

Memo:  
To: Dr. D.E. Townsend and Dr. C. R. Green  
From: E. Ingebretsen  
Subject: Quarterly Report of Research 1/86-3/86



Performance evaluation of GCA-MINIRAM:

Experiments have been performed with both the 0.5 m<sup>3</sup> chamber and the environmental chamber to evaluate the response of the GCA-MINIRAM to sidestream smoke, mainstream smoke and mixtures of the two diluted in the chambers to mass concentrations representative of ETS. The MINIRAM is a nephelometry (i.e. it measures integrated light scattering intensity from an aerosol sample) based instrument developed by GCA for the monitoring of suspended dusts in mines. The instrument is sufficiently compact to be used as a personal monitor and can be run in either a passive (without pump) or active (with pump) mode. Because of its ease of use we suspect that it may become popular in field monitoring of suspended particulate matter, in particular in ETS related research.

We also suspect, from theoretical considerations, that equal mass concentrations of aerosols with different particle size distributions will be measured as different mass concentrations by the method the MINIRAM employs. Since we know that fresh sidestream smoke has a somewhat smaller size distribution than fresh mainstream it seemed probable that the MINIRAM would have a different response factor for the two types of smoke and, more importantly, that the mass concentrations of mixtures of the two types of smoke, as would be encountered in real life situations, would not be accurately measured by the MINIRAM.

Mass concentration measurements were made simultaneously with the MINIRAM and the piezobalance on samples drawn from the environmental chamber after smokings of three types; one cigarette sidestream only, one cigarette sidestream plus mainstream exhausted from the smoking machine, and two cigarettes sidestream only. The following average results were obtained:

Smoking	Piezobalance	MINIRAM	MINIRAM/Piezobalance
1 cig. SS	381	680	1.78
1 cig. SS+MS	539	1404	2.38
2 cig. SS	896	1852	2.06

where the Piezobalance and MINIRAM values are mass concentrations in micrograms per cubic meter averaged over a two hour sampling period after the start of smoking. These results indicate that the MINIRAM measures a substantially higher mass concentration than the piezobalance under all conditions studied. Also indicated is the particle size bias of the MINIRAM. For equal mass concentrations particles of larger size will more efficiently scatter light and yield a higher mass concentration by the MINIRAM measurement. The addition of mainstream will increase the size distribution due to the larger size of the

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'mainstream vs. sidestream as will the higher concentration in the 2 cig. case due to greater coagulation. One sees from the results that the relative enhancement of the MINIRAM values over the the piezobalance values (which suffer no particle size dependent bias) follows the increase in particle size distribution.

Plans are to repeat these measurements with a human smoking in the chamber and to develop an analysis of the MINIRAM response from light scattering theory to support the experimental results. It appears that the MINIRAM may be a convenient method of assessing qualitatively large changes in RSP mass concentrations, however, large indeterminable inaccuracies in absolute mass concentrations may be encountered in field measurements where in addition to mixtures of sidestream and mainstream smoke other particulate matter of a range of particle sizes may be present.

Analysis of particulate decay data:

Particle size specific decay curves obtained by optical particle counter (OPC) measurements of ETS samples drawn from the 0.5 m<sup>3</sup> chamber indicated that in addition to the first order wall loss and air exchange decay a more rapid removal mechanism was active in the initial stage of the aging process. This more rapid removal mechanism was interpreted as being mass loss by evaporation which results in shrinkage of the particles and appears as particle removal in the OPC measurements. This interpretation is supported by condensation nucleus counter (CNC) measurements which reveal a strict first order decay of the total number concentration. Mass concentration decay measurements made with the piezobalance on samples drawn from the environmental chamber also indicate that evaporative mass loss of the suspended particulate phase takes place. These results provide a strong qualitative argument for the hypothesis of evaporation, however, a quantitative analysis of the process, which would provide potentially useful insights into the nature of ETS, has not yet been achieved. Efforts are under way coordinately with Steve Sears to derive a model which describes the observed particle decay curves.

The shape of the decay curves can be reproduced by a model that postulates that the particulate phase composition is some fraction volatile with the remainder nonvolatile. By including the first order wall loss and air exchange decay, first order decay of the volatile portion of the particulate phase, and accounting for transfer of particles to smaller particle size bins as they shrink, the form of the decay curves can reasonably be reproduced. A more sophisticated kinetic analysis building on these results is being pursued by Dr. Sears. Success in this effort will add the missing piece to the previously derived analysis of the physical processes taking place as ETS ages under controlled conditions which will then allow us to better understand real life ETS environments.

Filter efficiency measurements:

An apparatus has been constructed, and continues to be



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modified, which is designed to measure the particle filtration efficiency of cigarette filters. The method is based on the measurement of the number concentration of a model aerosol upstream and downstream of the filter as the aerosol flows through the filter. The model aerosol is formed by nebulization of a polystyrene latex suspension and contains particles which span the size range of mainstream smoke. An OPC is used to determine the aerosol number concentration and flow meters are used upstream and down stream of the filter to determine flow rates and dilution levels for ventilated filters.

A model has been derived that predicts a filter's vents open efficiency for each particle size given measurements of the vents closed efficiency and the dilution level at a series of flow rates. Analysis of the results will involve the comparison of the predicted to observed efficiencies to identify processes which may be active that are not included in the model. If differences are detected, filters which exaggerate a suspected effect will be used to further elucidate the hypothesized mechanism.

Experimental problems with accurate flow measurements are still being encountered and only a limited amount of data have been acquired at this point. Initial results with vents closed filters agree very well with the predicted effects of particle size and flow rate reflecting the change in the relative importance of the different filtration mechanisms as the particle size and the flow rate regimes are changed. Plans are to complete full set of measurements on four filter types in the second quarter.

#### Particle size - Taste perception:

A vibrating orifice aerosol generator (VOAG), borrowed from the Toxicology division, was evaluated for use in experiments planned to study what possible effect aerosol particle size may have on taste perception. The VOAG was found to be extremely temperamental meaning that it could not be made to produce an aerosol for more than several minutes at a stretch without repeated readjustment of a nozzle alignment. Since the taste experiments will require stable aerosol production for long periods of time it was decided that the VOAG would not be the an appropriate generating source.

Plans are to use two nebulizers (ordered and received) to generate flavored aerosols for sensory testing. Different particle size distributions will be attained by adjusting the concentration of a nonvolatile solute (present plans are to use glycerol plus a yet to be determined flavorant) in the solutions to be nebulized solution. The two aerosols with different size distributions will then be brought to the same mass concentration by appropriate dilution with clean air.

#### Fluorescence measurements:

The Perkin-Elmer MPF-66 fluorescence spectrophotometer has arrived and we are awaiting installation.



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ETS support:

Ongoing participation in the design of experiments and the interpretation of results for ETS research.

Other:

Preparation of an invited symposium paper on cigarette smoke aerosol measurements for the 40th TCRC (Oct. 13-16, 1986, Knoxville, Tenn.) has begun. A final draft is due July 1.

A memo has been submitted describing participation in an indoor air quality round table at the U. of Mass. Amherst April 1-2.



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