Oil mist and PM1
The real risk to employee health
Industrial air quality
The most pressing topic in machining

The public is more informed than ever over the importance of air quality; respiratory conditions such as asthma are reaching almost epidemic levels and air pollution overall is now the fourth greatest risk of death worldwide.

But while external air pollution takes most of the headlines, air quality is not just an outdoor issue. And it is not just an issue for public organizations either. Just as asbestos has caused problems retrospectively for employers, air pollution from other sources is now a key element in creating a safe working environment. And that is perhaps nowhere more important than in the production workshops of metalworking companies. The smell and sight of oily fog may seem part and parcel of the workshop environment, but that does not make it any the less dangerous.

Oil mist has been linked with a host of respiratory illnesses, including dermatitis, occupational asthma, allergic alveolitis and other lung diseases. That’s prompting health and safety organizations across the globe to investigate further the effects of oil mist inhalation. And as they delve deeper into the problem, guidance and regulations are becoming increasingly stringent.

The difficulty for metalworking companies is managing the oil mist risk while also contending with the pressures of lean manufacturing, shorter lead times and machine tools that are spinning faster and longer – all of which contribute to higher levels of industrial pollution.

But what is the nature of this industrial pollution? And what can manufacturers do to address it?
ABOUT THIS DOCUMENT

This document examines oil mist in metalworking environments; how it is generated, what it contains, what is the effect of its inhalation, and what is the most effective method of stopping it.

It provides an introduction to particulate matter and describes how ultra-fine PM1 now forms the dominant particulate in machining processes.
Understanding oil mist
A danger in the workplace

**OIL MIST – A BYPRODUCT WITH SERIOUS CONSEQUENCES**

A machine tool generates oil mist in two ways; through evaporation – as the machining process heats the coolant past boiling point, and from misting – as mechanical movement sprays the lubricant away from the cutting tip.

Some of this oil mist remains within the machine tool enclosure – if one is fitted. But often, oil mist will escape into the wider workshop environment, either through gaps in the housing or as the operator opens the machine doors. Some oil will settle on the floors and walls, creating slip hazards.

But – potentially more harmfully – much of the oil mist will stay in the air, posing an inhalation risk to anyone in the workshop.

Inhaling oil would be harmful enough on its own, but oil mist is not just composed of fine droplets of coolant. It is a cocktail of different man-made and organic materials that enter the mix as the machining process takes place. Combined, these materials create a noxious aerosol that can cause serious harm.

**INGREDIENTS IN THE OIL MIST COCKTAIL**

- Oil
- Water
- Additives
- Metal slivers
- Bacteria spores
- Coating particles
- Cutting tool shards
INTERNATIONAL STANDARDS

There is currently no EU standard for acceptable oil mist emissions. Instead individual countries have set their own limits. In every case, these limits are based on maximum permissible particle concentration levels in mg/m³. Levels set in Europe range from 0.2 mg/m³ in Switzerland to 5 mg/m³ in France and 10 mg/m³ in Germany.

However, in the UK, where the limits were previously set at 1 mg/m³ for neat oil and 3 mg/m³ for emulsion coolant, guidance levels have been removed by the UK government following two cases of industrial disease impacting over one hundred workers.

The UK government is now seeking new methods of monitoring oil mist levels using particle counters to monitor particle distribution rather than particle concentration.

Until that time, the UK government have stipulated that there is no safe level of oil mist, and companies must ensure that workers are adequately protected through good industrial ventilation systems.
WHAT IS PM?

The term PM has become a part of our everyday language when talking about air pollution, but what is it? And why is it important in the discussion of oil mist?

Particulate matter (or PM) is a mixture of solid and liquid particles suspended in the air. This particulate includes both organic and inorganic material, such as dust, soot, trace metals, mineral components and liquid contaminants. These particles range from a few nanometers in diameter up to around 100 micrometers. And it is by diameter that PM is commonly categorized – particularly when describing pollution levels.

**PM10** – Particulate < 10 µm in diameter

**PM2.5** – Particulate < 2.5 µm in diameter

**PM1** – Particulate < 1 µm in diameter

PARTICLE SIZE ILLUSTRATION
Humans have about 480 million alveoli with a surface area of 120 to 140 m², making the lungs the largest organ of our body in direct contact with the environment.

**HOW FAR DOES PM PENETRATE THE BODY?**

Differentiating between the various sizes of PM is important to understand the threat to human health. That’s because the damage that PM can cause us increases as the size of particulate decreases – smaller particles penetrate further into our body and do more harm.

**Particles > 10 µm**

Larger particles – with a diameter of more than 10 µm – are caught by the body’s natural defenses in the nose and throat.

**PM10**

PM10 particles become trapped in the upper airways – nose, throat, larynx and trachea – before being coughed up or swallowed. If PM10 particles manage to bypass the transition of the trachea into the main bronchi, they are removed by the ciliated epithelium – a layer of tissue covered with cilia that move back and forth to remove the foreign particle.

**PM2.5**

PM2.5 particles bypass the ciliated epithelium and travel further into the lungs – reaching the secondary and tertiary bronchi. Here, the particulate can trigger inflammatory reactions such as acute bronchitis and asthma.

**PM1**

Particles smaller than one micrometer represent the greatest health risk by penetrating the air sacs where oxygen exchange takes place. Since there is no ciliated epithelium present in this area, immune cells are responsible for purification. But if the level of contaminant is too high, the immune cells can trigger an inflammatory reaction in the alveoli.

Even more damaging, PM1 particles can penetrate through the walls of the alveoli into the blood vessels. Once in the bloodstream, the PM1 particles can then be distributed via the heart and circulatory system. The most immediate effect is inflammation, but as PM1 travels throughout the body, it has been linked with conditions as diverse as heart disease and arrhythmia, brain disorders, and various types of cancer. PM1 particulate has even been detected in the spleen and liver.
PM and oil mist
What’s the true danger?

PM quantity is often measured as a concentration in mg/m³. This concentration is a measure of the weight of PM10, PM2.5 and PM1 particles in a sample. When analyzing oil mist, the concentration measurement will usually point to PM10 as the most common particle size. But this does not provide a true reflection of the breakdown of particle sizes generated by machine tool processes.

When we look at the number of PM10, PM2.5 and PM1 particles in an oil mist sample we get a very different picture. Using particle distribution, we can see that ultra-fine PM1 particles are by far and away the most common particulate in oil mist.

This is evidenced in a study by the German Professional Cooperative Institute for Occupational Safety (Berufsgenossenschaftliches Institut für Arbeitsschutz). It found that in nearly all machining processes (turning, milling or grinding) and with nearly all coolant types (conventional oil, ester oil, emulsion or MQL), PM1 was clearly the most dominant particle type. Only the combination of milling and emulsion coolant generated primarily coarser PM10 particles.

Given PM10 is at least ten times larger than PM1, it is easy to understand why a measurement by weight provides a skewed outcome for particle variation analysis.

- Particle concentration measures particulate by the weight of a sample.
- Particle distribution measures pollutants by the number of different particles.
The combination of high-rotational speed tools, increased process heat and high-pressure coolants results in finer and finer aerosols.

How long these particles remain airborne also varies according to particle size, with smaller particulate having a considerably longer dwell time. While PM10 particles disappear within hours due to deposits, PM1 particles can float in the air for weeks. This means that not only is PM1 more dangerous to human health, but it is more prevalent, and it remains in the air for significantly longer than coarser particles too.

These negative effects are why metalworking companies should be most concerned with PM1 particles. And it is also why industrial filtration system should be designed to target PM1 – as currently not all separators are effective against this finer particulate.
Responding to the threat
Industrial filtration systems

The primary defense against the hazard of oil mist is industrial filtration systems. Here, three technological approaches have emerged that can be deployed either centrally, or locally to each machine or batch of machines.

**CENTRIFUGAL SEPARATORS (VDI GUIDELINE 3676)**

Centrifugal separators use centrifugal forces to separate the oil mist from the air flow. The incoming air is set in rotation so that the oil mist particles are deposited against the walls of the separator. Centrifugal separators target coarser particulate and have limited effectiveness against the lower-massed PM1.

**ELECTROSTATIC FILTERS (VDI GUIDELINE 3678)**

In electrostatic filter systems, the incoming aerosol is charged in an ionization zone where the particles are deflected into an induced electric field to collector plates. The separated oil mist then flows away by gravity. This separation technique is relatively well suited for oil mist, but not for emulsion mist or water-mixed coolant. Electrostatic filter systems are very maintenance-intensive, requiring regular cleaning and servicing.

**MECHANICAL SEPARATORS (VDI GUIDELINE 3677)**

Mechanical separator systems pass the incoming aerosol through several filter stages to remove the oil mist and other contaminants. In the first (and sometimes second) stage, coalescer filters separate the oil or emulsion from the air. These stages employ oleophobic fibers that collect and then coalesce small oil droplets into larger drops, which then drain against the air flow to a reservoir.

After the mechanical system has separated the oil or emulsion, a further filter stage removes the remaining microscopic particles so that even the smallest of particulate – including bacteria, metal slivers and other PM1 pollutants – are captured. Often this final filter stage uses a HEPA filter, which means that exhaust air from the mechanical separator is on a par with that found in some cleanrooms and operating theaters.
What can you do? Four steps to help manage the oil mist risk

**DEFINE THE PROBLEM**

Catalogue the processes and coolant types in use across your facility to determine the type of particulate that poses the most risk. Unless you operate exclusively with milling and emulsion coolant, PM1 will be the greatest threat to your workforce.

**AUDIT YOUR WORKSHOP**

Get a clear understanding of the current situation in your facility. Ask a specialist partner to measure oil mist concentrations across your workshop using particle counters. The accompanying report can be included in your risk assessment process.

**REVIEW YOUR CURRENT FILTRATION SET UP**

Is your existing separator system providing the required level of filtration for the pollutants that it is up against? Is it performing efficiently? Is it cost effective to run? Does it require regular maintenance to perform at the required level? Again, a specialist partner can help you review your current filtration system and provide guidance on ways to improve performance and overall air quality.

**CREATE A FORMAL RECORD**

Document all the reviews, risk assessments and steps that you undertake associated with oil mist and air quality in your facility. A written record documenting all your actions could be crucial in proving duty of care in the future.

Next steps...

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