Article written by Eng. Luciano Borghetti
From "Antincendio", September 2004

ALL ABOUT AEROSOL.

HOW TO EXTINGUISH FIRES AND PRESERVE ENVIRONMENT

STATE OF THINGS ABOUT THIS EXTINGUISHING AGENT USED IN UNPEOPLED AREAS
THE POINT ON SYSTEMS AND TECHNOLOGIES

The alarm caused by the destruction of the ozone layer as a result of the dispersion of halogenated gasses in the atmosphere affected the fire-fighting technologies that used halons (bromine modified CFC) as extinguishers and it induced the urge to find alternate technologies. Among the "not in kind" alternatives, aerosol extinguishing agents have been developed and listed in the SNAP list by US EPA.

At present, all the aerosol technologies can be used in unpeopled areas (that is, people must leave the area before aerosol is discharged).

Technical identification makes use of the aerosol definition: either solid or liquid particles (in this case solid) suspended and transported by a gaseous phase.

Aerosol as extinguishing agent

The are two technologies for the aerosol-based extinction:

- Condensed aerosol generated by a solid compound contained in a generator that, started up by an igniter, releases an exothermic chemical reaction generating a gas blast containing solid condensation particles, basically composed of potassium salts (f.i. K2CO3), H2O, N2, CO2 and inert gas.
- Dispersed aerosol consisting of extinguishing powder (of different chemical composition) diffused by a carrier gas, either halogenated or inert. Systems use components and equipments similar to those for gas installations. Another technology is typified by a system using halogenated gas as a carrier and an extinguishing gel/powder compound.

Both the above methods will spread the extinguishing agent consisting of a fine particulate that puts out the fire, mostly through a chemical reaction. The inert gas generated by the condensed technology or the carrier gas contributes to extinction only marginally, even though scientific accuracy has to take its contribution into account.

At present, only condensed aerosol technologies are available in the European market. They have different sized generators (therefore protecting different volumes) mainly using two cooling systems: chemical and physical/mechanical. These differences result in different features of the generated aerosol (more or less cool), a different momentum of the jet and different discharge times.

The extinguishing process here described is common to every condensed technology, although available technologies have technical features and chemical compositions that differ slightly.

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How fire is extinguished

The condensed aerosol extinguishing agents (resulting from implementation of generators) are formed by tiny solid particles of alkaline metals salts (about 40% of the weight of the generated aerosol) and gas (about 60% of the weight of the generated aerosol), mostly nitrogen, carbon dioxide and water vapour.

Aerosol extinguishes fire through chemical working, interfering with the chain reaction of combustion, removing the free radicals (they aren't disposable any more for banking up combustion). Physically, the aerosol takes energy from the combustion environment (cooling action). This two reactions occurs mainly on the surface of solid aerosol particles; therefore, the more particles are little, the larger surface of reaction is available, the more effective is the extinguishing action.

During a fire (reaction of combustion), atoms and unstable free radicals react mutually in the presence of oxygen; the reaction goes on till fuel is exhausted or until fire is estinguished with proper means (combustion reaction interrupted).

When a condensed aerosol generator is started up, the solid compound contained in the generator is transformed into aerosol, mostly composed of potassium salts (K2CO3) and H2O, N2, CO2 and inert gas. The tiny dimensions of the potassium salts particles (a few microns of diameter) transported by inert gas give the generated aerosol the power to flow round the obstacles, to penetrate the volumes and to get an even spread in the protected volume, exploiting, too, the convection currents caused by combustion.

Potassium salt particles (a few microns' diameter) transported by the inert gas are provided with a high reaction surface in relation to volume; this is a feature that increases its extinguishing power (weight being equal), thus diminishing the necessary amount of extinguishing agent.

Specific features of condensed aerosol technologies are: 1)the extremely moderate amount of extinguishing agent (estimated according weight) needed to extinguish fire per unit of protected volume; 2) its volume; 3) the small weight of the aerosol generators; 4) the ease of their installation.

When aerosol hits the flames, it chemically reacts forming potassium radicals (K+), resulting from dissociation of potassium salts (K2CO3).

Free radicals K+ bind with free radicals OH that fuel combustionm, forming stable compounds (KOH) and interfering with the combustive reaction (they render OH radicals no more available to fuel combustion) and thus extinguishing the fire.

Aerosol employment does not result in any significant reduction of the residual oxygen content inside the protected volume. At present, there aren't available data enough about toxicity for people when exposed to aerosol, either data concerning residual visibility (after the aerosol discharge). Therefore, aerosol employment is limited to unpeopled areas **and the installation of an automatic manual switch is required** to disconnect the extinguishing automated equipment **whenever protected areas be peopled**.

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Where aerosol installation is possible

Aerosol technology is suitable for class A, B, C, D fires.

Aerosols are expecially effective on class B fires, therefore on plastic materials and materials containing hydrocarbon derivatives: if applied on fires of materials liable to emit deep seated fires they couldn't extinguish the coals totally, at the risk of a rekindling due to exposure of the coils to oxygen fuelling.

Usage of aerosol technology isn't reccomended for fires involving the following combustibles, unless specific tests were made and certified by outsider laboratories:

- Chemical materials capable of releasing oxygen during combustion, such as cellulose nitrate.
- Chemical mixtures or compounds containing oxidizing materials such as sodium chlorate or sodium nitrate.
- Chemical compounds capable of self-supporting combustion, such as organic peroxides.
- Reactive metals (sodium, potassium, litium, aluminium, magnesium, titanium and zirconium), reactive hydrides or metallic ammide, as some of them can violently react with the extinguishing agent
- Oxidizing agents such as nitric oxides, fluorine.
- Pyrophoric materials such as white phosphorus or metallo-organic compounds [CH3MgCl, CH3MgJ, (C2H5)3Al…) AlH3) – LiH3…].

The above list could be not exhaustive. When in doubt, contact the technology manufacturer.

Aerosol fire-extinguishing systems

Condensed aerosol fire-extinguishing systems (composed of one or more than one generators) can be used to protect both small volumes (cubic metre fractions) and larger ones (thousands of cubic metres, such as machinery spaces on board ships). Basically, they are made of one or more than one unit (generators) of different sizes (therefore, different protected volumes) that can be used individually or in multiple conjunctions, both for localized protection and for totally saturated systems.

These installations are assimilable to the notions of preengineered system and modular system; each generator will be certified for the protection of a given volume and will define the largest size effectually protected; volumes exceeding the rating of the individual generator will be protected by installing a multiple number of generators, considering their single coverage.

Aerosol generators, installed either singularly or in multiple conjunctions can be put into effect in many ways. Authomatically, by a fire-detector system with an

alarm threshold and discharge delay, in case of unpeopled areas. **When, for whatever reason, people are present in the protected area, the system must be set on manual discharge and personnel must follow the required procedures before being able to put the system into effect.**

In case of unpeopled areas or areas where procedures make sure no human being is present, the system can be set on automatic discharge.

Specific attention must be paid to the system directions given by generators manufacturer. Frequently, power and the signal provided by the actuating card of the detecting system are not enough to ensure effectiveness to the implementation and it is therefore necessary to install an auxiliary implementing system, usually provided by generator manufacturers. However, it is also possible to have auxiliary implementing systems provided by manufacturers of detecting systems as sometimes they are necessary to implement fire-extinguishing systems using other technologies.

Specific attention must be paid to supervision current of the detecting system, that mustn't exceed parameters declared by generator manufacturer (detecting systems normally available meet these standards).

Aerosol generators can be also equipped with an automatic implementing system, peculiar to the generator, that can also connect others generators installed in multiple number. By releasing the system from the necessity to install a separate fire-detecting system, the generators automatic system can send out a remote signal of occurred intervention and it can implement the prescribed signalling as well as auxiliary implementations.

The automatic implementing system of the generators can also be installed in parallell with the fire-detecting system that has to be set up time-lagged so as to represent a back-up system of emergency implementation in case the fire-detector system fails (if the set temperature is reached, the automatic system of the generators assuredly intervenes, implementing all the generators).

A peculiarity of condensed aerosol generators is the possibility of being implemented whenever exposed to heat or flames (as for the threshold, the manufacturer manual should be referred to).

Condensed aerosol generators are composed of:

- A solid aerosol-forming compound
- A chemical/mechanical cooling system
- An ignition device (drowned in the solid compound)
- End plate discharge outlets
- A metal external housing
- Brakets

Physical state

In storage

- The aerosol-originating material is contained in the generators, in solid state. The solid compound contains the chemical aerosol-forming materials in combination with ligands and/or coolers.

When generators are ignited:

- When a condensed aerosol generator is ignited the solid compound contained in the generator is transformed in aerosol mainly composed of potassium salts (K2CO3) and H2O, N2 CO2 and inert gas.

Chemical formula

Different chemical formulas are available in the market. The above mentioned data are usually shared by most of manufacturer, with specific modifications detailed in the sources of information published by manufacturers themselves.

Quality requirements

In accordance with reference rules into effect or expected, failing proper instructions, sources of information and authentications published by manufacturers are as good as reference.

Average life in storage

The solid compound is very stable, therefore it is assumed a usable life (when installed) of ten or more years; the datum must be confirmed by authentications of accelerated aging, as usable life depends on environmental conditions of installation. Failing these data, manufacturer's declarations are as good as reference (as he is accountable).

Environmental impact

The aerosol-originating solid compound contained in the generators has no interaction with environment. The only precaution is to follow directions about its disposal at the end of its life-span.

The generated aerosol, although akin to gas, has no environmental interaction as the particulate is an inert salt and generated gases are naturally present in the atmosphere.

By convention, although it would be more suitable to consider the following parameters as inapplicable, they are simply considered equal to zero.

ODP Ozone Depletion Potential = zero
GWP Global Warming Potential = zero
Atmospheric Life Time = zero

Disposal

- For the disposal at the end of life-span, get in touch with the supplier
- Please, dispose of carefully
- Apply local and international rules

Notice

Handling: No special precaution is needed.

Usage

In case of intervented system, visibility within the protected volume is extremely poor and it is necessary to wear a breathing apparatus should it be necessary to operate inside the protected volume in the presence of aerosol.
The extinguishing agent does not produce dangerous elements of decomposition in contact with fire.
After making sure the fire is extinguished, aerosol can be evacuated by opening windows or passages and airing the volume.

Packing

Special packing is not required in addition to the one protecting generators during transportation.

Transportation

Owing to diversity of chemical compositions available in the market and diversity of implementation and cooling methods in generators, it is possible to have different classifications. Manifacturers will supply all the following parameters under their personal responsibility:

ADR/RID	Proper shipping name	XXXXX
	HI. No:	XX
	Danger labels	X
	Class	X
IMDG	Proper shipping name	XXXX
	IMDG Page	XXXX
	EmS	XXXX
	Class	XX
	MFAG	XXX
	Proper shipping name	XXX
	Class	XX

Factor of project
The necessary amount of extinguishing agent is given as the weight of the installed solid compound (contained in generators) to protect the volume of 1 cubic metre (gram/m^3). Usually the value (depending on individual features of each techonology) ranges from 50/60 grams/m^3 to 100 and more per cubic metre, depending on the protected risk: such data are noticeable from papers and manuals published by manufacturers.
A distinctive feature of aerosol generators, which has to be considered for a correct planning, is the covering of generator, which defines the greatest spatial parameters (width, length, height) covered by generators at the same time of largest volume protected.

Reference standards

At present, the following reference standards operate:

- Australian/New Zealand Standard: AS/NZS 4487:1997 – AS/NZS 1851.16:1997 (condensed only)
- IMO International Maritime Organization Msc/Circ. 1007 26 June 2001 Guidelines for The Approval Of Fixed Aerosol Fire-Extinguishing Systems Equivalent to Fixed Gas Fire-Extinguishing Systems, As Referred to In Solas 74, For Machinery Spaces. (Condensed and dispersed).

The following reference standards are in the final stage of implementation:

- CEN TC 191 WI 00191148
- Fixed firefighting systems - Condensed aerosol extinguishing systems-part 1: Requirements methods for components.
- Fixed firefighting systems – Condensed aerosol extinguishing systems-part 2. Design, installation and maintenance of Condensed Aerosol extinguishing systems.
- NFPA 2010 Standard for Fixed Aerosol Fire Extinguishing Systems (draft, condensed/dispersed)
- ISO International Standard Organization Iso 14520-1a (draft, condensed/dispersed) First edition Aerosol fire-extinguishing systems – Physical properties and system design – Part 1. General requirements.

Waiting for official publishing of CEN, ISO, NFPA rules, engineering, installation, use and maintenance instructions specific of each manufacturer must be applied. They have to be formally contained in the manuals to be provided with generators and be an integral part of the system planning and of the compliance certification issued by the installer.
Technology manufacturers are responsible of information contained in manuals. With the above mentioned documents, safety cards (MSDS) of generators must be supplied, as well as safety cards of the aerosol composition as resulting from the implementation of generators, which is the actual extinguishing agent.

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The editorial staff suggest as further reading on the subject to make reference to the following issues:
From "Antincendio", July 2003: How and Where to Apply the aerosol fire-extinguishing systems, by A. Fioretti, L. Borghetti.
From "Antincendio", February 2003: How to Cope with the false alarm problem, by Eugenio Tagliani.
From "Antincendio" August 2001: Extinguishing agents: with that aerosol fires are smothered, by Massimo Nazzareno Bonfatti.

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From "Antincendio", March 2000: Aerosol systems is the future for extinguishing agents, by Sandro Marinelli.
Articles quoted and whole volumes of "Antincendio", from 1994 to 2003 can be consulted on www.insic.it, the portal for safety experts, in the BIBLIOGRAPHY section.