WATER MIST IN TOTAL FLOODING APPLICATIONS

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INTRODUCTION

This paper is designed to present a current picture of water fog (mist) fire fighting technology, with an emphasis on the ability of water fog to act in a gas-like, total flooding manner appropriate to serving as an alternative to halon. The paper will provide some basic information about the Marioff company and the genesis of the various *Hi-fog* systems, discuss what Marioff has learned about the fire suppression and extinguishing factors at work, and provide basic details on some of the relevant testing that has been done to date in scenarios where halon is or could be used.

OVERVIEW

Marioff *Hi-fog* Oy, a Finnish company, has for eight years specialized in the development and supply of innovative high pressure hydraulic products to the marine and offshore markets. (The name Marioff derives from "marine" and "offshore".) It has been responsible for testing, flushing and commissioning high integrity systems such as subsea control packages and complete offshore oil platform piping.

About two years ago, as a result of the increasing demand for sprinkler protection on passenger vessels, Marioff decided to put its extensive hydraulic expertise to use in this connection by designing modern, safe and effective sprinkler systems to protect cabins and public spaces onboard ships. In addition to having demonstrated (in comparative test settings) equal or superior efficacy vis-a-vis conventional sprinkler systems, the *Hi-fog* sprinkler system has been chosen by many shipowners (see Table 1). Because it uses far less water and its pipe diameters are much smaller than typical sprinkler piping, a *Hi-fog* sprinkler system weighs less than 10% as much as a conventional sprinkler system, and is therefore faster and easier to install. These sprinkler systems are pumppowered and can use the normal heat frangible bulb activation mechanism, although other, faster response activation methods are possible. For the development of the shipboard sprinkler system, Marioff was awarded the coveted *Seatrade* Safety at Sea Award from among 200 competing firms worldwide.

Approvals have been obtained from many national maritime authorities and classification societies, including the American Bureau *of* Shipping.

The next *Hi-fog* system to be developed was a machinery space system, largely in response to the growing demand to find suitable alternatives for halon, life-threatening C02, and ineffective conventional

water spray systems. Again, due to Marioff's marine background, the initial target market was ships' engine rooms. Approvals have been achieved for this system, and several units have already been installed, with many more ordered. The power packs for these units consist of banks of pre-charged accumulators, sometimes combined with low pressure pumps and/or recharge pumps for refilling the accumulators in the (unlikely) event that a second discharge is required.

The third Marioff *Hi-fog* system to be developed was a handheld lance system for local applications. These can be powered by a pump or a pressurized cylinder. Depending upon the type of head used (Marioff has over 20 different sprinkler and spray heads), this type of system can generate a typical flooding-type discharge or be used as a "streaming agent", the latter offering an alternative to halon 1211.

The most recent *Hi-fog* system to be developed is what Marioff refers to as its "self-contained" system. These have already been installed in various shipboard and land-based (see Table 2) settings in lieu of halon and, in some cases, C02 or other alternatives such as conventional sprinklers. The self-contained system consists essentially of a pressurized cylinder (available in various sizes) and either a head directly on the cylinder valve or a head or heads connected to the valve assembly via some extension piping -- which is stainless steel tubing, in accordance with Marioff's philosophy to use only noncorrosive materials in all of its systems. The self-contained system requires no external water supply and is not dependent (in heat frangible bulb activated systems) on any electrical power source. Although able to operate independently of any detection system, Marioffs self-contained systems can also be activated using any conventional means (heat, smoke, optical flame detectors) as well as manually. When using a sprinkler head (with bulb), the system will always activate when a certain heat is reached so it works even when an electrical failure has occurred. These systems are available in wet pipe and pre-action configurations. Water volume, pressures, flow rates, and discharge times can all be varied according to the specific application.

In the **USA,** Marioff intends to focus on the halon alternative market, and will be emphasizing its self-contained (for halon 1301) and handheld (for halon 1211) systems in this connection. It is important to note, however, that total flooding, halon alternative applications can also be met using pump-powered or pump-supplemented systems.

The various Marioff *Hi-fog* systems have undergone nearly 500 independently witnessed fire tests at internationally recognized national testing laboratories in Europe. Present testing work is centered around continued refinement of the total flooding systems, but considerable work and testing is now underway in connection with smoke control and explosion suppression systems.

The Marioff Hi-fop *components and systems are protected by 36 worldwide patents and patent applications.*

BACKGROUND

The efficient fire suppressing effect of fine water fog (or mist) has been recognized for many years. This suppression is due to the large total surface area of the droplets and the high rate of speed at which they turn to steam, thus absorbing the energy of the fire. The average droplets contained in a water fog yield a total surface area at least 100 times greater than conventional sprinkler drops for the same water volume. Therefore, much smaller amounts of water are required to absorb energy from the fire.

Until recentty, practical use of water fog in fire protection has been restricted to very few applications, mainly because of the inability of the small droplets to penetrate the hot flue gases produced by even a moderately-sized fire. Marioff has overcome this problem by using experience gained with high pressure hydraulic technology. By forcing water at high pressure through specially developed nozzles arranged on spray or sprinkler heads, *Hi-fog* is propelled at a speed high enough to penetrate the flue gases of even a flashover fire. Therefore, the water fog is delivered directly into the combustion source, even in "hidden" fires. (It should be noted that Hi-&uses a mechanically reliable, single water line to produce the small droplet discharge. Moreover, *Hi-fog,* because of its enormous filtration capacity, use of noncorrosive materials only, and Marioff's years of experience in cleaning, flushing and filtration, does not suffer from any of the orifice clogging problems that existed in the past or mght still exist with other systems.)

In addition to hundreds of actual fire tests, most of them 'Worst case" in nature, other tests on droplet size measurements and distribution have been made. It is clear that droplet size is an important factor in *Hi-*&$extinguishing ability.

The combination of correct water droplet size, distribution, and high speed of penetration are the factors which we believe, based upon the testing undertaken, to be the key to fast suppressing and extinguishing -- even in adverse ventilation conditions.

Depending on the fire type and size, there are several factors at work in Hi-&$ability to suppress and extinguish. Always at work are gas-phase cooling and some surface cooling. Additionally, in a high temperature fire, the fog converts quickly to steam which produces an inerting effect and displaces the oxygen. This effect was first noticed during tests in simulated engine rooms when a hydrocarbon fire of 22 megawatts (2,500 degrees F), including two pool fires (one of them hidden) and a hidden spray fire, was extinguished in less than 5 seconds using only 10 liters (2.6 gallons) of water -- with doors and vents open.

TESTS RELEVANT TO HALON ALTERNATIVE (TOTAL FLOODING) APPLICATIONS

Marioff *Hi-fog* systems have been tested extensively in a wide variety of fire scenarios. Thus far, many of these tests have not been in the context of either total flooding or on objects which are typically protected by halon. In these tests, it has been found that *Hi-fog* is not dependent on a totally sealed space to suppress

or extinguish a fire. However, when the space is sealed, as it would be in applications protected by halon or any other gas, *Hi-fog's* already impressive effectiveness increases even further. More and more tests relative to halon replacement are being conducted so as *to* arrive at the optimum combination of hardware, flow rates, pressures, discharge times etc.

The following four test series outlined briefly below provide illustrations of some Marioff tests already conducted which are applicable or relevant to total flooding, halon alternative situations.

1. Electric switchgear Tests

Location: ABB Stromberg Research Center (Vaasa, Finland)
Date: August 3,1992
Report: 9 AFX92-98

The objective of the tests was to find out if the operation of a *Hi-fog* fire protection systems causes disruptive discharges in the main circuits of some l i e , typical electrical switching apparatus.
Main circuits of the following apparatus were tested:
- low voltage (690v) switchgear MDF including a frequency converter SAMI R3
- medium voltage **(24** Kv) switchgear MH
- medium voltage (24Kv) disconnector **OJON** 3-20
- busbar of low voltage (690v) switchgear MDF supplied with DC current

Even with the *Hi-fog* heads spraying normal tap water at h g h pressure directly into the open cabinets, there were no disruptive discharges in eight **of** nine tests. The one originally unsuccessful test was repeated twice, in one case using deionized water', and in the other moving the heads 12 inches. Both these second-stage tests were completely successful.
'Deionized water can be readily substituted for tap water. It has absolutely no deleterious effect on the efficacy of the *Hi-fog* systems.

2. Computer Room Smoke-Activated Fire Tests

Location: VTT Fire Technology Laboratory (Espoo, Finland)
Date: July 2-3, 1992
Report: PAL 2196/92

A series of **11** experiments was performed in a smoke sensitivity room. The experimental arrangement, i.e. the fire itself, the computer in the room, and the *Hi-fog* head location, was varied between the experiments. The two main objectives were:

1. to observe the performance of *Hi-fog* in extinguishing a computer room fire; and
2. to determine whether the combination of smoke from a PVC fire and Hi-&sprinkler fog cause any damage to computers that are not directty affected by the fire, itself.

In all function tests, the *Hi-fog* system was successful in extinguishing the test fires. Moreover, an independent, smoke contaminations expert conducting experiments at these tests commented: "It appears that the *Hi-fog* has the ability to "wash out" contaminates from the smoke thus greatly reducing the overall smoke damage effect."

3. *Enclosed Space Fire Suppression Tests*

Location: VTT Fire Technology Laboratory
Date: October 9 and 12,1992
Report: PAL 2206/92

A series of 16 tests was carried out to simulate fires in a typical small room as follows:
1. ticket stand (wood crib/heptane)
2. paint storage (paint/heptane)
3. transformer room (hydraulic oil)

All the experiments were performed in the fire test room (2.4 X 3.6 x 2.4 meters = 630 cubic feet). The door of the room was kept closed during the experiments with a gap of variable size under the door (to permit sufficient oxygen to achieve well-burning fires). One *Hi-fog* sprinkler head was fitted in the ceiling and connected to a self-contained pressurized bottle. Activation was either automatic or manual. The maximum amount of water used for each test was 6 liters (1.6 gallons).
In all cases, the fires were extinguished and reignition did not occur.

4. *Hidden Pool Fire with Changed Discharge Direction*

Location: VTT Fire Technology Laboratory
Date: May 6, 1993
Report: No report has yet been written by VTT. Below are Marioff's commentslassessments,

The objective of these tests was to determine the effects of changed discharge direction in a total flooding setting. The fire was a 50 square foot diesel pool fire, hidden beneath a complete horizontal obstruction. Two Marioff Hi-&spray heads were mounted above the obstruction (about 3 feet above the ground) and were pointing upwards. In all tests, the fires were extinguished in less than 30 seconds, using no more than 10 tiers (2.6 gallons) in any lest. No reignition occurred.

SUMMARY

Beyond its demonstrated efficacy, *Hi-fog* has been proven to be an excellent alternative to halon for many other reasons. There is absolutely no evidence to suggest that it is anything other than totally safe for people. When this factor is combined with the fact that its effectiveness is not greatly compromised when the space is not totally sealed, this means that actuation can be initiated before personnel evacuation and before shutting off ventilation and closing doors, windows, etc. Of particular relevance in the search for an alternative to an agent like halon, which has adverse environmental consequences, is the fact that *Hi-fog* poses absolutely no danger to the environment. *Hi-fog* system hardware takes up even less space than a halon system protecting the same area. For electric and electronic equipment areas, it is safe because of the extremely small amounts of water required (and, again, deionized water can be used if desired), and it provides extra benefits because it actually 'washes" damaging smoke particles to the ground. Again, due to the limited water amounts, no thermal shock effects have been observed in any tests undertaken thus far, which have included rapidly extinguishing massive hydrocarbon fires surrounding simulated engines.

Hi-fog systems are now undergoing tests by various US organizations. It is expected that they will be commercially available in the USA within the year. Based on our extensive, commercial experience in Europe --vis-a-vis halon, C02 and other fire protection systems, *Hi-fog* will be cost-competitive here in the USA as well.

Thus far, *Hi-fog* has been effective in every single type of fire scenario in which it has been tested; no practical limits on its use are known. A few of the halon-replacing scenarios where *Hi-fog* has been installed, orders achieved, or serious customer interest registered are flammable liquid storage areas, generator rooms, control rooms, archives storage, cultural resource applications, telecommunication installations, computer rooms (above and below floor), nuclear power stations, mobile storage, machinery spaces, and many more.

To the author's knowledge, no other water fog . mist system has yet received approvals from any authority worldwide as a stand-alone system.

Hi-fog, because it combines the many well-known, positive qualities of water without the disadvantages associated with standard water-based systems, is now regarded by many end-users throughout the world as the preferred choice to replace existing halon (as well as other types of fire protection system] installations.

ADDITIONAL INFORMATION IS AVAILABLE UPON REQUEST.

TABLE 1. MARIOFF MARINE REFERENCE **LIST**

Vessel	*Type*	*Operator / Yard*	*System*	*Progress*
'Olympia'	Cruise ferry	Viking	Galley system	Installed
'Mariella'	Cruise ferry	Viking	Duty free store	Installed
'Franz Suell'	Cruise ferry	Euroway	1200 sprinklers	Installed
'Festival'	Cruise ferry	Silja	2200 sprinklers	Installed
'Karneval'	Cruise ferry	Silja	2200 sprinklers	Installed
'Kalypso'	Cruise ferry	Slite	Galley system	Installed
'Europa'	Cruise ferry	Slite	2340 sprinklers	Installed
'Topaz'	Seismic vessel	GECO	160 sprinklers + engine room	Installed
'Diamond'	Seismic vessel	GECO	160 sprinklers + engine room	Installed
'Linden'	Sailing ship	Linden	30 sprinklers	Pending
NB 373	Cruise ferry	Euroway	1200 sprinklers	Pending
'Robin Hood'	Cruise ferry	IT-Line	1200 sprinklers	Installing
'Athena'	Cruise ferry	Slite	Galley system	Installing
'Bergen'	Ferry	Askøy	750 sprinklers + engine room	Installing
8821	Surface effect ship	Polyship Belgium	24 sprinklers + engine room	Start March 93
Nils Dacke	Cruise ferry	IT-Line	1200 Sprinklers	Start April 93

TABLE 2. MARIOFF LAND BASED REFERENCE LIST

Customer / Project	*Protection*	*System*	*Progress*
London Underground	Store rooms **Kiosks**	Self-contained	Installed /Installing
London Transport	Paper archives	Self-contained/pump	March install
Agrekko/Shell	Generator room	Self-contained	Commissioning
Polarcup. **Finland**	Printing machinery	Sprinkler/pump	Commissioning
BMW, Germany	Test room	Self-contained	Ordered