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# POLICE RESOURCES THAT ARE NOT MEANT TO BE LETHAL: A CRITICAL VIEW OF POLICE PEPPER SPRAY

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***Abstract.*** *This study investigates pepper spray's development, use and health risks as a police tool in Germany. The starting point is the discussion about deaths after pepper spray operations and the inadequate statistical recording of injuries and fatalities caused by pepper spray by state agencies. The authors trace the historical development of police forces, from the post-war years to the introduction of CN and CS gas to the establishment of pepper spray, referring to international models such as the USA and Austria. The focus is on assessing the effectiveness and hazard potentials of pepper spray, especially regarding the distribution of aerosol particles and their health effects on directly and indirectly affected persons. The authors criticise the lack of reliable studies on the risks in closed rooms and crosswinds, and that the health risks posed by aerosol particles are underestimated. In the empirical part, experimental analyses of the particle size and distribution of two pepper sprays used in Germany are presented for the first time. The article pleads for a differentiated and scientifically sound assessment of the health hazard potential of pepper spray in police operations and calls for better data collection and further research on the effects on those affected and bystanders.*

***Keywords:*** *Police Resources, Pepper Spray, Risk Management*

## Introduction

The topic is illustrated by four deaths after pepper spray operations by the police, which led to a minor inquiry by the parliamentary group "DIE LINKE" in 2009/2010. According to the questioners, scientists have warned of the side effects of pepper spray (BT, Drs. 17/3942). The claim that the ingredient chilli in pepper spray is harmless is complex to prove scientifically. It is clear from the Federal Government's response that it is not aware of any deaths or serious injuries that are causally related to the police use of pepper spray. In the Federal Government's response to its findings on the use of irritants by the police authorities of the federal and state governments, the number of injuries and deaths caused by the use of pepper spray is not statistically recorded separately. This leads to the conclusion that no data is available because it is not collected. The Federal Government points out that the police only use pepper spray in compliance with the principle of proportionality (BT, Drs. 17/4163). For example, a case during the G20 summit in Hamburg caused a stir when a young woman climbed onto a police clearing tank and was incapacitated by the questionable use of pepper spray, only

to be taken into custody afterwards. This statement can certainly be critically discussed.

## Theoretical approach

After the Second World War, the German police were disarmed and their officers denazified. Given its abundance of power during the National Socialist era, the police in the English occupation zone were organised in a decentralised and communal manner. To this end, a regional police force (RB police) has been set up in administrative districts, and a city district police force (SK police) has been set up in cities with more than 100,000 inhabitants. However, to fulfil their police duties, the RB and SK police received only a limited number of pistols, which were not allowed to be carried by patrol officers on early duty (Kawelovski, 2025). Against the background of the weapons from the Second World War still in circulation, the police task was difficult. There was an initial need for resources to close the gap between baton and firearm. In the four occupation zones, a rough division into protective police and criminal police emerged. This subdivision was expanded in 1951 to include the riot police, whose establishment was based on an agreement between the Federal Government and the Federal States of 27 October 1950 and as a reaction to the recruitment and barracking of paramilitary police units in the Soviet occupation zone. For fear of an armed confrontation within Germany, field, street, and house fighting initially dominated the training content of the riot police. With the transfer of police sovereignty to the states, police training in legal theory began in 1953. This process was accompanied in 1968 by massive protests by the so-called extra-parliamentary opposition against adopting the Seventeenth Act Amending the Basic Law (Emergency Acts). Due to the insertion of Article 87a of the German constitution and the guaranteed support by the Bundeswehr in times of internal emergency, the riot police were successively demilitarised and primarily deployed only in football stadiums and at demonstrations (Behrendes 2003).

In the 1970s, the riot police were faced with new challenges due to the increase in large-scale events, as they no longer had the necessary skills and resources to be able to act robustly in the event of collective violence. In 1975 and 1976, the riot police and police authorities were therefore equipped with the Chemical Mace irritant sprayer (RSG 1), type Smith & Wesson, MK V, which was called a "chemical club" because of its content of 0.7 grams of CN in 73 grams of irritant liquid, its translation from English and its effect. Additional uncertainty was caused by press reports reporting on an expert opinion by Dr. Dyer, according to which the use of RSG 1 had increased the number of malignant melanomas in users (IM NRW, 1976). Nevertheless, the RSG 1 was used in the autumn of 1976 to clear the reactor construction site in Brokdorf. It was observed that demonstrators were carelessly sprayed with the irritant CN by the police, which resulted in 26 people being injured (Augstein, 1976). Six months later, the chemical weapons that had been stored in the meantime were no longer available to the police for the time being, so that in Grohnde, Lower Saxony, during the most serious riots in the Federal Republic of Germany to date, the police officers deployed could only protect themselves with their half-shell helmets, plexiglass shields and short batons (Holecek, 2017).

In the area of responsibility, new resources of deployment typical of the police were examined, which were intended to affect troublemakers as little as possible from the point of view of the rule of law and humanitarian and to protect the police officers deployed in the best possible way (Schnoor, 1981). In this context, the irritant CS was tested. Experiments in which animals were injected with CN/CS or administered in gaseous form led to the assumption that CS was less toxic than CN (Cookson & Nottingham, 1996).

Since the significance of animal experiments for humans is very controversial due to frequent methodological deficiencies and a lack of standardisation, several practical

experiments with CN and CS were carried out on test subjects at the Linnich Police College (NRW). There were no significant differences in the effect of the two substances if they were applied in small quantities in liquid form with the RSG or by burning irritant spray bodies. However, when CN/CS from water cannons were used, to which the Minister of the Interior of the Federal State of North Rhine-Westphalia, Dr. Herbert Schnoor, was also exposed, increasing concentrations on the skin led to significantly different effects. While the test subjects exposed to the CN water cannon remained capable of acting, Interior Minister Schnoor and the other test subjects exposed to the CS water cannon were almost all incapacitated. They also showed significantly stronger symptoms of nausea, which is why CS was popularly known as "vomit gas". In addition, CS led to escalating breathing difficulties, skin irritation and the development of feelings of anxiety in those affected (Lutze, 1981). Practical tests with CN and CS at the police schools in Dachau (Bavaria) and Braunschweig (Lower Saxony) confirmed the North Rhine-Westphalian results. Nevertheless, CS was introduced for the police in Bavaria in August 1981. A little later, Baden-Württemberg and other Christian Democrat-governed federal states followed. In addition to the concealed RSG 2, replaceable spray cans with one per cent CN/CS as an irritant were also procured, which could be inserted into the trigger and safety device of the existing RSG 1 (LT BW, Drs. 10/1032). North Rhine-Westphalia, on the other hand, maintained that the introduction of CS was not yet ready for a decision, as conclusive studies on the use and mode of action of CS were still lacking. In addition, it was found that CS could incriminate potential troublemakers uncontrollably and beyond what was necessary and was therefore not a typical police weapon (IM NRW 1982, p. 3). The idea for an alternative and yet typical police weapon was the American Federal Bureau of Investigation (FBI), which has been using pepper spray since 1973 (Rosenfield, 2017).

The pioneer for the introduction of pepper spray in the police forces, on the other hand, was the Austrian police, whose police officers were increasingly attacked and injured by HIV-infected and mentally disordered people with bloody syringes and knives from 1992 onwards. It was recognised that in the case of attacks with syringes or knives, the distance to potential attackers must be up to seven meters to use the desired distance means in time. The working group of the Austrian Federal Ministry of the Interior, which was entrusted with the search for suitable police resources to defend against physical attacks on security organs with blood contact (AIDS official acts), came to the conclusion based on the state of knowledge at the time that only the use of Chemical Mace MK V appears to be expedient. In this context, a project group of internal and external (scientific) experts from the police was also formed, which initially subjected CS spray and pepper spray to practical testing as a promising product. Compared to the CS spray, the pepper spray showed a higher efficacy and reliability with a lower risk of damage to health. In addition, experience from the USA showed that about 20 per cent of those affected were immune to CS, while the immunity rate for pepper spray was only two per cent. Based on the knowledge gained, pepper spray was given preference and subsequently introduced as a service weapon in Austria in 1996 (Zwanzinger, 2025).

Based on a submission by the Police Technical Institute (PTI) of the German Police University, which also incorporated the findings from the USA and Austria, the IMK recommended the introduction of pepper spray in Germany to the states and the federal government in a resolution of its 157th meeting from 10.06 to 11.06.1999. As part of the gradual introduction of RSG with pepper spray, the PTI developed a Technical Guideline (TR) in 2008, which still serves as the basis for procurement by the police today, as it describes their requirements for the design and testing of RSG with pepper spray. To keep the risk to troublemakers, police forces and bystanders as low as possible, the TR of the PTI for RSG with OC or PAVA stipulates that the active liquid must be applied with a spray jet and that the irritant

content may only be 0.3 + 0.03 per cent by weight. Furthermore, the solvents and propellants must not be irritating, carcinogenic, toxic to fertility or mutagenic (PTI, 2008).

In a practical tactical approach, further factors must be considered to assess whether a reliable effect can occur in the sprayed persons in the form of an even justifiable exposure or whether such exposure can be avoided for uninvolved persons and users of the RSG. In this context, the first step is to assess the accuracy of the RSG. The indicator is the spray pattern diameter, which is calculated under laboratory conditions (PTI, 2008). It should be noted that the RSG has a spray jet suitable for use precisely (AGH Berlin, Drs. 17/13246). The RSG can be wind-dependent, and it rarely seems possible to safely hit and stop dynamically acting disruptors (LT RLP, Drs. 17/6054). In addition to the recommendations of the PTI, practical experience from Austria shows that a constant spray jet of more than two seconds is primarily required for a reliable effect of pepper spray (BMI Austria, 2012).

The critical question arises regarding using pepper spray in enclosed and/or crosswind-prone areas (football stadiums). Reliable studies, which are also desired by the operational police forces, are not yet available on this subject. It is undisputed that the use of pepper spray has acute effects on the eyes, skin and breathing of the people hit. However, observations that pepper spray used by the police can spread over a large area towards the end of the spraying process and in windy conditions require empirical verification. This is because acute effects and serious health consequences are also to be feared for persons indirectly affected by the use of pepper spray if they inhale the aerosol particles of a pepper spray. In the discussion on this subject, the lack of definition of a corresponding size (aerodynamic diameter) for the aerosol particles of the pepper spray is largely neglected. It is known from pharmacology that aerosol particles with an aerodynamic diameter of more than ten micrometres only reach the upper respiratory tract. Aerosol particles with a diameter of two to ten micrometres can also penetrate the bronchi, and particles with even smaller diameters can penetrate the deeper alveoli (alveoli of the lungs). In the latter case, the smallest particles enter the structural components of the lungs via the upper and lower respiratory tract, where gas exchange occurs during breathing. This increases the likelihood of a massive restriction of breathing (Huschbeck, 2019). It should be noted that despite several events that led to the introduction of pepper spray in the police some time ago, many police and politicians are subject to the erroneous belief that pepper spray alone emits a jet of liquid that only affects the persons directly hit (LT NRW, Drs. 16/13890).

## Methodology

During a rethinking process in parts of the police and politics, the test laboratory of the Laus company was commissioned by the first author to test the contents of two pepper sprays used by the German police. These were the original TW 1000 Professional RSG-5, 63 ml from Carl Hoernecke, Chemische Fabrik GmbH & CO. KG and the Curd's Police RSG 2000 from IDC System AG. The aim was to analyse the aerosol particles of the pepper sprays and their distribution under experimental conditions similar to those of the PTI. For this purpose, the size of the aerosol particles was measured (µm) with a helium-neon laser and their sum distribution was calculated. The distribution (D) resulted in the parameters D10, D50 and D90, corresponding to the percentage distribution of aerosol particles (volume%). Since the original TW 1000 Professional RSG-5 is the pepper spray used by most police forces, it was exciting to the authors. For this reason, the ingredients of three pepper spray cans of this brand were examined. In addition, the aerosol particles of two pepper spray cans, each of the Curd's Police RSG 2000 and the freely available Original TW 1000 Pepper-Jet, were analysed. The aim was to investigate possible health impairments caused by pepper spray in troublemakers, emergency

services and bystanders. In particular, the analysis of the over-the-counter pepper spray was intended to clarify whether possible dangers emanate only from police spray or are generally inherent in pepper spray. For this purpose, the measuring points of the individual pepper sprays were connected and presented in the following chapter (Results) as x and y coordinates. On the horizontal x-axis, the size of the aerosol particles is plotted in micrometres (µm). The vertical y-axis, on the other hand, shows the percentage distribution of aerosol particles (%).

## Results

In this chapter, the data from three measurements with the original TW 1000 Professional RSG 5 are first graphically displayed. The three measurements on the pepper spray most commonly used by the police show that a different number of sprays is possible (7-9 times). The aerosol particles have a size of 6.69 to 458.23 µm. In the D90 distribution, the aerosol particles were ≥ 320.28 µm during the first three sprays. During the further sprays, the decrease again after the fifth (1st and 2nd series of measurements) or seventh spray (3rd series of measurements). In the D90 distribution, the smallest aerosol particle size of 25.18 µm was measured in the last spray of the first series of measurements. In the D10 distribution, sizes of ≥ 97.81 µm (1st series of measurements), 82.97 µm≥ (2nd series of measurements) and ≥ 68.94 µm (3rd series of measurements) were measured in the first sprays. The size distribution also increased with further sprays and decreased again after the fifth (1st and 2nd series of measurements) and sixth sprays (3rd series of measurements). The smallest particle size of 6.69 µm was measured in the seventh spray of the second series of measurements. The D50 distribution also represents the mean value of the distribution sums and corresponds to the results described (Figs. 1-3).

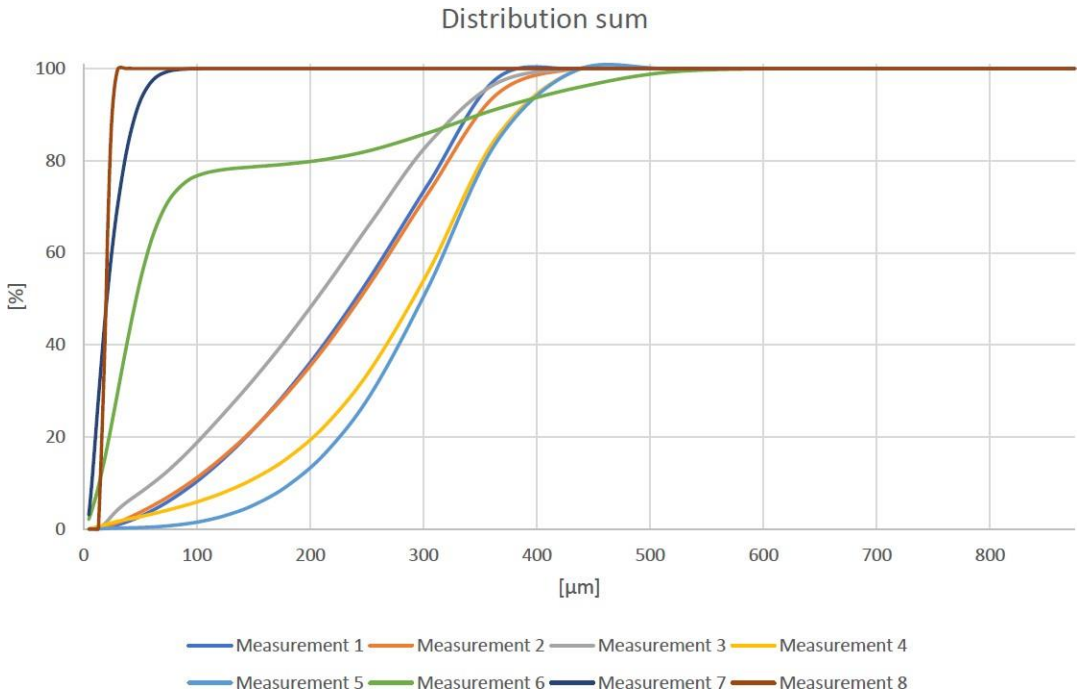


**Figure 1. First series of measurements with the TW 1000 Professional RSG 5.**
*Source: Study initiated by the first author.*

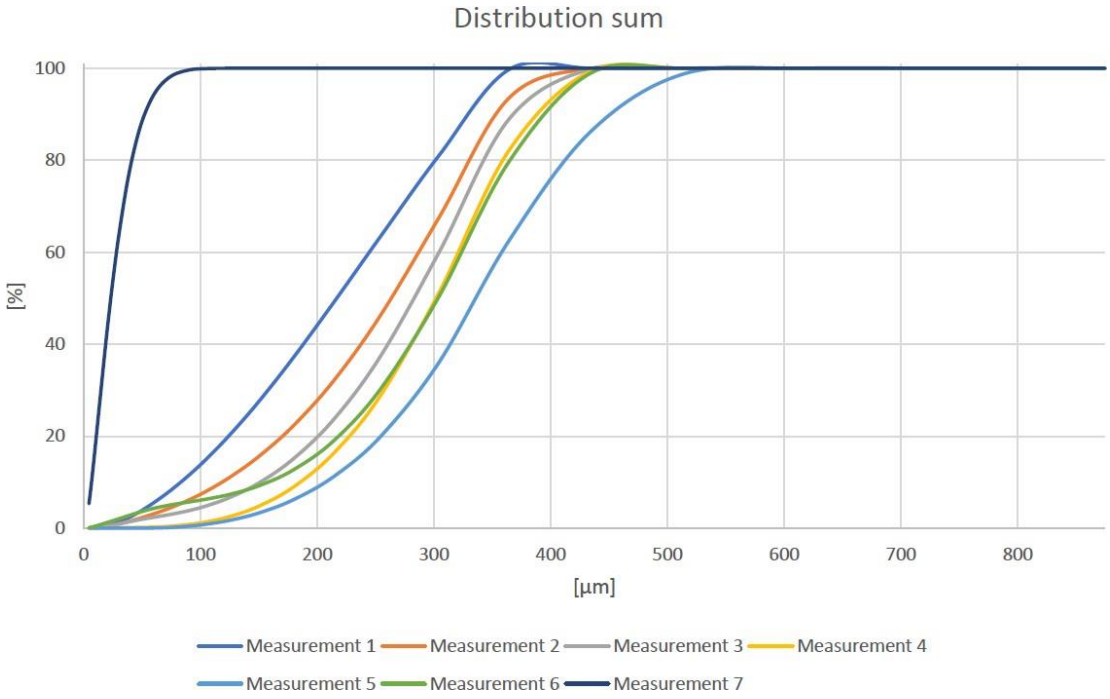


**Figure 2. Second series of measurements with the TW 1000 Professional RSG 5.**
*Source: Study initiated by the first author.*

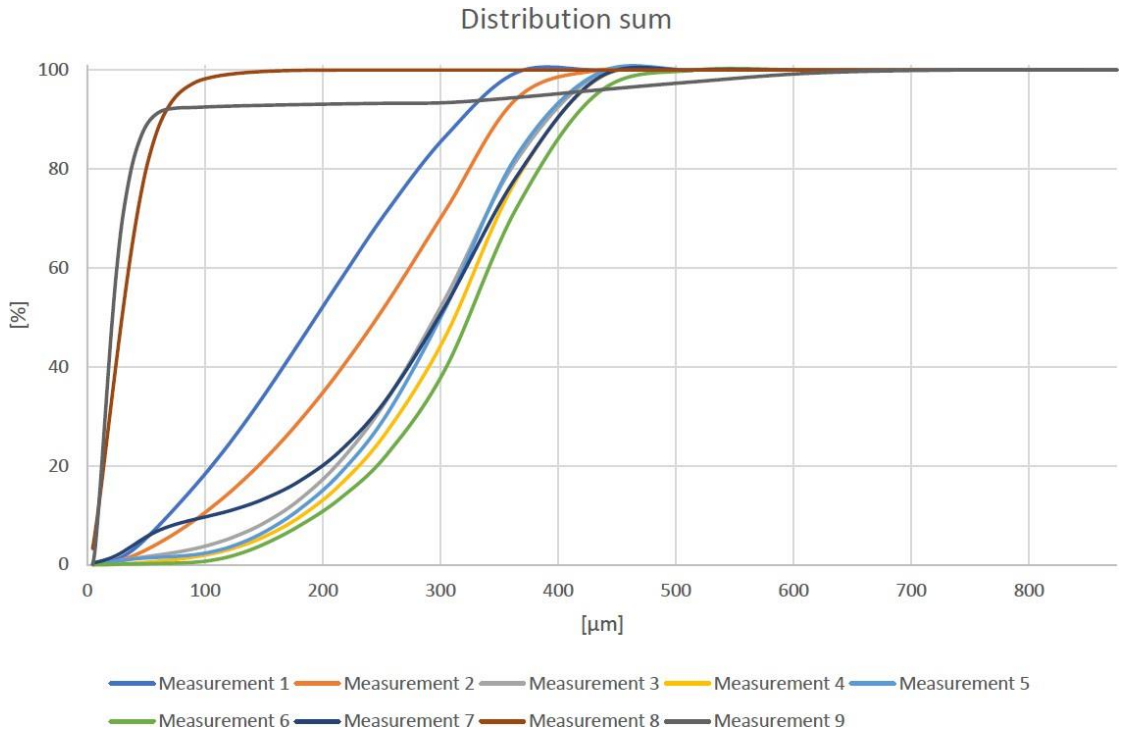


**Figure 3. Third series of measurements with the TW 1000 Professional RSG 5.**
*Source: Study initiated by the first author.*

In the next step, the data from two series of measurements are displayed with the Curd's Police Pepper Spray RSG 2000. Both measurements show that the aerosol particle sizes in the

Curd's Police RSG 2000 are between 6.78 and 782.79 µm. A distribution of D90 showed that the predominant aerosol particles (90%) of all first sprays were ≥ 285.83 µm. In the further sprays, the aerosol particle size increased to the sixth (1st series of measurements) and seventh sprays (2nd series of measurements) and then decreased again. In the D90 distribution, the smallest aerosol particle size of 66.10 µm was measured in the last spray of the first series of measurements. In the D10 distribution, it was determined in the first sprays of both series of measurements that a small proportion of the aerosol particles (10%) had a closely spaced size of ≥ 80.60 µm (1st series of measurements) and ≥ 72.06 µm (2nd series of measurements). At this time, the size distribution of aerosol particles increased with further sprays. It decreased again after the fifth spray (1st series of measurements) or fourth spray (2nd series of measurements). The smallest aerosol particle size of 6.78 µm was measured in the eighth spray of the first series of measurements (Figs. 4-5).

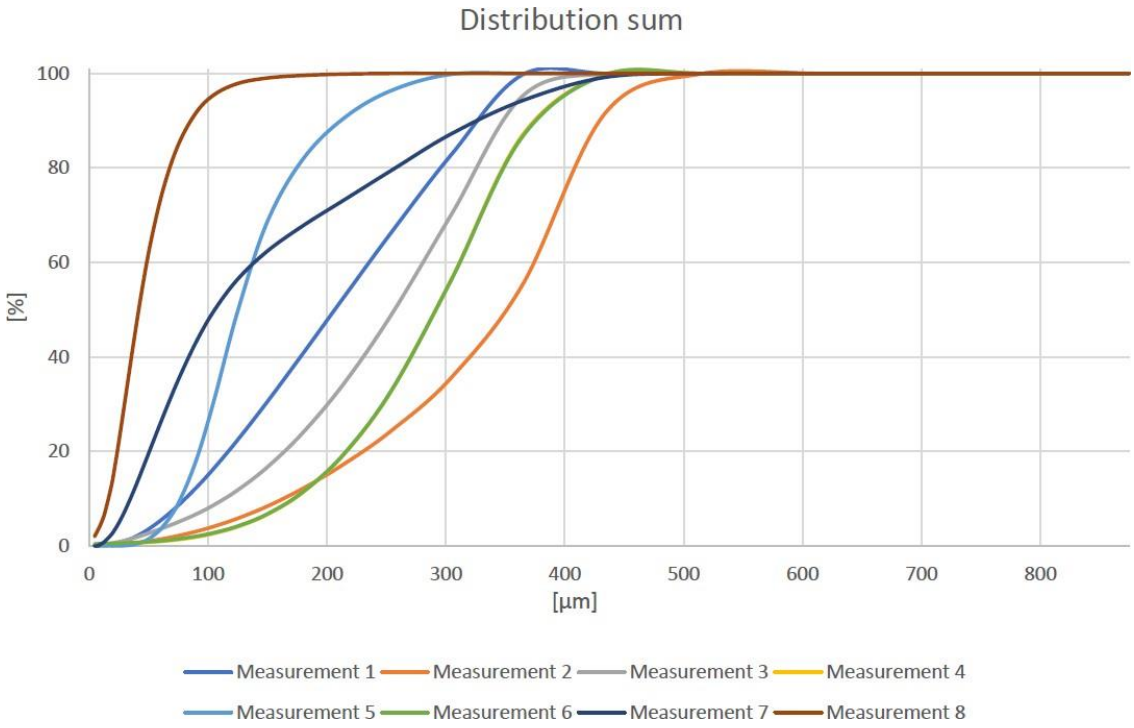


**Figure 4. First series of measurements with the Curd's Police Pepper Spray.**
*Source: Study initiated by the first author.*

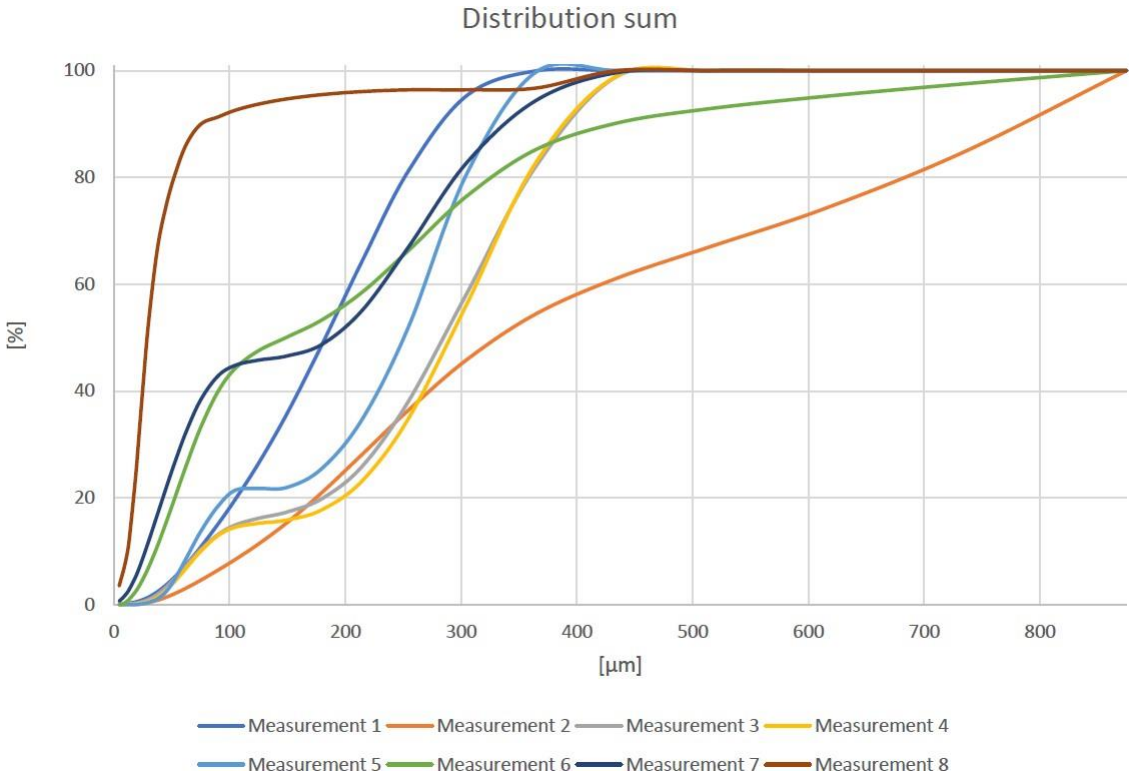


**Figure 5. Second series of measurements with the Curd's Police Pepper Spray.**
*Source: Study initiated by the first author.*

Finally, two measurements were carried out with the freely available pepper spray (Original TW 1000 Pepper-Jet), which shows that ten to eleven sprays are possible here. The aerosol particles of this over-the-counter pepper spray have a size range of 1.68 to 432.25 µm. A comparison with the pepper sprays used by the police shows almost identical results. In the distribution sums D90 and D10, comparably large aerosol particles are emitted, so it does not give the impression that the Original TW 1000 Professional RSG-5 and the Curd's Police RSG 2000 are pepper sprays specially developed for the police with higher effectiveness and lower risk potential. However, the aerosol particles of the original TW 1000 Pepper-Jet appear in the 11. Spray with a size of 1.68 µm is dramatically small. The spray tests with this pepper spray allow three conclusions. First, the aerosol particles of the very first sprays are ≥ 103.04 µm. Secondly, the aerosol particles become larger after further sprays and only smaller again after the ninth or tenth spray. Thirdly, aerosol particle sizes of ≤ 10.00 µm are emitted in the last spray bursts (Figs. 6-7).

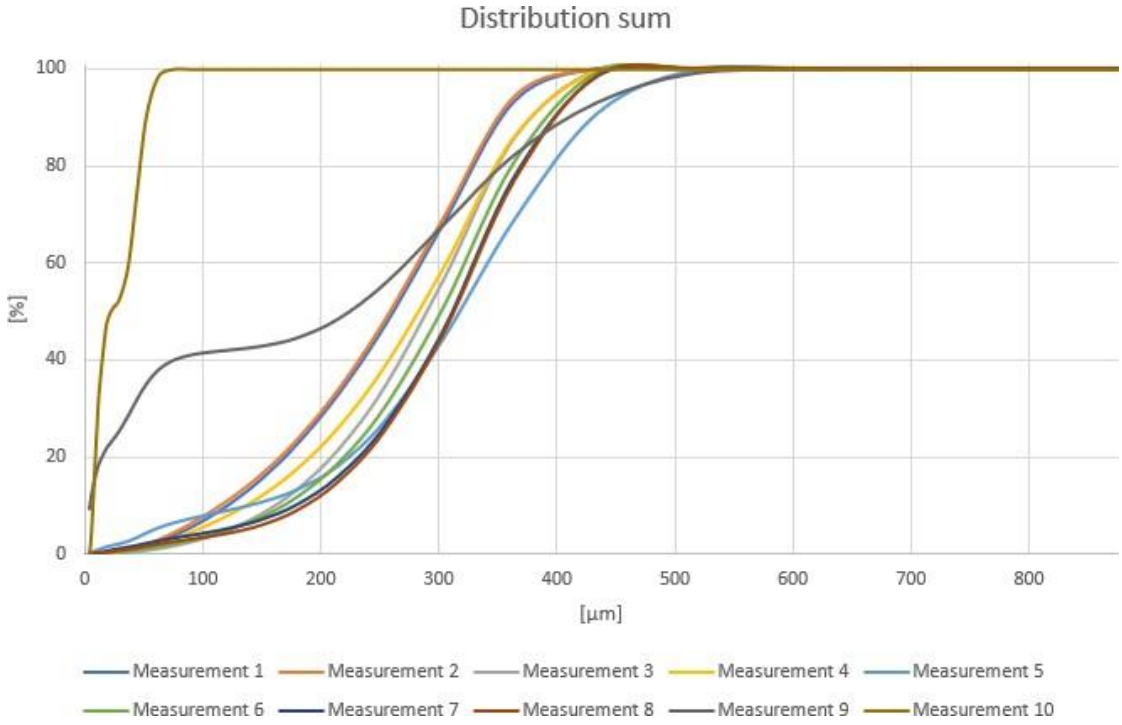


**Figure 6. First series of measurements with the Original TW 1000 Pepper-Jet.**
*Source: Study initiated by the first author.*

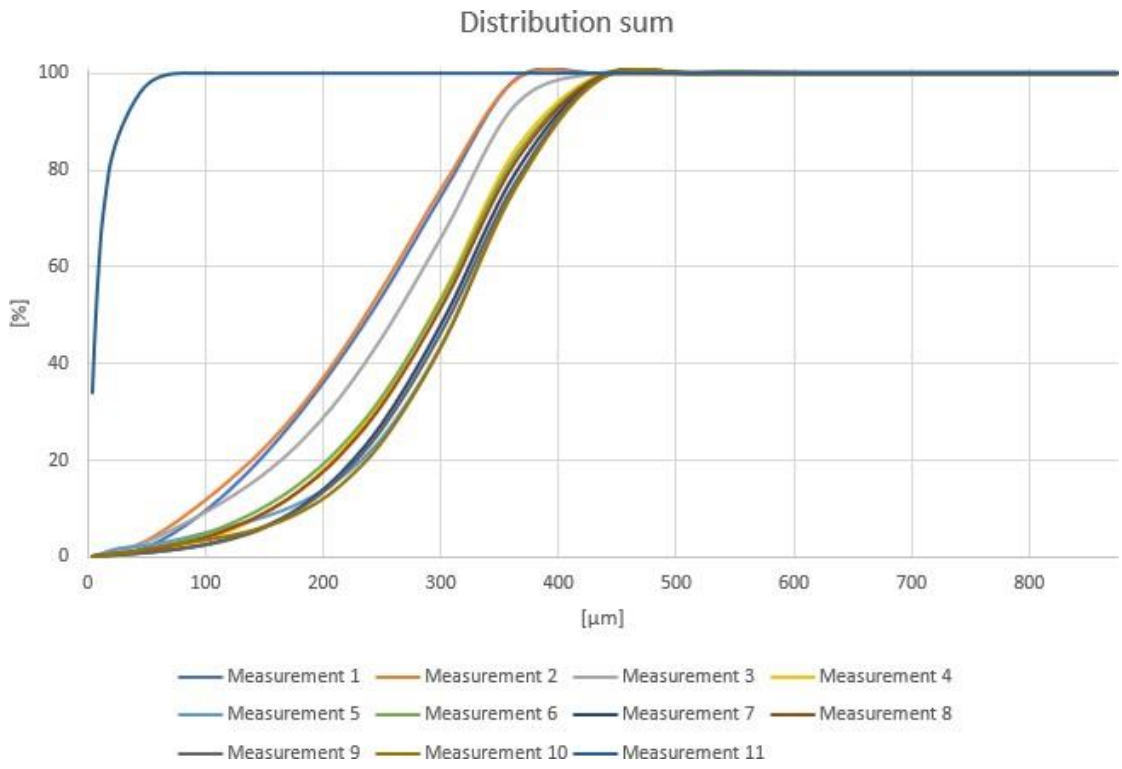


**Figure 7. Second series of measurements with the Original TW 1000 Pepper-Jet.**
*Source: Study initiated by the first author.*

The available results consistently show that when all three pepper sprays are used, the contents are atomised with the last spray, which poses a risk of deep inhalation of respiratory-irritating aerosol particles for troublemakers, emergency services and bystanders.

Police officers should not empty their pepper spray, knowing this fact, but stop spraying before the atomisation begins. The use of pepper spray can have adverse effects. The spraying of liquids by outdoor agricultural irrigation systems shows that in strong winds, an effect occurs that gives the impression that the liquid is hitting a hard surface (Fig. 8).

**Figure 8. Irrigation system in agriculture.**
*Source: Own illustration.*

It can therefore be assumed that aerosol particles from the liquid jet of a pepper spray are whirled up by the wind and distributed over a wide area. Thus, it cannot be ruled out that troublemakers, emergency services and more or less distant bystanders may also be affected by the consequences of using pepper spray.

## Discussion

During the first sprays of all three pepper sprays, it was measured that a small proportion of the aerosol particles (D10) had a size of ≥ 68.94 µm. In the D90 distribution, the aerosol particles were ≥ 285.83 µm in all first sprays. The size distribution increased with further sprays and decreased again towards the end of the spraying process. The smallest particle size of 1.68 µm was measured in the eleventh spray of the Original TW 1000 Pepper-Jet (2nd series of measurements). The aerosol particle sizes of all first and middle sprays are similar. Only propellant gas and residual particles are emitted in the last sprays, which leads to significant deviations from the first and middle sprays. The results coincide with the Austrian operational experience. The influence of the wind on the liquid jet and the aerosol particles it contains becomes plausible. This leads to a better understanding of the dangers of pepper spray, mainly when used in enclosed and/or crosswind-prone areas. Pepper spray in closed rooms is considered excluded for tactical reasons due to the contamination of troublemakers, emergency services and bystanders (LT RLP, Drs. 17/6054). However, the police use pepper spray in all rooms, as aerosol spread and acute danger to all those involved is excluded as long as they are outside the liquid spray jet (LT NRW, Drs. 16/13890). The latter must be critically questioned

based on the available findings, since at the end of the use of pepper spray in unfavourable wind conditions, there is a risk of deep inhalation of aerosol particles with irritation of the alveoli. To increase the risk, it must be taken into account that RSG 4 is usually used against crowds of people in football stadiums if they cause violence (LT Nds., Drs. 17/6110). Compared to the smaller RSG 3, RSG 4 can be classified as even more dangerous, as it can spray seven times the active ingredient simultaneously. This circumstance is taken into account by the fact that in the deployment orders, the deployment of the RSG 4 is made subject to the reservation of the police commander, except in self-defence situations (LT BY, Drs. 17/9585).

The initial euphoria about a practical police resource that can be used indiscriminately and without consequences has thus given way, at least in Austria, to the realisation that the use of pepper spray must be carefully weighed. The primary goal of the Austrian police is, therefore, not so much to use pepper spray in a situation-appropriate manner as to prevent its use in advance, if possible, or to prevent it as moderately as possible and to give preference to the use of physical violence (BMI Austria, 2012).

In Germany, on the other hand, reference is made to the fact that the use of pepper spray takes place on occasions in which the police would otherwise use physical force, batons or pistols, whereby the use of pepper spray reduces the risk of injury and is less harmful to health (Hamburgische Bürgerschaft, Drs. 21/8091). In its meta-study, the National Institute of Justice also focused on injuries suffered by police officers and troublemakers due to police coercion. In this regard, it was quantitatively empirically determined that pepper spray reduces the probability of injury for troublemakers by 70 per cent and increases it by 18 per cent for police officers (Alpert et al., 2011). Of note is another investigation into the use of direct coercion by the Los Angeles Police Department (LAPD). According to the study, more police officers were injured than troublemakers due to the use of pepper spray. The number and ratio of police officers injured by pepper spray and troublemakers seem to be significantly reversed compared to other means of coercion.

The brightfield figures on police officers and citizens injured by pepper spray in Germany can be found in the annual reports of the Central Information Centre for Sports Operations (ZIS) for football matches of the Bundesliga, Bundesliga 2, Bundesliga 3, DFB Cup and the associated travel routes. According to the report, in the 2023/2024 season, a total of nine state and 18 federal police officers, 40 troublemakers, 27 bystanders/injured parties and ten stewards were injured by the use of pepper spray (ZIS, 2024). In addition to a high number of injured federal police officers, a lower proportion of injured troublemakers can be attributed to the use of pepper spray by the federal police. It also seems striking that no injured bystanders/injured parties and stewards were recorded as a result of the use of pepper spray by the Federal Police. This leads to the conclusion that the Federal Police uses pepper spray less and more appropriately in problematic operational areas.

## Conclusions & recommendations

This article investigates the introduction of pepper spray in the German police, which was on the one hand due to technical reasons and on the other hand, goes back to several events that were taken as an opportunity by actors from the police and politics to push ahead with the equipping of the police with pepper spray. In addition, this article sheds light on the traces of the use of pepper spray by the police. Contrary to the assumption in North Rhine-Westphalia, pepper spray spreads aerosol-like over a large area in windy conditions. This can lead to serious health consequences if the aerosol particles are inhaled. The particle size plays a decisive role in this. Therefore, the Austrian Ministry of the Interior stipulates that the particle diameter must not be smaller than two µm. There is no such regulation in Germany, although pepper spray carries various risks. In particular, a danger to bystanders in crowds cannot be ruled out. If there are vulnerable people in a crowd (e.g. pregnant women, children, asthmatics, Long Covid sufferers), the risk potential increases. The following recommendations are therefore derived from the knowledge gained:

1. Revision of the Technical Guideline for Irritants
2. Moderate use of pepper spray
3. Constant review of proportionality
4. Statistical recording of all pepper spray operations
5. Improved training and further education of police officers

Using pepper spray by the police is complex and involves opportunities and risks. In Austria, for example, one "bundled spray jet" is intended to achieve a slightly higher range. It may be less susceptible to wind but also fans out (but possibly less) and releases slightly fewer aerosols. In addition to technical investigations, careful consideration, improved regulations, and further research are required to ensure the safety of all parties involved and maintain the effectiveness of the equipment.

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