UKLA Metalworking Fluid Product Stewardship Group
TOPIC REVIEW 1 Sensor Technology: Monitoring Metalworking Mist and Reducing Exposure Risks

Introduction: Exposure to metalworking fluid (MWF) mist causes occupational asthma, occupational hypersensitivity pneumonitis, and reduced lung capacity. The GB Health and Safety Executive (HSE) withdrew its MWF Workplace Exposure Limits (WEL) values after they failed to prevent previous respiratory outbreaks among machinists. The regulatory-approved mist monitoring method (MDHS 95-3) has also declined in use because it no longer matches the formulation of modern water-mix MWFs. The review considers whether real-time air quality sensors can address this methodological gap for monitoring MWF mist and inform the use of control measures (e.g., local exhaust ventilation).

Research Methods: The review draws on peer-reviewed studies published in international scientific journals, spanning 1980 to 2023. A range of evidence sources was considered, including occupational exposure monitoring and hygiene studies, as well as laboratory-based evaluations of air quality sensors. The summary highlights current limitations of low-cost sensors for occupational settings.

Main Findings: The UKLA Product Stewardship Group previously commissioned the HSE Laboratory to test various Direct Reading Aerosol Monitors (DRAMs) for monitoring MWF mist. All tested DRAM models responded linearly to increasing concentrations of MWF mist, but some consistently over- or underestimated the total mist mass relative to reference research-grade aerosol monitors. This highlighted the importance of calibration methods for the occupational use of DRAMs. Recent advances in technology have expanded the availability of Low-Cost Optical Particle Sensors (LC-OPS) that provide real-time data on particle size distribution and mass estimation.

• Optical Particle Counters (OPCs): These measure particle size and count via light scattering as air passes through a laser or LED. They struggle with ultra-fine particles (<0.3 µm).

• Nephelometers/Photometers: These measure light scattered by whole clouds of particles simultaneously, using size-selective inlets to estimate broad mass fractions (e.g., PM2.5 and PM10).

Discussion and Analysis: Large-scale environmental studies show that fewer than 10% of low-cost models meet the strict accuracy standards required for regulatory or research instruments. Many are prone to drift, bias, and reduced lifespans. LC-OPS performance can decline rapidly at humidity levels above 65%, as this affects particle optics and causes coincident errors in dusty atmospheres. Manufacturers also use proprietary algorithms to convert raw photometric data into particle counts, calibrated against standard dusts like Arizona Road Dust, which often do not match real-world particles. To ensure valid data, an LC-OPS must be calibrated in its specific environment, requiring costly reference instruments

like DustTrak or Grimm spectrometers and specialised expertise—resources small businesses typically cannot afford or access.

Conclusion and Knowledge Gaps: The US Environmental Protection Agency (EPA) and EU CEN advise that current LCS are not sufficient to replace approved compliance monitors but may help to map local real-time variations or serve as early warning systems. There remains a significant knowledge gap in standardised occupational monitoring using these sensors, even when used for monitoring emissions rather than personal exposure. More research is needed to assess how low-cost optical sensors perform over the long term in different workplace environments, and to evaluate the risks of sensor contamination and drift.