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Health and Safety Executive

Summary of work undertaken to assess workplace exposure and control measures during the manufacture and handling of engineered nanomaterials

Prepared by the **Health and Safety Laboratory**
for the Health and Safety Executive 2015

RR1068
Research Report

HSE

Health and Safety Executive

Summary of work undertaken to assess workplace exposure and control measures during the manufacture and handling of engineered nanomaterials

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The aim of this research was to develop an improved understanding of the UK nanomaterial industry and of worker exposure to engineered nanomaterials, through visits to companies manufacturing or using these materials. The visits were undertaken to assess exposure to airborne nanomaterials and to assess the effectiveness of the controls used to reduce exposure.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

HSE Books

First published 2015

Acknowledgements

We would like to thank all companies who participated in this study.

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1. Summary

Nanotechnology is moving from the focused research environment to wider application in the workplace. Across Great Britain (GB) there are companies, small and large, manufacturing or using nanomaterials. As yet the scientific community does not have a good understanding of whether working with nanomaterials poses a risk to the health of workers as is suggested by some stakeholders.

The Health and Safety Executive (HSE) commissioned a project with the Health and Safety Laboratory (HSL) to improve understanding of the nanomaterials industry across GB and its employees' potential exposure to materials at the nanoscale.

HSE and HSL made attempts to identify and engage with companies which manufactured or used nanomaterials, but only four volunteered to take part in this project. The project therefore only represents a very small sample of the industry and a finite selection of nanomaterials. The observations presented here represent a limited data set; they need to be understood in this context and not overgeneralised.

The objectives of the project were:

- To carry out visits to companies to assess exposure to airborne nanomaterials during their manufacture, handling and use.
- To assess the effectiveness of the controls used to reduce exposure to nanomaterials.

The key findings from the project work are:

- An increased understanding of some of the tasks and activities undertaken during the manufacturing, handling or use of nanomaterials and the potential for exposure to airborne nanomaterials.
- Existing good hygiene control practices can be used to reduce exposure to airborne nanomaterials. It is therefore important that in any work with nanomaterials, a thorough assessment is made of all control methods to be used.
- An exposure monitoring strategy suited to small businesses in order to monitor emission of airborne nanomaterials was evaluated and found to be practical and cost effective.
- The company COSHH assessments were not specific to nanomaterials and all of the assessments reviewed could have been improved. Respiratory protective equipment (RPE) offering protection against particles was provided at three of the four companies. Of the three companies using RPE only one company had carried out face-fit testing of some their staff. The other two companies had not conducted face-fit testing. From both the occupational hygiene assessment and the measurements, it was found that in general the local exhaust ventilation (LEV) systems in place were appropriate and effective except for a poorly designed LEV system at one company. From the measurements, it was observed that short-term release of nanomaterials could take place during maintenance work or when emptying powder collected in LEV system bins.
- An effective risk management assessment strategy could include a combination of a simple exposure monitoring approach and an occupational hygiene assessment of the process and the controls. This strategy would be practical and cost- effective. It could be used to evaluate whether tasks or processes give rise to potential emissions before committing to more comprehensive monitoring. In some circumstances, the use of real-time monitors can allow the immediate detection of leaks or releases of nanomaterials.

However, there remain challenges to measuring emissions of (or exposures to) specific nanomaterials where background levels of ultrafine particles[1] are high or fluctuate.

- There is not enough evidence yet to propose a measurement methodology which should be used to underpin separate specific Occupational Exposure Limits (OELs) for nanomaterials if these were to be proposed.

2. Background

The intention was to select a cross-section of sites where nanomaterials were being processed. This involved:

- recruiting companies through established contacts, directories, trade associations and the internet.
- organising site visits to carry out practical, short-term or comprehensive exposure measurements and evaluations of the effectiveness of controls used.
- collecting contextual information using a questionnaire (the blank questionnaire is shown in Annex 2).
- developing a real-time monitoring strategy using real-time instruments and additional sampling devices for subsequent morphological and chemical characterisation of the collected airborne particles by Electron Microscopy (EM).

3. Methodology

Each site visit included an assessment of the effectiveness of the Local Exhaust Ventilation (LEV) systems by an experienced HSL occupational hygienist, completion of the contextual questionnaire, and a record of activities undertaken at the time of the sampling and exposure-monitoring work.

The following tasks were undertaken:

- A site-assessment protocol for short-term monitoring of airborne nanomaterials using hand-held, real-time, measurement instruments and particle-sampling devices was prepared.
- Companies were contacted and the project objectives explained and consent for their participation sought.
- For some companies 'pre' visits were undertaken to address any concerns about participating in the project before the field-measurement work was carried out.
- Activities/tasks were monitored using the "short-term monitoring" protocol. When thought necessary, more comprehensive monitoring was also carried out.
- During the field visits, worker's activities at the time of the measurements were recorded and a questionnaire completed by the company (the blank questionnaire is shown in Annex 2).
- An assessment of the LEV systems was carried out by an experienced HSL occupational hygienist.
- Data were analysed and a confidential, draft report sent to the participating company for review; changes were then made to the reports to address any comments/factual inaccuracies.
- The methodology applied during the "short-term monitoring" was designed to take into account the needs of Small and Medium Enterprises (SMEs), but was also applied to larger workplaces (see Annex I for a short summary of the methodology).

[1] The term 'ultrafine particles' describes particles at the nanoscale which are unintentionally produced or naturally occurring; they are generally generated from combustion processes. This can include particles from industrial and environmental pollution of the air.

Control assessment

Each site visited included a control assessment by an experienced HSL occupational hygienist who carried out basic evaluations of:

- risk assessments as required under the Control of Substances Hazardous to Health (COSHH) Regulations (where available);
- the effectiveness of the LEV systems (using dust lamps and anemometers);
- personal protective equipment (PPE) worn;
- completion of the questionnaire as shown in Annex 2.

Short-term, airborne monitoring:

Aerosol measurements were mainly based on the use of hand-held, real-time particle counters (Condensation Particle Counters (CPC) and Optical Particle Counters (OPC)) with the collection of a limited number of samples for chemical and physical off-line analysis by EM. The combined size range covered by the CPC and OPC instruments was 10 nm to 20,000 nm (20 µm).

Activities at the time of the measurements were documented to better understand the background fluctuation in airborne particle concentration with time. This 'background' differs from the engineered nanomaterials released during manufacturing or handling processes and can include ultrafine particles (<100 nm diameter) from industrial and environmental pollution of the air.

Real–time particle measurement of particle surface area: In addition to the number concentration instruments, a portable real-time instrument, the Aerotrak 9000, was used to measure the surface area of the aerosol particles in the range of 10 to 1,000 nm, which could deposit in the gas-exchange (alveolar) regions of the lung.

Comprehensive airborne measurements: This involved the deployment of additional research-type instruments with a superior size classification and resolution and included a Scanning Mobility Particle Sizer (SMPS) and an Electrical Low Particle Impactor (ELPI).

4. Results

HSL carried out six site visits to four companies which varied from medium-sized to large, representing only a small sample of the industry. Therefore the observations presented here need to be understood in this context and not overgeneralised.

An occupational hygiene assessment and two measurement site visits were carried out at Company 1 and 2. During the first visit to Company 1, the manufacturing process was unexpectedly interrupted during the early stages of the data collection so the maintenance activities were monitored for the remainder of the visit. On a return visit to Company 1 additional measurement data was collected. Company 2 undertook two activities which were very different in nature and carried out on different days. For Company 3 and 4 all monitoring and assessments were carried out in one visit.

Manufacturing/handling processes

Across all four companies a range of tasks were monitored including production pre-processing and processing of nanomaterials, bagging, handling (e.g. weighing, moulding and machining), material recovery, emptying of powder collected in LEV system bins, maintenance and cleaning activities. Most of the tasks monitored involved manufacturing processes or handling of powders with the amount of material handled ranging from hundreds of grams to greater than 100 kg.

It should be noted that none of the tasks or processes monitored in this project involved the manufacturing or handling of nanotubes or nanofibres, or the machining of composites containing nanomaterials.

Companies' perceptions of nanomaterials

Of the four companies visited, only one believed there were specific risks associated with the nanomaterials they were handling and had carried out training for their employees. The other three did not believe that the substances they were handling posed specific risks to health and as such training on nanomaterials had not been given. One company had advised their employees to treat the material as nuisance dust.

Overall assessment of the control measures

COSHH assessment

COSHH assessments were available from three of the four companies. The fourth company considered that there was no need for a COSHH assessment as the material was non-hazardous. The COSHH assessments were not specific to nanomaterials and all of the assessments reviewed could have been improved by specific consideration of the hazards, risks and control measures required (including training requirements) for the nanomaterial(s) present in the workplace.

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Engineering controls

Most of the activities that related to the handling or production process of nanomaterials in a powder form employed some degree of engineering controls. These controls ranged from an extracted and enclosed process (one company) to the use of capturing (captor) hoods. During the visits, dust lamps were used to visualise airborne particles generated by the processes observed and any leakage.

Using a dust lamp, no leaks were observed from the enclosed and extracted system at one company. At two companies the LEV systems appeared visually effective; however, at one, there was scope for improving hood design and placement. The fourth company's LEV system was ineffective due to a poorly designed hood. Suggestions for improvements were given.

However, from both the occupational hygiene assessment and the measurements, it was found that, in general, appropriate and effective controls were in place for production processes except for a poorly designed LEV at one company (mentioned above). However, from the measurements, it was observed that short-term release of nanomaterials could take place during maintenance work or when emptying powder collected in LEV system bins. When a release during powder-handling activities was identified, the particles, in some circumstances, agglomerated to larger particles.

Personal Protective Equipment (PPE)

PPE worn at the companies was, on the whole, appropriate for the work carried out with the exceptions of:

- powdered latex gloves (worn at two companies) – this glove material can put the wearer at risk of skin allergy and asthma.
- Respiratory Protective Equipment (RPE) offering protection against particles was provided at three of the four companies. RPE used included FFP2 or FFP3 disposable respirators and TH2 powered-hood devices. Where companies considered it was appropriate, RPE was used in addition to LEV or and where no local engineering control was in place (e.g. during powder recovery, LEV/process system bin emptying, or maintenance work). Of the three companies using RPE only one company had carried out face-fit testing of some their staff. The other two companies had not conducted face-fit testing.

Overall assessment of the short-term monitoring approach

The use of a short-term exposure monitoring approach helped demonstrate that only a fraction of the airborne particles were likely to have originated from the handling of the nanomaterials.

Using several portable, hand-held, real-time instruments covering a size range from nanometres (10 or 20) to several micrometres (at least 10 µm) was a practical approach to assess short-term emission from processes. However, real-time instruments do not yet provide chemical or morphological information on the particles and hence it was necessary to assess these air samples using electron microscopy (EM). In addition to the measurements a parallel hygiene assessment was considered to be essential to check the appropriateness of the control measures being used.

The technical limitations of the short-term monitoring approach

In the workplaces visited, measuring emissions of engineered nanomaterials (i.e. in terms of number concentrations) from the processes and tasks observed was difficult for the following reasons:

- there was substantial spatial and temporal variation to background levels of ultrafine particles in the size range below 600 nm;
- high background levels of ultrafine particles (above 100,000 particles/cm^3 between 20 nm and about 1,000 nm) were measured using a CPC;
- industrial and traffic emissions of ultrafine particles below 600 nm (e.g. combustion and diesel particles) contributed to this background;
- other sources of nanoparticles present in the workplace may have been emitted from machinery, for example, diesel engine exhaust emissions from lift trucks operated inside the premises;
- there were low emission concentrations from the production tasks or processes monitored.

The use of an OPC instrument in addition to a CPC instrument was beneficial. In some circumstances, when monitoring powder-handling activities, the OPC was useful as the engineered nanoparticles agglomerated to form larger particles and were detected using the OPC rather than the CPC.

5. Discussion and conclusions

Overall findings

This project represents only a very small sample of the industry and a finite selection of nanomaterials. The difficulties encountered at the start of the project in identifying and engaging companies which manufactured or used nanomaterials hampered the project and resulted in the limited view of industry across the UK.

Some companies percieved there to be no specific risks with the materials they were handling and as such had not carried out training specific to work with nanomaterials.

Applied good control practices can be used to reduce exposure to airborne nanomaterials. It is therefore important that in any study, an assessment of all control methods used is thoroughly assessed.

An effective risk management assessment strategy could include a combination of a simple exposure monitoring approach and an occupational hygiene assessment of the process and the controls. This strategy could be used to evaluate which tasks give rise to potential emissions before committing to expensive monitoring. However, there remain challenges to measuring emissions of (or exposures to) specific nanomaterials where background levels of ultrafine particles are high or fluctuate.

The company COSHH assessments were not specific to nanomaterials and all of the assessments reviewed could have been improved. RPE offering protection against particles was provided at three of the four companies. Of the three companies using RPE only one company had carried out face-fit testing of some their staff. The other two companies had not conducted face-fit testing. From both the occupational hygiene assessment and the measurements, it was found that in general the LEV systems in place were appropriate and effective except for a poorly designed LEV system at one company. From the measurements, it was observed that short-term release of nanomaterials could take place during maintenance work or when emptying powder collected in LEV system bins.

Benchmark/Exposure Limits

Proposed benchmark or exposure limits for airborne nanomaterials in the workplace based on numbers have been defined for "primary" or free non-agglomerated/non-aggregated nanoparticles[2]. The problems associated with using these benchmark or exposure limits are:

- The OPC can only measure agglomerates and the CPC will measure both primary particles and agglomerates. In the presence of agglomerated nanoparticles (e.g. when a release occurs during the handling of powders containing nanoparticles), these instruments will count agglomerate made of many "primary" nanoparticles as one particle, thus making it impossible to quantify the total primary number of particles.
- The relatively low emissions, compared to high background levels and fluctuations found at several of the visited sites, limited the use of a simple subtraction of the background particle number concentration from the total particle number concentration in order to obtain the specific engineered particle number concentrations.

Even though health-related mass concentrations were not measured during this project, personal respirable- and inhalable-mass concentrations could also be evaluated especially when monitoring powder-handling activities because nanoparticles aggregate and agglomerate. Further characterisation and quantification of the elements by e.g. X-ray fluorescence (XRF) or Inductively Coupled Plasma Mass Spectrometry (ICPMS) could also be performed for some types of nanomaterials.

Characterisation of nanomaterials

With improvements in technology over the last few years, approaches to the characterisation of airborne nanomaterials from samples collected in workplaces have moved towards semi-quantitative rather than qualitative techniques. There is a need for more research in this area, particularly semi-quantitative analysis of particles by EM and harmonisation of reporting results.

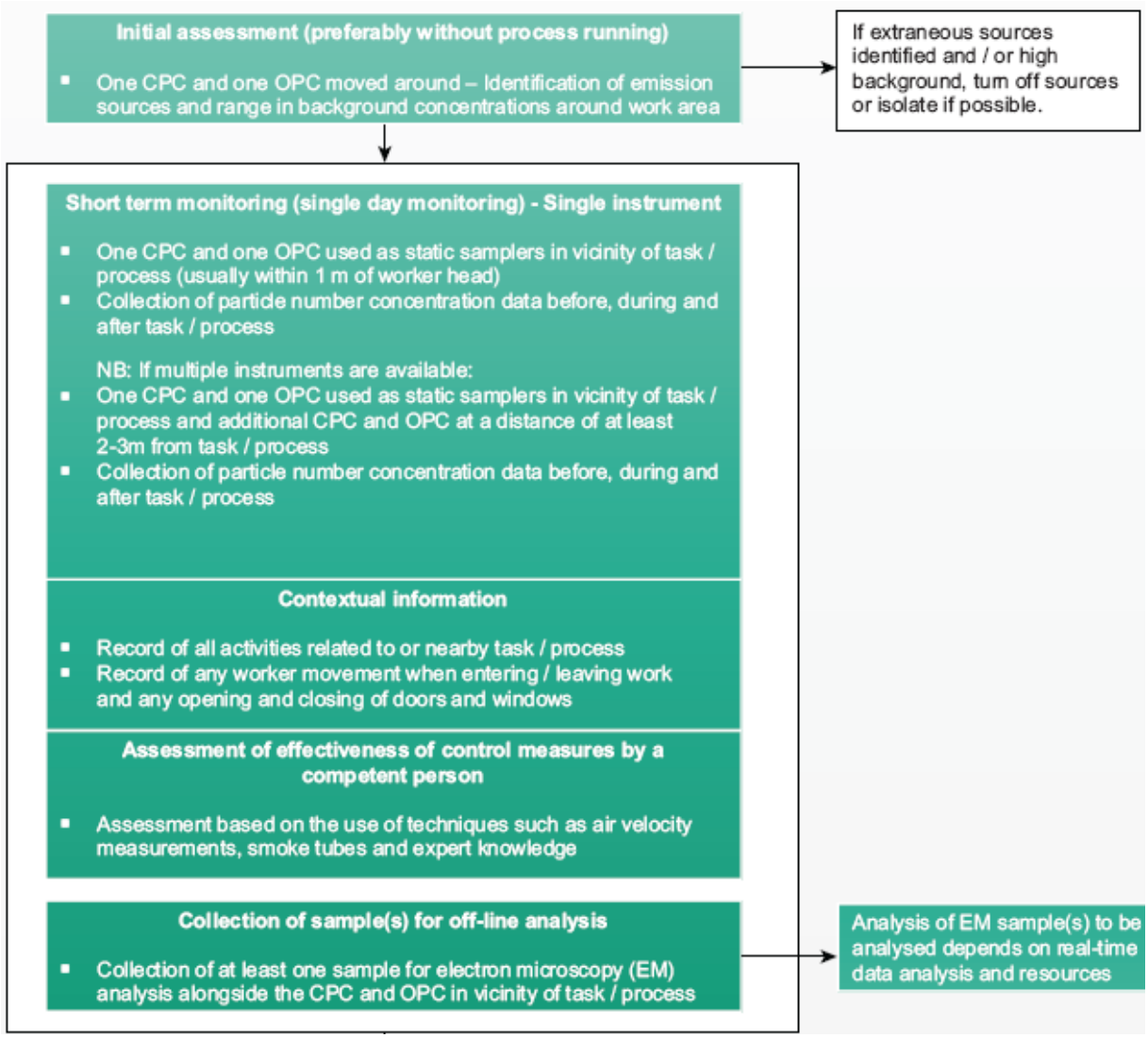
Long-term monitoring

Where the situation merits further investigation, a long-term monitoring programme (e.g. over several days) could be an option but very few researchers have investigated the potential benefits. Difficulties arising from a fluctuating background of ultrafine particles could be addressed by a long-term monitoring approach and this could smooth any short-term variation of the background number concentrations.

In the future, as monitoring instruments are miniaturised, there could be more emphasis on the personal sampling of workers. However, the short-term monitoring strategy currently gives a practical and cost-effective approach to monitor emission of airborne nanomaterials. It could be used to evaluate whether tasks or processes lead to potential emissions before committing to expensive monitoring. In some circumstances, the use of real-time monitors could allow the immediate detection of leaks or release from processes.

[2] Van Broekhuizen et al (2012). Exposure limits for nanoparticles: report of an international workshop on Nano Reference Values. *Ann. Occup. Hyg.*, Vol. 56, No. 5, pp. 515–524, 2012

ANNEX 1 - Summary of protocol strategy – Short-term monitoring based on real-time hand-held instruments



ANNEX 2 – Blank questionnaire

Company information

Name of Occupier:

Address:

Postcode:

Name of Contact Person(s) and Phone Number:

Contact E-mail address:

1. Which best describes your company/department/laboratory activities?

(Tick appropriate box)	Yes	No
1.1 Manufactures nanoparticles/nanofibres?		
1.2 Uses nanoparticles/nanofibres to produce products containing them?		
1.3 Process products containing nanoparticles/nanofibres?		
1.4 Tests/characterises/analyses the properties of nanoparticles/nanofibres?		
1.5 Tests/characterises/analyses the properties of products containing nanoparticles/nanofibres		
1.6 Historical review of facility *(Include how long has nanomaterials been used? Other company* sites? *(Any other relevant information?)*		

2. Demography

	(Add number and any comments into appropriate box)
2.1 Number of sites?	
2.2 Total number of employees on this site	
2.3 Total number of employees using nanomaterials?	
2.4 Gender of the potentially exposed work force? *(Number of male and female employees)*	
2.5 Age range of workers potentially exposed to nanomaterials? *(Age range of employees)*	
2.6 Length of shift? *(In hour, day or night or both)*	
2.7 Number of days worked per week?	

3. Nanomaterials information:

	(Fill in boxes)
3.1 Which nanoparticles(s)/nanofibres(s) is/are produced, used or released? *(record commercial name, chemical composition)*	
3.2 Physical characteristics of nanoparticles/nanofibre?	

(crystal structure, shape of particles, purity)	

(Tick appropriate box)	Yes	No
3.3 Are the sizes of the nanoparticles(s)/nanofibre(s) known? *(Tick appropriate box?)*		

If YES how big are the primary particles? *(Circle appropriate size)*
(a)<20nm (b) 20nm to <50nm (c)50nm to 100nm (d) >100nm

3.4 What is the form of the nanomaterials produced, used or handled before being released? *(Please circle appropriate form)*

a) Powder b) Bound c) Suspension d) Liquid

3.5 If **Powder** how has it been modified to make it less flyable? *(circle appropriate type)* No

(a) fine powder (b) granules (c) pellets

3.6 If **Bound** record the weight or percentage of nanoparticles(s) /nanofibre(s) in the composite?

3.7 If in **Suspension** record the weight or volume ratios of the nanoparticles(s)/nanofibre(s) in the product.

3.8 If **Liquid** record the weight or volume ratios of the nanoparticles(s)/nanofibre(s).

3.9 Record how much nanomaterials is used per **task**?

3.10 Record how much nanomaterials is used per **year**?

4. Risk Assessment Information

(Tick appropriate box)	Yes	No
4.1 Does your organisation think there are any special risks associated with the nanomaterials handed/or produced?		
If NO Ask for the evidence of why they do not feel there is a risk *(collect any information they have)*		
4.2 Does your organisation carry out a specific risk assessment for nanoparticles/nanofibres*?*		
4.3 If YES How does your organisation determine if there are risks *(Tick all appropriate boxes a) to h)*		
a) Have conducted reviews of scientific literature		
b) Consult government regulations and guidance		
c) Consult industry guidelines		
d) Seek expert consultation		
e) Consult MSDS		
f) Carried out toxicity /eco-toxicity testing		
g) Routine update in place		

h) Other (please give details)		
4.4 If NO why has no risk assessment been carried out?		
4.5 Is there a COSHH assessment or equivalent risk assessment for the nanomaterials?		
4.6 How often is the COSHH/risk assessment reviewed? (Please circle appropriate period) a) 3 months b) 6 months d) 1 year e) 2 years f) never g) 5 Years		
4.7 Have all routes of exposure been considered?		
If **NO** What routes have not been considered? (*Please specify)*		
4.8 Does the risk assessment identify administrative controls for nanomaterials?		
If YES please specify the way administrative controls are used.		
4.9 Any other formal operating procedures relevant to health? (e.g. permits to work, safety procedures etc. *(Tick appropriate box and get photocopies where possible).*		
4.10 Are there current MSDS's available for nanoparticles/nanomaterials? *(Tick appropriate box and get photocopies where possible)*		

5. Information and training

(Tick appropriate box)	Yes	No
5.1 Have employees been informed of the hazards/risk associated with the use of nanoparticles/nanofibres?		
5.2 Do all employees who handle nanomaterials receive health and safety training on handling of nanomaterials?		
5.3 Do you keep training records?		
5.4 Who is providing the training? *(please circle all appropriate)* N/A a) Internal source b)External source c) Combination of resources		

6. Activity/Task/Process information

(Tick appropriate box)	Yes	No
6.1 Is the nanomaterials produced/manufactured?		
If YES *(please circle appropriate)* a) small scale production (start-up) b) pilot plant production c) full scale production *(Please specify the production type/describe production process)*		

6.2 Is the nanomaterials used/handled?		
If YES Describe the use/handling process *(e.g. weighting, mixing, and spraying of nanomaterials).*		
6.3 Is the nanomaterials released by processing?		
If YES Specify/describe processing *(e.g. dry cutting of composite polishing etc)*		
6.4 Total number of employees potentially exposed directly?		
6.5 Total number of employees potentially exposed indirectly?		
6.6 Duration of tasks/activity/process performed		
6.7 Frequency of task/activity/process *(Number of times per day/week etc)*		

7. Cleaning and Spillages

(Tick appropriate box)	Yes	No
7.1 Do employees use a vacuum cleaner?		
If YES What type of cleaner? *(Please specify H-type or other)*		
If No What is used to clean down?		
7.2 What arrangements are in place to maintain the vacuum cleaner		
7.3 How do employees clean (or decontaminate equipment used for nanomaterials *(please specify)*		
7.4 Are there separate disposal containers for nanomaterials?		
7.5 How do employees handle spillages of nanomaterials *(Please specify)*		

8. General Ventilation

8.1 Description of general ventilation in the location of where nanomaterials are used *(e.g. is it natural ventilation (windows/doors), 'forced' or mechanical ventilation or air conditioned?)*

9. Engineering controls

(Tick appropriate box) **See main report**	Yes	No
9.1 Are engineering controls used to safely manage workers exposure to nanomaterials		
If YES Which type of control is used? *(Please indicate by ticking yes or no as appropriate for a) to m)*		
a) Total enclosure		
b) Partial enclosure		
c) Glove Box		
d) Laminar flow booth		
e) Down flow booth		
f) Fume-cupboard		
g) Receptor hood		
h) Movable hood		
i) Canopy hood		
j) Slot exhaust		
k) Automated manufacturing process		
l) Wet process		
m) Other *(Please specify)*		
9.2 Are exhaust filtration systems being used?		
If YES which type? *(Please specify)*		
9.3 Do you have your engineering controls (Local Exhaust Ventilation (LEV)) thoroughly examined and tested by a competent person?		
9.4 Is the thorough examination and test adequate? *(Tick appropriate box and get photocopies where possible)*		

9.5 Do you carry out regular maintenance and inspections on your LEV system?		
If YES What types of check are performed? *(Please circle all appropriate)* a)Visual b)Smoke test c) Air velocity d) Other *(Please specify)*		
9.6 How often do you carry out checks on your LEV system? *(Please specify)*		
9.7 Where does the exhaust air from the control system go? *(Please specify)*		
9.8 Have the operators been trained in how to use the control measures? *(Tick appropriate box.)*		

10. Respiratory Protective Equipment (RPE)

(Tick appropriate box)	Yes	No
10.1 Do employees use Respiratory protection?		
If YES Which type of RPE is used? *(Please circle appropriate and specify model and class of filter and type)* a) Airline/Breathing apparatus b) Full face c) Half mask d) Disposable		
10.2 Is use of RPE required or voluntary?		
10.3 For cartridge or disposable respirators how often are they changed? *(Please specify)*		
10.4 Has every employee been face fitted with his/her own respirator?		
10.5 Has every employee received training in the use of RPE?		
10.6 Has every employee received training in the maintenance of their own RPE?		
10.7 How is the in-use RPE stored? *(Please specify where the RPE is stored e.g. on work bench, in cupboard etc)*		
10.8 Are there records of RPE maintenance?		

11. PPE - Gloves

(Tick appropriate box)	Yes	No
11.1 Do employees use glove protection?		
If YES Which type of gloves is used? *(Please circle appropriate and specify make and material thickness e.g. Nitrile, natural rubbers, PVC etc)?*		

a) Disposable b) Reusable		
11.2 How often are glove replaced? *(circle the appropriate)* a) After each activity b) Daily c) Weekly d) Monthly e) Other (please specify)		
11.3 Is use of gloves required or voluntary?		
11.4 Has the operator had training in putting on and taking off gloves?		
I1.5 Are gloves taken off correctly? *(Please circle appropriate)* a) Yes b) No c) Not observed		
11.6 Does the employee wear a second pair of gloves under the outer glove?		
11.7 When performing a task are the gloves worn? *(Please circle appropriate)* a) 0-10% of task b) 10 -50% of task c) 50- 100% of task		

12. PPE - Eye Protection

(Tick appropriate box)	Yes	No
12.1 Do employees use eye protection?		
If YES Which type of eye protection is used? *(Please circle appropriate and specify make and material)* a) Safety glasses b) Full face coverage (visor) c)Goggles		

13. PPE – Coveralls

(Tick appropriate box)	Yes	No
13.1 Do employees use coverall protection?		
If **YES** Which type of coveralls used? *(Please circle appropriate and specify make and material? e.g. Tyvek, cotton, poly/cotton etc)* a) Disposable b) Reusable		
13.2 How often are coveralls replaced? *(circle the appropriate)* a) After each activity b) Daily c) Weekly d) Monthly e) Other (please specify)		
13.3 Is use of coveralls required or voluntary?		
13.4 Has the operator had training in putting on and taking off coveralls?		
13.5 What storage facilities are provided for work clothing and home clothing? *(Please specify)*		
13.6 Are coveralls taken home?		

13.7 Where are coveralls cleaned? (At home, on the premises, professional laundry etc) (*Please specify)*

14. Exposure monitoring results

(Tick appropriate box)	Yes	No
14.1 Do employees monitor the working environment for nanomaterials?		
If YES What type of monitoring?*(Please specify)*		

15. Welfare Facilities

(Tick appropriate box)	Yes	No
15.1 Do you allow your employees to eat, drink, smoke or apply cosmetics in work areas?		
15.2 Do you provide hand care products for employees use?		
If YES Do the employees use them?		
If YES *(Please specify products used)*		
15.3 Are hygiene facilities (showers/changing areas) provided?		
If YES Do the employees use them?		
15.4 Do you have displayed the appropriate warning signs?		
If YES what display signs are around? *(please specify)*		

Published by the Health and Safety Executive 08/15

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RR1068

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