TECHNICAL MONITORING REPORT AND ENVIRONMENTAL CONTROL

FIR.EX. S.R.L.

VIA DEL CASALE DI SAN BASILIO N.9 – 00156, ROMA

11 maggio 2021

Firmato digitalmente da
Fabrizio Martinelli
CN = Martinelli Fabrizio
O = Ordine dei Chimici Lazio, Umbria, Abruzzo e Molise
OU = Numero di iscrizione:002316
T = Chimico
SerialNumber = TINIT-MRTFRZ69D21E472P
e-mail = dr.martinelli@tiscalinet.it

INDEX:

Index:	2
Premise	3
Scope	3
Regulatory aspects	3
Compound’s features	3
Toxicological aspects	5
Sampling plan	5
Environmental conditions	6
Determination of combustion gases	7
Determination of ammonia	9
Determination of fine powders	9
Determination of relative humidity	10
pH determination	10
Conclusions	11

PREMISE

The Company FI.REX. S.r.l. produces and sells a commercially-named aerosol exstinguishing product named, Fire Kloud®.

It is a “Clean Agent” extinguishing agent, triggered by an exothermic transformation process of the extinguishing mass into aerosol, containing potassium salts, of very little dimensions suspended in inert gas.

The newly generated aerosol acts as a saturation agent, being able to extinguish outbreaks not directly sprayed with a long inertization period. The small dimensions of the potassium saults’ particles enables the aerosol to flow around obstacles, and to penetrate into recessed volumes and to distribute itself evenly in the protected volume.

SCOPE

The Fire Kloud® extinguishing mechanism inhibits the self-catalysis of the combustion process without contextually reducing the oxygen content in the environment, in favor of the safety of any occupant present in the site or of any perishable object. The Fire Kloud® shutdown mechanism inhibits the self-catalysis of the combustion process without simultaneously reducing the oxygen content.

The goal of the current presentation is to define the correct classification in terms of CLP and ADR and gather information, based on previous instrumental checks, the chemical composition of the aeriform mixture that is generated in a closed environment, following the phase transformation reaction of the extinguishing compound from solid to aerosol, in relation to the critical levels of toxicity for human beings.

This second aspect is possible due to the unchanged extinguish compound’s composition.

All the following relates to a representative sample of compound reacted in a free safe environment.

REGULATORY ASPECTS

COMPOUND’S FEATURES

Properly, the company, direct manufacturer of the compound, is identifiable as Downstream User, and is configured, pursuant to art. 3 par. 13 of REACH as “responsible for the formulation of mixtures”, since it acquires the starting substances necessary for making the compound, (mixing) and then markets the final solid mixture, inside a container of mixture.

The dangerous substances used for the commercial formulation produced, with the relative hazard classifications indicated, are those shown in the following table:

Tab. 1:

Chemical substance	N° of registration REACH	Hazard classification	Hazard Statement
Potassium nitrate	01-2119488224-35-xxxx	oxydizing	H272
Dicyandiamide	01-2119474914-28-xxxx	Not dangerous	-
Zinc stearate	01-2119982400-42-xxxx	Not dangerous	-
Trietilenglicol	01-2119438366-35-xxxx	Not dangerous	-

The resulting product, of which the latest release of the Safety Data Sheet is attached, is instead classifiable as Self-reactive Solid and takes the following dangerous characteristics :

Tab. 2:

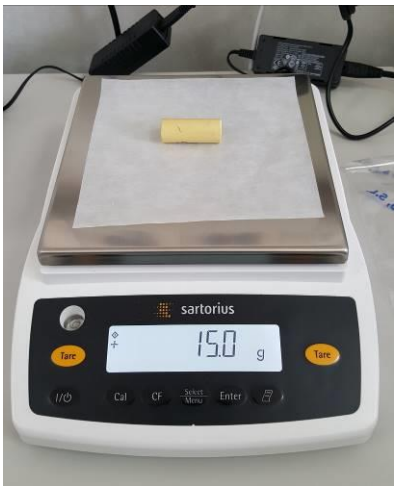
Warning	P-precautionary statement -Reg. CE 1272/2008	Hazard statement Reg. CE 1272/2008	Labeled hazard symbols
Hazard	P210, P280	H242 Sost. Autoreattiva tipo D	

Nevertheless it is also classifiable on the basis of the “European Agreement concerning the international carriage of dangerous goods by road (ADR) and protocol of signature”., Amendment 2021, as issued with the Commission Directive 2020/1833/EU of 02 October 2020 and implemented with Decree of 13.01.2021 (GU n.34 of 10.02.2021), which adapts for the sixth time to the scientific and technical progress the annexes of Directive 2008/68/EC of the European parliament and of the Council on the inland transport of dangerous goods, in voluntary application for national transport from 01.01.2021 and mandatory from 01.07.2021

Tab. 3:

N° identificativo della materia	3178
Matter’s definition	Flammable inorganic solid n.o.s.
Class and code	4.1, F3
Packaging group	III
Category of transportation	3
Tunnel restriction code	(E)
label	4.1
N° Kemler	40
Special provisions	274
Packaging instructions	P002 – IBC08 – LP02 – R001
Tanker transport vehicle	AT
Tanker labeling code	SGAV
Partial packaging exemption	Allowed limited to the “5 kg” condition in chapter 3.4
Total packaging exemption	Allowed limited to the “E1” condition in chapter 3.5.1.2
Partial exemption for Quantitative	Up to 1000 kg per transport unit - as chapter 1.1.3.6.3
Transport in bulk	Allowed limited to the VC1, VC2 condition

TOXICOLOGICAL ASPECTS



SAMPLING PLAN

The tests conducted in 2015-were carried out inside a specific designed case in order to simulate optimal conditions for aerosol development, in case of fire, which are declared by the manufacturer to be approximately 50g. of compounds per cubic meter of air in the room as to be protected.

A display case with internal volume of 0.31m3 was used and consequently 15g were placed in for each test, in a special space with the possibility of trigger it by remote controlling.

On the cases's walls, whose WxWxH were respectively 750x750x550mm, specific holes have been drilled in order to allow sampling and analysis of the air (contained in the aerosol) according to the most appropriate method as described below. The homogeneity of the aerosol's distribution inside the chamber was guaranteed by means of an internal system of rotating blades fans.



The procedure for each test was as follows:



1. Insertion in the specific appropriate internal space with a known compound weight.
2. Pipelines' positioning necessary for sampling and/or direct measurement probes;
3. Closing of the case and sealing of unused nozzles;
4. Verification of boundary conditions;
5. Product's priming and ventilation's activation;
6. Beginning of the sampling (or direct measurement method) at the end of the transformation of the product into aerosol, for about 5 seconds;
7. End of the sampling or stop of recording interruption after 5 minutes from the start time.

Tests have been retested for several times, in compliance with table A.1 of Appendix A of the UNI EN 689: 1997 standard.

The analysed parameters are shown in the following table together with the respective risk's classification, and occupational exposure limits Tab. 4:

Inquinante	Simbolo di pericolo	Hazard statement	Precautionary statement	T.L.V.	
				T.W.A (ppm)	STEL/C (ppm)
Oxigen – O2		H270, H280	P202, P220, P244, P370+376, P403	—	—
Carbon oxyde – CO		H220, H280, H331, H360, H372, CGA-HG04, CGA-HG10	P202, P210, P260, P271+P403, P280, P377, P381	25	—
Carbon Dioxide – CO2	-	H280	P403	5000	30000
Nitrogen oxides– NO, NO2 ed NOx		H270, H331, H314, H318	P202, P220, P260, P262, P271+P403, P280+P284, P370+376	—	—
Sulfur dioxide – SO2		H280, H314, H331, CGA-HG22	P202, P261, P262, P271+P403, P280+P284, P405, P501	—	0,25
Ammonia – NH3		H221, H280, H331, H314, H400, CGA-HG22	P202, P210, P260, P262, P271+P403, P273, P280, P377, P381, P501	25	35
PM 2.5, PM 1.0, PM 0.5 e PM 0.25		H332	P261	3	—
U.R.	—	—	—	—	—
pH	—	—	—	—	—

Where, as known the TLV, which can be differentiated between TWA, STEL and C, represent the limit concentrations perceived as time-weighted averages (variable according to the type) to which an operator suited for the job can be exposed without incurring to any health damage.

These are set by the Conference of Governmental Industrial Hygienists based in Cincinnati, OH, as an annual review commitment. They are valid in all UN member countries except for more restrictive nationals authorities limits.

Before proceeding with new measurements, he made sure that the conditions were suitable and reproducible as linearly as possible.



ENVIRONMENTAL CONDITIONS

These tests have been taking place on the same working day starting from 10 AM ending up at 6 PM .

The stable weather conditions had features of a warm sunny July day, without wind:

Environmental conditions (average values):

Temperature:	33,3 °C
Relative Humidity:	40,5 %
Wind's Speed:	0,15 m/s
Wind's direction:	—
Atmospheric Pressure:	1012 hPa

DETERMINATION OF COMBUSTION GASES



For this purpose, a continuous meter Mod. GA-21plus serial number 21647055, was used, since capable of measuring simultaneously the parameters shown in the following chart, with infrared and electrochemical sensors.

Before starting the test, the instrument was calibrated and calibrated with reference gas.

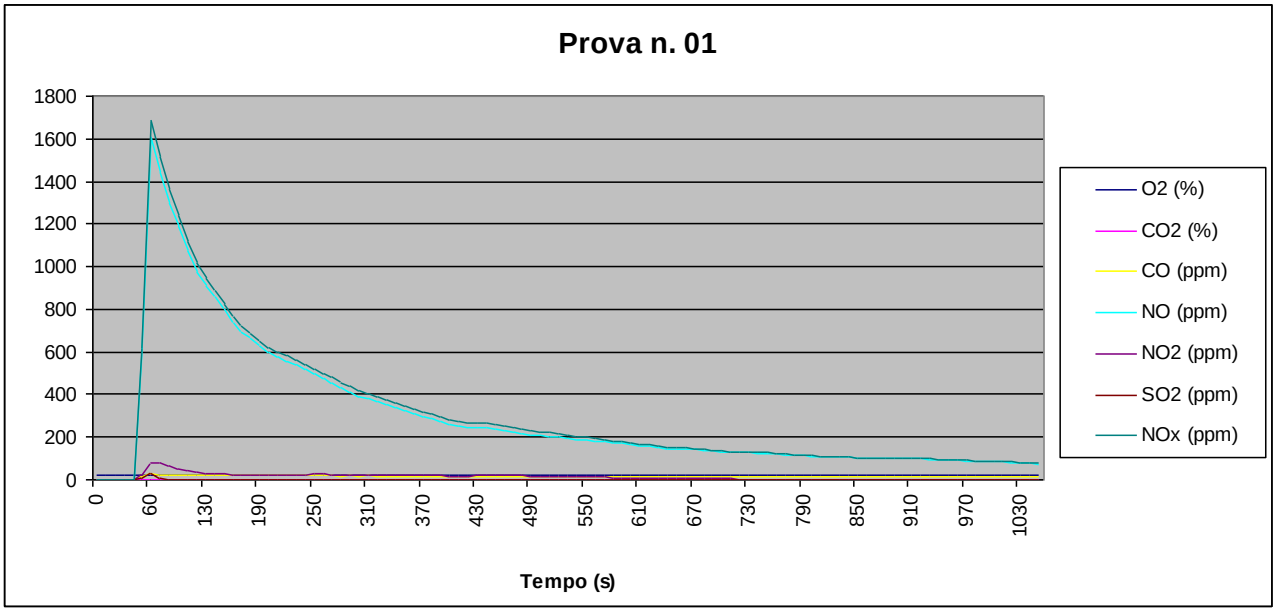
For each parameter the average value of each measurement is reported.

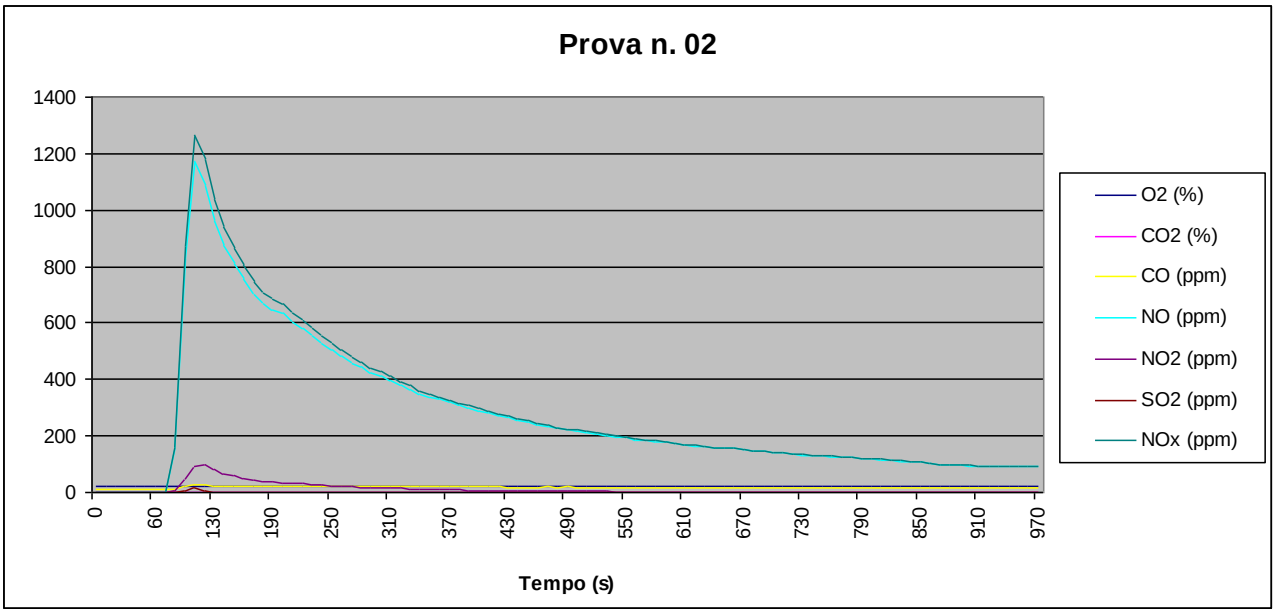
Tab. 5:

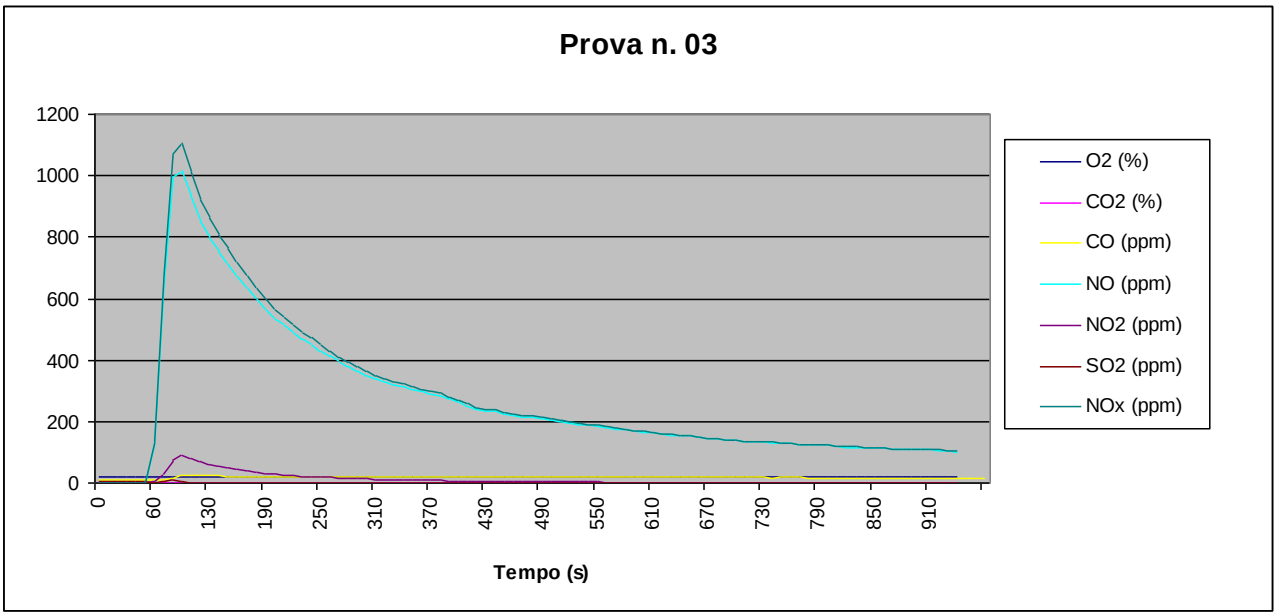
Parameter	u.m.	Test n. 01 (105 measur.)	Test n. 02 (97 measur.)	Test n. 03 (94 measur.)
T	°C	52,4	54,6	55,0
O_2	%	20,9	20,9	21,0
CO_2	%	0,8	0,8	0,8
CO	ppm	15,8	18,0	19,8
NO	ppm	297,8	273,4	270,9
NO_2	ppm	14,1	11,2	11,6
NO_x	ppm	311,9	284,6	282,5
SO_2	ppm	0,4	0,4	0,8

The measurement was carried out continuously with a measurement interval of 10 seconds per each measure.

Attached the precise values are available, while only the time trends for each test are shown below.


Prova n. 01
1800
1600
1400
1200
1000
800
600
400
200
0
0
60
130
190
250
310
370
430
490
550
610
670
730
790
850
910
970
1030
Tempo (s)
O2 (%)
CO2 (%)
CO (ppm)
NO (ppm)
NO2 (ppm)
SO2 (ppm)
NOx (ppm)


Prova n. 02
1400
1200
1000
800
600
400
200
0
0
60
130
190
250
310
370
430
490
550
610
670
730
790
850
910
970
Tempo (s)
O2 (%)
CO2 (%)
CO (ppm)
NO (ppm)
NO2 (ppm)
SO2 (ppm)
NOx (ppm)


Prova n. 03
1200
1000
800
600
400
200
0
0
60
130
190
250
310
370
430
490
550
610
670
730
790
850
910
Tempo (s)
O2 (%)
CO2 (%)
CO (ppm)
NO (ppm)
NO2 (ppm)
SO2 (ppm)
NOx (ppm)

DETERMINATION OF AMMONIA

The product's transformation reaction into aerosol involves the formation of Ammonia, certainly one of the most dangerous gases relatively to the volumes generated in relation to its dangerous characteristics.

The sampling method involves the enrichment of the ammonium ion by bubbling a flow with a well known quantity of aeriform mixture on a selective trap consisting of a weakly acidic aqueous solution due to the presence of sulfuric acid.

Through the Nessler reaction the present level of ammonia in the solution was subsequently quantified in UV spectrophotometry and then parameterized to the quantity in air per m3.

The results exemplifies the overall average concentration of Ammonia present in the relative volume of air. The method adopted does not allow an instant reading with a temporal trend of the concentration.

Below each sample's result:

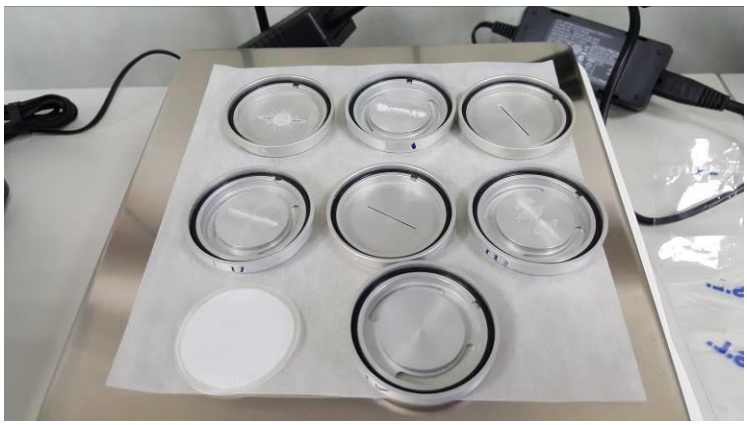
Tab. 6:

Sample	Concentration (mg/Nm^3)	Notes
5	28,16	Free Compound
6	25,89	Free Compound
7	24,75	Free Compound
8	27,68	Free Compound

DETERMINATION OF FINE POWDERS

With a similar method to the one used for the previous measurements, the average concentrations of fine powders present in the aerosol were determined.

A known volume of aeriform mixture, at a constant flow of 9l/min, flowed inside a multiple four-stage impactor.





The following absolute quantities and percentages of fine dust were determined thanks to a gravimetric method.

Tab. 7: - Prova n. 9

Molecular fraction	Concentration (mg/Nm^3)	Relative Percentage (%)
> 2,5 µm	2.052	43,40
< 2,5 µm - > 1,0 µm	200	4,23
< 1,0 µm - > 0,5 µm	648	13,71
< 0,5 µm - > 0,25 µm	1.104	23,35
< 0,25 µm	724	15,22
Totale	4.728	100,00

DETERMINATION OF RELATIVE HUMIDITY

The water percentage in the gaseous effluent was determined gravimetrically by aspirating a known flow of gaseous' effluent through a tower of anhydrous silica gel of a given weight.

For a better representativeness of the following data per each silica's gel trap, two cycles of aerosol generation were sampled, the two cycles were both 15 minutes long:

Tab. 8:

Test n°	Concentration (g/Nm^3)	Relative Percentage (%)
5 + 6	28,43	2,19
7 + 8	71,42	5,52

pH DETERMINATION

pH's determination of the aeriform mixture was carried out by letting the gaseous effluent rise in a trap of distilled water.

The subsequent electrochemical determination yielded the following results:

Tab. 9:

Tests	Concentration (mg/Nm^3)	Notes
1	9,0	Free Compound
2	8,7	Free Compound
3	8,9	Free Compound

CONCLUSIONS

Based on experimental research evidence;

Given that the application scope of the solid matrix (i.e. compound) provides for its use as an extinguishing aerosol generator, which can therefore be actioned or activated only in cases of fire emergency;

Taking in consideration that the concentration peaks have been noticed to be relevant in the first few minutes after the initiation of the reaction;

Verified that none of the gases generated as known exceeds any of the threshold that would make the aerosol incompatible with human exposure;

Verified that even with a saturated environment due to a generated mixture of gases, the residual oxygen concentration remains compatible with the presence of people in the environment, net of fumes, gases and vapours generated by combustion in the same environment ;

Though with all the experimental limits, limits due to simulated environment, with the use of a free matrix-due to lack of identical official sampling-and analysis methods;

We consider legitimate to be able to state that the extinguishing product in aerosol, commercially called Fire Kloud®, produced and marketed by the company FI.REX. S.r.l. both from a mere toxicological point of view, compatible with the use for which it is intended to be used and not dangerous for the environment within the limits for standard use.

EurChem
European Chemi

Il Chimico

Dott. Fabrizio Martinelli
(Presidente Ordine Chimici e Fisici

DOTT. FABRIZIO MARTINELLI CHIMICO 2316

ALBO DEI CHIMICI
DI ROMA n. 2316/A