-available fuel evaporation and combustion models.

Another approach to the modelling of water mist fire suppression is the use of a model which incorporates a kinetic scheme to examine the chemical interaction between the water mist and the flame. This type of model can predict the minimum oxygen displacement required to extinguish various combustibles using water mist, and also can predict the level of combustion by-products. NRC is initiating a project to develop this type of model.

CONCLUSIONS

Water mist has been demonstrated to be a potential candidate as a halon alternative for certain applications. Currently, shipboard machinery spaces have been identified as an ideal location for the application of a water mist system. Electronic equipment is another area where water mist technology can be used. Studies have shown that with suitable spray characteristics, elements of an intelligent detection system and signal-processing logic, water mist can replace halon in electronic and telecommunication equipment rooms.

At present, the evaluation of the performance of water mist systems is primarily based on full-scale tests. This results in delays and high costs for the development of water mist technology. Further experimental and theoretical work is needed to determine the physical and chemical interaction between water mist and the fire. Further development of computer models will be essential in developing an understanding of the extinguishment processes and the design of water mist systems.

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