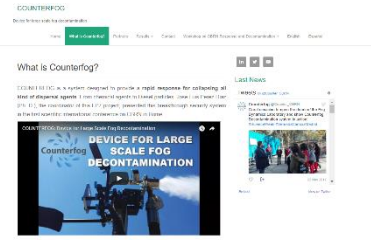
Counterfog

FINAL REPORT

ANNEX

MEDIA

❖ COUNTERFOG WEB PAGE



❖ COUNTERFOG AIR DECONTAMINATION SYSTEM

❖ COUNTERFOG AIR DECONTAMINATION SYSTEM - TVE1

❖ DEVICE FOR LARGE SCALE FOG DECONTAMINATION: COUNTERFOG –1ST SCIENTIFIC INTERNATIONAL CONFERENCE ON CBRNE

❖ REPORT ON COUNTERFOG- CHANNEL 1 OF BULGARIAN NATIONAL TV

Device for large scale fog decontamination. White Book

Project Number: 312804

	Wp no.	Deliverable no.	Nature[1]	Lead participant
UAH	**7**	---	**O**	**UAH**

White Book

Prepared by	**José Luis Pérez Díaz. Email: jl.perezd@uah.es**
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[1] R = Report, P = Prototype, D = Demonstrator, O = Other

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1. INTRODUCTION. CBRN THREATS

Europe -as well as other modern societies- suffers the risk of Chemical, Biological, Radiological and Nuclear (CBRN) events. These include natural and accidental and deliberated man-made threats severely affecting human health as well as the environment in a large scale.

The lethal power of CBRN agents and their power to cause massive fatalities rely on their ability to disperse and propagate. In this sense, the most dangerous agents are those which are dispersed in air and penetrate the lungs. For example, casualties caused by inhaling Anthrax spores dispersed in air are two orders of magnitude greater than those caused by a cutaneous infection of the same spores. This is also true for chemical and radiation agents.

The activity of a dispersed agent is many times greater than that of the same agent in a bulk or aggregate state. This is a general law and is due to the exponential increase of the surface to volume ratio for decreasing sizes of particles, spores or drops. This principle is also well-known in medicine, i.e. a patient inhales sprayed medicaments to effect the respiratory system quickly. It is also well-known in other fields: for example, coal powder suspended in air makes an explosive atmosphere much worse than any other explosion in mines; even flour suspended in air makes an explosive mixture that can often cause serious accidents in factories.

Taking this into account, a priority for any rapid response against a CBRN attack should be to collapse any kind of dispersion, fog or smoke into a physically bulk state. This would avoid further propagation; drastically diminish the lethality and therefore the impact of the attack.

Counterfog, funded by the Seventh Framework Program of the EU Commission, has been developed with this purpose. The present document tries to summarize its characteristics as well as to make simple recommendations for its adequate use.

2. Description

Counterfog is a system designed to provide a rapid response for collapsing all kind of air-borne dispersed agents –including Chemical, Biological, Radiological and Nuclear agents as well as solid micro-particles like those in smoke generated by Diesel engines and other non-exhaust traffic particles.

The system was mainly developed for removing CBRN agents from the air in case of a terrorist attack or accidental release. Additionally, it can be also applied to remove contaminating particles responsible for the spread of respiratory diseases in highly polluted cities.

Counterfog has proved to be able to remove the noxious small air borne particles, spores, or bacteria in a few minutes. Counterfog essentially uses water and compressed air to provide a jet of fog made of micron-sized liquid droplets. These droplets collide with the noxious particles present in air aggregating them and making them to fall down or to adhere onto surfaces.

Size is the key. If liquid droplets were too big, particles would just flow around them. If liquid droplets were too small, they would not have mass enough to aggregate particles.

Less than 1% of a harmless additives have demonstrated to be enough to wash out even hydrophobic particles. Additionally, Counterfog is able to provide and disperse catalytic in air nanostructured TiO_2 micro-particles which effectively will decompose any chemical agent.

Other decontaminants and disinfectants may also be dispersed with Counterfog. The optimal size of Counterfog droplets minimizes the volume of the waste to be collected afterwards.

Counterfog is therefore environmental friendly both because of the use of harmless substances and the minimization of waste.

Toxicity tests done up to the date have found no significant harm in mice exposed to Counterfog action.

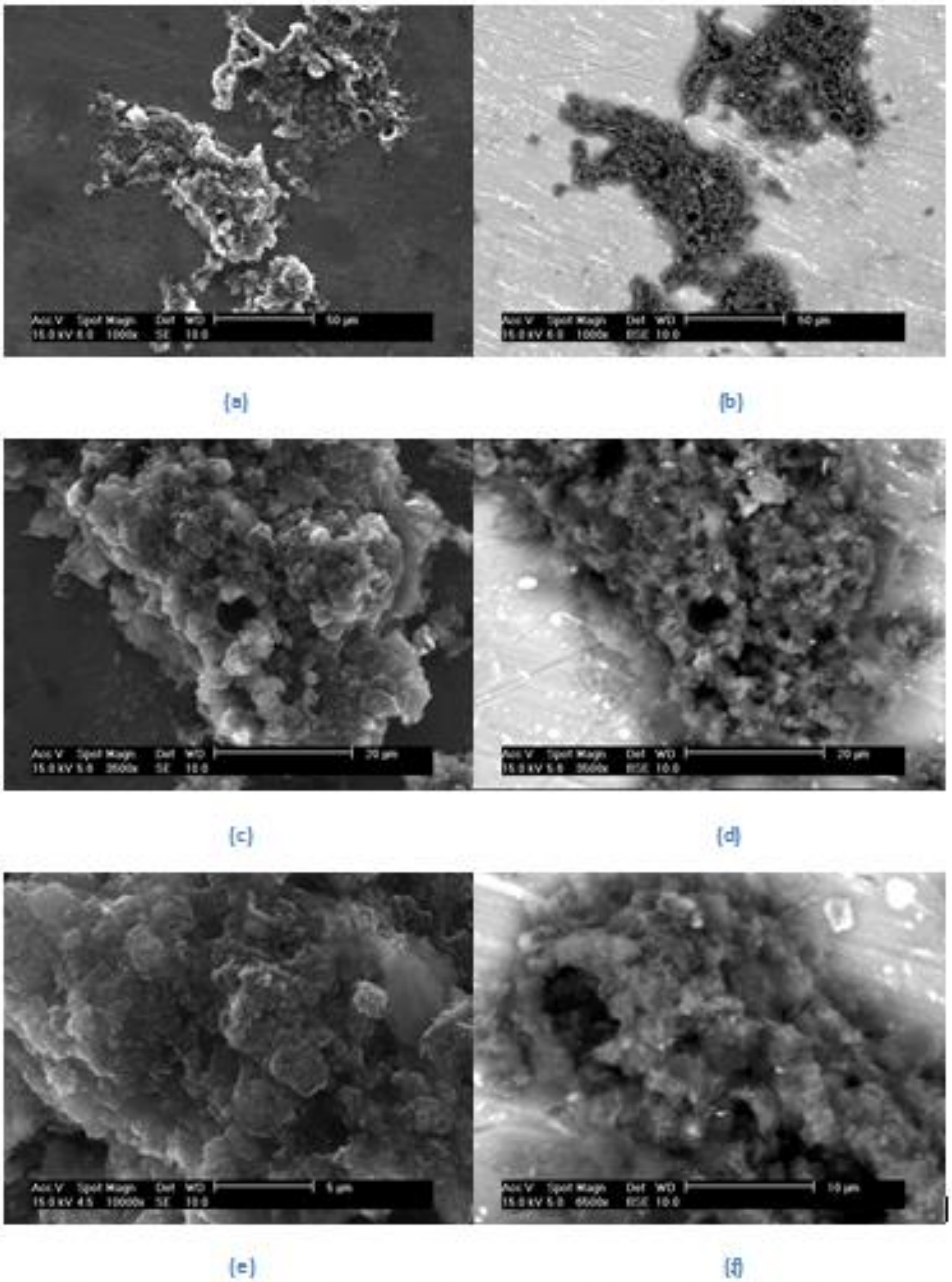


Figure 3. Examples of residue deposited on the floor of the test room after Counterfog system implementation.
(a)(c)(e) Taken in secondary electron detector (SED)
(b),(d)(f) Taken in backscattered electrons detector (BSE)

3. INSTALLATION OPTIONS

Counterfog can be installed permanently in a building, facility or industry. A set of nozzles would be distributed along the facility along with pipelines supplying compressed air and water from a technical room where the corresponding machinery should be installed. Manual or automatic activation can be provided, even in connection to the fire protection unit.

Additionally, a set of nozzles can be deployed and fed using flexible or semi-flex pipelines from portable machinery –for example on board of a truck-. This system could be deployed to confine a CBRN source wherever it is located –for example from a derailed wagon-.

Finally handheld portable nozzles can be manually operated to specifically apply a decontaminating solution or catalysts suspension.

4. SCENARIOS

4.1 DIRTY BOMB (RADIOLOGICAL SALT POWDER)

A dirty bomb or Radiological Dispersal Device (RDD) combines radioactive material with conventional explosives. The evil purpose of the weapon is to contaminate the area around the explosion with particles of radioactive material. The radioactive dust will deposit in the lungs of any breathing person in the area.

Thousands of radiological sources are used in Health, Research and Industry. Cesium-137, Cobalt 60 and Iridium -192 may be used to make a dirty bomb. Therefore a theft of one of them becomes a quite serious concern.

A Fixed Counterfog System activated immediately after the explosion of an RDD will collapse the cloud removing all particles in air in a few minutes preventing them to be air borne and inhaled. This will minimize the amount of radioactive particles inhaled by victims and will make evacuation and response safer.

Water droplets containing the captured radioactive particles will be then deposited onto the floor, furniture, etc. Mechanical means of absorption and/or adsorption –i.e. a vacuum cleaner or wipes- can be used to remove and dispose them according to their activity and composition.

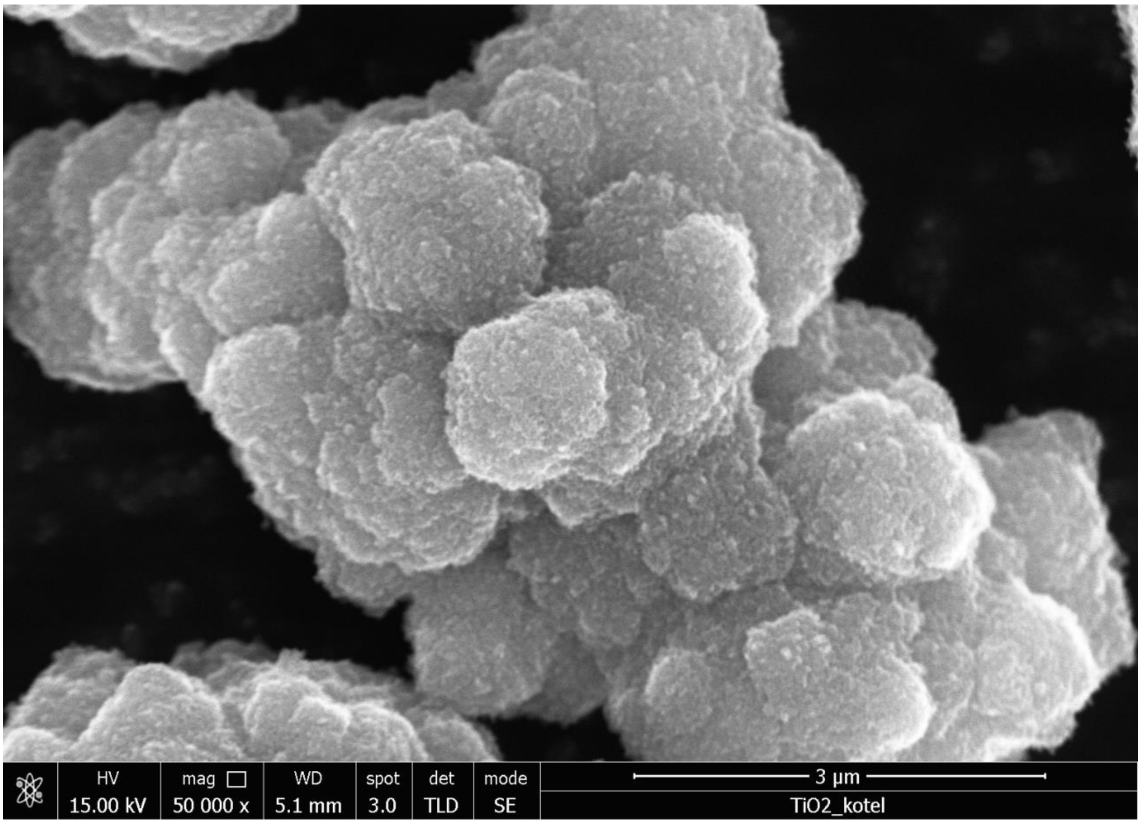
Victims in the area will still require to be washed to remove all the radioactive particles from skin and hair and clothes should be disposed as usual in current procedures.

4.2 CWA INDOOR RELEASE

Chemical warfare agents (CWA) released in gaseous state in a building or infrastructure will affect the whole building or infrastructure with a high impact. Sarin attacks in Tokyo metro were the most famous example.

In this scenario, Counterfog can disperse nanostructured TiO_2 micro-particles in air. These particles have demonstrated to adsorb and quickly catalyze the decomposition of the CWA. The fast application of Counterfog will therefore prevent the diffusion of the CWA and minimize their deadly effects.

After decomposition of the CWA a second application of Counterfog just with water will help to remove the particles from air.



4.3 OUTDOOR TOXIC CLOUD

Chemical species released outdoors may create a toxic cloud affecting population in large areas. Additionally, toxic clouds are usually produced altogether with smoke –although the visible smoke does not necessarily match the toxic cloud-.

Boundary environmental conditions are completely different from those in a building or closed area. However, this not precludes that Counterfog may be useful for mitigation and counteraction of CBRN in open field. Performances in open field would be conditioned by dynamic processes: diffusion, convection, wind and other transport phenomena. While the effects of Counterfog in a building are effective a few minutes after activation of the system because droplets slowly fall down, in open field a continuous activation of Counterfog may be required.

Counterfog can be deployed to create a barrier to stop the diffusion of a toxic cloud. This will be more effective, the closer to the source it is.

However, an advantage of this scenario is that the chemical species are known in advance and additives or catalysts can be preloaded in the Counterfog system. Additionally, Counterfog barriers around a plant can be activated with minimal inconveniences preventing or mitigating the diffusion of the toxic cloud.

4.4 ACCIDENT HAZARDOUS FREIGHT TRANSPORT

Transport accidents proved to be as deadly as industries. Routes and railways usually run close to or even throughout large populated areas. Hazardous goods can include toxic, flammable or explosive substances.

As in the case of a leakage of chemical agent from an industrial plant the dispersion of the toxic cloud may be altogether with smoke. Counterfog can be deployed to create fog jets barriers –with catalysts if needed- around the source or even to protect facilities.

4.5 BIOLOGICAL AGENT DISPERSED

Some biological agents like Anthrax spores are known to survive an explosion and are relatively easily available. A potential scenario for a terrorist attack may be a bag of Anthrax spores dispersed in air in a building. Spores would be in the air and anybody breathing infected air in the building will quite likely become ill and die. Additionally, there have been evidences of terrorists manipulating biological agents like *Botulinum* toxins or Black Death. Evidences of terrorist groups trying to use explosives to disperse the agents have been published as well. This may occur for example in the atrium of a shopping mall or in a railway station.

Venting cannot be a real solution as the spores would be transported and spread out of control to other sites and may be breathed by people if not evacuated. The area of evacuation required in case of venting may be extremely large.

Filtering is not practical for a large atrium. Even though HEPA absolute filters retain spores and bacteria, it is impractical to extract the air of the atrium throughout filters as spores would be diluted extremely slowly.

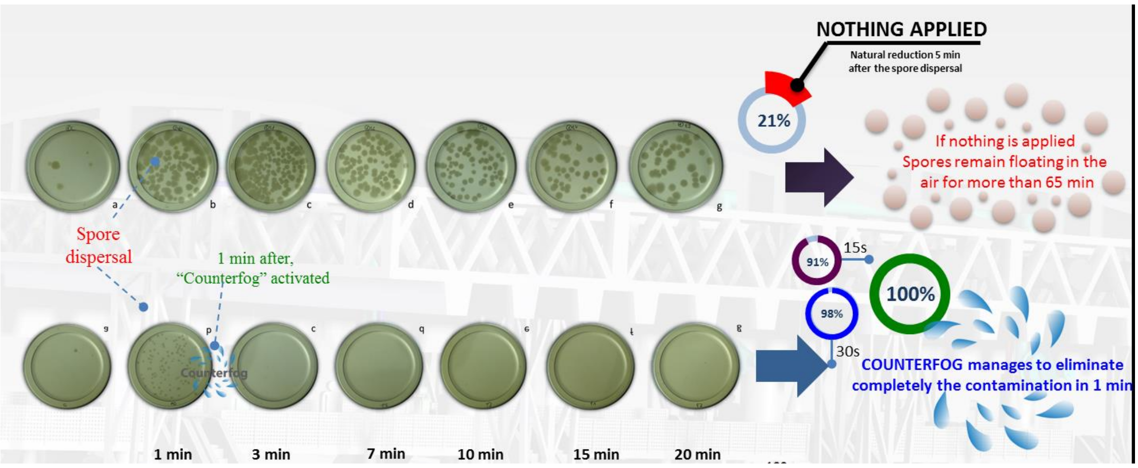
The action of the fixed Counterfog system providing a (breathable) water fog will wash out spores and particles from the air in a few minutes making them to lay down (still alive) on the floor, furniture, etc. but preventing them from being air borne. This would require the decontamination (disinfection) of surfaces afterwards.

Alternatively Counterfog may be activated providing a hydrogen-peroxide (or another disinfectant) fog able to disinfect bacteria and spores from air and surfaces. This fog would be definitive against bacteria and spores both in air and on surfaces but it would be harmful for people breathing it. Therefore it is recommended only after evacuation is completed.

The fixed Counterfog installation would be activated (optionally with a solution of hydrogen peroxide) to drive spores and bacteria down to the floor or surfaces. As a collateral effect all dust or soot particles floating in air are also expected to be washed out.

No visible waste would be produced. If the fog is made of water, the microorganisms would be alive on the surfaces (floor, table, furniture, etc.).

Alternatively, a Counterfog with hydrogen peroxide is able to decontaminate them. At least this has been demonstrated with bacilli.



5. Fire protection complementarity

Counterfog has a limited fire suppression capacity as any other water mist device. The particularity of Counterfog comes from the fact that does not require high pressure to provide a large flow of fog. However, as the amount of water used is small the extinction power –that can be easily calculated- is also limited.

However, a more striking firefighting potential of Counterfog is related to smoke control. Counterfog could be used in different ways to remove smoke with some advantages.

For instance, a Counterfog nozzle pointing outside extracts smoke from behind. Counterfog water droplets will capture polluted particles and collapse them into the ground and other surfaces preventing the smoke to pollute the environment.

An appropriated set of Counterfog nozzles are also expected to provide a fog curtain and to prevent smoke dissemination. Counterfog could be useful for confinement of smoke avoiding its diffusion and cooling it down. This last effect is extremely beneficial to prevent flash over.

A connection to the fire protection system can be provided in order to trigger Counterfog activation in case of detection of smoke.

6. Recommendations for installation

Counterfog has been demonstrated in fixed, portable and deployable versions. All the machinery can be installed in a technical room with restricted and controlled access and a set of nozzles can be distributed all along the facility. Water and compressed air pipelines will be required. Additionally third component vessels and valves will be provided to supply the catalytic nanostructured TiO_2 if needed.

A secured access to the technical room is mandatory. If the system is manipulated by an unauthorized person the reset procedure must be followed. See Prevention of misuse below.

Counterfog must be designed by skilled and authorized engineers and installed and maintained by authorized installers and maintainers.

Activation of the system may be triggered manually, by smoke detection connected to the fire protection control unit, specifically connected to CBRN sensors or connected to anomaly sensors specifically developed in Counterfog.

The broad spectrums of agents that can be collapsed by Counterfog altogether with its harmless characteristic make it wise to recommend a safe-side triggering. A Counterfog activation based on a false alarm is harmless while the mitigation of a real CBRN event would be enormous if activated in the very early stage.

However, visibility constraints have to be considered in connection to the evacuation strategies.

Water and air pipelines, provided with filters, must be designed according to corresponding Moody charts. Their dimensions have to satisfy the appropriate pressures in nozzles according to our test results.

The compressor must have a granted power supply to ensure the feasibility of the system. Therefore it is convenient to duplicate the compressors, feeding one of them from electrical general supply and the other from an alternative diesel engine-generator.

It is recommended to monitor the system continuously. It can be done through sensors able to alarm in case of incidents such as pressure failures, the opening of restricted zones doors or the shortage of Chlorine in water, among others.

It is as well recommended to use an automatic chlorinator to continuously monitor free chlorine levels.

7. RECOMMENDATIONS FOR POLICY MAKERS

Counterfog has demonstrated to be able to quickly remove a broad spectrum of CBRN agents from air -irrespectively of their origin (accidental or deliberated).

If installed in a facility –i.e. a railway station, airport, large atriums, arenas, Malls, etc. where a lot of people may be gathered together, it will provide a unique tool to minimize and mitigate the deadly effects of a CBRN event as for instance a dirty bomb. In addition to the increase of resilience in these installations it will discourage terrorist from trying any CBRN attack.

Additionally, in case of fire Counterfog may help to reduce and mitigate the effects of smoke strongly increasing resilience.

In case of industry or transport facilities where leakages of CBRN are relatively likely, a Counterfog installation would be able to confine the cloud and wash out the agents preventing the dissemination over the territory.

Counterfog mainly uses water and air to provide an environmental friendly protection. The cost of a Counterfog installation is expected to be quite similar to (or even lower than) that for fire protection and some synergies can also produce savings when installed simultaneously.

In terms of resilience and number of lives that are protected it is quite reasonable to mandate the installation of this technology in crowded facilities and critical infrastructures.

Portable units can also be provided to be quickly deployed by responders in case of CBRN events. These units can prevent the dissipation of toxic clouds avoiding the high impact on society of such episodes.

Last, but not least, Counterfog has demonstrated to be useful to remove solid air borne particles from air –including those originated by traffic-. The permanent installation of Counterfog in large cities both indoor or outdoor seems to be an effective way of cleaning the polluted air therefore strongly contributing to people’s health and environment protection.

8.1 GENERAL PROVISIONS

It must be considered that Counterfog equipment is under pressure (typically below 15 bar).

Counterfog equipment must only be used by authorized and instructed personnel.

The access to machinery and mouthpiece must be restricted; allowing only the access to authorized personnel. Electrical supply must be ensured even if there is a cataclysm.

Maintenance personnel must follow a safety guideline similar to pressurized equipment and compressor safety guidelines.

Counterfog systems have to be designed, built and supervised by duly trained and certified personnel.

8.2 PREVENTION OF *LEGIONELLA* & MICROORGANISMS

Legionellosis is an illness caused by bacteria pathogen called *Legionella*. *Legionella* is an environmental bacterium that grows up between 20 ºC and 45 ºC and survives at temperatures over70 ºC. Its natural habitat is the surface of water reservoirs, lakes and rivers, as well as sanitary water pipes and tanks.

Legionella can also be dispersed by the air if there is an aerosol producer mechanism in a colonized place. The bacterium can stay suspended in the air and enter in human's respiration system.

To ensure the lack of *Legionella* in COUNTERFOG facilities is necessary to maintain free chlorine in tanks and pipes, according to the respective law that exist for other water systems –i.e. thermal towers or fire protection sprinklers-. It is recommended to use an automatic chlorinator to continuously monitor free chlorine levels.

It is mandatory to have a facilities maintenance record that includes date, protocol and results of every revision or analysis.

A correct maintenance of the facilities (tanks and pipes) is fundamental in the control of the *Legionella*. The surfaces of metal corroded by the oxide, or the calcareous precipitations due to hard waters, are perfect for the formation of biofilms, which would make it difficult to disinfect water with normal doses of chlorine.

Another factor to take into account are the sediment of sand in the form of slime that are deposited in the bottoms of the water tanks, because they prevent a correct chlorination as the chlorine reacts with the dirt. In addition the limo acts as a refuge not only of *Legionella* sp. but of other microorganisms such as amoebas (*Acanthamoeba* sp). *Legionella* is able to live inside these amoeba, so they are protected against chlorine and abrupt temperature changes.

It is convenient to revamp water tanks and pipes from time to time to ensure correct chlorine levels. The frequency of revamping has not been tested yet, but it seems justifiable to revamp more frequently if the temperature of the water is higher.

8.3 NOISE

Counterfog nozzles emission spectrum maximum is around 4 kHz. Maximum emission values for measured frequencies produce a maximum of 115 dBC for ½ nozzle, 12 bar air and 8 bar water.

On account of the maximum acoustic values and frequencies observed, every operative working near Counterfog nozzles must wear Peltor™ Optime™ III ear protectors or similar. These ear protectors are designed to provide high level of attenuation, especially in low frequencies.

9. WASTE

COUNTERFOG uses small droplets to collect air borne particles and collapse it making up an aqueous solution on ground and on every horizontal surface, even vertical surface if the nozzle pushes there that. Counterfog uses a minimal amount of water and therefore the waste is also minimal.

Eventually, total decontamination and place remediation process requires a subsequent procedure of aqueous waste collection according to procedures and depending on the type of agent that has been collapsed. Water treatment and decontamination procedures are different for radiological, chemical or biological agents.

Decontamination is not necessary after an operational test of the system or activation based on a false alarm. Water deposited on ground is innocuous and can even be let to evaporate itself.

10. MAINTENANCE

In spite of the youngness of the Counterfog installations, it is possible to estimate the probability of failures according to the common technologies used: mainly hydraulics, pneumatics and fire-protection systems.

A maintenance plan must be designed by the Counterfog engineers including periodic revisions.

It is recommended to check moving parts (as valves), electronic devices (as detectors) and the Counterfog system at least every 6 months. This period could change according to the installation risk and significance. Counterfog maintenance can stick to that of the fire protection systems.

Cleanliness in pipelines must be also verified every 6 months. Pipes pressure and integrity must be checked as well.

It seems to be convenient for valves to have maintenance taps to shut off the supply and make easier the verification. A verification device for valves can be developed to this aim.

It is crucial to check correctly the integrity of automatic Counterfog activation sensors, the anti-sabotage systems and the access control security systems.

Compressors maintenance must be provided according to manufacturer, they must be also checked every 6 months, unless other frequencies were recommended. The system is always pressurized, so every failure in pipelines could be checked by testing their pressure.

11. Prevention of Misuse

There are many known techniques suitable to disperse agents in air –and unfortunately publically available-. Traditionally explosives are the simplest, but devices creating aerosols –like "painting guns", or sprayers- can also be used. The noxious aerosols must be under 2.5 microns size to persist in floating a time longer than hours.

In case of a fixed installation of the Counterfog a possibility to be sabotaged has been detected but simple procedures can prevent them. In case that a terrorist tries to use the Counterfog to disperse some agents –in spite of its limited dispersion capability- they would need to access to the water containers to pollute them and then to activate the system.

Obviously a first procedural measure to prevent this will be to secure the access to the containers and trigger an alarm system if violated.

Therefore a securing system is mandatory. If the system is manipulated by an unauthorized person the reset procedure must be followed.

A second barrier could easily be an interlock preventing the activation of Counterfog in case of violation of the access to the container or in case that they are opened. Furthermore, even if all these barriers were not enough they would have some practical problems as most of chemical agents suffer hydrolysis and would be neutralized. Additionally, some disinfectant –like chlorine- must be added to water to prevent accidental Legionella- what also would kill quite a few number of biological agents. Remember that even if all these barriers are broken through, the effect of Counterfog as "dispersing" system would last only a few minutes and not hours as it would be the case with well-known alternative systems.

12. Reset procedure

For a reset of the system proceed as follows:

All tanks must be emptied.

Water Filters must be disassembled, cleaned and washed out.

Air filters must be cleaned.

In case a security breach has taken place it must be checked that no agent has been delivered to tanks, pipes, valves, filters or nozzles. In that case chemical, biological or radioactivity tests must be done in case there is any reasonable doubt.

Only authorized personnel can undertake these procedures.

13. Legal notes

Counterfog has been registered as trade mark by Universidad de Alcalá.

Patents protecting several elements, devices and methods used in Counterfog have been applied.

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CONTACTS

PROJECT COORDINATOR

José Luis Pérez Díaz

Universidad de Alcalá

Jl.perezd@uah.es

PROJECT PARTNERS

University of Strathclyde

Yi Qin- qin.yi@strath.ac.uk

Georgi Nadjakov Institute of Solid State Physics
Bulgarian Academy of Sciences

Ognyan Ivanov- ogi124@yahoo.com

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Javier Quiñones- Javier.quinones@ciemat.es

ÚACh

Vaclav Stengl- stengl@iic.cas.cz

Vojenský výzkumný ústav, s. p.

Karel Mazanec- mazanec@vvubrno.cz

Klas Nylander- klas.nylander@consilium.se

BPE ®

Wolfgang Hornig- info@b-p-e.de

Asociación Europea de Ferroviarios

Francisco González -pacogonzalez.aec@gmail.com

Elisa María Ruiz Navas- emruiz@ing.uc3m.es