

RESPIRATORY HAZARDS FROM FIREARMS USE: PROTECTING TACTICAL OPERATORS WITH AVON PROTECTION'S MITR™-M1 HALF MASK

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INTRODUCTION: THE UNSEEN DANGER IN THE OPERATOR'S ENVIRONMENT

For decades, firearms users—from frontline law enforcement officers to specialist tactical operators—have approached their profession with a focus on the obvious threats: hostile adversaries, ballistic risks, and the demands of operational performance. Yet another hazard has lurked quietly in the background, largely invisible but no less dangerous.

Every live-fire exercise, every qualification session in a range, every tactical scenario involving the discharge of a weapon produces a complex cloud of airborne contaminants¹. For years, these emissions were tolerated as a necessary by-product of the job. But recent science² has shown that such exposures are not benign. They are harmful, cumulative, and potentially life changing.

Just as firefighters today face heightened scrutiny over chronic exposures to toxic combustion products, firearms operators are beginning to see their own occupational health risks clearly quantified. The evidence is growing; gunshot emissions damage human lung cells, induce inflammation and DNA damage, and contribute to long-term disease risk.

This white paper examines the nature of these hazards, the latest scientific findings that document their impact, and the health and operational implications for both specialist and non-specialist

users. It concludes by presenting Avon Protection's MITR™ system as a mission-ready solution—one designed not just for protection, but for preserving the health and effectiveness of those who serve.

WHAT REALLY HAPPENS WHEN A WEAPON IS FIRED

Each trigger pull sets off a series of rapid chemical and mechanical events: the ignition of the primer, the combustion of the propellant, and the violent passage of the round through the barrel. The result is not just the expulsion of a bullet, but the creation of a highly complex aerosol of gases and particles.

AIRBORNE GUNSHOT PARTICLES (AGPS)

Recent research^{1,2} has confirmed that gunfire produces airborne gunshot particles (AGPs) that are respirable in size, ranging from nanoparticles (<100 nm) to several micrometres. Over 90% of these particles are ultrafine (<30 nm), small enough to penetrate to the deepest regions of the lungs. These particles are enriched with metals including lead, copper, zinc, antimony, and barium — elements with well-documented toxicological profiles.

AMMUNITION TYPE MATTERS

The type of ammunition influences the exact emissions. Traditional lead-core rounds (SS109) release¹ substantial quantities of airborne lead, a neurotoxin with no safe exposure threshold. In response, militaries and police agencies have turned to steel-core or "lead-free" ammunition (such as NM229 or NM255). Yet studies show that while these reduce lead emissions, they significantly increase airborne **copper and zinc nanoparticles** due to higher barrel friction.

¹ Espen Mariussen, Lise Fjellsbø, Tomas Roll Frømyr, Ida Vaa Johnsen, Tove Engen Karsrud, Øyvind Albert Voie, Toxic effects of gunshot fumes from different ammunitions for small arms on lung cells exposed at the air liquid interface, *Toxicology in Vitro*, Volume 72, 2021

² Kim, Y.H., Vance, S.A., Aurell, J. *et al.* Chemistry and lung toxicity of particulate matter emitted from firearms. *Sci Rep* 12, 20722 (2022). <https://doi.org/10.1038/s41598-022-24856-5>

In fact, NM229 has been measured emitting up to three times more copper and four times more zinc than lead-core ammunition. These metals, when inhaled as ultrafine particles, trigger oxidative stress and cellular damage.

TOXIC GASES

Alongside particulates, combustion gases are also a concern. Carbon monoxide (CO), nitrogen dioxide (NO₂), sulphur dioxide (SO₂), and ammonia (NH₃) are all present. In poorly ventilated ranges, CO can elevate carboxyhaemoglobin in blood, impairing oxygen delivery and degrading both judgment and endurance.

WHAT THE SCIENCE TELLS US: FROM CELLS TO SYMPTOMS

Until recently, much of the concern around firearms emissions was anecdotal—headaches after long days on the range, flu-like symptoms reported by trainees. Now, controlled laboratory research has begun to show exactly what these emissions do to human cells and bodies.

CELLULAR-LEVEL TOXICITY

A 2022 study² exposed **human small airway epithelial cells** directly to airborne gunshot particles. The results were stark:

- Cell viability decreased in a dose-dependent manner.
- Cells showed marked increases in reactive oxygen species (ROS), a hallmark of oxidative stress.
- Inflammatory cytokines such as IL-8 were released, signalling respiratory irritation and immune activation.
- DNA strand breaks were observed, confirming genotoxic potential.

In simple terms, gunshot emissions injure lung cells, inflame airways, and damage DNA. Over time, this combination is a recipe for chronic disease, reduced lung capacity, and cancer risk.

GENOTOXIC AND CARCINOGENIC PATHWAYS

The Mariussen et al. 2021 study¹ further demonstrated that fumes from steel-core ammunition induced dose-dependent DNA damage and reduced cell viability by up to 40% in 24 hours. The findings align with epidemiological concerns: chronic, low-level exposure to DNA-damaging aerosols can seed the conditions for cancer later in life.

ACUTE HUMAN SYMPTOMS

Operators firing steel-core “lead-free” rounds in training have reported^{1,2} fever, cough, and fatigue, a syndrome resembling “metal fume fever” experienced by welders. These acute responses are consistent with inhalation of zinc and copper oxide nanoparticles, which are powerful inducers of systemic inflammation.

LONG-TERM HEALTH BURDEN

The health implications of repeated exposure to gunfire emissions extend beyond the immediate irritation felt on a range. Documented and plausible long-term outcomes include:

- **Chronic respiratory disease:** asthma, chronic bronchitis, and COPD linked to airway inflammation.
- **Neurological decline:** from systemic absorption of metals like lead, which persist in bone and tissue.
- **Cardiovascular effects:** systemic oxidative stress increasing risk of hypertension and heart disease.
- **Cancer risk:** arising from persistent DNA strand breaks and oxidative stress in lung cells.

Critically, the burden is not confined to elite tactical units. Range instructors, recruits, and patrol officers—all of whom may spend cumulative hours in contaminated environments—are exposed. Instructors, by virtue of constant presence, may face the highest occupational risk.

OPERATIONAL CONTEXT: MORE THAN JUST BULLETS



Firearms emissions are only one part of the respiratory hazard spectrum faced by operators. Tactical personnel are exposed to a wide range of airborne threats, both in controlled training environments and unpredictable live operations.

- **Chemical agents:**

Riot control agents such as CS gas are still frequently employed in public order scenarios and tactical training. Their acute effects—bronchospasm, mucus overproduction, and severe respiratory irritation—are well known. In some individuals, repeated exposure can lead to long-term sensitisation and chronic respiratory symptoms.

- **Pharmaceutical and illicit agents:**

Increasingly, responders may also encounter hazardous airborne particulates from potent synthetic opioids (e.g., fentanyl and its analogues), methamphetamines, and other drugs encountered during law enforcement or interdiction operations. Even minute quantities of these substances can pose significant inhalational risks, with effects ranging from acute respiratory depression and neurological impairment to longer-term health consequences.

- **Smoke and pyrotechnics:**

Flashbangs, smoke grenades, and operational fires generate a mixture of toxicants including formaldehyde, acrolein, and metal oxides. These compounds can cause both immediate respiratory distress and cumulative harm with repeated exposures.

- **Public order and healthcare considerations:**

The COVID-19 pandemic demonstrated that law enforcement and frontline personnel are also vulnerable to infectious disease threats. Officers deployed in public order situations, healthcare support roles, or crowded custody environments face increased risk of exposure to airborne pathogens, including viruses, bacteria, and other bioaerosols. Beyond COVID-19, influenza, tuberculosis, and emerging respiratory pathogens present ongoing challenges. Protecting officers against these risks is not only a matter of occupational health but also of operational continuity—sick personnel mean diminished capacity at precisely the moments when demand on services is highest. Scalable respiratory protection, therefore, plays a dual role: safeguarding individuals in tactical contexts and ensuring resilience in wider public safety and health emergencies.

THE OCCUPATIONAL IMPERATIVE: DUTY OF CARE

The evidence is unequivocal: firearms use exposes operators to harmful aerosols and gases with both acute and chronic health consequences. Left unaddressed, these exposures threaten not only individual health but also operational readiness, organisational liability, and long-term workforce sustainability.

Across the Five Eyes community, recognition of these risks is growing. Just as cancers have been recognised³ as occupational diseases among firefighters in Sweden, Canada, Australia, and parts of the USA, firearms operators may soon see similar acknowledgment. The question for agencies is not whether these exposures exist—they do—but how best to mitigate them.

³ IARC Monographs Volume 132: Occupational exposure as a firefighter – IARC

THE TACTICAL SOLUTION: AVON PROTECTION'S MITR™-M1 HALF MASK

Addressing these hazards requires a protective system tailored for tactical reality. Bulky full-face respirators are rarely practical in fast-moving operations, while disposable masks lack the sophistication to capture ultrafine metallic particulates. Avon Protection's MITR™-M1 half mask provides a scalable, mission-ready answer.

MITR™-M1 HALF MASK

- **Lightweight and ergonomic:** At 250g, designed for prolonged wear.
- **Tactical compatibility:** Curved cheek design enables proper rifle cheek weld; optics and comms remain unhindered.
- **Rapid deployment:** Quick-clip helmet integration allows donning without removing headgear.
- **MITR™-PF Compact Particulate Filter**
- **High efficiency:** 99.97% filtration against oil- and non-oil-based particulates.
- **Covers key threats:** Lead, copper, zinc, antimony, barium, smoke particulates, asbestos, biological powders, synthetic opioids.
- **Rugged resilience:** Tested in extremes of temperature and humidity, resistant to operational shocks.
- **Low breathing resistance:** Maintains performance under stress, minimising fatigue.

While not designed for gases or oxygen-deficient environments, the MITR™-PF filter directly addresses the most pressing hazards in firearms use—metallic particulates and aerosols—now proven by science to be among the greatest risks.

Standards and Compliance

The MITR™-M1 Half Mask and MITR-PF filter aligns with:

- **European respirator and filter standards**
 - EN143 to P3R (MITR-PF)
 - EN140 (MITR-M1)
- **NIOSH U.S. occupational safety certification**
 - P100 (MITR-M1 and MITR-PF)
 - Approval number: TC-84A-9852
- **UK PPE regulations**
 - 1992 and 2018 amendments

This ensures agencies can procure with confidence, meeting both operational needs and legal duty-of-care obligations.

MITR-M1 is part of a scalable, modular system which protects the eyes, nose and mouth. Components which make up the MITR System include the MITR-PG1 Powered Goggle, a first-of-its-kind, the MITR-RF riot filter, and more accessories to allow you to scale up your protection, dependent on the environment.

MITR™-M1 HALF MASK CORE COMPONENTS



CONCLUSION: BREATHING EASY UNDER FIRE

The science is now clear. Gunshot emissions are not a trivial by-product of firearms use—they are a toxic occupational hazard. Studies^{1,2} have shown that these emissions reduce lung cell viability, trigger inflammation, generate DNA damage, and contribute to both acute illness and long-term disease. Operators, instructors, and recruits alike are at risk.

Just as ballistic vests became a standard issue once the risks of exposure were fully recognised, respiratory protection must now be viewed as essential, not optional. Avon Protection's MITR™ system provides a solution that is practical, tactical, and scientifically justified.

For those entrusted with national security and public safety, the imperative is simple: no operator should have to risk their long-term health simply to train or perform their duty. With the MITR™ system, firearms users can finally safeguard their breathing as effectively as they safeguard their lives.

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