# Assessment Strategy for Nanoparticle Aerosols

This is a basic assessment strategy for evaluating nanoparticle aerosol concentrations in occupational settings.  Please note that this strategy follows common exposure assessment principles and is not unique to nanomaterials.

1. **Roughly categorize the potential hazard of the material without regard to its particle size.** One should distinguish between materials that are intrinsically highly hazardous, such as radioactive materials, infectious, and other materials such as drugs and pesticides that can be dangerous on single exposures.  Familiarize yourself with the known health effects and dose responses for the material of interest, so that you are properly prepared to assess the workplace.
2. **Learn what you can about the physical and chemical characteristics of the material.** Ask current users about the physical forms, melting and boiling points, solubility in water or other solvents, aggregation behavior, dustiness, reactivity with other materials, etc.  Their experience with the material may hold important clues to understanding and controlling the material in an occupational setting.  Review the MSDS for the material as well as standard chemical technology references, to build a baseline understanding of the chemical reaction potential for the material.  A fibrous material should be evaluated for biological persistence by analogy with other examples.  Condensation particle counters and scanning mobility particle sizers would not be able to discriminate fibers from the background concentration of ambient nanoparticles.  Consult with a microscopist to develop an appropriate electron microscopic or other microanalytical method in such circumstances.
3. **Assess the general magnitude and manner of material processing.  Determine the likely routes of exposure.** Are there tiny, small, medium, large, or very large amounts of material handled?  The dose or amount of exposure is always relevant, and the potential for continuous, intermittent, or only accidental emission is important to assess.  The frequency and duration of operations and the type of equipment used for handling and containment should be considered in estimating the potential routes and degree of exposure.  Make note of the personal protective equipment already adopted, and ask specifically if users have noticed any signs of contamination outside of those areas where the material is processed.  Recognize that invisible or unsuspected surface contamination may occur and be transferred to unprotected articles and hands, mouth, eyes, or food.
4. **Assess the workplace ventilation if the release or generation of aerosol is considered the principal route of possible exposure.** Determine the quality of general and local exhaust ventilation by standard means.  Smoke tubes will help visualize airflow patterns.  Flow or pressure measurements can be compared to design specifications for exhaust systems.
5. **Identify potential emission points during maintenance activities as well as normal operations.** Integrate this information with the frequency and duration of activities to select the most significant and probable sources of exposure or emission.  Consider any potential weaknesses in the containment system, with exhaust utilization, or other control.  The outcome of this step is a list of target operations to monitor.

6. **Identify potential interferences that may mask or be misidentified as process emissions.** Any high-temperature operation may volatilize materials, some of which might condense to nanoparticles. Low-temperature zones may similarly condense airborne vapors. Electric motors with unsealed brushes, hot extrusion processes, welding, soldering, and heat sealing are some possible sources.

7. **Use the condensation particle counter or similar monitor to sample ambient air around your office, laboratory, or other locations, as well as outside, as a training exercise to become familiar with the monitoring equipment and its response to variations in nanoparticle backgrounds.** Test the response of the instrument to fresh air inlets and scraping a carpet, for example. To observe the short-term and longer-term changes that can occur, repeat background monitoring on different days, both indoors and outdoors. Recognize that a high background may mask process emissions or make them more difficult to detect, so be prepared to reschedule monitoring for another day. Fresh air inlets are usually a few hundred or thousand particles/$cm^3$ less concentrated than the general room air. To determine if a local source is causing a high ambient room background concentration, sample the fresh air supply for the room. If the source is local or coming from a neighboring room, the fresh-air-supply concentration will generally be lower than the local room concentration. Take into account the degree and manner of room air recirculation. On "high-general-background" days, the fresh air supply will be high along with the local room concentration. Tap the sampling probes to see the 1- or 2-second spike in instrument response. Download the data to a computer, export the data file to a spreadsheet program, and learn how to adjust the time scale to customary units of time. Record climatic conditions such as wind direction and speed, and relative humidity when sampling outside ambient air. Such data might be useful in assigning a cause to high ambient background levels or to shifts in median particle size.

8. **Sample the ambient air at the selected target operation or location, when the operation or other activities are not running.** It is important to understand the background variability at the target location. If the background is relatively low for the area, you may begin operational sampling.

9. **Investigate any background concentrations that are above the low readings for the area.** If you find ambient concentrations 2–3 times the lows for your area, you will need to decide to either track down a neighboring source or attribute it to high general background variability. High general backgrounds are a mystery. Perhaps fan-room filters are out of place and allowing more outside aerosol to enter, or perhaps the distribution of outdoor particle sizes on that day are different, and more of *those particles most likely to penetrate* the thin filters (100–300 nm) are passed, because the outside concentration is relatively higher in this size band. If you have time (and since a high background may postpone the operational sampling), it would be valuable to track the high air-inlet concentrations back to other rooms and to the fan room. Make observations of the room and outdoor temperatures and humidities. With enough observations, patterns may eventually emerge to explain the mystery. Once you have eliminated the possibility of interfering emissions from neighboring sources, you may do some preliminary monitoring of the target operation, provided that you recognize that you will need to repeat your measurements when there is a lower background. The experience you gain while probing the operation will be useful in building your understanding of the emission character of your target process.

10. **Repeatedly sample the target operation.** Search for the most significant readings. If you find little response, repeat the measurement at slightly different locations to ensure the correctness of your finding. A hot plume of vapor or gas may rise very rapidly from the source, and your sampling probe may be in the induced draft of fresh air surrounding the plume. A questionable positive response should be repeatable, both in timing with operational events, and in general character, before you accept the measurement as a positive response. Observing the concentration–time-history profile on a graph is an essential tool. Variations in ambient background could easily be confused with a moderate response. Repeated measurements of emission levels will provide important information on the variability of the emission and improve the understanding needed to control it with greater certainty.

11. **Graphically display concentration profiles comparing background levels with operational results.** The visual display of quantitative information is important for easy recognition of trends, patterns, and significant differences. When there is wide variability of results, as is the nature of lognormally distributed phenomena, scale your results logarithmically to keep the information in perspective. If there is little variability between results and background, a linear scale is sometimes more dramatic, but avoid mixing logarithmic and linear scales in the same report, because it is easy to confuse and mistake graphical magnitudes in that situation (always highlight the use of logarithmic scales to the reader). Of course, prepare a written report to review and share your findings.

12. **Engage the users of nanomaterials in interpreting any findings.** Operators are more familiar with process variables and behavior. Discussing the graphical results with them will often lead to important, new insights on potential controls and other exposure possibilities. Discuss with the operations team the opportunities for feasible control of emissions discovered. Unnecessary emissions should be eliminated. Necessary emissions should be reviewed according to the hierarchy of controls and avoided to the extent feasible.