Issues with particulate sampling - an update

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Overview

- A short story, maybe a cautionary tale..

- What we've been up to …and why
- A little study on filter losses
- What will we do next ?
- Other problems we wish we'd never got involved in

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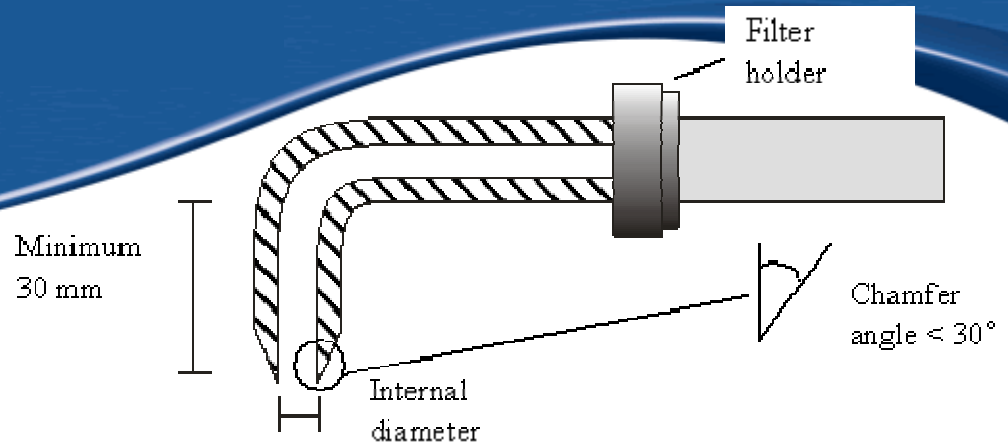
Why we started this



- We have a slight problem regarding sampling nozzles
- The European standard for low dust EN 13284-1, specifies certain requirements on nozzles
- Some were validated during the development of the standard – but a number of types used in the UK were not
- So we thought – let's do a simple project to validate the UK nozzles and all will be well

Like so many of Dave and my hair-brained schemes ……. It seemed such a good idea at the time

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EN 13284-1 - Low dust standard

- < 50 mg/m3 at standard conditions
- In-stack or out-stack
- Method validated around 5 mg/m3
- Average half hour sampling time
- LOD approximately 0,3 mg/m3
- Filter weighing procedure
  - Oven/desiccator conditioning
- Used for CEM calibration

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Joint Industry Project Background

- Small scale project funded from UK Govt JIP funds
- Involved NPL, STA, with the support of a number of stack testing teams, equipment suppliers, manufacturers and plant operators
- Field study to compare UK nozzles alongside validated nozzles.
- Work carried out at a cement plant – low dust regime

I should have known things were not going to go to plan when the plant was struck by lightning

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Field testing of the nozzles

- Four teams monitored over a three day period, 9 test runs
- All filters weighed by the same laboratory (CES)

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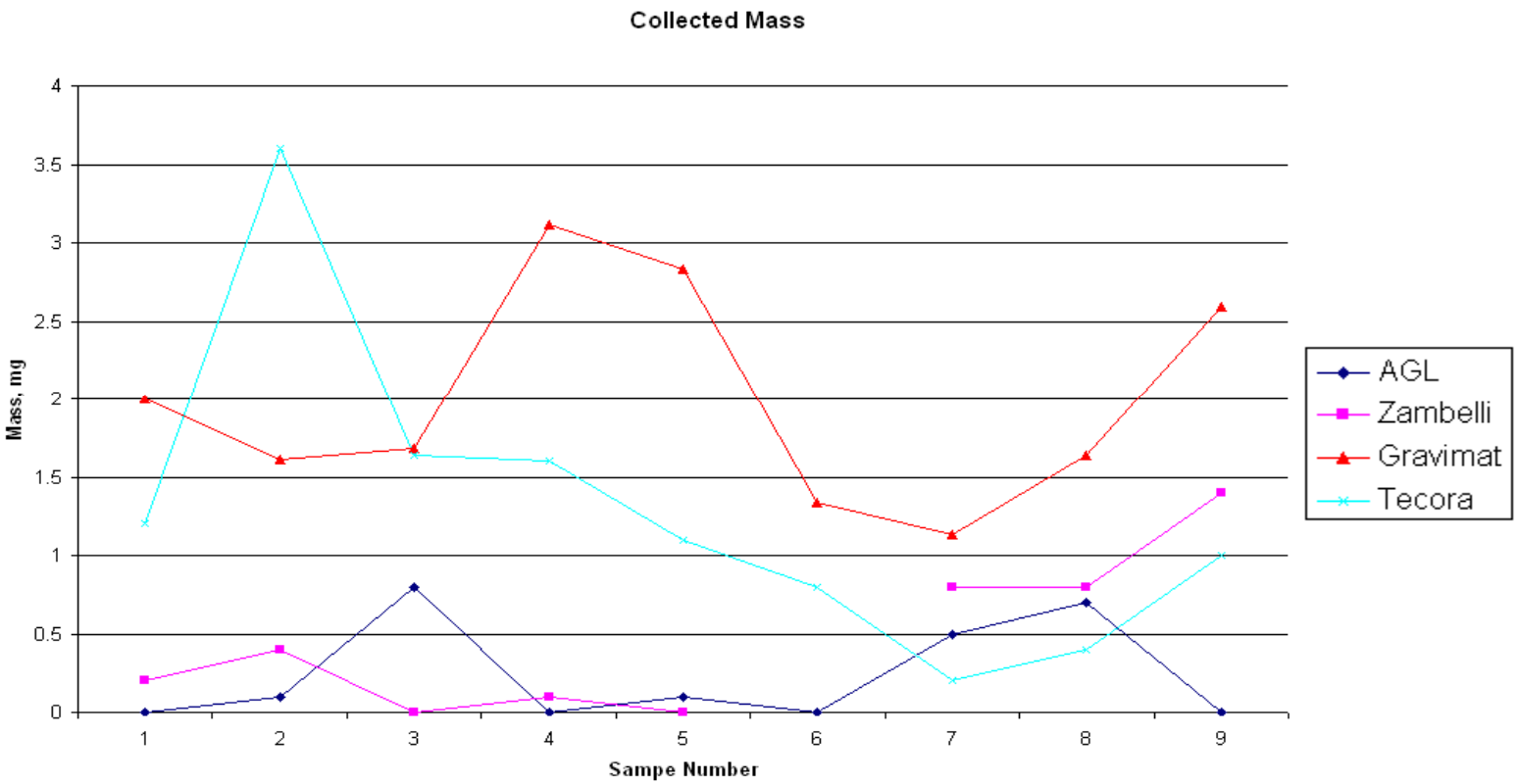
Results of the field tests



- Not very good correlations, to say the least
- Issues observed with filter handling on site
- Some tests had negative weight gain

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Initial investigation of filters

- Project plan changed to investigate filters and filter holder performance
- Set of different filter types and filter holders tested at NPL
- All filters/holders compliant with standard but designs very different
- Used particulate free air from the NPL stack simulator

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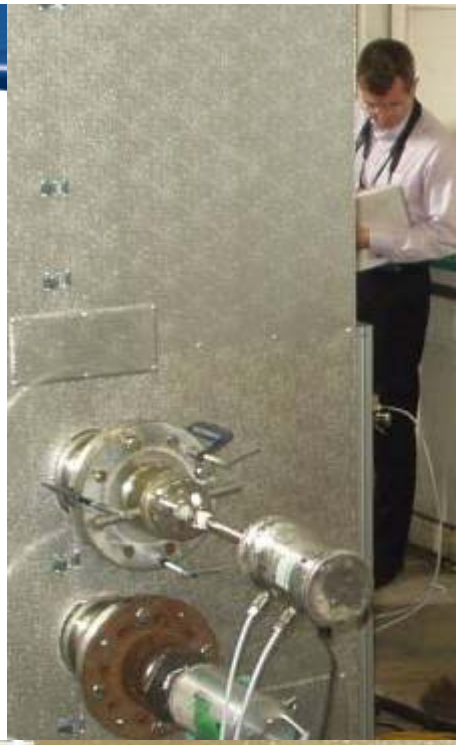
Small digression - Stack Simulator

- Simulates stack conditions, with up to four teams sampling through standard ports.
- Two 1.5m path lengths for cross stack instruments
- Recirculating design
- Gas conditions
  - Water vapour 25% by volume
  - Gas velocity up to 10 m/s
  - Controllable pressure
  - 180 C
  - Controllable range of gas mixtures, including low oxygen combustion gases
- Concentrations referenced using FTIR
- Particulates next



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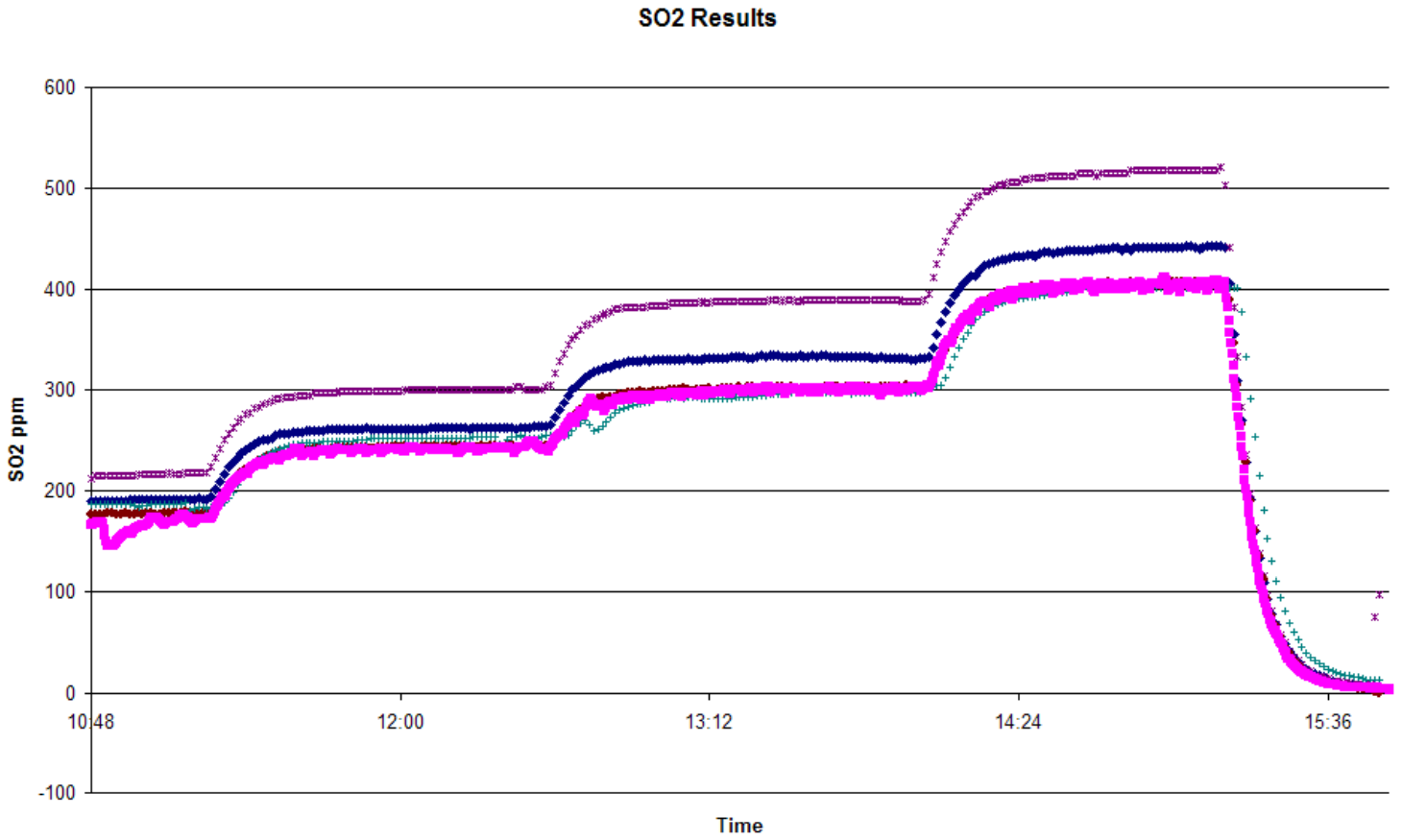
Example Results from Simulator

- Example of results from a trial of a proficiency testing scheme



Back to the filter tests

- Tested quartz fibre and glass fibre 47 mm filters.
- 3 filter holder designs

From simulator

Example results

Quartz fibre filters

	Mass change mg
Loss from these filters	-0.29
	-0.14
	-0.26
	-0.27
Average loss from QF	- 0.24 +/- 0.065 mg
Collected here	0.21
	0.20
	0.19
	0.21
Average loss from GF	+ 0.20 +/- 0.010 mg

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Conclusion from initial study

- On average 0.3 to 0.6 mg of filter material is lost within first 10 minutes of testing
  - This can easily be 10 to 40 % of the collected dust
- Appeared that this was caused by loose material being lost during the initial few minutes of testing
- Further work was proposed to investigate the losses
- Reports from particulate monitor manufacturers on the performance of manual sampling supported the findings
- Additional tests by CES also found ~ 0.6 mg losses

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The second set of projects

- Defined a two stage project to clear up the issue
- Funded by Environment Agency for England and Wales
- Series of lab tests at NPL to understand the issues
- Definition of a pre-conditioning phase to remove loose material
- Programme of testing at a particulate wind tunnel to demonstrate effect of pre-conditioning

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Lab testing

- Tested three 47mm filter types
  - Two types quartz fibre filters
  - One laser cut
- PTFE filters used as control
- Five filter holders (in-stack)
  - Quantitech (TCR Tecora)
  - AGL Airtesting (Millennium)
  - Westech (APEX)
  - JS Holdings (x2) –two types of backing plate

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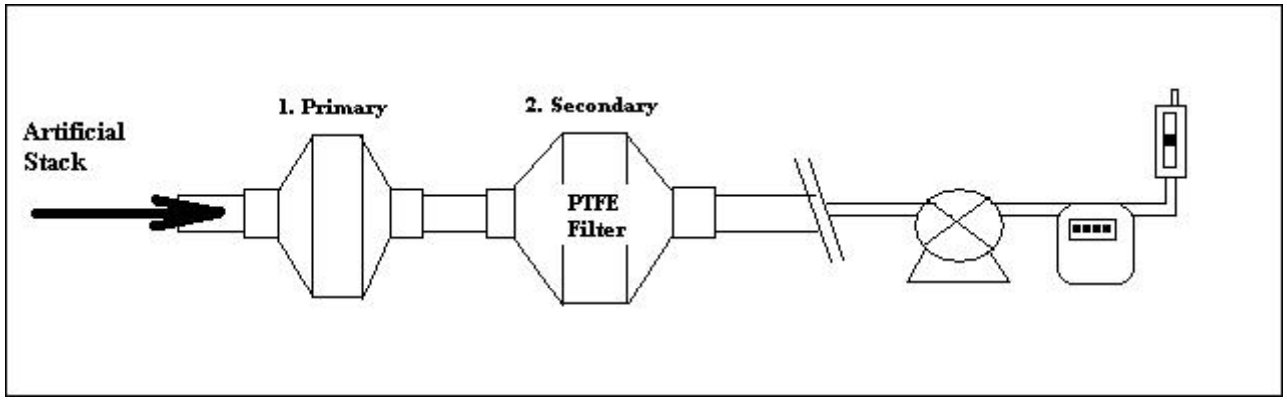
Lab testing

- Test plan addressed effect of filters/filter holders
  - Effect of pre-conditioning
  - Effect of leak test
  - Filter handling
  - Flow rate
- More than 200 filters tested and weighed



Results of lab testing

- Losses were seen with all combinations of filter and filter holder, on average ~ 0.3 to 0.6 mg loss
- Largest losses seen with mechanical damage to laser cut filters ~ 1.3 mg loss
- PTFE filters allowed identification of filter loss vs mechanical damage
- Pre-conditioning does help, but completely
- Very strange results seen with tests of the effect of the leak test procedure
- Using a higher flow rate doesn’t cause higher loss

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Wind Tunnel Testing

- Set of tests using four trains and two instruments on a particulate wind tunnel facility at UK Health Safety Lab
  - 2 x Andersen USEPA M5/M17 Sample system
  - 1 x Millennium USEPA M5/M17 Sample system Supplied by AGL Airtesting
  - 1 x Forward scatter dust monitor (PCME)
  - 1 x Light scatter dust monitor (Land)
  - 1 x Gravimat automatic sampler (CES)
- 40 off 47mm filters supplied by Whatman, conditioned in two ways by NPL;
- 20 x Filter condition to BS EN 13284 weighing procedure
- 20 x Filters conditioned to a modified version of BS EN 13284 weighing procedure

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Wind tunnel tests

- 12 tests with three M5/M17 USEPA Sample systems one Gravimat automatic sampler, one PCME forward light scatter monitor and one Land light scatter monitor.
- Tunnel set @ 10m/sec, with 1, 3, 10 mg/m3
- Unit 1 (Andersen) Set @ 20 l/m using AGL filter holder and support 596 holes @ 0.5mm.
- Unit 2 (Andersen) Set @ 20 l/m using JSH filter holder and support 96 holes @ 4mm.
- Unit 3 (Millennium) Set @ 40lpm using Westech filter holder and support 596 holes @0.5mm.
- Gravimat (sick) Set @ 20lpm using sintered Gravimat filter holder.

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Results of wind tunnel filter study

- Still assessing results but some conclusions can be drawn
  - Good agreement between instrumental methods
  - Some confusing results from the manual tests
  - Higher flow rate sampling (not surprisingly) gave better results

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Comments

- Most effective improvement will be to increase flow rate, leading to collection of greater mass –
  - Currently the standard only gives criteria based on weighing uncertainties
- Filter holder design should be standardised
  - Including choice of backing
- Filter handling greatest cause of loss, due to mechanical damage
  - Examine use of filter cartridges – where complete unit is weighed
- Should we even be trying to quantify dust at very low levels ?

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Acknowledgements

- Environment Agency and DTI for funding
- STA, D Curtis and S Medhurst
- Support in kind for the first project, as staff time, provision of services and access to site was provided by:
  - Source Testing Association
  - CES EI – who carried out grvimat testing and performed all weighing for initial field tests
  - Lafarge Cement – for provision of support on site
  - Redwing Environmental
- And we are grateful for following suppliers for loan of equipment and supply of filters
  - Quantitech
  - TCR Tecora
  - AGL/Millennium (USA)
  - Apex
  - Zambelli
  - Westech
  - Sick Maihak
  - Whatman
- The Companies and personnell involved in the second wind tunnel project are:
  - Environment Agency: Rupert Standring
  - AEA Technology: Alan Leonard
  - Health and safety Laboratory's: Simon Hill
  - CES Environmental Instruments Ltd: Dave Slack, Martin Rodgers
  - PCME: William Averdieck, Bruce Greetham
  - NPL: Rod Robinson

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Other projects

- UK FTIR standard
- Proficiency testing schemes
  - Gases
  - Stack simulator
  - Weighing / washings
- Standard uncertainty calculations

- And we still haven’t validated the nozzles !

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