Assessing occupational exposure to ultrafine particles during metal 3D Printing

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AGENDA

Short introduction

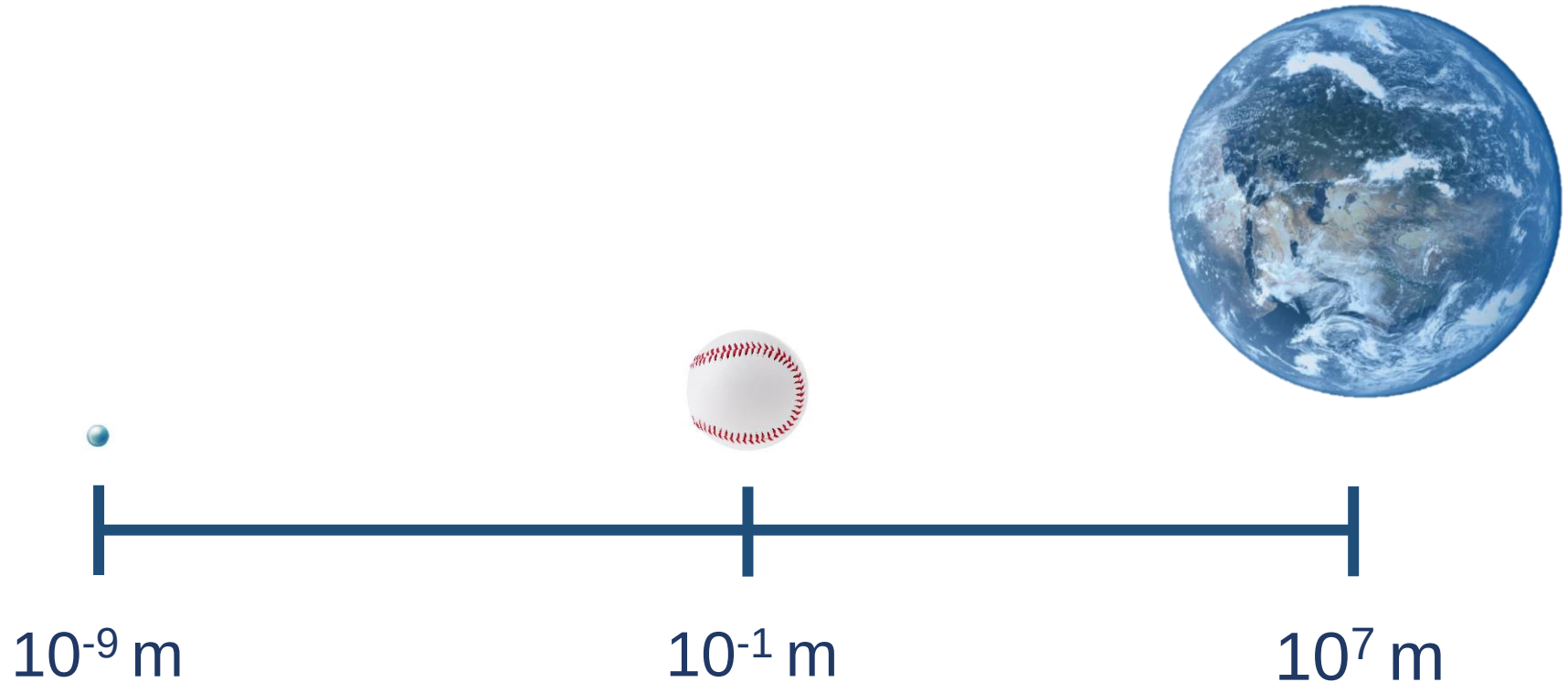
Methodology

Main results

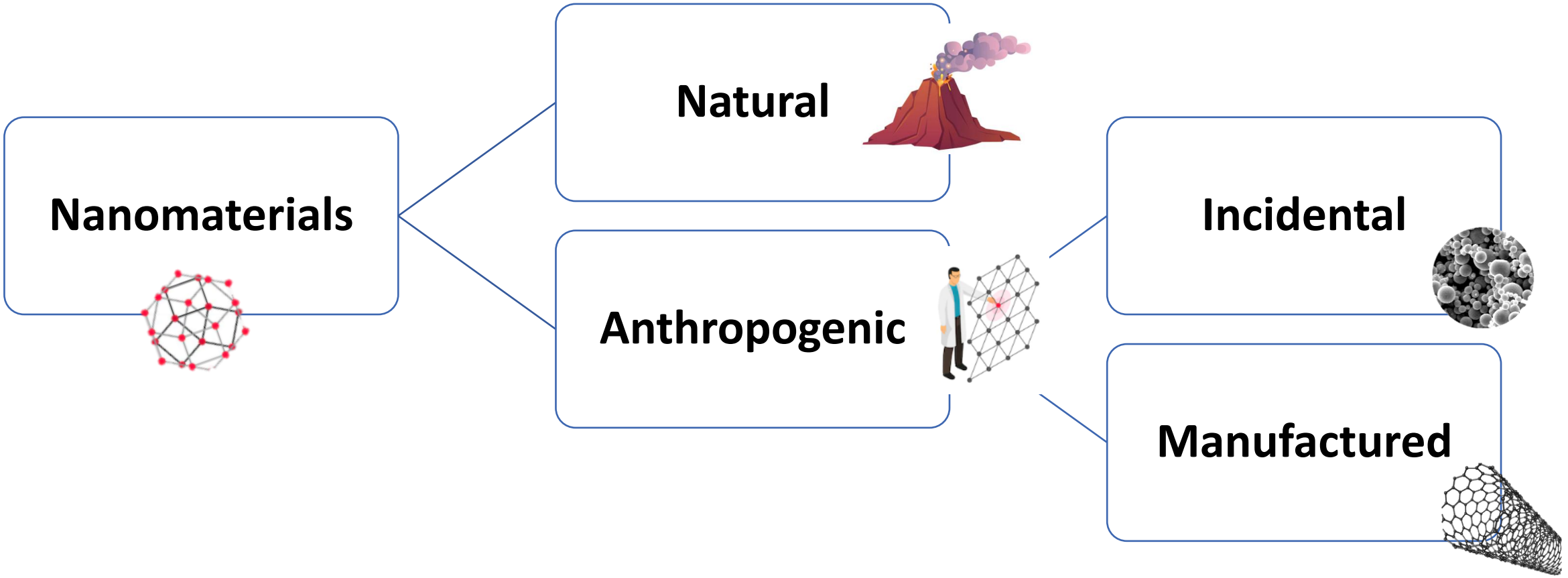
Conclusions

Next steps

SCALE



NANOMATERIALS



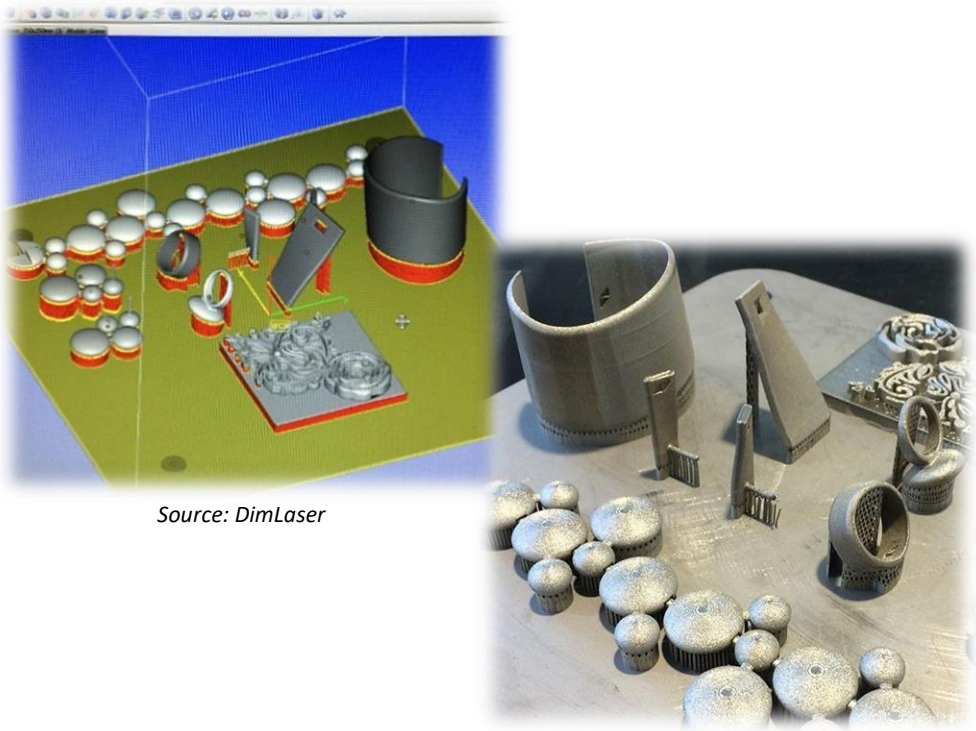
INCIDENTAL NANOMATERIALS

Engine exhaust system

Welding fumes

3D metal printing emissions

METAL 3D PRINTING



Source: DimLaser

Definition

"Process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies."

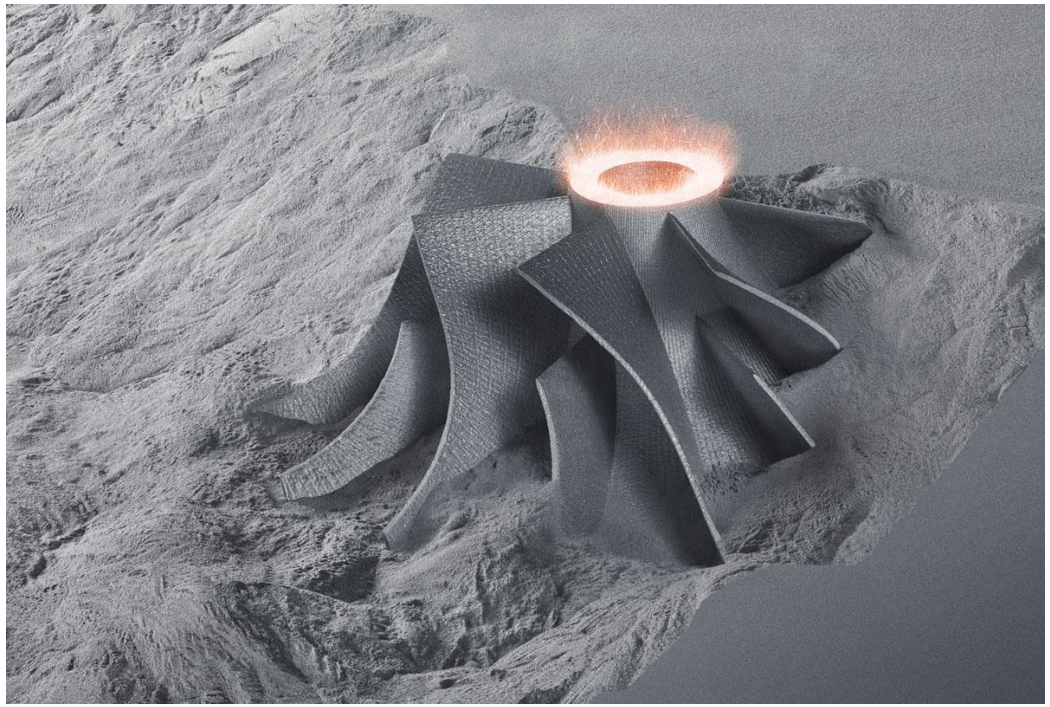
(ISO/ASTM 52900:2015)

Goal: create three-dimensional parts by successive additions of materials

METAL 3D PRINTING

Possible occupational risks:

- Mechanical and physical risks
- Explosive Atmosphere / Fire
- Exposure to artificial optical radiation (laser)
- Ergonomic aspects
- Exposure to metal particles:
  - Coarse (10-2,5 µm);
  - Fine (2,5-0,1 µm);
  - Ultrafine (≤100nm).



Source: Trumpf

CASE STUDY: MAIN GOAL

- To investigate the potential exposure to incidental nanoparticles during metal 3D Printing.

- To be pilot research on studying the suitability of both quantitative and qualitative approaches to manage this occupational risk.

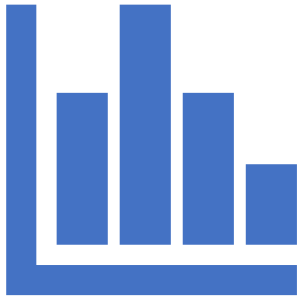
CASE STUDY: METHODOLOGY

- Selective Laser Melting (SLM) Technology
- Stainless steel 316L (powder for additive manufacturing)
- Powder used: 59,15 cm^3
- Powder on the part: 0,35 cm^3 (≈0,59%)

-	Background
Task 1	Printing process
Task 2	Removing and cleaning the final part from the printer (inside the machine operating area)
Task 3	Filtration/ sieving the powder to reuse and cleaning the powder container

CASE STUDY: METHODOLOGY

Qualitative approach



Quantitative approach

CASE STUDY: METHODOLOGY

Quantitative approach

- Scanning Mobility Particle Sizer (SMPS) to measure **nanoparticle size distributions and number concentration;**
- Thermo-hygrometer to measure **air velocity, room temperature and relative humidity**;
- Personal air sampling pump to collect **samples** for Scanning Electron Microscopy (**SEM**) and Energy-dispersive X-ray spectroscopy (**EDS**) analysis, using polycarbonate membrane filter.

CASE STUDY: METHODOLOGY

Qualitative approach

- **Control Banding Nanotool (version 2.0)** (Zalk et al., 2009)
- **Stoffenmanager Nano** (Duuren-Stuurman et al. 2012)

Stoffenmanager Nano Version 1.0: A Web-Based Tool for Risk Prioritization of Airborne Manufactured Nano Objects

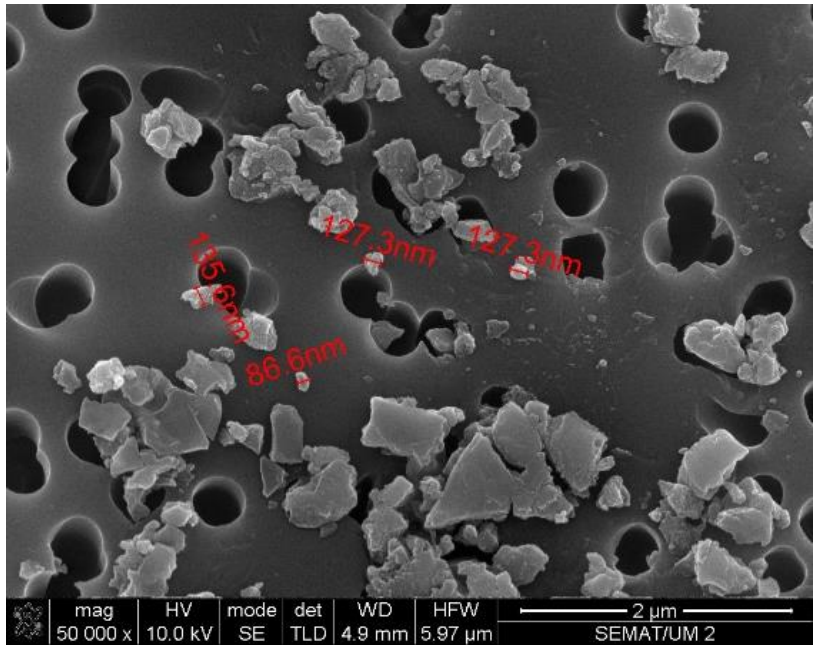
BIRGIT VAN DUUREN-STUURMAN[1]*, STEFAN R. VINK[1], KOEN J. M. VERBIST[1], HENRI G. A. HEUSSEN[2], DERK H. BROUWER[1], DINANT E. D. KROESE[1], MAIKEL F. J. VAN NIFTRIK[1], ERIK TIELEMANS[1] and WOUTER FRANSMAN[1]

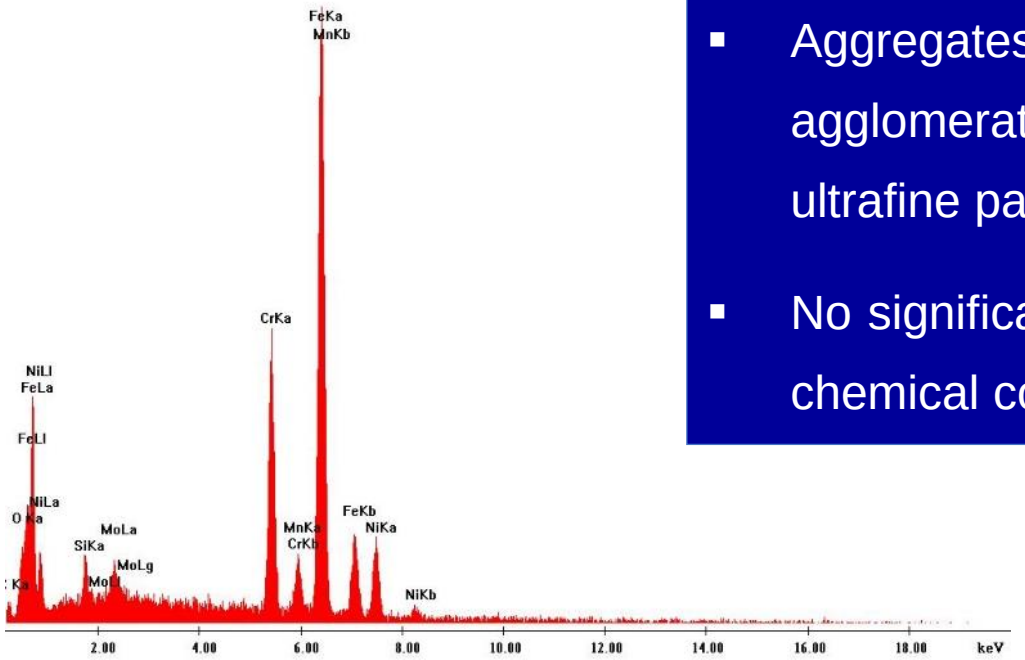
Evaluating the Control Banding Nanotool: a qualitative risk assessment method for controlling nanoparticle exposures

David M. Zalk · Samuel Y. Paik · Paul Swuste

CASE STUDY: MAIN RESULTS

Quantitative approach: SEM and EDS

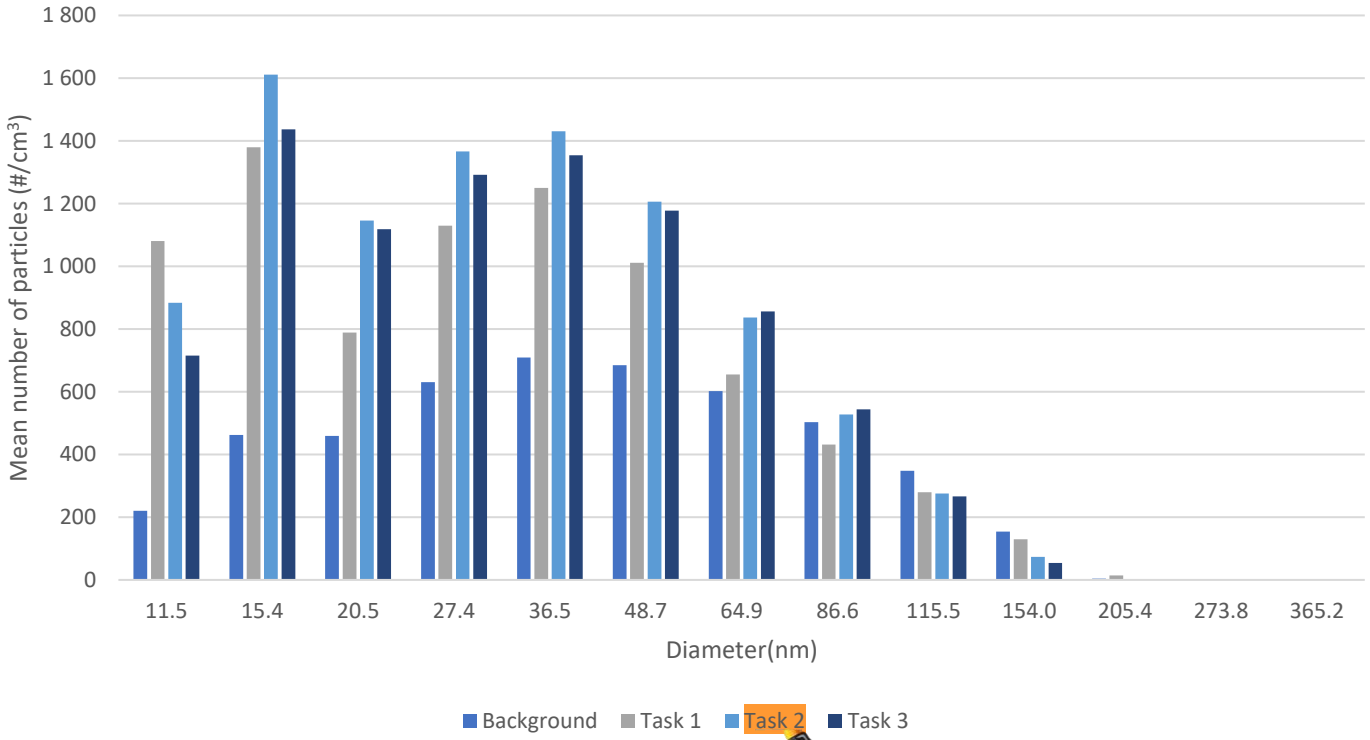




- Aggregates and agglomerates of fine and ultrafine particles
- No significant changes in chemical composition

CASE STUDY: MAIN RESULTS

Quantitative approach: SMPS



- Higher number concentration of particles during removing and cleaning the part
- Lowest on background measurements
- Tasks 2 and 3: higher numbers in smaller particles

CASE STUDY: MAIN RESULTS

Qualitative approach: CB Nanotool 2.0

	Task 1	Task 2	Task 3
Severity Score | Band	58 | High	58 | High	58 | High
Probability Score | Band	85 | Probable	70 | Likely	70 | Likely
Overall Risk Level Without Controls	RL 4 - Seek specialist advice	RL 3 - Containment	RL 3 - Containment

CASE STUDY: MAIN RESULTS

Qualitative approach: Stoffenmanager Nano

	Task 1	Task 2	Task 3
Hazard Band	E | Highest	E | Highest	E | Highest
Exposure Band	2 | Medium	3 | High	3 | High
Overall Risk Level With Controls	RL 1 – High priority	RL 1 – High priority	RL 1 – High priority

CONCLUSIONS

- **Quantitative approach**: lack of occupational limits for comparison is a significant limitation; it does not give insights on how to control the risk;

- **Qualitative approach**: difficult to use this approach for incidental nanoparticles due to the lack of background information on the particles (such as size, shape, and solubility, among others). These methods are designed for engineered nanomaterials,

- **There is an opportunity when using these approaches combined**:

  - qualitative assessment gives inputs on control measures;

  - quantitative assessment provides more detailed information about particles that may provide more accurate inputs for the qualitative approach.

NEXT STEPS

- Design a tool to assess the risk of exposure to incidental nanoparticles, using both qualitative and quantitative approach;

- Validate this tool in a case study in a Metal 3D Printing process.

Thank you for your attention!

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