



EVALUATION OF EXPOSURE MODELS with measurement data

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INTRODUCTION

- › Currently no quantitative model available to assess exposure to NOAA
 - › Models available for assessing exposure to powders (in mg/m^3)
 - › Metric conversion tools can convert particle number concentration to mass concentration.
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- › **Objective:** to evaluate the performance of the ART model and the Stoffenmanager Nano 1.0 exposure model by using nano exposure measurement data



DATA SELECTION

- › Data availability vs. data quality
- › Contextual information for model input
- › Defined activities in the applicability domain of the model
- › Raw data available
- › Similar measurement strategy / Controlled environment
- › SMPS and APS measurement results available

- › Dumping powder (n=44)

- › Drop height
- › Moisture content
- › Three substances

	Al ₂ O ₃ (gamma)	SiO ₂ (amorphous)	TiO ₂ (anatase)
CAS number	1344-28-1	7631-86-9	1317-70-0
Average size diameter	20 nm	15 – 20 nm	10 – 25 nm
Purity	99.9 %	99.5 %	99.5 %
Bulk density	3.5– 3.9 g/cm ³	2.4 g/cm ³	3.9 g/cm ³
Moisture content	2.34 %	9.15 %	0.66 %



PERFORMANCE CHECK ART AND STM-N

- › Source receptor models
 - › Mechanistic approach

- › ART model
 - › www.advancedreachtool.com
 - › Mass concentration estimate (mg/m³)
 - › Developed for bulk materials

- › Stoffenmanager Nano 1.0
 - › www.stoffenmanager.nl
 - › Exposure banding
 - › Relative scoring



Stoffenmanager

Nano module 1.0

Stoffenmanager

Nano module



METRIC CONVERSION

- › Density assumed: bulk or 1 g/cm³
- › Assumed median size of bin range as particle diameter
- › Summation of SMPS and APS (background correction)
- › Assumed spherical particles

$$C_{mDp} = 10^{-12} \cdot \rho_p \cdot C_{Dp} \cdot \pi/6 \cdot d_{m/a}^3$$

Where

C_{mDp} = Mass concentration in mg/m³

ρ_p = particle density in g/cm³

C_{Dp} = Number concentration #/cm³

$d_{m/a}^3$ = particle diameter in nm

(Hinds, 1999)



METRIC CONVERSION RESULTS

Density=1	N	GM (mg/m ³)	GSD	Min (mg/m ³)	Max (mg/m ³)
Al ₂ O ₃	16	0.20	2.08	0.07	0.62
SiO ₂	12	2.69	2.85	0.35	13.39
TiO ₂	16	0.20	2.60	0.06	0.92

Bulk density	N	GM (mg/m ³)	GSD	Min (mg/m ³)	Max (mg/m ³)
Al ₂ O ₃	16	0.76	2.08	0.26	2.29
SiO ₂	12	6.50	2.85	0.84	32.40
TiO ₂	16	0.77	2.60	0.23	3.57



ANALYSIS

- › Analysis
 - › Plot measured concentration vs. model estimate
 - › Correlation (Spearman)
 - › (Relative) Bias
 - › Deviation from ART uncertainty factors

- › Sensitivity analysis
 - › Densities: Bulk density vs density = 1 g/cm³



ART ESTIMATES

- › Substance emission potential:
 - › Moisture content

- › Activity emission potential:
 - › Drop height

ART ADVANCED REACH TOOL

My Scenarios Science Support

Near Field Primary Emission Source — Activity Class

To which activity class does your activity belong?

Select Activity Class

- Impaction on contaminated solid objects ⓘ
- Handling of contaminated solid objects or paste ⓘ
- Spray application of powders ⓘ
- Movement and agitation of powders, granules or pelletised material ⓘ
- Transfer of powders, granules or pelletised material ⓘ
- Compressing of powders, granules or pelletised material ⓘ
- Fracturing of powders, granules or pelletised material ⓘ

Activity Subclass/Example Activities

Activity Class
Transfer of powders, granules or pelletised material

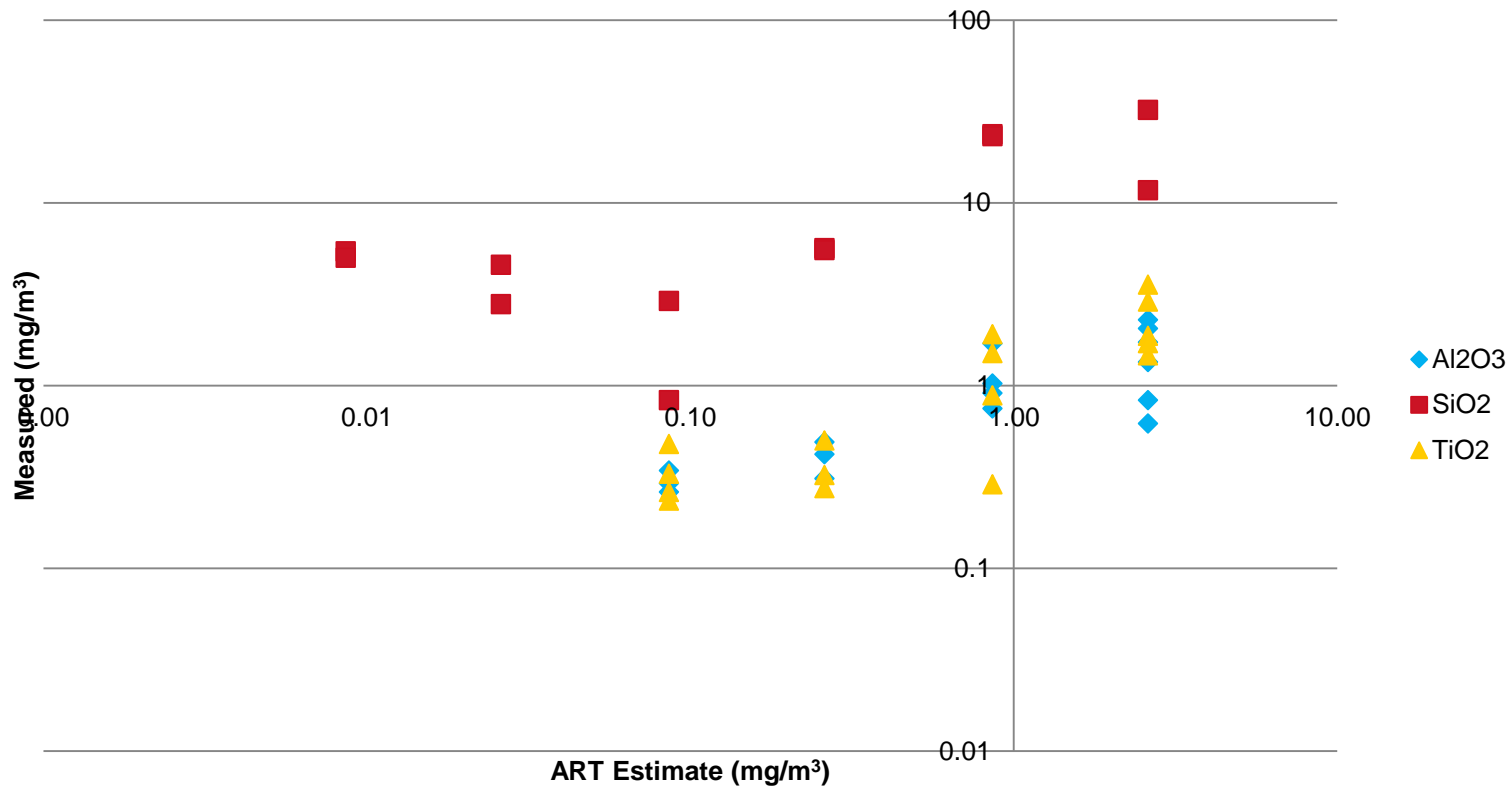
Activity Subclass

- Choose —
- Falling of powders, granules or pelletised material
- Vacuum transfer of powders, granules or pelletised material

Previous Next



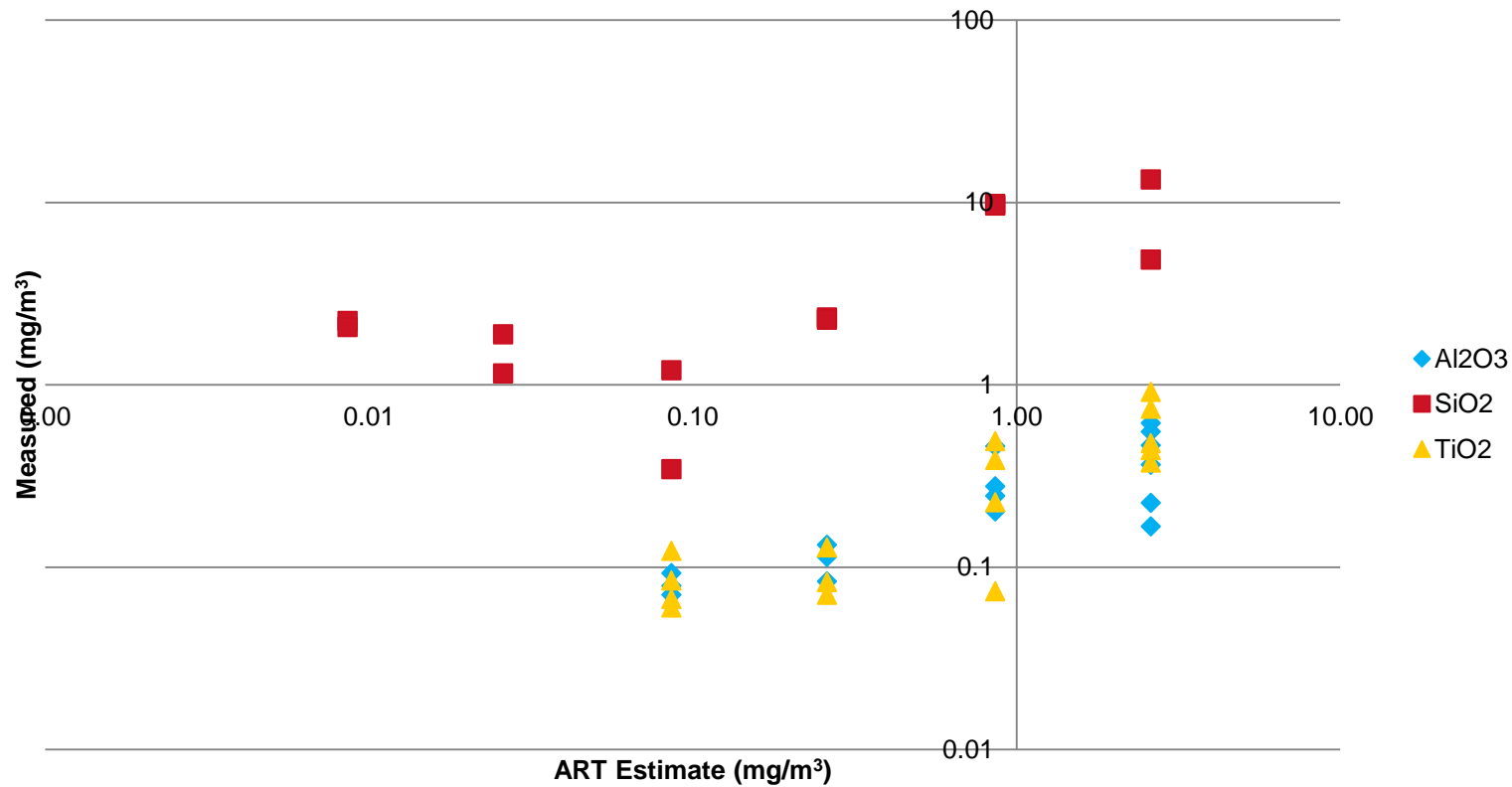
APS+SMPS Bulk density (ART)



Substance	Spearman	p-value	N
Al ₂ O ₃	0.83	<0.0001	16
SiO ₂	0.75	0.005	12
TiO ₂	0.81	0.0002	16
All	0.28	0.0663	44
Al ₂ O ₃ + TiO ₂	0.83	<0.0001	32



APS+SMPS dens=1 (ART)





ART EVALUATION

Bulk density

Substance	Relative Bias (%) (bias/GM*100%)	(Total) Bias	GM measured (mg/m ³)
Al ₂ O ₃	-10.7	-0.08	0.76
SiO ₂	-97.7	-6.35	6.50
TiO ₂	-29.2	-0.23	0.77

Substance	# in UF	%	Total
Al ₂ O ₃	16	100	16
SiO ₂	4	33.3	12
TiO ₂	15	93.8	16
All	35	79.6	44
Al ₂ O ₃ + TiO ₂	31	96.9	32

Density = 1

Substance	Relative Bias (%) (bias/GM*100%)	(Total) Bias	GM measured (mg/m ³)
Al ₂ O ₃	230.2	0.47	0.20
SiO ₂	-94.4	-2.54	2.69
TiO ₂	176.1	0.35	0.20

Substance	# in UF	%	Total
Al ₂ O ₃	11	68.8	16
SiO ₂	6	50.0	12
TiO ₂	12	75.0	16
All	29	65.9	44
Al ₂ O ₃ + TiO ₂	23	71.9	32



STM-N ESTIMATES

- › Only one variable of variation
 - › Moisture content
- › Relative STM-N Multiplier used
 - › No quantitative estimate
 - › Only rank correlation
 - › No bias calculation possible

Edit risk assessment

+ Explanation

+ Step 1: General

+ Step 2: Product characteristics

▾ Step 3: Handling / Process

i Characterize your task * Handling of products with medium speed or force, which leads to some dispersion of dust ▾

i Duration task: * 4 to 8 hours a day ▾

i Frequency task: * 4 to 5 days a week ▾

i Is the task being carried out in the breathing zone of an employee (distance head-product <1 meter)? *

Yes No

Please note: because you selected 'yes', the option 'the employee does not work in a cabin' was automatically selected at step 5. If however you do want to select a cabin, than select 'no' for this question.

i Is there more than one employee carrying out the same task simultaneously? *

Yes No

+ Step 4: Working area

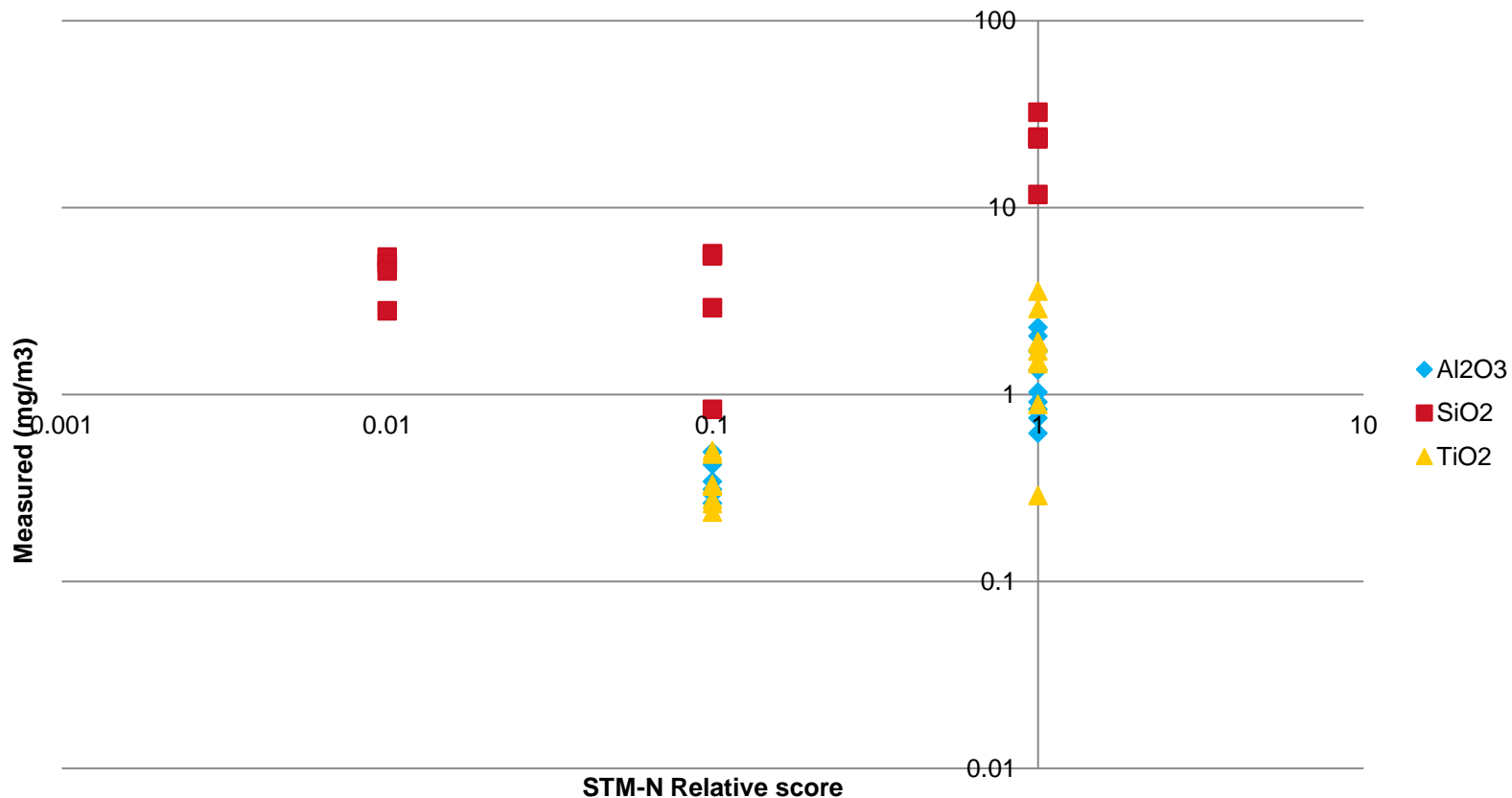
+ Step 5: Local control measures and personal protective equipment

+ Step 6: Risk assessment

Save Close



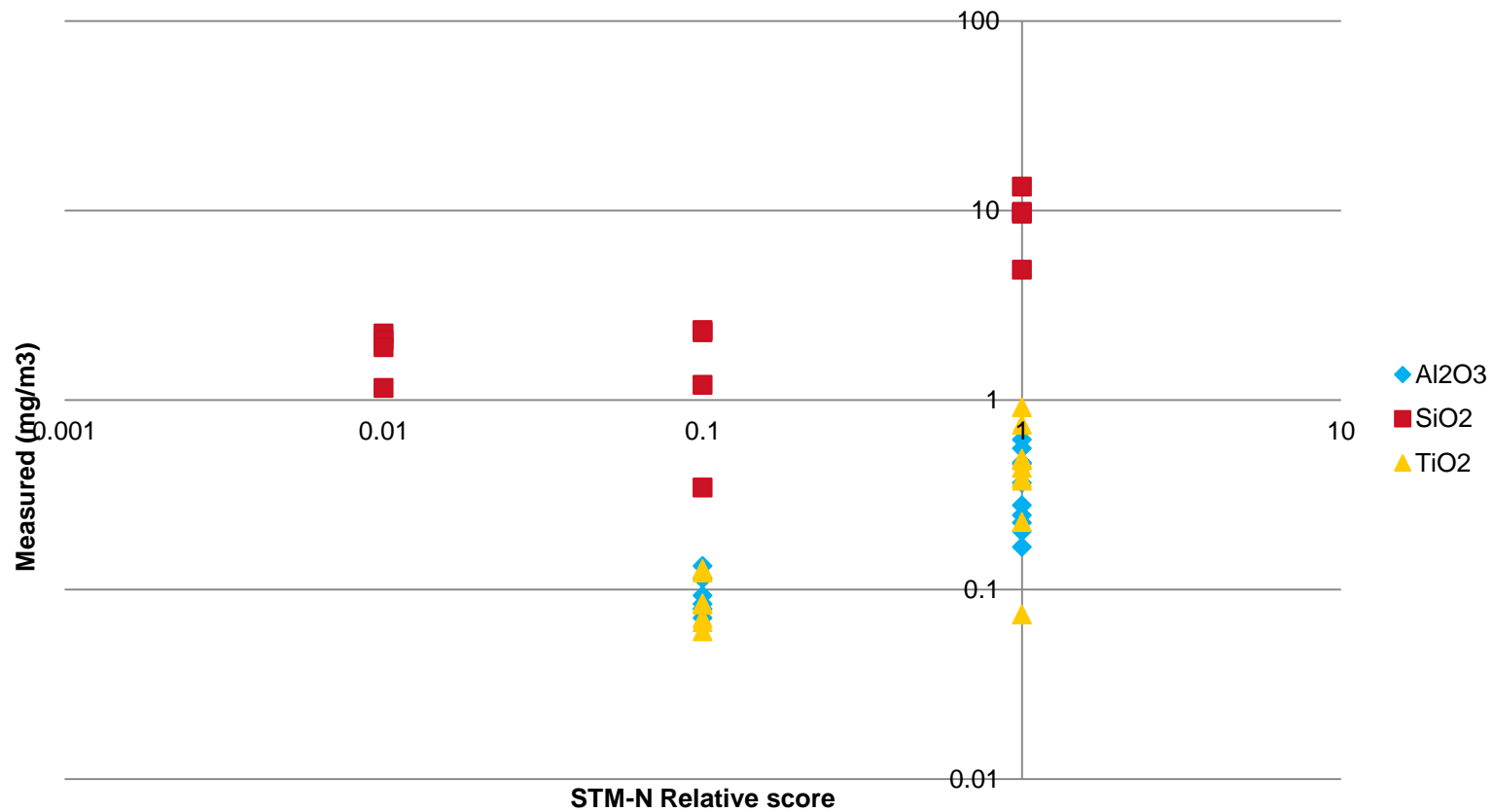
APS+SMPS Bulk density (STMn 1.0)



Substance	Spearman	p-value	N
Al ₂ O ₃	0.84	<0.0001	16
SiO ₂	0.74	0.006	12
TiO ₂	0.75	0.0008	16
All	0.23	0.14	44
Al ₂ O ₃ + TiO ₂	0.80	<0.0001	32



APS+SMPS density = 1 (STMn 1.0)





CONCLUSIONS

- › Mass-based model assessments correlate reasonably well with converted nano particle number concentration data (for 2 out of 3 nanomaterials)
- › Correlation different for different nanomaterials
- › Metric conversion from particle number to mass seems to result in reliable estimates
- › Similar pattern for bulk density and density = 1, but different bias
- › More variation in exposure scenarios needed



DISCUSSION

- › Limited number of exposure scenarios
 - › Limited to powder dumping scenario

- › Only controlled environment
 - › More workplace data needed for more variation

- › Metric conversion introduces uncertainty
 - › Particle shape and diameter assumption



**THANK YOU FOR
YOUR ATTENTION**

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