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COOLING PARTICULATE AEROSOLS BY DRY EXTINGUISHING POWDERS

by

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ABSTRACT

The use of solid particulate aerosols is limited because of their generation at very high temperatures. Methods of cooling the aerosols are being researched by various institutes and industries, inorder to enable the dispersion of the aerosols at ambient temperature without reducing their effectiveness and homogenous penetration into the fire zone. Methods of cooling the aerosol by chemical and physical processes are described, and a selected method of cooling by a specific designed mechanical device that contains dry extinguishing powder is demonstrated via a video film. Test results are discussed and possible applications are described.

April 20, 1994
Ref: EJ 4/0649

1. ____________

The new emerging technology of particulate aerosol fire suppressants (SFE/EMAA) created via chemical reactions within the raw materials can be applied to a variety of total flood extinguishing applications.

This technology has been discussed at previous conferences (NMERI May 93) and is presented in an additional poster at this conference. The present paper addresses the specific problem of engineered systems based on this technology, whereby the particulate aerosol has to be cooled to the environmental temperature in order to prevent ignition due to it's high exothermic activation characteristics .

The chemical process (combustion) responsible for the aerosol generation is essential in creating the small active particles that float in the gaseous products. The extinguishing mechanisms by which this aerosol acts on a fire, include:

a. Chemical interference in the fire chain reactions.

b. Heat absorption (due to their large surface area).

c. Physical hindrance to the flame front propagation.

d. Disturbance to the fuel evaporation process, dilution of the combustion zone and combustion rate slow-down.

In order to cool-down the aerosol but still maintain it's extinguishing capability, various chemical substances (solids, liquids, gases) were tested for heat - absorption/dissipation characteristics and their experimental results are listed herein.

2. TECHNICAL BACKGROUND

The chemical process that creates the SFE/EMAA extinguishing properties is actually a highly energetic combustion process. The SFE material, it's ingredients belonging to the propellant family, undergoes an exothermic combustion process in order to create finely dispersed (under 1µm size) dry powder floating in air. This aerosol-type dry powder has high extinguishing capabilities, however since the combustion process takes place at approximately 2000°K, the aerosol's temperature is very high, and near the original material location, it can reach 1000°K and more.

At an application ratio of 509 SFE to a protected volume of 1 cubic meter the combustion of SFE will result in ambient air temperature that is increased from 30°C to 60°C. Such an increase in temperature for some applications may be unaccepted and for others not desirable at all. In order to benefit from it's extinguishing effect and at the same time ensure the safety of human personnel, a reliable and effective cooling method is required.

There are various chemical and physical methods that can be employed. Physical methods include flame arrestors, heat-sink metal materials or heat absorbing chemicals (that do not react chemically during the process).

Chemical methods include materials which endothermically react to absorb the heat generated. The selected method and the used configuration should result in the required heat absorption. At the same time, this method must not render the extinguishing agent ineffective or cause decomposition or interaction to form toxic or environmentally unfriendly products.

The following are the desired system requirements related to the cooling process:

a. Cool the aerosol at the generator's nozzle (exit) down to 70°C (343°K).

b. Integrated in the aerosol generating device without damage/hindrance to the aerosol production and discharge process.

c. Does not affect the aerosol quality and quantity (required for extinguishing purpose).

d. Compatible with the surrounding environment, non-toxic and causes no-damage to equipment.

e. No ODP and no GWP, non-toxic to environment.

f. Causes no clean-up problems.

g. Safety in operation.

h. Low life cost cycle.

The R&D scope of work included among others, the following targets:

a. Define the chemical processes related to heat generation rate of the SFE and select chemical and physical processes that can absorb this heat. Define the ΔH emitted and the ΔH absorbed by these processes.

b. Select endothermic chemical reactions that do not affect the main dry powder products obtained in the regular SFE combustion process. (i.e the KCl K_2CO_3, K_2O, etc. are still the main products and their amount is not lowered). Select physical methods that pressure the aerosol.

c. Select chemical materials that cool down the aerosol by simple processes requiring no additional catalysts, additives, ignition devices, etc.

d. Define the possible methods by which the selected materials (c) come in contact with SFE products in such a way (high active area) as to obtain the optimal cooling effect.

e. Design testing procedures of the methods (c) for laboratory and field tests.

f. Perform tests (according to (a) to (d) or several formulations (at least 3) of optimal method and cooling medium.

h. Perform field tests on the optimal method (f) with SFE in the generator devices.

i. Evaluate the results obtained (g) and report on the selected cooling process, it's integration in SFE generating devices.

The following materials were selected for the preliminary SFE cooling Zests.

SFE COOLING TECHNIQUES

1. Dry Chemicals:
   - Sodium Bicarbonate (SB)
   - Boric Acid (BA)
   - Hollow Stones
   - Vermiculit
   - Perlit
   - Dry Gravel

2. Liauids:
   - Water
   - Ethanol
   - Ethylene glycol
   - Acetone

3. Liquified Gases:
   - CO_2
   - N_2

4. Mechanical:
   - Heat exchangers
   - Blowers/Fans

3. TEST RESULTS

The test results obtained by the various techniques are listed herein.

Tables 1 and 2 describe the results obtained with various dry chemicals, and liquids. Specific tests were conducted on pre-engineered prototypes of aerosol generators, with cooling materials such as water and CO_2.

3.1 COOLING SFE BY CO_2 (at various CO_2 pressures)

An SFE charge (500 gr) was activated in "mushroom" type delivery system that contained 4 optional spra /mist nozzles. CO_2 from a 6kg container was discharged at variable pressures. Temperatures were recorded at two points - (I) 0m distance, (II) 0.35m distance from the aerosol exit.

The following results were obtained.

Pressure (bar)	0	4	8	12
ΔT_0 (I)	900°C	900°C	450°C	400°C
ΔT_{35} (II)	*	230°C	180°C	85°C

3.2 COOLING SFE BY WATER

Test No. 1

Injection type generator, contained 0.18 kg SFE.
Environment temp. (T_0) = 090°C.
Temperature measured at 0 distance and 0.35 distance from nozzle exhaust.

Results: $\Delta T_0 = 1090°C$
$\Delta T_{35} = 189°C$

Test No. 2

Mist-spray type generator, contained 1 kg SFE.
Environment temp. $(T_0) = 35°C$

Results: $\Delta T_0 = 80°C$
$\Delta T_{35} = 66°C$

Test No. 3

"Spider-type" generator, contained 0.3kg SFE.
Environment temp. $(T_0) = 32°C$.
Temperature measured at a distance of 0.1 m from water level.

Results: $\Delta T_{10} = 12.9°C$

The various cooling techniques are detailed in drawings Fig. 1 to 3. The pre-engineered generators prototypes were filmed in action, and still pictures are adjacent. A video film of the various generators activation tests and cooling devices will be shown during the poster session.

4. Conclusions

Various chemical and physical methods have been tested for the cooling process of SFE particulate aerosol. The most promising cooling agents (at this preliminary stage) are:

a. Water (spray/mist or liquid)

b. CO_2

c. Dry powders (MAP, Purple K, Carbonates).

The temperature of the aerosol was cooled down to ambient temperature (and even lower) by various mechanical devices as well as chemical cooling agents.

Future R&D efforts will include additional materials evaluation and further engineering o mechanical specific design for flame arresting and cooling processes.

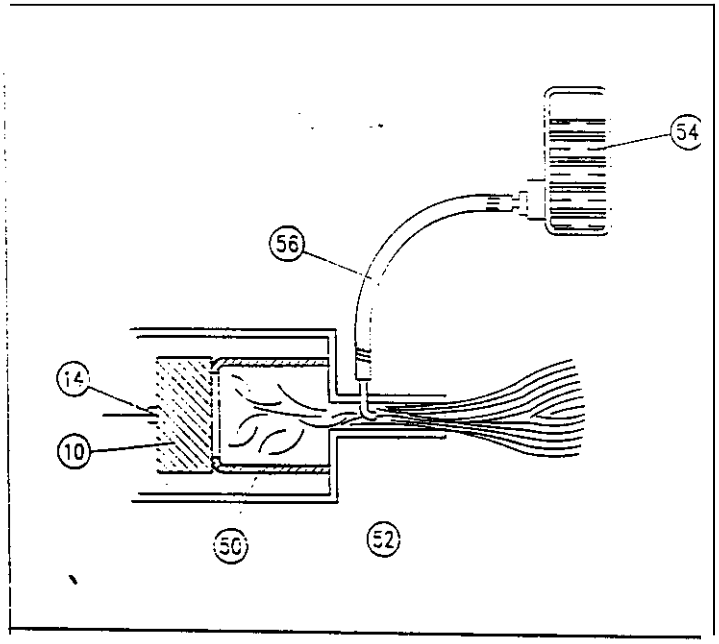


FIG. 1

Injection type generator

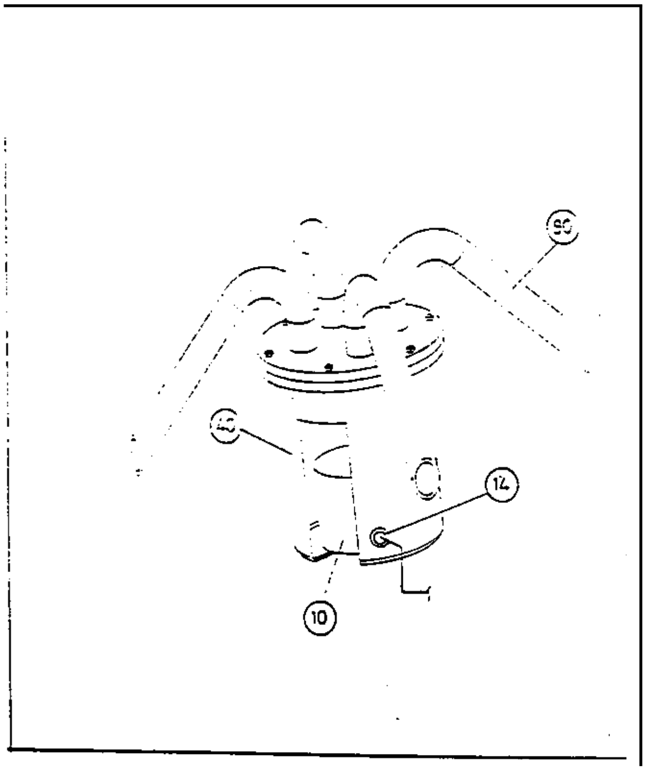


FIG. 2 .

**Spider-type''generator

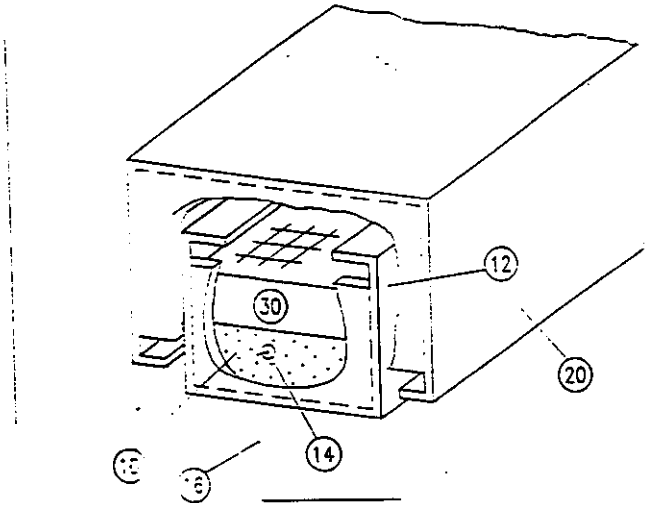


FIG. 3

Heat Absorbing Construction

TABLE 1

S.F.E. COOLING BY CHEMICALS.
TESTS DATE : 11.1.93.- 20.1.93.

Test No.	chamber volume in m3	S.F.E. kind	S.F.E. weight in kg.	cooling material	cooling material amount	thermocouple location	cooling efficiency. delta T	remarks
1	outdoor	tablet NO. 4	150 gr.	S.B.	h=70 mm.			visible fire jet h=150 mm.
2	3 m3	tablet. NO. 4	150 gr.	S.B.	h=70 mm.			1' pan fire extg. time = 30 sec.
3	outdoor	tablet NO. 4	150 gr.	B.A.	h=50 mm.			visible fire jet h=200 mm.
4	outdoor	tablet NO. 4	150 gr.	B.A.	h=300 mm			no visible fire jet
5	outdoor	tablet NO. 4	150 gr.	------	-----			combustion time in empty can = 54 sec.
6	3 m3	tablet NO. 4	150 gr.	B.A.	h=300 mm			1' pan fire extg. time = 30 sec.
7	outdoor	tablet NO. 4	150 gr.	B.A.	h=300 mm			combustion time of S.F.E. = 69 sec.
8	outdoor	tablet NO. 4	150 gr.	B.A.	h=350 mm	h=350 mm.	T = 625 C	
9	3 m3	tablet NO.2	150 gr.	hollow stones	h=50 mm.			1' pan fire - no extg.
10	3 m3	tablet NO.2	300 gr.	hollow stones	h=50 mm.			1' pan fire extg. time = 20 sec.
11	0.2	tab. a2	10 gr.	----	----	h1=170 mm.	650 C	
12	0.2	tab. a2	10 gr.	B.A.	h=25 mm.	h1=170 mm.	385 C	
13	0.2	tab. a2	10 gr.	B.A.	h=50 mm.	h1=170 mm.	260 C	
14	0.2	tab. a2	10 gr.	S.B.	h=25 mm.	h1=170 mm.	400 C	
15	0.2	tab. a2	10 gr.	S.B.	h=50 mm.	h1=170 mm.	320 C	
16	0.2	tab. a2	10 gr.	vermiculit	h=25 mm.	h=170 mm.	330 C	
17	0.2	tab. a2	10 gr.	vermiculit	h=50 mm.	h1=170 mm.	40 C	
18	0.2	tab. a2	10 gr.	perlit	h=25 mm.	h1=170 mm.	313 C	
19	0.2	tab. a2	10 gr.	gravel	h=50 mm.	h1=170 mm.	25 C	
20	0.2	tab. a2	10 gr.	dry gravel	h=50 mm.	h1=170 mm.	32 C	
21	0.2	tab. a4	10 gr.	dry gravel	h=25 mm.	h1=170 mm.	75 C	
22	0.2	tab. a2	10 gr.	hollow stones	h=50 mm.	h1=150 mm. h2=350 mm.	T1=53 C T2=19 C	
23	0.2	tab. a2	20 gr.	hollow stones	h=50 mm.	h1=150 mm. h2=350 mm.	T1=169 C T2=56 C	
24	0.2	tab. a2	20 gr.	hollow stones	h=50 mm.	h1=150 mm. h2=350 mm.	T1=125 C T2=56 C	
25	0.2	tab. a2	30 gr.	hollow stones	h=50 mm.	h1=150 mm. h2=350 mm.	T1=134 C T2=69 C	2" pan fire extg. time=60 sec.
26	0.2	tab. a2	10 gr.	wet hollow stones	h=50 mm.	h1=150 mm. h2=350 mm.	T1=72 C T2=38 C	no extg. of 2" pan fire
27	0.2	tab. a2	20 gr.	wet hollow stones	h=50 mm.	h1=150 mm. h2=350 mm.	T1=156 C T2=75 C	2" pan fire extg. time=35 sec.

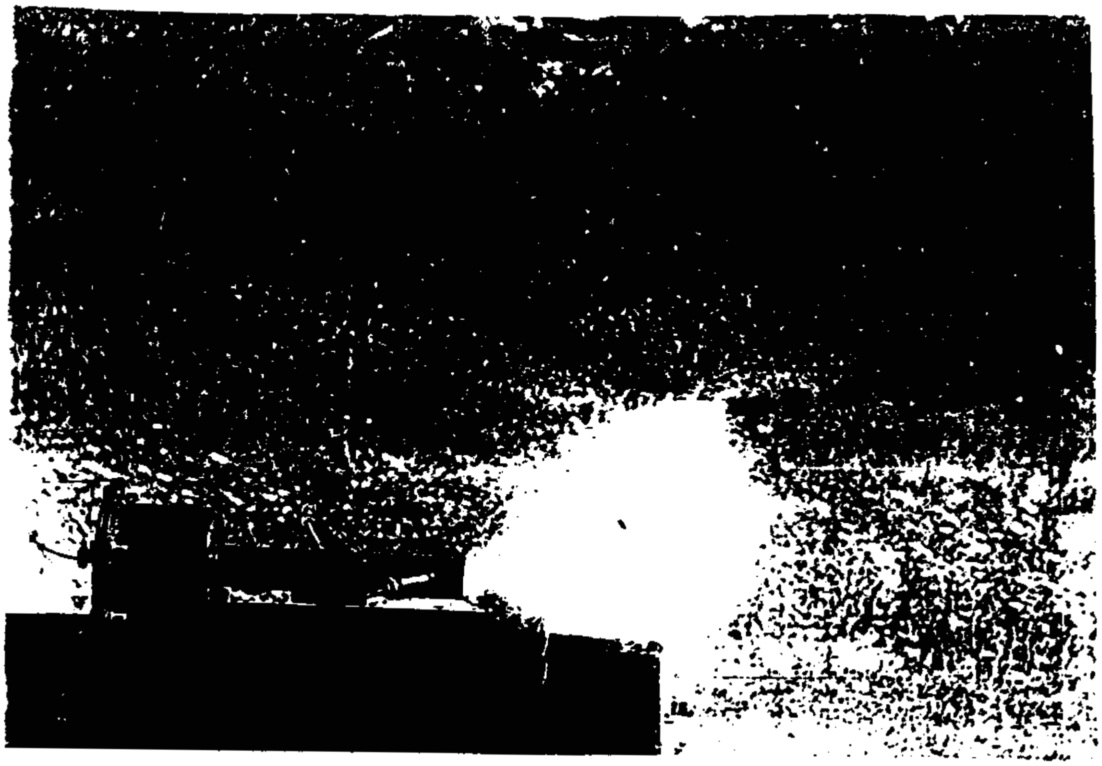
TABLE 2

ET - Ethanol
SB - Sodium bicarbonate
BA - Boric acid
Gravel -
Hollow stones

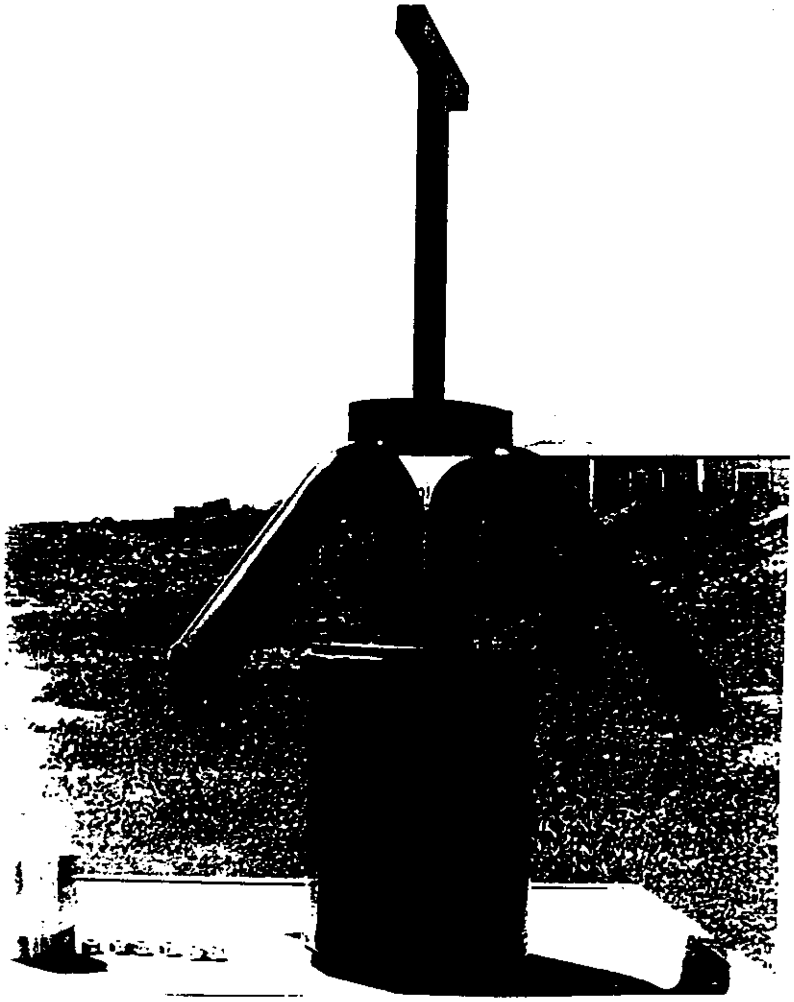
S.F.E. AEROSOL COOLING BY LIQUIDS.

TESTS DATE : 24.1.93.- 25.1.93.

TEST no.	CHAMBER VOLUME	S.F.E. WEIGHT	EXTING. TIME	LIQUID DISCRIP.	AEROSOL TEMP.	LIQUID TEMP.	REMARKS
1	0.2 m3	20 gr.	18 sec.	ET./WAT. 1 lit.	DELTA=17	DELTA=11	
2	0.2 m3	20 gr.	16 sec.	ET./WAT. 1 lit.	DELTA=19	DELTA=9	
3	0.2 m3	20 gr.	14 sec.	WATER 1 lit.	DELTA=14.3	DELTA=7	
4	0.2 m3	20 gr.	18 sec.	WATER 0.5 lit.	DELTA=23	DELTA=26	
5	0.2 m3	20 gr.	75 sec.	WATER 0.3 lit.	DELTA=36	DELTA=19	residue 7 gr.



INJECTION - MIST TYPE GENERATOR



SPIDER - TYPE GENERATOR

WATER COOLED AEROSOL

LIQUID - COOLED
GENERATOR