AEROSOL Disinfection

In public health hygiene

pulsFOG®

Imprint

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Introduction to epidemic control

An epidemic is a communicable *(infectious*) disease *(e.g. plague, cholera, smallpox, Ebola, influenza, such as avian flu, Spanish flu, SARS)*, often with fatal consequences, that spreads uncontrollably over and on humans or animals in the form of mobile bioactive microbes *(bacteria, viruses, spores)* within an incubation period. Other epidemics such as malaria and the Zika virus need intermediate hosts *(e.g. insects, which are then the target of a control measure)* to spread themselves. In most cases, transmission takes place by touching infected, often moist surfaces of articles of daily use, infected liquids, droplets, dust or insect bites. The origin and spread of an epidemic is facilitated by the dense coexistence of humans and animals, as well as poor hygienic precautions. Particularly dangerous are pathogens that, for the first time, are transmitted unprepared *(no vaccine or drug available)* and surprisingly from animals to humans (corona, swine flu). The chain of infection which then begins ends only by the "starving" of bioactivity, development of resistance in humans and/or dilution of the concentration of the pathogen by interrupting the transmission chain by means of appropriate measures of prevention *(quarantine)* and (bio-)chemical disinfection.

Risk areas

After initial signs of illness, transmission risks are to be minimised through the avoidance of unprotected contact with detected infected organisms and risk areas, social distancing and hygiene measures *(such as washing hands, cleaning doorknobs)*. Risk areas can be all buildings frequented by humans, animals and insects, e.g. hospitals, barracks, bathrooms, public toilet facilities, garages,

Large room disinfection with mobile fogger

lounges, waiting rooms and meeting rooms, such as schools, cinemas, theatres, sports stadiums, grandstands, prayer rooms, residential and park areas around hotels, as well as slaughterhouses, animal stables, work and guest rooms, kitchens, railway stations, airports and ports. They also includes transport containers such as ships, containers, cars for laundries, buses, trams, railway carriages and aircraft. Last but not least, the pipe and filter systems of air conditioning systems and underground sewers, which lead from hospitals, animal stables, slaughterhouses, hotels and restaurants to the municipal sewage treatment plant have to be considered. These underground pipe systems connect the sources of infection *(e.g. hospitals)* with the still clean environment *(e.g. hotels, inns*), as a result of which the disease is spread by nocturnal vectors *(disease carriers such as cockroaches, rats and bats*) that spend the day undetected in such pipe systems and multiply. If risk areas are identified, they can initially be cleansed of dirt deposits and treated with biocides, taking into account the objects they contain. Unmaintained air conditioning systems in office buildings, factories, hotels, workshops and other common rooms distribute influenza or corona viruses in all connected rooms, for example if filter systems are missing, unsuitable, defective or clogged.

Aerosol disinfection and pest control of urban sewers

Indoor application with cable-bound electric cold fogger. Such devices with low noise levels are preferably used in hospitals, hotels and catering establishments.

The type of treatment (*spraying, fogging*) depends on the use of the room: the more sensitive the contents, the smaller the droplet spectrum of the spray or fog nozzle used should be with the water volume reduced *(e.g. in laboratory and operating theatres, libraries, offices, kitchens)*.

Direct floor treatment in the interior and environment with lightweight portable thermal fogger. The machine is swung back and forth in the floor direction (about 30°). Due to the swinging method, the fog remains close to the ground (usually with a higher contamination density)!

Chemical control

After limiting a suddenly occurring "hotspot" of an epidemic disease, comprehensive control measures are introduced, including chemical cleaning in the deserted risk areas and their surroundings. Selected biocidal agents are used with the help of spraying machines or foggers. These differ according to the water dilution of the control agent used and the associated droplet size, which must be smaller the more sensitive the objects or the stock in the risk area and accordingly the lower the selected water thinning.

The appropriate equipment must be determined in advance *(spraying or ULV or fogger, smoking systems).* The classification of the various injection, spraying and fogging processes according to the droplet sizes produced is shown below:

Application method	Droplet size	Water consumption
High volume	Wet droplet spraying with droplet size > 300 µm	> 600 litres/ha
Medium volume	Spraying with 200 – 300 µm	200 - 600 litres/ha
Low volume	Spraying with 100 – 200 µm	100 - 200 litres/ha
Very low volume	Spray fogging with droplets <150 µm	10 - 100 litres/ha
Ultra Low Volume Ultra Low Volume	Fogging with droplets <100 µm Fogging with aerosols <50 µm)	< 5- 10 litres/ha < 5 litres/ha

- **The conventional targeted spraying method**

with a water consumption of 200 - 600 litres/ha and droplet sizes > 300 microns is the first choice for so-called "spot treatments", where a manageable limited area can be treated with wet droplets and sensitive objects *(power lines, food, paper, materials)* can be excluded from the spray jet. This method is not usable in underground sewer systems. It consumes large quantities of water, is labour-intensive and requires careful treatment of all surfaces, cavities, corners and cracks. The corresponding spraying apparatus is inexpensive *(hand pumps)*, but it becomes very expensive for large-scale use with mobile equipment for a spray tank with a volume of several hundred litres and motorised spraying apparatus. The dripping wet spraying of disinfection solutions with large amounts of water contaminated with biocides can become dangerous to the environment if soil fauna and groundwater are endangered or if the contaminated water run-off via a sewer system reaches the local wastewater treatment plant and impairs its biological function *(destruction of sewage bacteria)*.

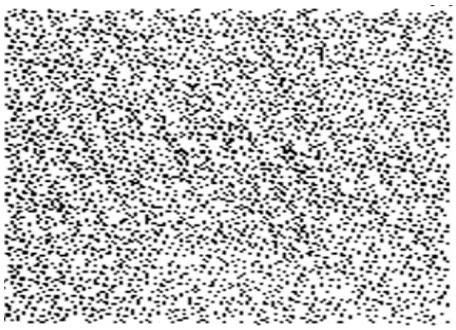
- **The alternative aerosol/fogging disinfection**

Invisible disinsection with pulsFOG "SUPER PRO" ULV machine

For control of easily recognisable external disinfection and disinsection of traffic areas around residential buildings with pulsFOG thermal foggers using fogging additive in the biocide solution.

Fogging disinfection using the ULV process *(Ultra Low Volume)* is a noticeably drier treatment with 100 times less dilution (less water). Due to its dual effect of room and surface treatment, it is one of the most successful control methods when one considers cost-effectiveness, effectiveness, environmental protection and simplicity of implementation as a whole. Taiwan, the most successful country in epidemic control, uses pulsFOG equipment for its brigades. Experiments carried out as early as the 1970s at the TU Munich (Technical University) with different droplet sizes led to the important finding: ***the smaller the droplet diameter at higher concentrations, the better the biological result*** *(also found under Matthews: "Pesticide Application Methods", IPARC Institute London)*.

Benefits of aerosol disinfection



Example of a fog droplet covering with selected droplet size. Note that in the gaps between the droplets in the picture, due to their smaller size, countless invisible smaller droplets from the overall spectrum of biocide fogging are present. In purely mathematical terms, up to 19000 droplets/cm² could be present.

The use of fog aerosols (droplets <100 µm) uses the associated enormous surface area enlargement of the active substance *(compared to the wet spraying process)* to reduce the water consumption involved without losing

effectiveness. Due to their high surface tension, the aerosols exhibit no flow behaviour, which prevents dripping into the ground.

- Due to the 100-fold reduction in the amount of water, larger risk areas *(e.g. airport halls, railway stations and even football stadiums)* can be treated with portable machines. At the same time, the inherent dynamics of the floating active ingredient fog equalise inaccuracies in the manual distribution, which are unavoidable with directed spray methods due to so-called spray shadows, also due to an imprecise working method on the part of the operator.

Treatment of a warehouse from the outside to the inside with a fogging range of up to 100 m

- In the case of complicated room structures, the floating capacity of the aerosols can be used to reach hard-to-access areas with the help of fans or to achieve large fogging ranges *(up to 100 m)* from a fixed installation site of the fogger (e.g. from the intrance). From a purely mathematical point of view, droplet coverings of aerosols of 150-19000/cm^2 can be built up *(Matthews, IPARC Institute, London)*. The cumulative enormous surface of such a large number of droplets facilitates evaporation or entry into the gas phase of the active ingredient involved, whereby hidden vectors and microbes can be better reached and neutralized. *(e.g. with PES, formalin, glutaraldehyde, phenols)*. There is no dripping with disadvantages for the soil fauna or harmful draining into a sewer system to the sewage treatment plant.

Usage conditions

For optimal distribution and expansion of the active ingredient in outdoor use, at least a relative humidity of 70-80% should prevail in the risk area. Therefore, the addition of an evaporation-inhibiting polyvalent alcohol in the biocide solution such as monopropylene glycol *(approx. 5-10% of the total mixture*) is usually advisable. This well-tolerated additive stabilises the relative humidity in the fog cloud and prolongs the floating and acting time of the biocide. Please note, that aerosols are not able to penetrate into dry porous material. The effect is therefore limited to the surface. The prior moistening of such materials *(e.g. rough concrete surfaces)* helps to achieve depth penetration. Applications in the open air near infected buildings only promise success with low air movement *(max. 6 km/h)*.

Biocides

The choice of the appropriate disinfectant is determined by the sensitivity of the risk area and its isolation. Agents with an inherent tendency towards a gas phase *(e.g. from redstone)* are preferable for interiors if work there is to be as residue-free as possible with a short-term effect. They are "dry" and prevent staining on sensitive objects. Other agents without a gas phase (e.g. quats such as the ZOONO product) deliberately prevent a gas phase with the aim of producing a long-term effective covering. Such agents are preferably applied with cold foggers or pulsFOG BIO machines.

Fog with a larger droplet spectrum *(<100 µm)* can also be used in windless outdoor installations. Basically, the following applies: the smaller the target object (*the harmful organism*), the smaller the lethal-acting droplet produced can be in order to develop its optimal effect. In other words: a cockroach as an intermediate host of an epidemic-like disease requires a larger droplet for the lethal dose than a malaria vector such as a mosquito, which can be destroyed with a single 8-16 µm droplet. With many agents, smallest droplets from 10 µm to gas molecules are sufficient to neutralise viruses and bacteria floating in the room, for example. The same applies to foul-smelling odour particles in the air, which are often carriers of pathogens *(e.g. in buildings of sewage treatment plants or landfills)*.

The properties of the droplets also depend to a large extent on the formulation of the biocide. Particularly uniform droplet spectra in the fog cloud are obtained from oil-soluble active ingredients *(e.g. phenols*), if these can be additionally diluted with clean low-viscosity mineral oil *(flashpoint > 65 °C),* or with water-soluble active ingredients, if these are mixed with water and a polyvalent alcohol as an evaporation inhibitor *(e.g. monopropylene glycol)*.

Products based on Peracetic acid (PES) + H2O2 split off atomic oxygen, which is extremely reactive and immediately connects with foreign (organic) particles including microbes *(i.e. it "burns")*. This "combustion process" prevents the formation of resistance by the harmful organism. The unstable gas molecule made of PES/H2O2, which develops rapidly in the fog cloud due to its summarized large droplet surface area, transforms itself into atomic oxygen, water and vinegar without environmental problems. This allows use in the human (also veterinary) domain and in the food industries taking into account possible fire hazards when treating easily combustible materials indoors. PES is preferably used with cold foggers or power-independent pulsFOG BIO foggers. The usual standard thermal foggers can only be used to a limited extent with PES if an automatic shut-off device is installed and acid-resistant materials are available for the active ingredient lines and containers. Due to the action of heat in the common thermal fogger, a stronger gasification of the active substance of PES takes place, so that only a small action against germs can be expected near the floor in case of a stationary application.

A proven fogging-capable PES fog product is manufactured by Kesla Chemie under the trade name **Wofasteril SC** and also used by the military *(BDS 2000)*. Furthermore, internationally known and proven for thermal fogging is the product HYPEROX from Antec and KICKSTART from Cid Lines.

On the basis of quaternary ammonium with a special formulation for a long-term effect, an environmentally friendly, ready-to-use product with broadband properties is available under the trade name "ZOONO". Details can be found on the Internet.

Formulation and dosage

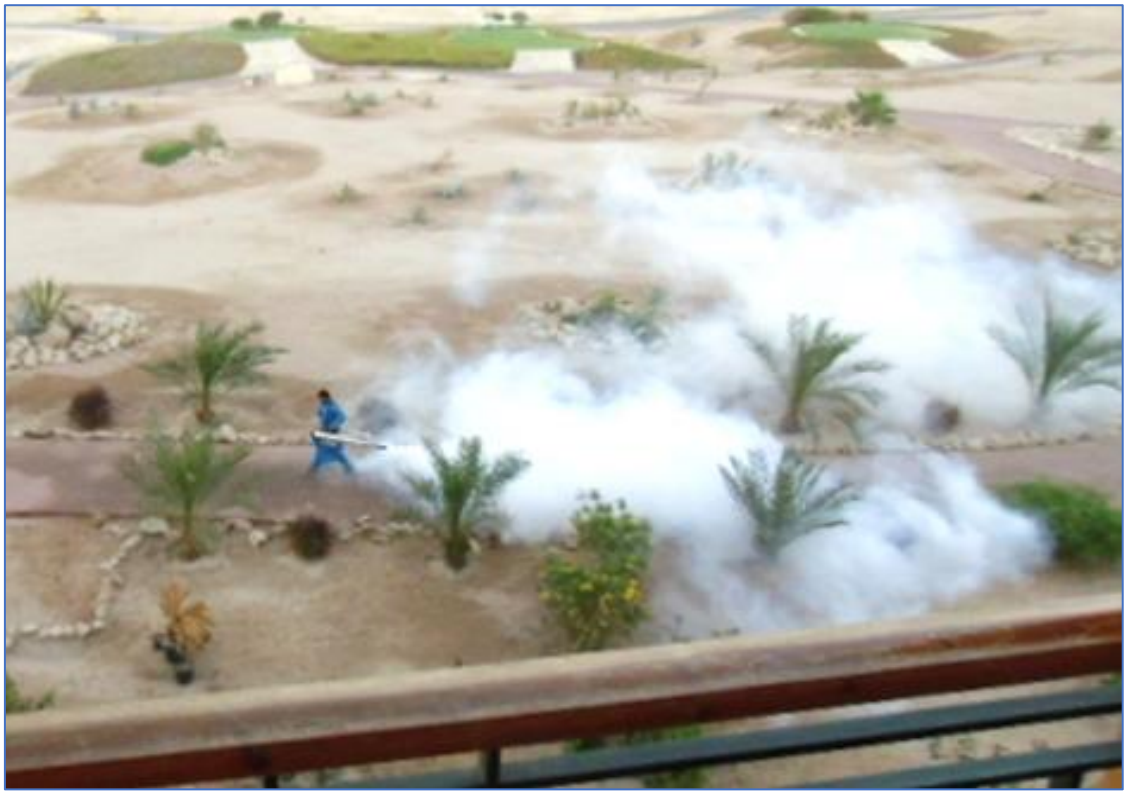
Comparative concentration for the wet spraying process	1%	2%	3%	Ejection distance of the fogger in metres
Quantities of the active ingredient with pulsFOG application /1000 m³ (litres)	1.5-2	3-4	4.5-8	
+ Water (litres)	4	5	6	
+ Additive KK-2 Special (litres)	0.5	0.5	0.5	
=Total/1000 m³ (litres)	6-6.5	8.5-9.5	11-14.5	
Fogging time with pulsFOG machines	**min**	**min**	**min**	**min**
K-10	30	45	55-70	25
K-22	18	27	33-52	50
K-30	6	9	11-14	70

The dosage of the agents is given as a concentration indication on the respective label or can be taken from the operating manual or the safety data sheet. Those agents that are suitable for the fogging method due to their physical and chemical properties *(e.g. aldehydes, phenols, peracetic acid with H2O2)*, are diluted according to a conversion table with little water (usually 4-6 litres/1000 m^3 space + a formulation excipient, *(e.g. VK-2 from pulsFOG or simply monopropylene glycol from the chemical wholesaler)*) and fogged per volume of the risk area. In the top row, this conversion table assumes the spray method according to the information on the label of the agent, thereafter the 1, 2 and 3% applications of the agent are distinguished.

Below that, the fog dosage per 1000 m^3 space is derived as well as the recommended minimum amount of water and the fog additive *(e.g. VK-2 or monopropylene glycol).* The purpose of the additive is to prevent the generated aerosols from too fast evaporation, or to preserve the relative humidity in the fog cloud and to make the fog visible for better distribution monitoring. To avoid oxidation losses, PES is to be mixed with distilled water. In contrast, formalin is only fogged undiluted *(15-20ml/m^3 space)*.

Vector control along the roads

Due to the dual effect in the space and on the surfaces, the dosage in the open air can also be carried out per unit surface (e.g. per ha), with setting a slightly larger droplet spectrum on the fogger (*<100 µm*). In this case, the average quantity would be used that, according to the label, is conventionally sprayed in 100 litres of water, but this average quantity would be diluted in only 5 – 10 litres of water including 10% fogging additive for 1 ha of floor area (ULV application).



Observed from the hotel balcony: pulsFOG thermal fogger used outdoors. In order to keep the fog droplets close to the ground, a larger droplet spectrum (<100 µm) should be generated. The larger dosing nozzles used for this purpose increase the flow rate of the agent, with the result that a higher walking speed of the operator is necessary. This walking speed can be checked monitoring the consumption in the transparent active ingredient tank. The visibility of the fog generated allows an even distribution in the terrain.

Suitable dosing nozzles

The flow rate to the fogging nozzle is controlled with the help of dosing nozzles. With the atomising energy of the fogging nozzle of the device (the motor) being constant, the droplet size can be influenced and controlled by different flow rates. Various exchange nozzles are available for this purpose:

	Dosing nozzle numbers for aqueous fogging mixtures					
pulsFOG machine type	Dry fog <15-20 µm		Standard fog < 30 µm		Moist to wet fog <50-150 µm	
TURBO ULV	No. 7		No. 8		No. 9, No. 10, No. 11	
K-10 sp	No. 7, No. 8		No. 9		No. 10, No. 11	
K-10-O	No. 8		No. 9		No. 10, No. 11	
K-22-O	No. 2 x 8, 2 x 9		No. 2 x 10		No. 2 x 11, 2 x 12	
K-22 BIO Portable	**rear**	**front**	**rear**	**front**	**rear**	**front**
	2 x 8	2 x 8, 2 x 9	2 x 8	2 x 10	2 x 9	2 x 11, 2 x 12
K-30-O	No 2 x 11		2 x 12		2 x 13, 2 x 15, 2x20	
K-22-20-O	No 2 x 9		No 2 x 11		No 2 x 12	
K-22-20 BIO	No 2 x 8 | 2 x 9		No 2 x 8 | 2 x 10		No 2 x 9 | 2 x 11, 2 x 12	
K-30-20-O	No. 2 x 11		No. 2 x 12		No 2 x 13, 2 x 15, 2 x 20	
K-30-20-BIO	No 2 x 9 2 x 10		No 2 x 9 2 x 12		No 2 x 10 | 2 x 15, 2x 20	
K-50 BIO	No 2 x 10 | 4 x 15		No 2 x 12 | 4 x 20		No 2 x 15 | 4 x 25	

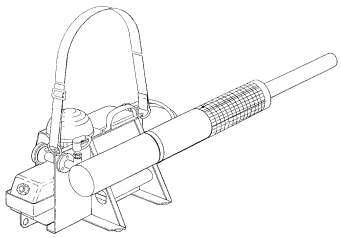
Preparation and training

The execution of a public disinfection measure is usually carried out by the local fire brigade or a health organisation, which also has the necessary equipment *(devices, protective suits, full face masks, biocides*) and training courses.

In Taiwan: *Example of the training of a health team in the open air - the planned execution of an epidemic control measure with the help of pulsFOG foggers. It is well known that Taiwan and South Korea can boast the greatest success worldwide in fighting the spread of influenza viruses (e.g. Covid 19).*

The Eternal Struggle

The invisible microcosm in which epidemic microbes exist is responsible for the undetected formation and spread of a pathogen "hotspot" within a quarantine period. The ability of microbes to mutate presents us with the task of developing new adapted vaccines and drugs year after year. An unknown epidemic cannot be prevented by precautionary measures. The use of chemicals is therefore always part of curative control measures to limit and eliminate the disease.



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