ASSIST INFORMATION SHEET:

3D printer safety in schools

3D printing is a relatively new technology and industry and is also one of the latest technologies to enter schools. Prior to the purchase of 3D printers for a school it is important to consider all facility, site and safety requirements of the hardware and the thermoplastic/s to be used so any risks can be minimised.

Operational and safety considerations

- **Siting:** Follow the manufacturer's instructions for proper siting, ensuring printer is installed on a level and stable and surface. If the surface is not level the objects printed maybe distorted. The area where printer/s are located should be well ventilated.
- **Protection from heat and moving parts:** Safety guards should enclose 3D printers to ensure there is no exposure to moving parts. Enclosures will also prevent students from touching the hot extruder whilst 3D printing is in process and whilst material, nozzle and platform are cooling once printing is complete.
- **Maintenance:** Ensure regular electrical testing and tagging and compliance with Australian Standards for manufacturing.
- **Scrapers, tools:** Sharpened scrapers are often used to remove the print off the printer bed and to also clean the printer bed. Use with care.[1]
- **Users:** 3D printers should only be used and operated by appropriately trained and authorised personnel.

Thermoplastics and emissions

Filaments

The two most common types of filament for 3D printing in schools are the thermoplastics Acrylonitrile butadiene styrene (ABS) and Polylactic acid (PLA).

ABS is an oil-based polymer. It is a strong, sturdy material that prints projects with structural integrity and resilience. In industry it is used for constructing things such as automotive trim, protective headgear and LEGO® building blocks. ABS filament has a high melting point and so has a tendency to warp and must be printed on a heated bed.

PLA is made from renewable, organic resources such as sugarcane and cornstarch. It is, therefore, biodegradable and used in disposable plastic cups and food packaging. In 3D printing PLA produces a superior level of print detail and finer aesthetic quality. Due to its low melting point it lays on the print bed with little shrinkage.

For school use, PLA is considered a safer option than ABS.[1,5]

For Safety Data Sheets for a range of both ABS and PLA filaments see the Sigma-Aldrich website https://www.sigmaaldrich.com/catalog/search?term=3D+printing+filament&interface=All&N=0&mode=match%20partialmax&lang=en&region=AU&focus=product

Emissions

There is little known about the types and magnitude of emissions from desktop 3D printers and there are currently no standards that measure or assess the emissions. As a result, there is not much known about the possible impact on the safety and health of users.

- **Risks and controls of emissions and ultrafine particles**

Under GHS Classification neither ABS nor PLA are considered a hazardous substance or mixture[2]. However, studies[3] have concluded that 3D printer filament, combined with intense heating releases emissions (fumes and ultrafine particles) that may pose health risks to users. Both filament types will give off fumes as they are heated and these may cause eye, skin and respiratory tract irritation. Overexposure may cause headaches and nausea.

Care also needs to be exercised when conducting post-processing activities, such as sanding or polishing, which may generate ultrafine particles.

To mitigate risk, 'all reasonable steps should be taken to limit the exposure of users to fumes and particles generated by 3D printers'.[4]

- **Ventilation and filters**

Ideally, each printer should have a high efficiency particulate air (HEPA) filter and a carbon filter. HEPA filters remove the ultrafine particles and carbon filters trap the fumes. The printers should also be situated in a well-ventilated area[5].

Task ventilation could be useful in a school setting. Conducting 3D printer work inside a fume cupboard or a low flow enclosure to prevent fume exposure is a viable option.

It is generally recommended substituting ABS filament for the safer PLA filament for use in 3D printers in the school environment. If, however, ABS or any other material that is not PLA is required, then an enclosure with an inbuilt filter is recommended.

Considering the issue of air-conditioning, it is best if it is there is an outside air intake or else there may be insufficient air changeover. One would have to take into consideration the size of the room, the air exchange, the type of filament being used and how long it was operating for.

Science ASSIST recommends the following to reduce the risks associated with 3D printer emissions:

- 3D printers should ONLY be situated in a **large, well-ventilated room** to minimise exposure to particle and gaseous emissions.
- If at all possible, purchase printers that are **enclosed and have inbuilt filters** so fumes and particulates are contained.
- Use **PLA filament** rather than ABS filament.

References and further reading

[1]'3D printing safety in schools. Safety issues and location', Makers Empire website, https://www.makersempire.com/3d-printing-safety-in-schools/ (Accessed November 2018)

[2] Sigma-Aldrich. 2014. ABS 3D printing filament, black, 2.85 mm, Safety Data Sheet, Sigma-Aldrich website, https://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=AU&language=en&productNumber=3DXABS002&brand=ALDRICH&PageToGoToURL=https://www.sigmaaldrich.com/catalog/product/aldrich/3dxabs002?lang=en

[3] 'RMIT scientists investigate health hazards of 3D printing', RMIT University website, https://www.rmit.edu.au/news/all-news/2016/february/rmit-scientists-investigate-hazards-of-3d-printing (18 February 2016) **Recent Australian study**

[4] University of South Australia. 2015*. 3D Printer technology – Pre-purchase considerations and safe use*. WHS Guideline. UniSA website, http://w3.unisa.edu.au/safetyandwellbeing/SMS/guidelines/3D_printer_purchasing_safety_guidelines.pdf (October 2015)

[5] 'What teachers need to know about safety and air filters re: 3D printers in schools', Makers Empire website, https://www.makersempire.com/what-educators-need-to-know-about-safety-and-air-filters-re-3d-printers-in-schools/ (Accessed November 2018)

'How toxic are ABS and PLA fumes? 3DSafety.or examines VOCs', 3D Printing Industry website, https://3dprintingindustry.com/news/toxic-abs-pla-fumes-3dsafety-org-inquires-vocs-60796/ (28 October 2015)

'PLA Filament Guide 2018 – Explained and Compared', All3DP website, https://all3dp.com/1/pla-filament-3d-printing/ (Accessed November 2018)

Science for Environment Policy, European Commission DG Environment News Alert, Edited by SCU, The University of West England, Bristol, http://ec.europa.eu/environment/integration/research/newsalert/pdf/commercial_desktop_3D_printers_emit_ultra_fine_particles_48si9_en.pdf (February 2015)

Stephens, B., Azimi, P., El Orch, Z., *et al.* 2013. 'Ultrafine particle emissions from desktop 3D printers', *Atmospheric Environment* 79, 334–339. doi:10.1016/j.atmosenv.2013.06.050, https://pubs.acs.org/doi/full/10.1021/acs.est.5b04983

'Top tips for 3D printing in schools', Fizzics Education website, https://www.fizzicseducation.com.au/Blog/x_post/Top-tips-for-3d-printing-in-schools-00129.html (14 December 2016)

'Ultrafine particles and the potential risks of printing without ventilation', 3D Printing Industry website, http://3dprintingindustry.com/news/ultrafine-particles-and-the-potential-risks-of-printing-without-ventilation-14944/ (29 July 2013)