Application Note:
General Guidelines for the Safe Handling of Nanocrystalline Powders & Dispersions

1. INTRODUCTION:

There are three main routes by which a chemical can enter the body; namely, oral, skin and inhalation. In case of powders the principal route is through inhalation. If an individual is exposed to an excessive airborne concentration of any chemical over a long period of time, undesirable health effects can result.

It is always recommended to handle powders in a way that prevents airborne dust to be generated, however, some nuisance-level dust is expected to be generated while transferring, packaging or processing.

Following information is provided to serve as a general guideline for safe handling of *nanoparticles powders and dispersions* during processing and use, both at the lab and manufacturing scale. Dispersions of nanomaterials in solvent systems that are hazardous and flammable may require additional precautions.

NOTE
Information provided is based on our knowledge related to specific chemical safety in conjunction with Nanophase safety programs related to Respiratory Protection, Safe Handling of Nanopowders, and Personal Protective Equipment. It is assumed that a user has general skills in the safe handling of chemicals and related materials and has implemented a chemical hygiene program.

2. CHEMICAL DESCRIPTION (TYPICAL)

Name:	Metal Oxide Powders (Non Hazardous Class of Chemicals)
PEL (OSHA):	Total Particulates n.o.r. 5-15mg/m^3, Respirable Fraction 3-5mg/m^3
TLV (ACGIH):	Inhalable Particulates n.o.r. 5-10mg/m^3, Respirable Fraction 2-3mg/m^3
Particle Size:	In dry state, nanomaterials forms loose agglomerates (typically >1000nm) and behave as conventional powders. De- agglomeration to primary nano-sized particles will not occur until powders are subjected to sufficient amount of energy in a suitable medium, such as water or organic solvent.

Note: These PEL and TLV values are for PNOS only, follow the established concentration limits where specific PEL and TLVs are defined for a particular chemical(s).

3. PERSONAL PROTECTIVE EQUIPMENT SELECTED and HANDLING

OSHA (US) has set maximum exposure standards (PEL) for many airborne toxic materials which provide a basis for proper selection of respiratory protection equipment. In cases where OSHA PEL for a powder does not exist Nanophase uses nuisance dust standards in association with general chemical safety to identify the PPE and handling conditions.

It is important to note that currently there are "NO" US standards, measurements, and protective equipment available that are specific to nanoparticle safety. However, based on the fact that nanoparticles in dry state are generally present as loose agglomerates, the

conventional method for air contaminants monitoring and controls are considered as best practical information. In addition, when these particles are dispersed in liquid and further stabilized with suitable dispersants the particles become de-agglomerated and typically have a hydrodynamic diameter >100nm.

Sections 3.1 through section 3.3 are the general guidelines for personal protective equipments covering a range of operations from laboratory scale to production. Section 3.4 describes the specific personal protection for different area of operations at Nanophase (TABLE 1A & B), which can be used as a general use guideline for similar operations and situations handling nanomaterials, particularly in the US. It is the responsibility for the user of these materials to ultimately ascertain the best practices that should be implemented in their specific operation(s).

3.1. **Skin Protection:**

Always wear protective gloves and clean body-covering clothing. Disposable gloves usually made of lightweight synthetic material such as Nitrile is recommended to guard against potential mild irritants. Either a lab coat or clothing suitable for chemical operations is recommended. In handling a large quantity of powder in pilot or production environment, a Tyvek type jump suit should be considered. In handling a large quantity of dispersion in pilot or production environment, a Tychem type jump suit should be considered.

3.2. **Eye Protection:**

Use chemical safety goggles, glasses, and/or full face shield where dusting and splashing of chemicals is possible. Maintain eye wash fountain and quick-drench facilities in work area.

3.3. **Respiratory Protection:**

3.3.1. ***Ventilation System:***

Use a system of local and/or general exhaust ventilation, which is adequate to limit personal exposure to levels, which do not exceed the PEL or TLV. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area.

NOTE: As described earlier, in dry state, nanoparticles are present as weak agglomerates and can be handled by using an adequate conventional filtration medium (such as HEPA, which is 99.97% efficient).

3.3.2. ***Personal Respirators (NIOSH Approved):***

If airborne concentrations exceed the identified PEL or TLV and engineering controls (*such as local exhaust*) are not feasible, a half-face dust mask particulate respirator (Moldex or 3M N100 or P100) may be worn for up to ten times the exposure limit or the maximum use

concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A Powered Air Purifying Respirator (PAPR) equipped with HEPA filter cartridge may be worn up to 25 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece high efficiency particulate respirator may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest.

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3.4 **Personal Protective Equipment (PPE)**

Nanophase uses the following Personal Protective Equipment (PPE) during nanomaterials handling. The PPE were selected with the help of Nanophase management and safety equipment supplier's assistance. MSDS documents and air quality testing for possible chemical contaminants were reviewed to select the appropriate respirators and filters for specific area of operations**.** Specific model numbers for respirator and safety glasses along with the vendor information is provided in Table 2.

TABLE 1A-Handling of Laboratory Scale Chemicals (Normally <25kg)

Protective Measure	***Powders***	***Dispersions***
**Respiratory Protection	Engineering Control: Fume Hood If engineering controls are not feasible then the use of a proper respirator mandatory. **Moderate to Heavy Handling of Powders** Powered Air Purifying Respirator (PAPR) Manufacturer:3M Model or NIOSH No.: GVP Series Cartridge Type: 3M HEPA (99.97%) **Light Handling of Powders** Dust Mask Respirator: 3M or Moldex N100 (99.97% efficient)	Fume Hood is not required. Use Fume Hood if further processing of dispersion (e.g., sonication or mixing in open air) creates mist/aerosol. If engineering controls are not feasible then the use of respirator is required **Handling of Dispersions** Powered Air Purifying Respirator (PAPR) Manufacturer:3M Model or NIOSH No.: GVP Series Cartridge Type: 3M HEPA/OV (99.97%)
Skin Protection	Use nitrile disposable gloves	Use impervious Nitrile or Butyl disposable gloves
Eye Protection	Safety glasses with side shield	Safety goggles
Clothing	Lab Coat	Lab Coat

TABLE 1B-Handling of Production Scale Chemicals (Normally >25kg)

Protective Measure	**Powders**	**Dispersions**
**Respiratory Protection	Engineering Control: Adequate local ventilation is required. Actual air monitoring of personnel exposure is necessary to establish a baseline to determine the type of respirator, if any, is required. If engineering controls are not feasible a use of respirator is mandatory. **Moderate to Heavy Handling of Powders** Powered Air Purifying Respirator (PAPR) Manufacturer:3M Model or NIOSH No.: GVP Series Cartridge Type: 3M HEPA (99.97%) **Light Handling of Powders** Dust Mask Respirator: 3M or Moldex N100 (99.97% efficient)	Fume Hood is not required. Use tank exhaust and/or local ventilation if further processing of dispersion (e.g., sonication or mixing in open air) creates mist/aerosol. If engineering controls are not feasible a use of respirator is mandatory. **Handling of Dispersions** Powered Air Purifying Respirator (PAPR) Manufacturer:3M Model or NIOSH No.: GVP Series Cartridge Type: 3M HEPA/OV (99.97%)
Skin Protection	Use nitrile disposable gloves.	Use impervious nitrile disposable gloves. For liquid chemicals that are severe skin irritant use thick Butyl gloves.

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TABLE 1B-Handling of Production Scale Chemicals (Normally >25kg) (continued)

Eye Protection	Safety glasses with side shield	Safety goggles and additional face shield when splashing is a concern
Clothing	Clothing or uniforms normally acceptable for working in a chemical operation. For Heavy Handling of powders Tyvek disposable suit is required.	Clothing or uniforms with additional skin protection clothing (aprons, sleeves etc.) is normally acceptable for working in a chemical operation. For Heavy Handling of liquid chemicals Tychem disposable suit is required.

*****Evaluation for Respirator Fit Use***
Respirators must be fit tested for use under a formalized Respiratory Protection plan. Development of Respiratory Protection program must be in compliance with OSHA (US) standard 29 CFR 1910.134. Fit test is not required for PAPRs, however, training must be provided.

TABLE 2- PPE Suggested Purchase Guide

Equipment/Use	*Model/Catalog#*	*Manufacturer*	*Distributor*
Powered Air Purifying Respirator (PAPR)	GVP-CBL501/116328-58217 **Cartridges** HEPA #8174190 OV/HEPA #81065	*3M*	Conney Safety
Dust Mask (D/M) N100	8233/70015	3M	Conney Safety
Dust Mask (D/M) N100	2730N100	Moldex	Conney Safety
Safety Glasses for Handling Powders	ASTRO OTG 3001 SPARTAN 400	UVEX	Conney Safety
Safety Goggles for handling dispersions	Flex Seal Goggles	UVEX	Conney Safety
Safety Face Shield for handling dispersions	Protecto Shield	WILLSON	Conney Safety
Clothing Tyvek Suit w/shoe covers Tychem Suit w/shoe covers Tychem Aprons/sleeves	 TY127S and FC440S CPF-1 and QC440S QC275B and QC500B	 DuPont	 Conney Safety Lab Safety Supplies
Gloves Nitrile Butyl/Silvershield	 Industrial Gloves, powder free Integrated, Butyl/Silvershield	 Sempermed North	 Conney Safety Lab Safety Supplies

4.0 Waste Disposal Practices

Most nanomaterials produced by Nanophase consist of an insoluble metal oxides and a solvent, depending upon the formulation of the dispersion. A waste stream or waste product (mostly non-hazardous) may be generated during the handling, processing, and use of these materials. Before disposing waste, it is recommended to check with the local authorities to determine specific disposal requirement governing the area of operations.

Unless permitted, do not dispose waste to the sanitary sewer or storm discharge at any time. Always handle & dispose waste in full compliance with all applicable international, federal, state, and local regulations.

5.0 Key to Abbreviations

ACGIH:	American Conference of Governmental Industrial Hygienists, Inc
NIOSH:	National Institute for Occupational Safety and Health
OSHA:	Occupational Safety and Health Administration
PEL:	Permissible Exposure Limits
TLV:	Threshold Limit Value
n.o.r.:	not otherwise regulated
CAS:	Chemical Abstracts Service
D/M:	Dust Mask
PAPR:	Powered Air Purifying Respirator
PNOS:	Particulate Not Otherwise Specified
HEPA:	High Efficiency Particulate Arrestor or Air
OV:	Organic Volatile

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