Annex 6

Potential implications of the internal TEOM offset

1. The TEOM offset described in Chapter 5 is applied to all UK measurements of both PM_{10} and $PM_{2.5}$. The full implications of the offset to UK ambient measurements is currently not known and requires further investigation. A summary of the potential effects is given in the following paragraphs.

A6.1 Comparison of TEOM with gravimetric measurements

2. Currently in the UK, a scaling factor of 1.3 is applied to TEOM measurements in an attempt to provide an estimate of the equivalent gravimetric concentration, as described in Section 5.3.2. In the absence of the internal TEOM offset, the estimation of this scaling factor would change. An initial comparison between the TEOM and gravimetric (Partisol) instruments at the London Kensington site was undertaken to explore how the relationship between the two instruments would change.

3. A regression analysis of TEOM measurements against the 'Gravimetric' (Partisol) measurements over the period January 2002 to October 2003 at the Kensington site yielded a relationship 'gravimetric' (Partisol) = 1.48 * TEOM –3.7 (r^2 = 0.78). Forcing the regression line through 0 gave a slope of 1.325 (that is, close to 1.3). With the TEOM offset removed, the relationship was 'gravimetric' (Partisol) = 1.51*TEOM 'raw' + 0.7 (r^2 = 0.78), that is the intercept was closer to 0 in the case where the offset was removed. Forcing the regression line through 0 gave a slope of 1.55.

4. Table A3.1 summarises the data analysis in terms of the number of days above 50 µg m^{-3}. The TEOM 'raw' * 1.55 has more days with mean PM_{10} concentration above 50 µg m^{-3} because of the larger scaling factor and absence of an offset. The impact on annual and daily mean EU limit value is different. This analysis suggests that removing the TEOM offset enables the derivation of a more accurate TEOM to 'gravimetric' scaling factor at this site. It should be stressed, however, that although an improvement was observed in the accuracy of the scaling factor at this site by removing the internal offset, further more detailed analysis is required to confirm that a similar improvement would be achieved at other locations.

Table A3.1 Comparison between the TEOM and Partisol instruments at the London Kensington site (January 2002 to October 2003).

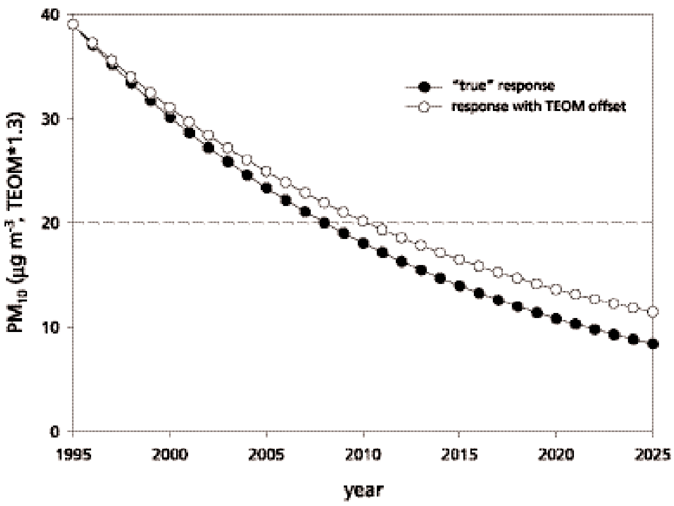
	Partisol	TEOM	TEOM 'raw'	TEOM * 1.325	TEOM 'raw' * 1.551
Mean concentration (µg m^{-3})	27	21	17	28	27
Number of days above 50 µg m^{-3}	44	8	5	35	39

A6.2 Effect on PM_{10} and $PM_{2.5}$ trends

5. The TEOM offset also affects the observed trends in PM_{10} and $PM_{2.5}$. A TEOM instrument would record 3.0 µg m^{-3} even if particle concentrations were 0. The actual effects are complex and would depend on how the data were processed, for example the application of factors other than 1.3 to initially attempt to give the TEOM some sort of equivalence with the gravimetric method. Figure A3.1 shows the hypothetical effect on the trend in PM_{10} at a monitoring site. Two cases have been considered: with and without and offset. An initial concentration of 39 µg m^{-3} (TEOM * 1.3) is assumed in 1995, which is thought to be typical of an inner London roadside location. For the TEOM without the offset a larger factor than 1.3 is required to give the same equivalence with the 'gravimetric' method (in this case a factor of 1.49 would be required based on annual mean concentration) for the base year in 1995. It has then been assumed that ambient PM_{10} concentrations are reduced by 5% year on year, that is, not a linear decrease. For the case with the offset it has been assumed that the 5% annual reduction in PM_{10} only applies to the fraction of PM_{10} that does not include the offset.

6. By 2005 the concentrations would have reduced to 23.4 and 24.9 µg m^{-3} for the without/with offset respectively. By 2010 the corresponding concentrations are 18.1 and 20.2 µg m^{-3}. Clearly, there is a significant difference between the two modes of operation on measured future ambient concentrations and it is important to note that with the offset on, the measured concentration would be above the limit value for this example.

Figure A3.1 Potential effect on the trend in PM_{10} concentrations on TEOM measurements for TEOMs with and without the internal offset scaling.



7. Figure A3.1 shows, therefore, that the TEOM with the offset responds more slowly to decreases in atmospheric concentration than the same instrument with the offset removed. The implication of this example is that the trends in measured PM_{10} and $PM_{2.5}$ considered in Chapter 7 could give a pessimistic impression of the actual reductions in airborne particulate, both PM_{10} and $PM_{2.5}$.

A6.3 Effect on $PM_{2.5}$ to PM_{10} ratios

8. The ratio of $PM_{2.5}$ to PM_{10} is important since this is the basis by which CAFE proposed a range of limit values for $PM_{2.5}$.
The effect on the $PM_{2.5}$ to PM_{10} ratio will depend on the ambient concentrations of each particle fraction and will therefore be site dependent. Table A3.2 shows the effect of the offset at two locations in London. At the Bexley suburban site the ratio decreases from 0.58 to 0.50 if the offset is removed. At the Marylebone Road kerbside sites, where concentrations are much higher than Bexley, the ratio declines less (from 0.65 to 0.61).

9. The constant offset of 3.0 µg m^{-3} for both PM_{10} and $PM_{2.5}$ TEOM measurements is relatively more important for $PM_{2.5}$ than PM_{10}. This is because ambient concentrations of $PM_{2.5}$ are less than PM_{10} and, therefore, the offset accounts for a larger proportion of $PM_{2.5}$ measurements.

10. Further work is required to calculate the effect on the $PM_{2.5}$ to PM_{10} ratio at UK and European sites. Following this work it would also be necessary to consider the implications (if any) for setting an ambient air pollution standard for $PM_{2.5}$, as is currently recommended by the CAFE Working Group (CAFE, 2004). CAFE has recommended a $PM_{2.5}$ standard derived from a mean $PM_{2.5}$ to PM_{10} ratio of 0.6.

11. The removal of the offset factor would also affect the fraction of particles assumed to be coarse, although not the absolute concentration. Using the results in Table A3.2 as an example, the coarse particle fraction would increase at Bexley Belvedere from being 42% of the total PM_{10} to 50%. Likewise, at Marylebone Road the coarse fraction would increase from 35% to 39%.

Table A3.2 Effect on $PM_{2.5}$:PM_{10} ratios of the TEOM offset (2002).

	PM_{10}	$PM_{2.5}$	$PM_{2.5}$:PM_{10} ratio	$PM_{2.5}$:PM_{10} ratio (offset removed)
Bexley Belvedere (suburban)	11	19	0.58	0.50
Marylebone Road (kerbside)	22	34	0.65	0.61

A6.4 Effect on modelled concentrations

12. The effect of the TEOM offset on the modelled concentrations shown in this report is both complex and dependent on how the models were initially constructed. In the case of the national empirical modelling described in Chapter 8, an initial assessment has been made of the consequences of the TEOM offset on predicted concentrations at the London Kensington and Marylebone Road sites. Again, it should be stressed that the analysis is preliminary and aims only to illustrate the principal potential effects of the offset factor.

Table A3.3 Potential effect of the TEOM offset factor on the national site-specific PM_{10} modelling.

	Year	Primary	Secondary	Other	Total (TEOM)	TEOM factor	Total (gravimetric equivalent)
With offset	2002	4.6	4.9	10	19.5	1.3	25.4
	2010	3.6	4.2	10	17.8	1.3	23.1
No offset	2002	4.6	4.9	7	16.5	1.5	24.8
	2010	3.6	4.2	7	14.8	1.5	22.2

13. Table A3.3 illustrates the potential effects on PM10 predictions using the national empirical modelling on predicted concentrations at the London Kensington site. For the purposes of this illustration it has been assumed that a factor of 1.5 is applicable to convert the TEOM to gravimetric equivalent in the case where the TEOM offset is not used. The overall effect in the model is to reduce by 3.0 µg m–3 the PM10 that is considered in the 'other' category for the case without the offset. The table also shows that the reduction in PM10 concentration predicted between 2002 and 2010 is different in each case. With the TEOM offset the reduction is 2.2 µg m–3 and without the offset it is 2.6 µg m–3. A similar analysis at Marylebone Road also shows that the projected decrease in PM10 between 2002–2010 with the offset removed is larger (10.7 versus 9.2 µg m–3). These results, therefore, suggest that current national modelling of PM10 could be pessimistic in terms of the future reductions in PM10 concentration.

14. The offset factor would manifest itself in a different way for the ERG modelling. In the regression analyses used to derive the different particle fractions, the TEOM offset would be considered as part of the secondary aerosol fraction. It is, therefore, likely that the ERG results are optimistic with regard to future concentrations since the constant TEOM offset of 3.0 µg m^{-3} would also have been adjusted downwards into the future in response to declining concentrations of secondary aerosol. Further work is being undertaken to determine the implications of the offset in the ERG model.

15. A consideration of the TEOM offset used for $PM_{2.5}$ in Canada has resulted in the agreement that as from 1 January 2002, all measurements should be made without the offset applied (Environment Canada, 2003). This decision was reached because it was thought that the factor was not appropriate for $PM_{2.5}$ measurements since it was originally derived using PM_{10} measurements.

16. Because the TEOM offset takes the form of a linear relationship in the form $y = mx + c$, it is possible to retrospectively remove it from all UK (and European) datasets for PM_{10} and $PM_{2.5}$.