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Technologie-orientierte Partikel-, Analysen- und Sensortechnik

Instrumentation and validation of solid aerosol testing technologies

Topas GmbH

Dipl.-Ing. D. Konzack

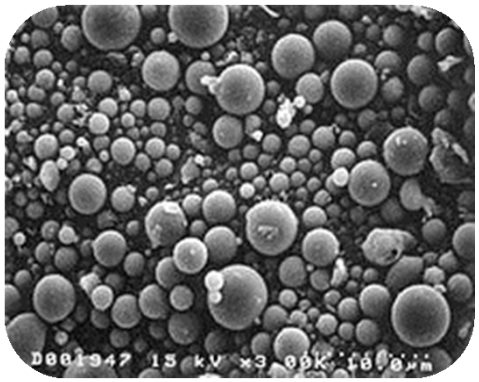
Dr.-Ing. R. Adam

Topas GmbH
Oskar-Röder-Straße 12 - 01237 Dresden
Germany

Web: www.topas-gmbh.de
Mail: office@topas-gmbh.de
Tel: +49-(0)-351-216643-0

Instrumentation and validation of solid aerosol testing technologies

- Why testing with solid aerosols?
- From nature to laboratory – ease natural process
  - Formation
  - Transportation
  - Deposition
- Example of solid aerosol testing for general air filters



Pic. 1: Flyash, SEM view

Pic. 2: Sand storm in Texas

Why testing with solid aerosols

- Adherence of solid aerosols **is desired**
  - Filtration

Pic. 3 - 5

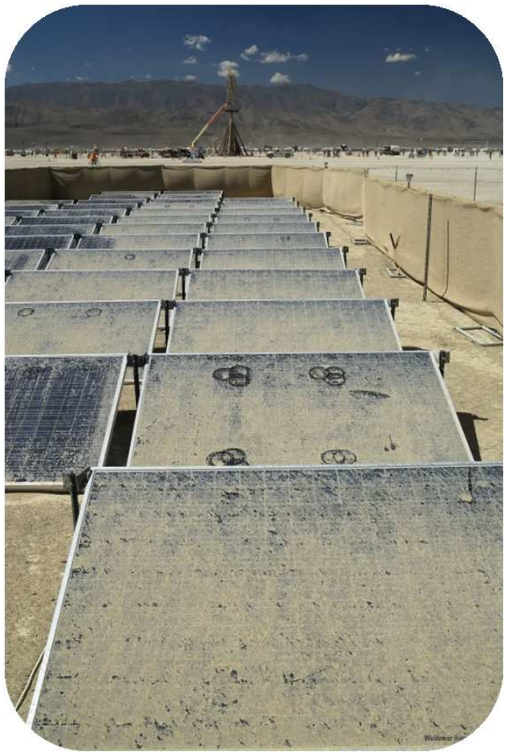
  - Powder coating

Pic. 6 - 10

Why testing with solid aerosols

- Adherence of solid aerosols **is not desired**
  - Glass surfaces that should be allways transparent or are difficult to clean

Pic. 11 - 13



Pic. 14

From nature to laboratory – ease natural process

Solid aerosol process in nature

formation

↓

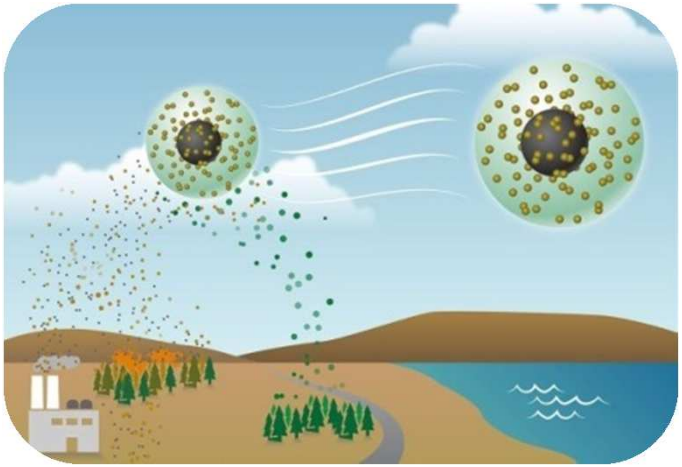
transportation

↓

deposition

From nature to laboratory – ease natural process

Nature



Pic. 15

- Drying salt water droplets
- Fires and combustion
- Swirling dust
- Biological emissions

formation

transportation

deposition

Laboratory

Pic. 16: ToPAS SAG 410

- Creating and drying salt water droplets
- Burning gas
- Disperse solid or biological material

From nature to laboratory – ease natural process

Nature

- Transportation by wind and water

Pic. 17 - 18

formation

transportation

deposition

Laboratory

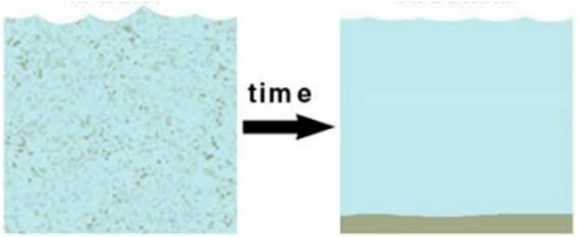
- Transportation by turbulent air streams in tubes and pipes

Pic. 19 - 20

From nature to laboratory – ease natural process

Nature

- By electrostatic
- By washing out from rain
- By sedimentation



Pic. 21 - 23

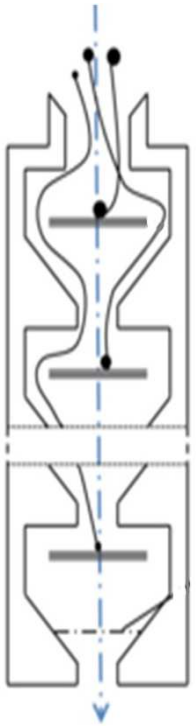
formation

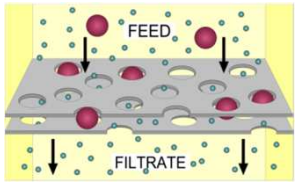
transportation

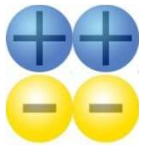
deposition

Laboratory

- By impaction
- By filtration
- By washing
- By sedimentation







Pic. 24 - 27

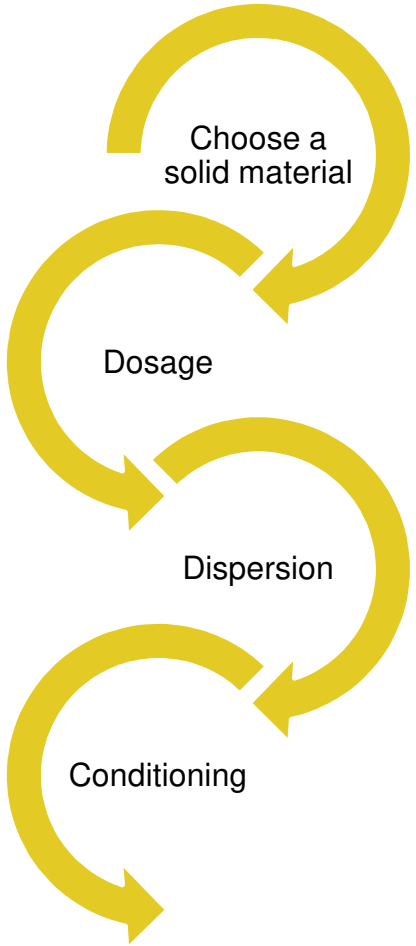
Producing a test aerosol

formation

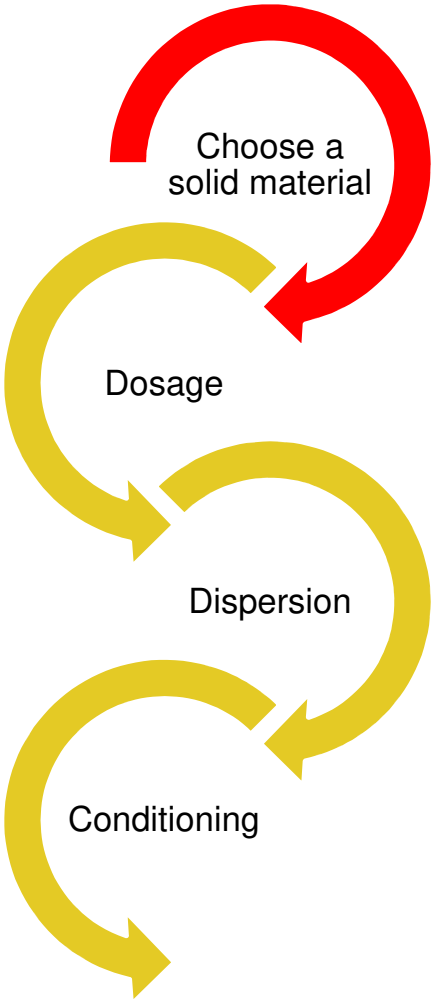
transportation

deposition

- Creating a test aerosol contains a lot of error potential
- Always the same sub processes

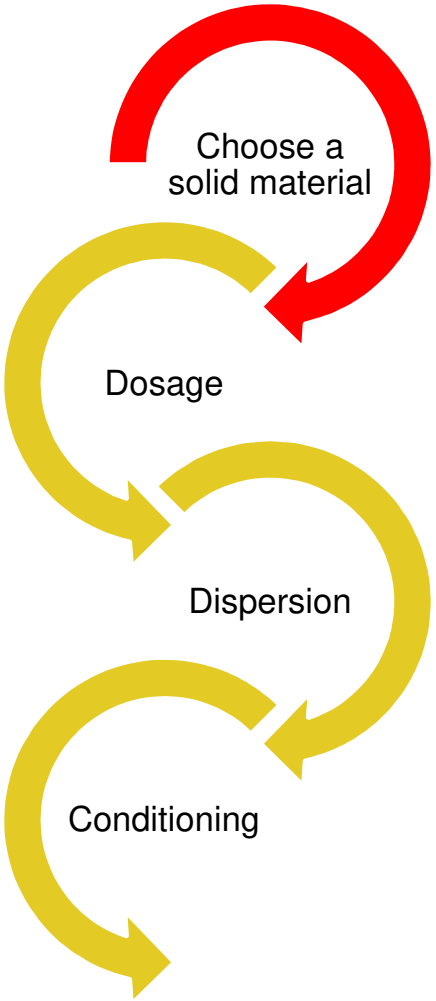


Producing a test aerosol - Choose the right solid material



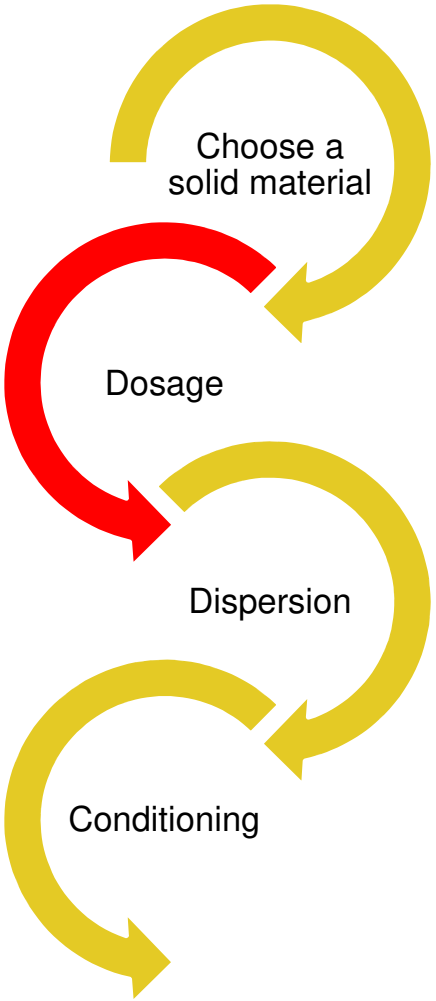
- Solid aerosols gets created out of a powders
- Powder parameters determine aerosol behavior e.g.: fluidity of a powder
- Aerosol behavior have to match natural aerosol characteristics
  - Particle size distribution (PSD)
  - Chemical composition
  - Functional parameters (e.g. particle density, colour, refractive index)
- Reproducable quality and low price

Producing a test aerosol - Choose the right solid material



- It is possible to collect natural solid aerosols (e.g. by filtration) and to re-disperse them
  - Well suited for complex, unique mixtures of different powders
    e.g. natural dusts
  - For comparison to artificial powders
- Resulting re-dispersed aerosol must be compared with the starting natural aerosol
  - Particle losses during collection / re-dispersion are possible

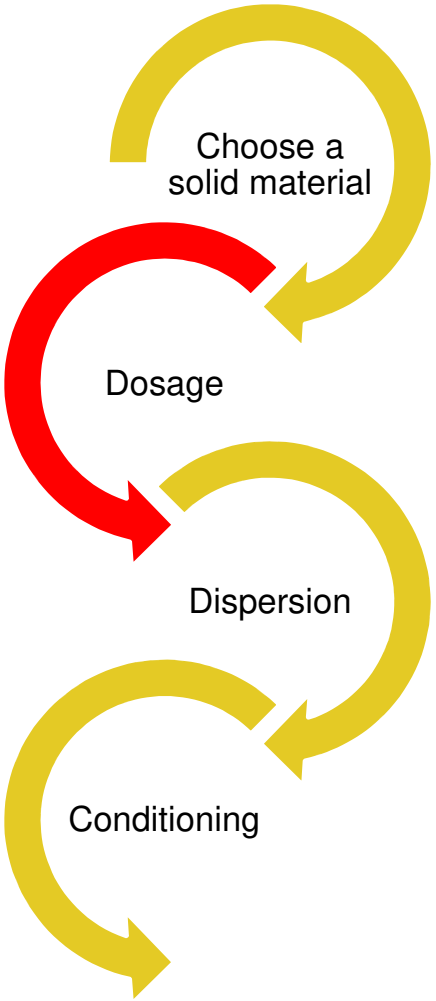
Producing a test aerosol - Dose the solid material



- Different material ⟷ different solutions
- Standardized in VDI 3491 Blatt 3:2015-10

- Important application parameters:
  - Massflow, batch or continiously, continuity of dosing
- Important material parameters
  - Density, flowability of a solid, compacting, …

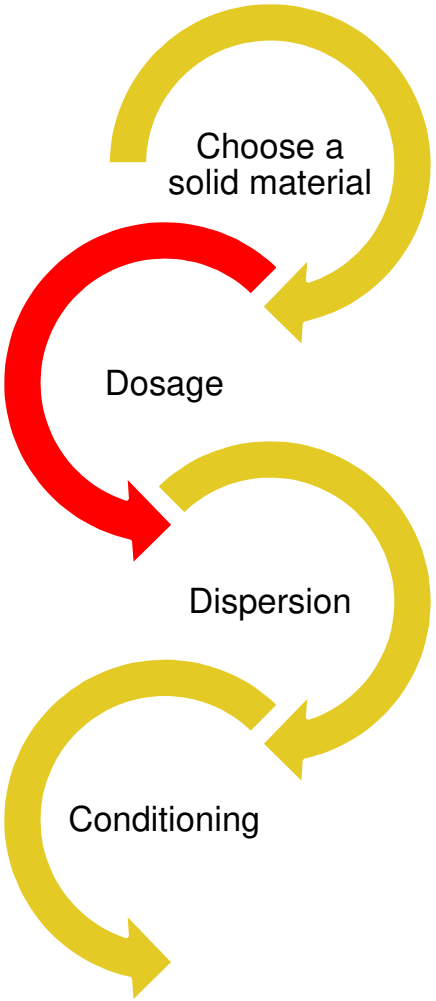
Producing a test aerosol - Dose the solid material



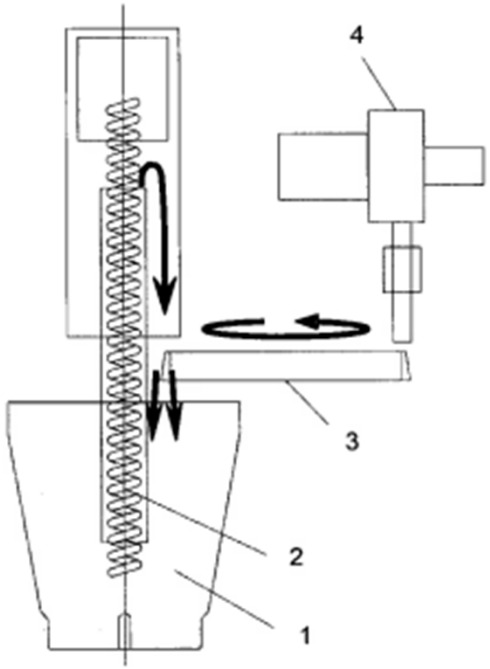
- Some examples for implemetation
  - Vibration feeder

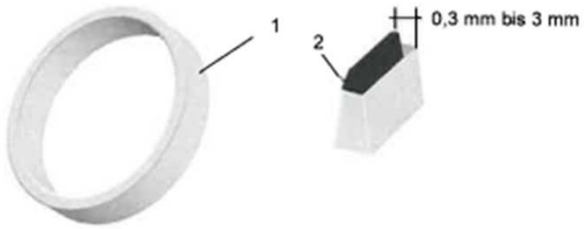
Pic. 28: VDI 3491 Blatt 3:2015-10 - Entwurf

Producing a test aerosol - Dose the solid material



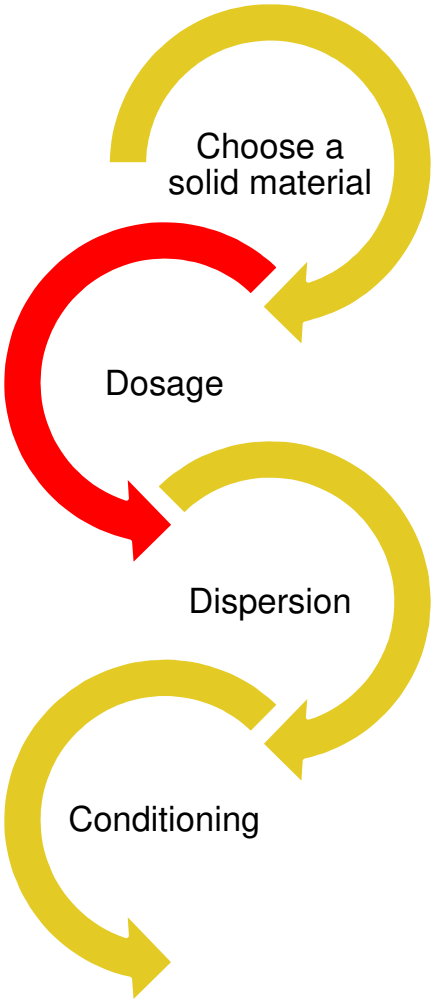
- Some examples for implemetation
  - Continuous material string



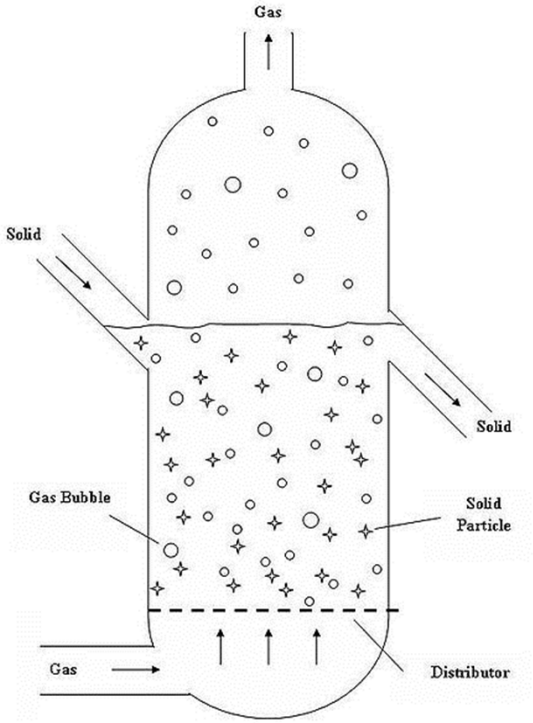


Pic. 29: VDI 3491 Blatt 3:2015-10 - Entwurf

Producing a test aerosol - Dose the solid material

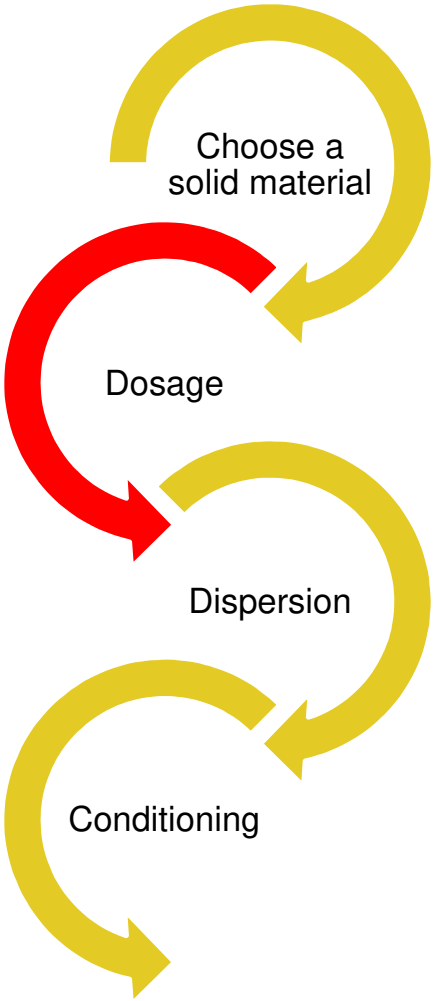


- Some examples for implemetation
  - Fluidised bed

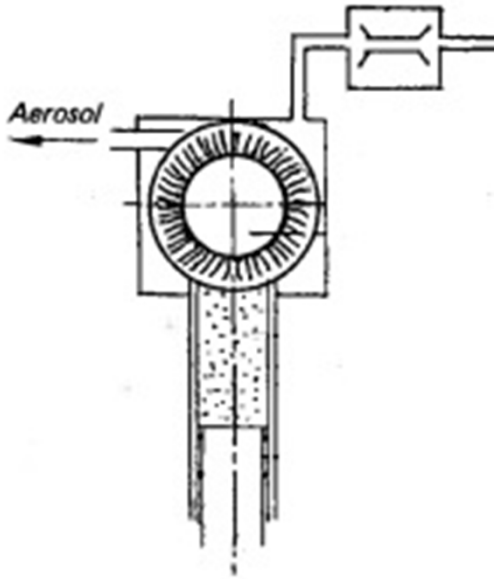


Pic. 30

Producing a test aerosol - Dose the solid material

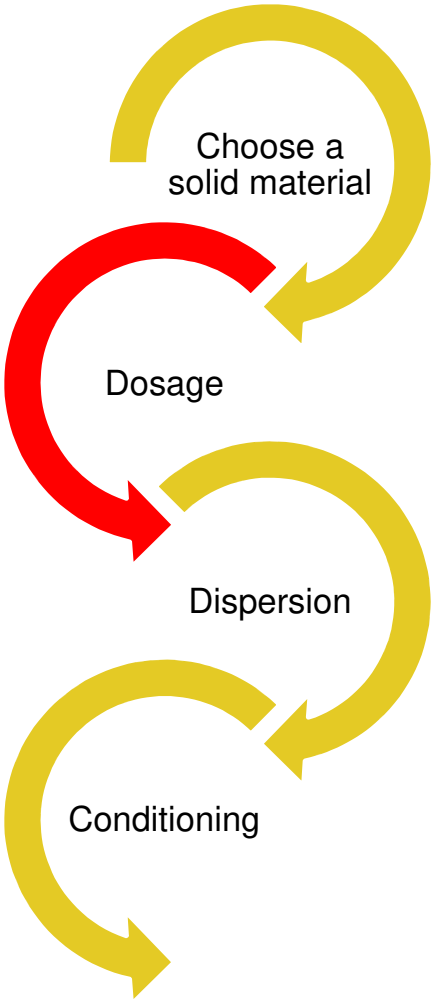


- Some examples for implemetation
  - Press a string out of a volume

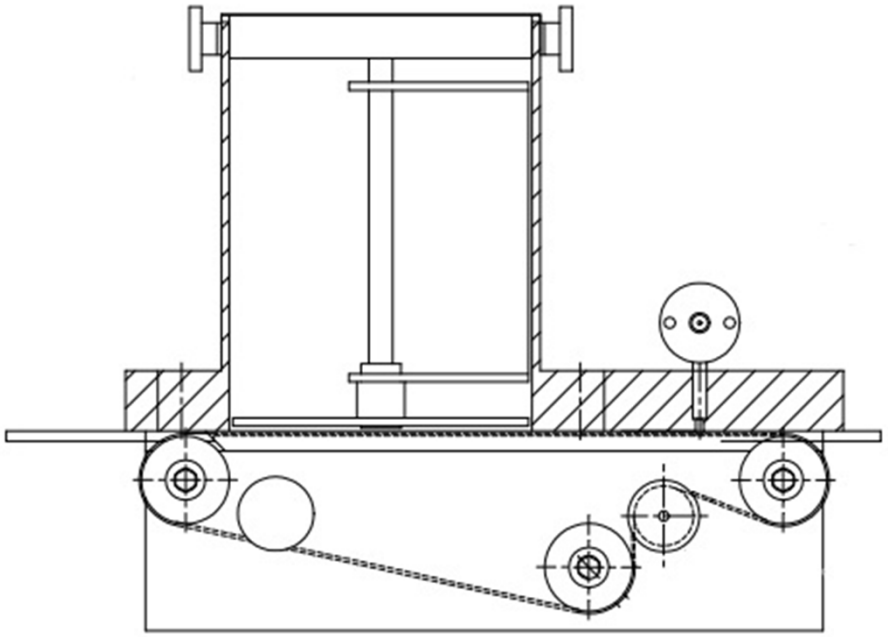


Pic. 31: VDI 3491 Blatt 3:2015-10 - Entwurf

Producing a test aerosol - Dose the solid material

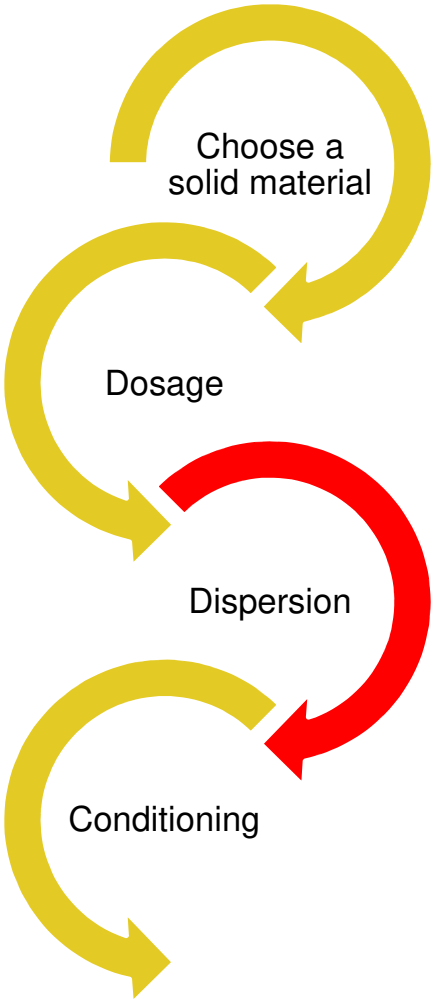


- Some examples for implemetation
  - Filling defined Volumes

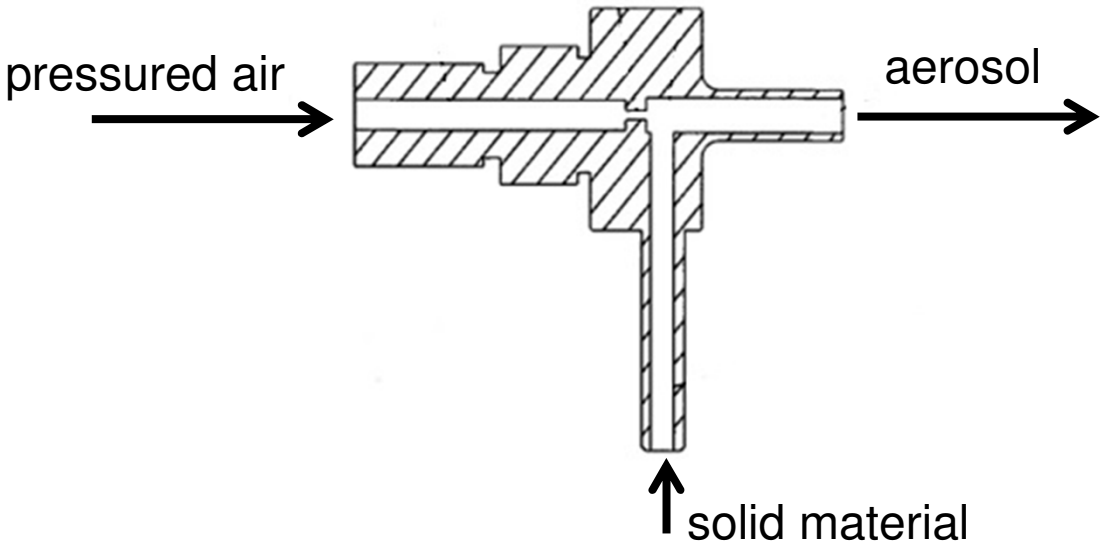


Pic. 32: VDI 3491 Blatt 3:2015-10 - Entwurf

Producing a test aerosol - Disperse dosed solid material

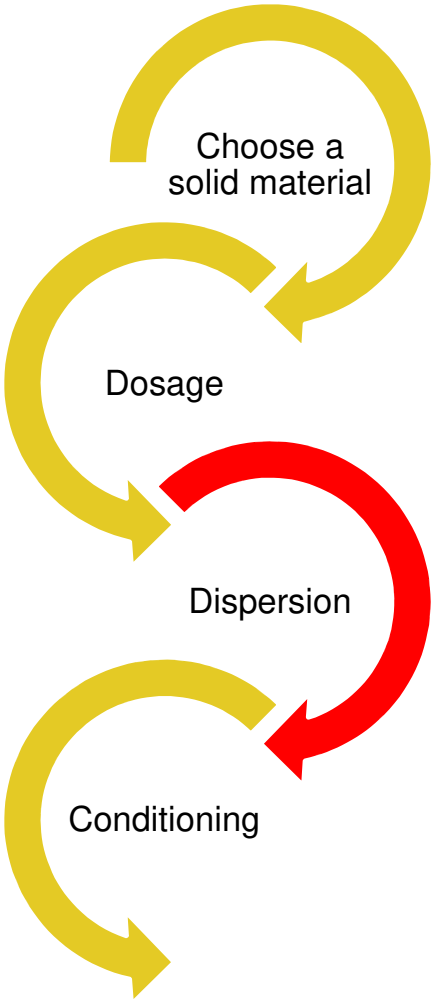


- Solid material could be dispersed in a air jet produced by a nozzle
- Indruduced energy can crack up agglomerates



Pic. 33: VDI 3491 Blatt 3:2015-10 - Entwurf

Producing a test aerosol - Disperse dosed solid material



- Solid material could be dispersed in a air jet produced by a nozzle
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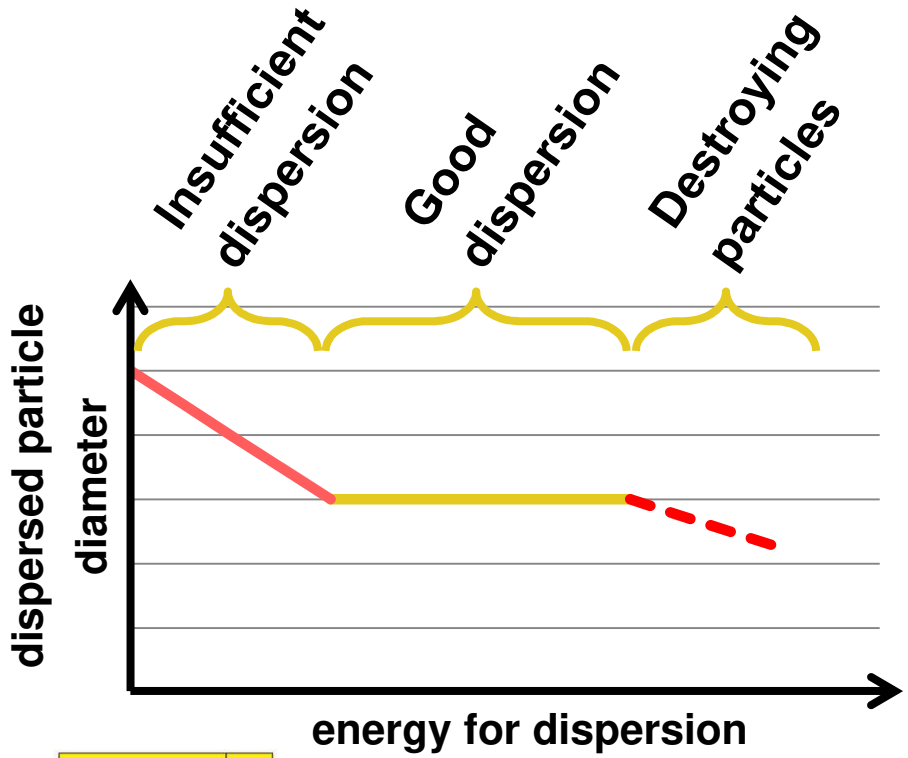
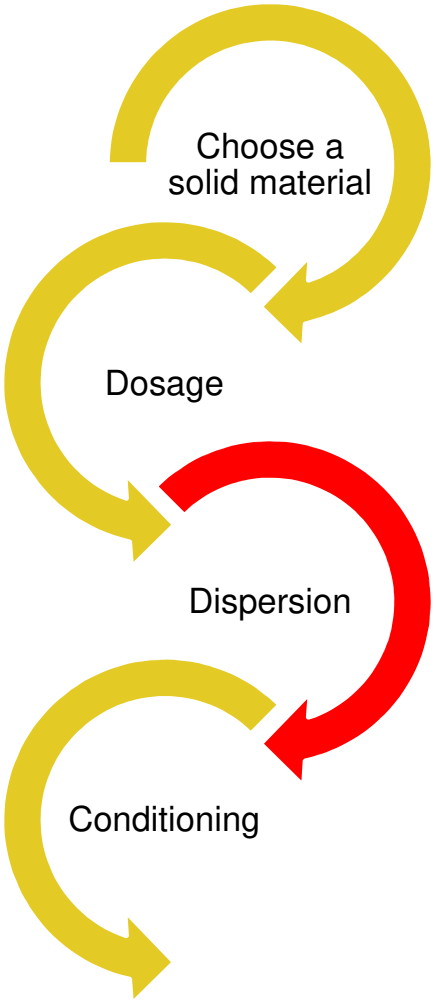


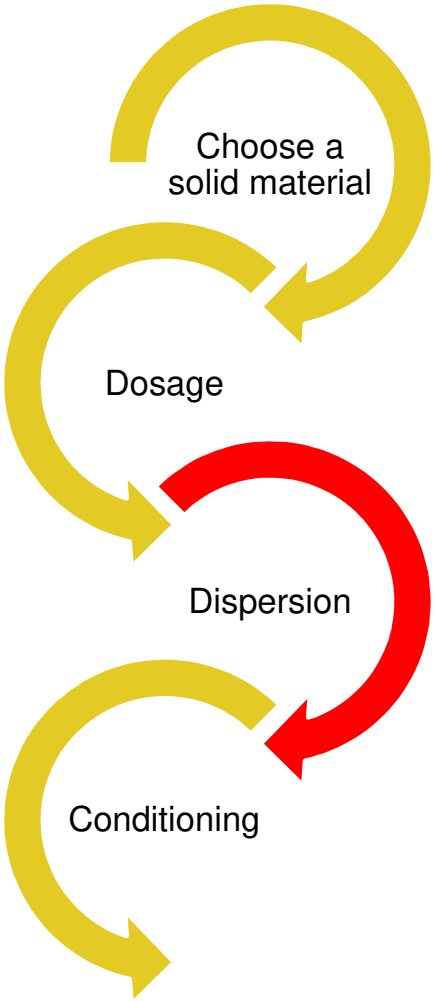
Producing a test aerosol - Disperse dosed solid material



- Indruduced energy could cause some damage
  - Accelareted particles, especially mineral powders, could be very abrasive
  - Care for material combinations

Pic. 34: stainless steel tube damaged by a mineral aerosols

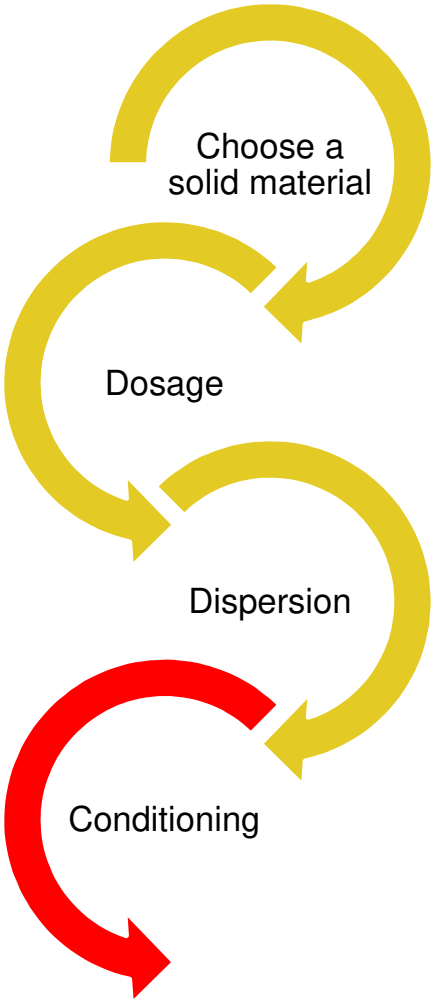
Producing a test aerosol - Disperse dosed solid material



- Indruduced energy could cause some damage
  - Accelareted particles, especially mineral powders, could be very abrasive
  - Care for material combinations

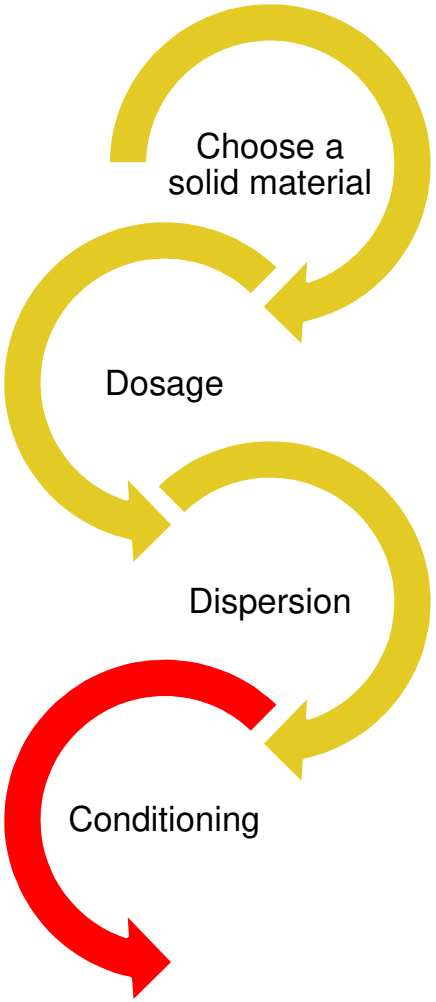
Pic. 35: TOPAS ceramics inlay for dispersing nozzles

Producing a test aerosol - Contitioning the aerosol



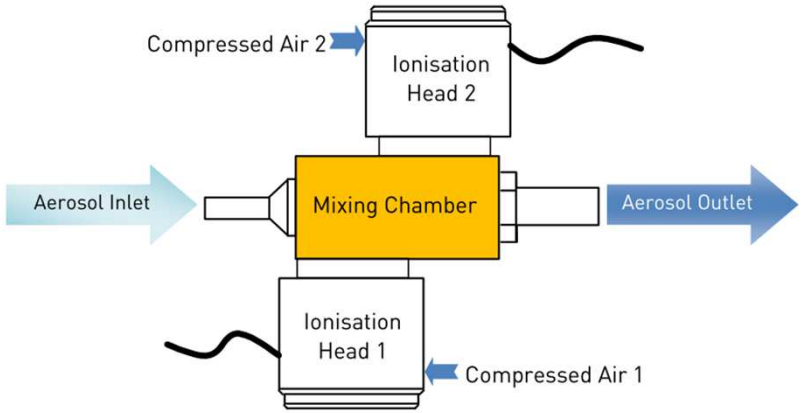
- Conditioning to act like a natural aerosol
  - Dilute the aerosol
  - Reach a target temperature or humidity
  - Accelerate to a target flow rate
- Correct effects of the dispersion
  - High electric charging possible due to fast dispersion (static electricity)
  - Neutralizers could bring the aerosol back to charge equilibrium

Producing a test aerosol - Contitioning the aerosol



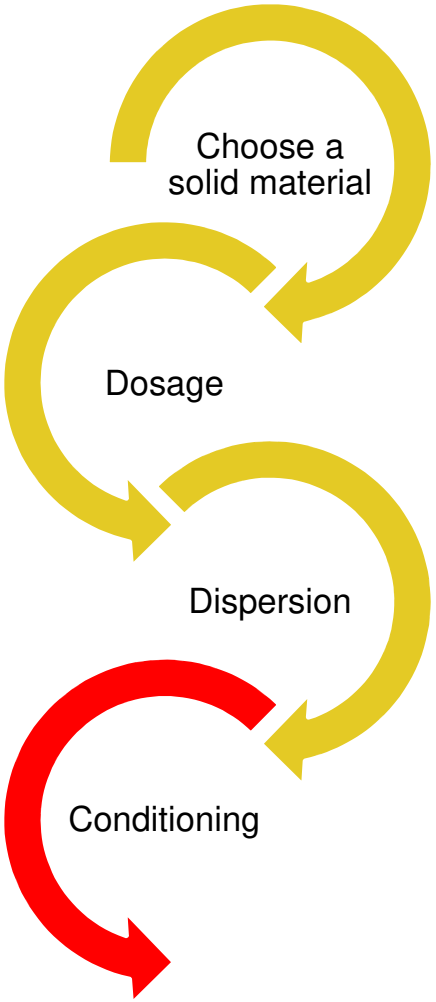
- 3 ways to neutralize
  - With radiation sources
  - With X-ray emission
  - With bipolar corona discharge

Pic. 36



Pic. 37: Schema of bipolar corona neutralisation

Producing a test aerosol - Contitioning the aerosol



- Charge level and polarity of natural aerosols are mostly unknown
- Possible to measure charge level on site using field mills
- Produced aerosols could be charged to meet natural aerosol behavior
  - Bipolar corona discharger can charge aerosols using different proportions of negative and positive ions

Transportation of a test aerosol

formation

transportation

deposition

- Aerosols gets transportet by air streams
- Turbulent conditions keeps the aerosol homogeneous
- Physical effects and disturbances interact with the aerosol
  e.g.: separation by density, heat, flow rate,…
- Homogeneity could be lost in dead zones

Deposition of a test aerosol

formation

transportation

deposition

- Deposition by electrostatic, washing or filtration
- Easy because gas phase can flow nearly free while only particles gets manipulated

- Separation by Sedimentation may requires more constructive effort
- A VDI standardization group is currently in action to examine how a sedimentation process can be implemented reproducibly

Example of solid aerosol testing for general air filters

- ToPAS ALF 114 for general air filter test
- See DIN EN ISO 16890: Air filters for general ventilation

Air conditioning → Formation → Transportation → Deposition (and measurement) → Filtration & Exhaust

Pic. 38: ToPAS ALF 114

Image sources

Pic 1: found at 24.10.2017 on http://www.fhwa.dot.gov/PAVEMENT/recycling/fach01.cfm

Pic 2: found at 24.10.2017 on https://en.wikipedia.org/wiki/Dust_Bowl#/media/File:Dust-storm-Texas-1935.png

Pic 3: found at 24.10.2017 on https://upload.wikimedia.org/wikipedia/commons/c/cf/Heizkraftwerk-2005-10-18.JPG

Pic 4: found at 24.10.2017 on https://upload.wikimedia.org/wikipedia/commons/2/22/Taschenfilter_Fein.jpg

Pic 5: found at 24.10.2017 on https://i0.web.de/image/060/17295060,pd=5/partikel-dieselruss-filterfaser.jpg

Pic 6: found at 24.10.2017 on https://upload.wikimedia.org/wikipedia/commons/thumb/8/8a/Blasted_then_powder_coated_before_and_after_from_York_Powder_Coating.jpg/281px-Blasted_then_powder_coated_before_and_after_from_York_Powder_Coating.jpg

Pic 7: found at 24.10.2017 on http://www.picserver.org/pictures/curry-powder02-lg.jpg

Pic 8: found at 24.10.2017 on https://de.wikipedia.org/wiki/Datei:Pistolenvergleich.jpg

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Pic 18: Microsoft Office Clipart File j0293828.wmf

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Pic 30: found at 24.10.2017 on https://commons.wikimedia.org/wiki/File:Fluidized_Bed_Reactor_Graphic.JPG

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Thank you for your attention!

Vielen Dank für Ihre Aufmerksamkeit!

Topas GmbH www.topas-gmbh.de

Oskar-Röder-Straße 12 | 01237 Dresden office@topas-gmbh.de

Germany +49-(0)-351-216643-0