# Peril of particles

*Mark Venables examines the issues facing managers as they balance the needs of people and productivity associated with laser and 3D printing processes, particularly in meeting their health and safety obligations in the light of recent nanoparticle research*

While laser technology is in a very different place to 3D printing, in terms of evolution, they do share some common ground over the risks posed to human health through the emission of potentially hazardous airborne contaminants linked to each process.

In the case of lasers, advances in dust and fume extraction systems over the last 20 years from companies such as BOFA International have helped protect workers from harmful emissions, while simultaneously improving productivity by keeping laser systems clear of material deposits. From $CO_2$ laser systems, which can still be found in high-speed packaging lines, through to high-powered solid state YAG lasers and new generation optical fibre technologies, today's advanced extraction systems are proven to remove contaminants often invisible to the human eye.

John Horsey, technical manager at BOFA, says that one of the biggest challenges for plant managers operating laser systems is understanding how substrates react not so much in metals and glass where fume is mainly particulate, but in organic materials, which produce much more complex emissions and can present significant risk to operator health. "Potential health problems are usually associated with plastics, which give off Volatile Organic Compounds when lasered, most of which have associated occupational exposure limits under the Control of Substances Hazardous to Health (COSHH) regulation," he points out. "PVC is worth a special mention in this context since it releases acidic hydrogen chloride and small amounts of phosgene, both of which are extremely toxic."

***John Horsey, technical manager at BOFA***

### The harmless and the harmful

Of course, not all airborne contaminants are harmful. Those particles larger than 50 microns are not usually inhaled (a human hair is around 70 microns); those of more than 10 microns become trapped in the nasal cavity or upper throat area; and particles 3-5 microns in size can reach the upper lung area, but are ejected by the mucociliary system to be coughed up or swallowed.

"It's those contaminants measuring around 2 to 3 microns that are of particular concern for respiratory function, because these can penetrate into the alveolar lung region," he adds.

"Moreover, while particles of less than 0.5 microns will mostly be exhaled, nanoparticles are thought to be able to pass into the pleural cavity, with no mechanism to eject them. These can carry complex chemicals and some of these can trigger reactions in the body."

## Do **you** comply?

All businesses have a legal obligation to ensure safe working environments for the people they employ. For process industries, this means maintaining a dust and fume-free workplace through the removal of solid particles (particulates), liquid droplets (usually aerosols or mists) and vapours or gases by way of an appropriate dust and fume extraction system.

Typically, emissions are produced through activities such as laser and ink jet coding onto food and pharmaceuticals packaging, soldering, welding, laser cutting and engraving, spraying, and hand and mechanised grinding.

Exposure levels to potentially harmful airborne emissions are tightly mandated through the COSHH regulations under the direction of the HSE and are expressed as workplace exposure limits (WELs). Airborne emissions vary according to the materials being worked and some of the fumes resulting from productive processes can be toxic or harmful.

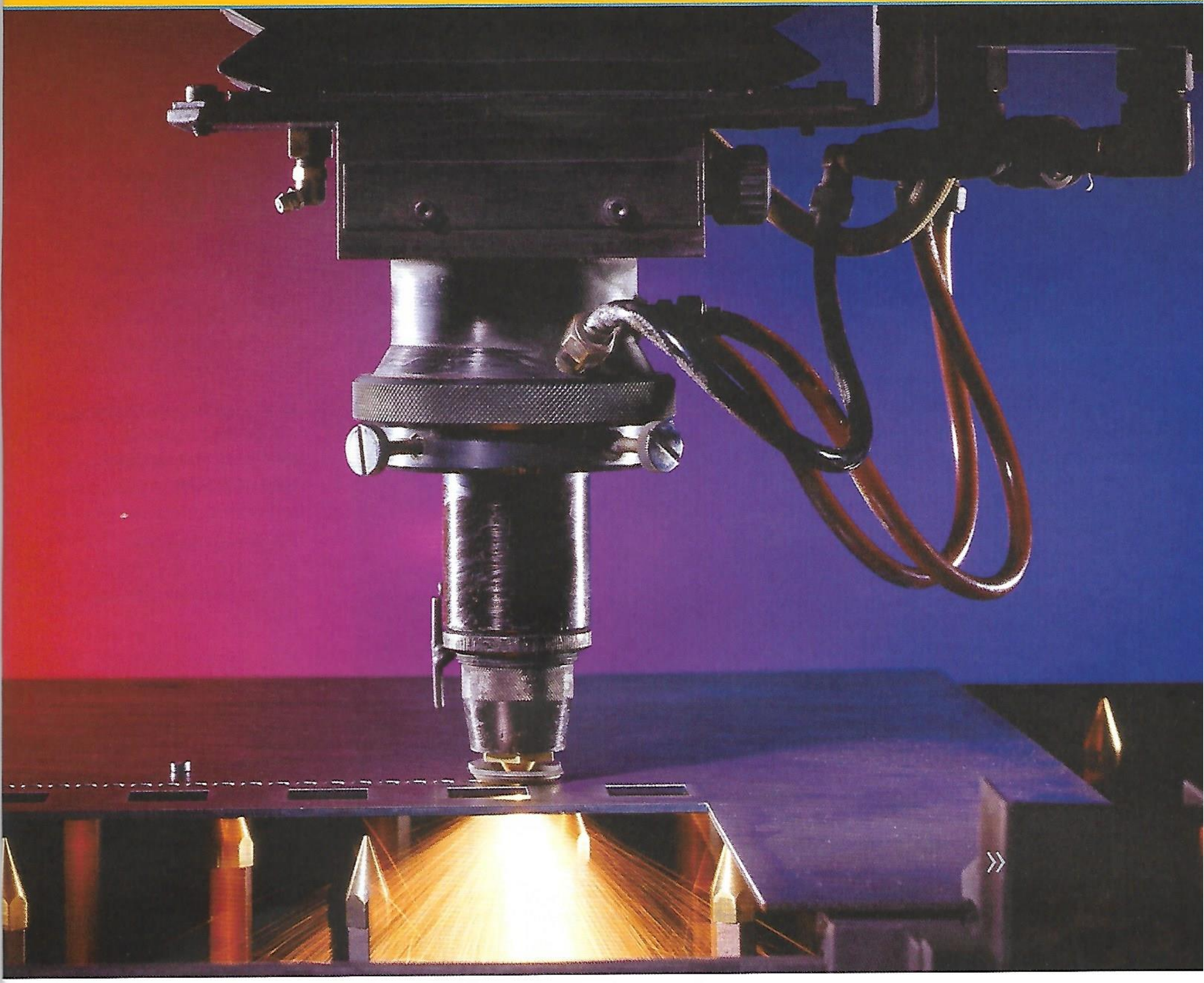
WELs are presented for most substances as time-weighted averages for either 15 minutes or eight hours and in both ppm (parts per million) or $mg/m^3$ (milligrams per $m^3$).

Employers are under a legal obligation to assess the risk to health created by work involving hazardous substances, taking account of any relevant WELs. This means looking at the prevention or control of exposure to such substances, either by doing away with the process, changing the process (by enclosing it for example), installing local exhaust ventilation and, as a last resort, using personal protection equipment.

Central to compliance for industrial processes is an effective fume and dust extraction system. A typical BOFA system would include patented DeepPleat Duo pre-filtration, which uses reverse airflow operation to reduce the velocity of contaminant as it enters the filter chamber, ensuring larger particulates fall into a steel drop-out chamber.

Smaller particulates are drawn into the main HEPA filter, while vapours and gases are removed via a layer of activated carbon.

Where control measures are installed, these must be thoroughly inspected and tested at least once every 14 months (in practice every 12 months) and a suitable record kept of the examination and tests for at least five years.



One of the biggest challenges facing companies is that not all product safety sheets provide comprehensive information about the effect of lasering on the constituent properties. Horsey says that, before starting any new process, engineers should clarify substrate composition and the effect of lasering on, say, plasticisers added to plastics.

This will ensure the matching of any identified risk to the correct dust and fume extraction system, which typically should include active air flow control, a pre-filtration stage, use of a High Efficiency Particulate Air (HEPA) filter and a layer of activated carbon.

**Perils of 3D printing**

As for 3D printing, this is a relatively recent innovation and, because it is an additive process, the immediate risk of exposure to harmful particulates appears to be lower.

However, in common with lasering, there is now a growing focus among health and safety specialists, including the Health & Safety Executive (HSE), on the potential effect in the workplace of nanoparticles produced through 3D printing.

Nanoparticles are created routinely through daily activities such as cooking, but, as highlighted by an Illinois Institute of Technology research project, it's the material being worked that determines the risk. The research identified that a 3D printer using a lower temperature polylactic acid feedstock emits about 20 billion ultrafine particles (UFP) per minute, whereas a higher temperature acrylonitrile butadiene styrene feedstock printer produces about 200 billion UFPs per minute. However, it isn't necessarily the level of exposure that is a concern, but the hazard associated with the material properties.

"Other laser processes have been shown to produce significant numbers of nanoparticles, but our work on a recent project involving lasering carbon suggests that a high-quality fume extraction system will provide the necessary environmental control in the workplace," Horsey adds. "However, the message for engineers operating lasers and 3D printers in industrial settings is to ensure a proper and detailed assessment of the risks associated with working with hazardous substances, firstly through engagement with the materials manufacturer, and then by implementing a comprehensive and appropriate local exhaust ventilation strategy."

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