Annex 5

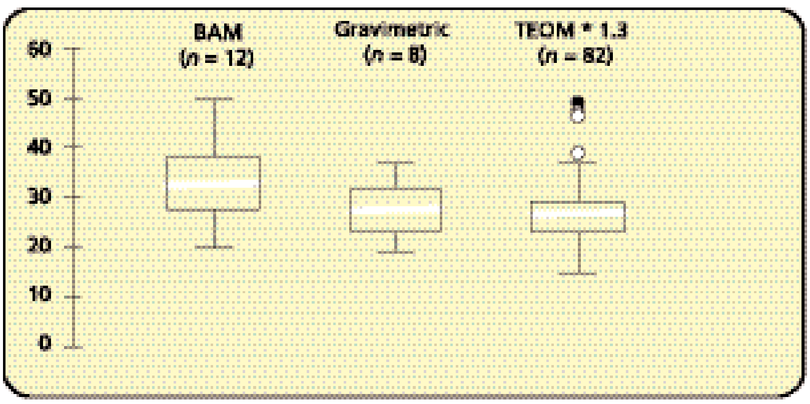
Performance of unheated ß-attenuation analysers

1. ß-attenuation analysers are widely used in the UK by local authorities as well as at one AURN site. They are predominately unheated Met One Beta Attenuation Monitors (BAM 1020). As these samplers are unheated, they will tend to exhibit the same losses of semi-volatile material as a sampler operating at ambient conditions, and the advice has been to treat the results as gravimetric equivalent. There is mounting evidence that these monitors overestimate gravimetric concentrations, which is believed to be a result of water on the filters. (There is now a version of the BAM available that has a 'Smart Heater', which controls the temperature to no more than +5°C above ambient, so as to maintain humidity at 20–45% and minimise problems due to water.) This Annex assembles and assesses the evidence for the performance of unheated ß-attenuation monitors.

2. There have been no systematic long-term co-location studies of ß-attenuation monitors and gravimetric samplers in the UK. A 4-month study was carried out in 1998 by KCL-ERG that used a ß-attenuation monitor alongside a Partisol gravimetric sampler: it showed a mean PM_{10} concentration that was19% higher with the ß-attenuation monitor. The remaining evidence is derived from indirect comparisons.

3. Local authorities throughout the UK have been monitoring PM_{10} at roadside locations as part of their LAQM duties. The information from these studies has been collated and is summarised in Figure A5.1. Assuming that the types of monitor employed are independently distributed in relation to distance from the road and traffic flow, that is, that ß-attenuation monitors are as likely to be used at the kerbside of a very busy road as a TEOM or a gravimetric sampler, then the results suggest that, on average, ß-attenuation monitors give rise to annual mean

Figure A5.1 Box and whisker summary of mean PM_{10} concentrations (µg m^{-3}) measured by local authorities throughout the UK at roadside sites using three different instruments. (Most studies were conducted for 12-month periods. The central line is the mean for each dataset, while the box shows the interquartile range.)



concentrations that are 18% higher than gravimetric values and 22% higher than TEOM * 1.3 values. These results must be treated with some caution, as the assumption may not be valid. Thus, these results alone are insufficient to reach a firm conclusion, but they will add weight to the findings of other indirect studies, as set out below.

4. There is now a substantial monitoring network of PM_{10} monitors in and around London that includes both TEOM and ß-attenuation monitors. The results for 'background' sites in 2003 are shown in Table A5.1. The TEOM * 1.3 annual mean results have been used in Chapter 6 to plot a concentration surface across London (Figure 6.49). Figure A5.2 shows a similar plot including the ß-attenuation monitor results. It is clear that at least three of the four ß-attenuation monitor sites stand out from the pattern created by TEOM * 1.3 data. If the TEOM * 1.3 concentrations at each of these ß-attenuation monitor sites are estimated from Figure 6.49, then this shows that the ß-attenuation monitors are giving rise to annual mean concentrations that are on average 27% higher than the TEOM * 1.3 values.

5. Further evidence of the performance of ß-attenuation monitors derives from the national model developed by Netcen (Section 8.2.1.2). This model has been compared with 2002 measured annual mean PM_{10} values from national monitoring sites. The results are shown separately for roadside and background sites in Figures A5.3 and A5.4. The TEOM * 1.3 values are predicted without obvious bias (except perhaps for a slight underprediction at roadside sites), but on average ß-attenuation monitor values are underpredicted by around 15%. This would suggest that ß-attenuation monitor values are about 18% higher than TEOM * 1.3 values.

Figure A5.2 Interpolated annual mean PM_{10} background concentrations across London in 2003 using ß-attenuation monitor and TEOM * 1.3 data. (May be compared with Figure 6.49, which is TEOM * 1.3 data only.)

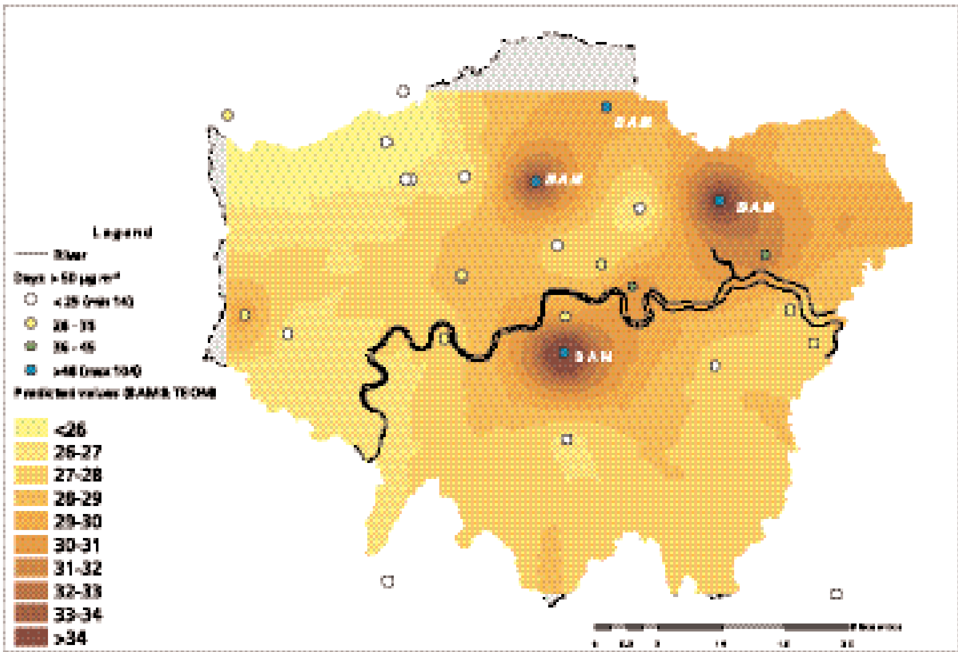


Table A5.1 PM_{10} monitoring at 'background' sites in London in 2003.

Site name	Site type	Network	Site code	Method	Days >50 μg m^{-3}	Data capture (%)	Annual mean TEOM * 1.3 (μg m^{-3})
London Bexley	Suburban	AURN	GB0608A	TEOM	33	87	27
London Brent	Urban centre	AURN	GB0616A	TEOM	24	86	27
London Eltham	Suburban	AURN	GB0586A	TEOM	24	89	27
London Hillingdon	Suburban	AURN	GB0642A	TEOM	28	80	30
London N. Kensington	Background	AURN	GB0620A	TEOM	28	88	29
Thurrock	Background	AURN	GB0645A	TEOM	38	88	31
Hertsmere background (Borehamwood)	Background	HBAPMN	HM1	TEOM	20	88	25
Three Rivers background	Background	HBAPMN	TR1	TEOM	27	78	23
Sevenoaks 2 – Greatness	Background	KAQMN	ZV1	TEOM	14	91	23
Barking & Dagenham 2 – Scrattons Farm	Suburban	LAQN	BG2	TEOM	43	89	32
Barnet 2 – Finchley	Background	LAQN	BN2	TEOM	23	90	26
Bexley 2 – Belvedere	Suburban	LAQN	BX2	TEOM	30	88	27
Brent 1 – Kingsbury (AURN)	Background	LAQN	BT1	TEOM	25	86	26
Croydon 3 – Thornton Heath	Suburban	LAQN	CR3	TEOM	17	86	26
Enfield 3 – Salisbury School Ponders End	Background	LAQN	EN3	**BAM**	41	82	**29**
Greenwich 4 – Eltham	Background	LAQN	GR4	TEOM	24	91	27
Haringey 2 – Priory Park	Suburban	LAQN	HG2	**BAM**	65	87	**35**
Harrow 1 – Stanmore Background	Background	LAQN	HR1	TEOM	16	85	23
Hounslow 2 – Cranford	Suburban	LAQN	HS2	TEOM	20	88	26
Islington 1 – Upper Street	Background	LAQN	IS1	TEOM	25	91	27

Site name	Site type	Network	Site code	Method	Days >50 µg m^{-3}	Data capture (%)	Annual mean TEOM * 1.3 (µg m^{-3})
Kens and Chelsea 1 – North Kensington	Background	LAQN	KC1	TEOM	29	90	29
Lambeth 3 – Loughborough Junction	Background	LAQN	LB3	**BAM**	69	89	**38**
Mole Valley 2 – Lower Ashstead	Suburban	LAQN	MV2	TEOM	14	91	25
Redbridge 1 – Perth Terrace	Background	LAQN	RB1	**BAM**	65	86	**36**
Richmond 2 – Barnes Wetlands	Suburban	LAQN	RI2	TEOM	33	90	27
Southwark 1 – Elephant and Castle	Background	LAQN	SK1	TEOM	31	91	30
Tower Hamlets 1 – Poplar	Background	LAQN	TH1	TEOM	42	88	31
Tower Hamlets 3 – Bethnal Green	Background	LAQN	TH3	TEOM	28	85	27
Waltham Forest 1 – Dawlish Road	Background	LAQN	WL1	TEOM	16	69	25

Key: BAM, ß-attenuation monitor.

Figure A5.3 Comparison of national modelled and monitored PM_{10} in 2002 at roadside sites.

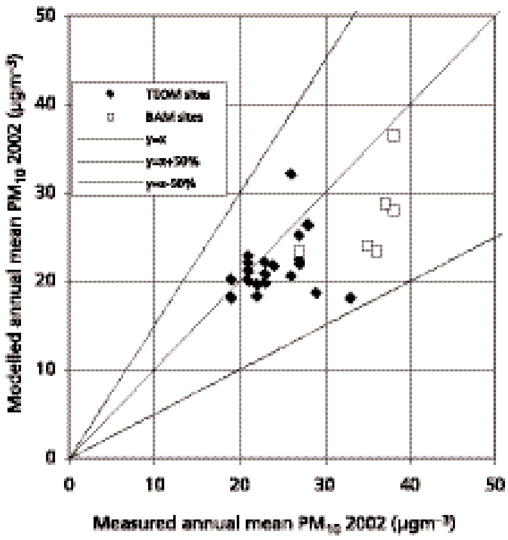
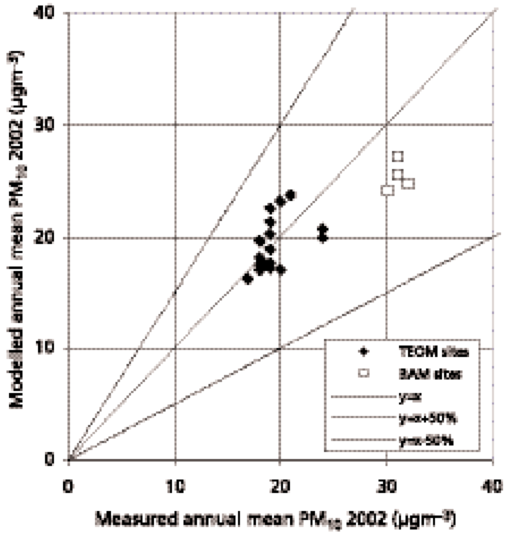


Figure A5.4 Comparison of national modelled and monitored PM_{10} in 2002 at background sites.



6. Finally, the results have been examined to see whether there is a different relationship between the annual mean values for unheated ß-attenuation monitors and the number of days above 50 µg m^{-3} (Figures A5.5 and A5.6). The results show no strong differences between the three types of sampler. TEOM * 1.3 values are broadly similar to the patterns for gravimetric samplers and ß-attenuation monitors at both roadside and background sites, although there is some evidence that TEOM * 1.3 values lie somewhat below those for gravimetric samplers and ß-attenuation monitors, especially at locations with lower annual mean concentrations.

Figure A5.5 Relationship between number of exceedences of 50 µg m^{-3} and annual mean PM_{10} concentrations at background sites for three different instruments. (The consultation draft of this report included an incorrect graph, which showed BAM monitors to have a different relationship. This graph shows the corrected data.)

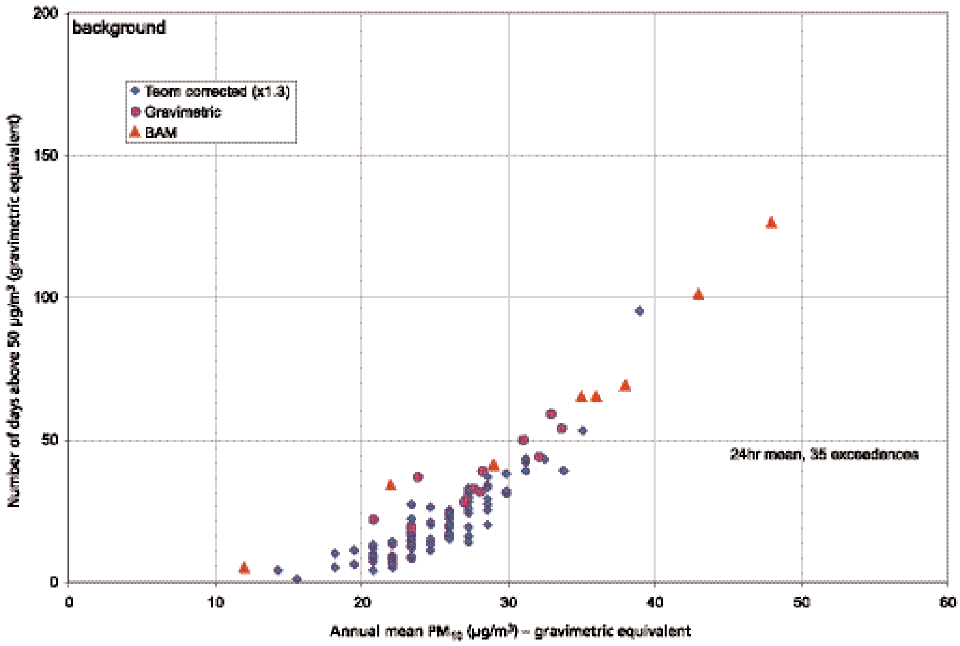
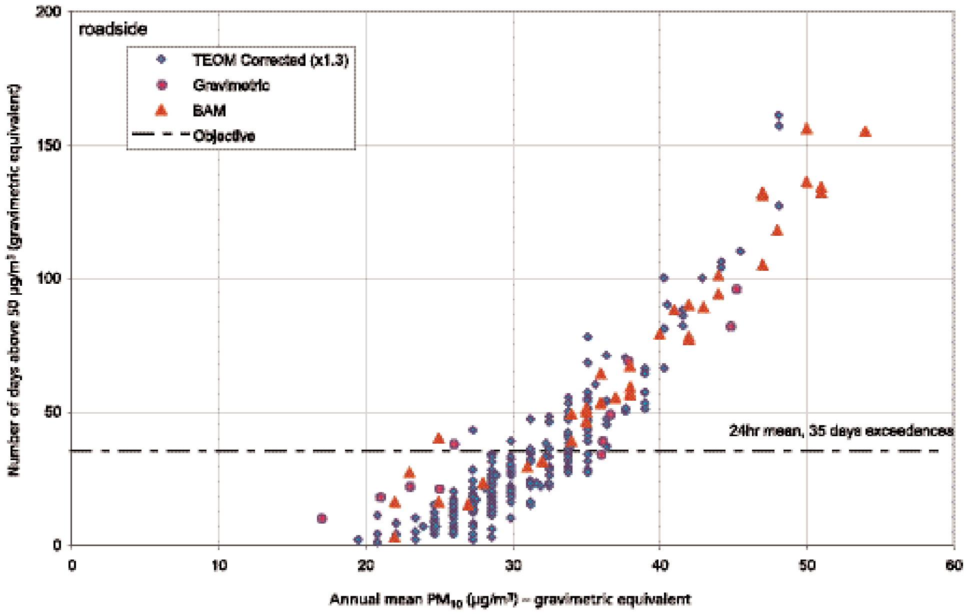


Figure A5.6 Relationship between number of exceedences of 50 µg m^{-3} and annual mean PM_{10} concentrations at roadside sites for three different instruments. (The consultation draft of the report included an incorrect graph, which showed BAM monitors to have a different relationship. This graph shows the corrected data.)



7. In conclusion, there is mounting evidence from a number of sources to show that unheated BAM 1020 analysers overestimate gravimetric PM_{10} concentrations. The annual means derived from ß-attenuation monitors appear to be around 20% higher than gravimetric or TEOM * 1.3 values. Improved information will derive from collocation studies that are being initiated by Defra and Devolved Administrations, which will include the unheated BAM 1020 sampler and the BAM 1020 with the Smart Heater.