

Appendix 2

AIR QUALITY MODELLING AND ASSESSMENT OF EMISSIONS FROM FLETTON BRICKWORKS AT WHITTLESEY (HANSON BUILDING PRODUCTS)

Executive Summary

This report assesses the likely air quality impacts of the emissions from the fletton brickworks near Whittlesey operated by Hanson Building Products, namely the Saxon and King's Dyke works. The pollutant considered was sulphur dioxide, which is emitted from 2 stacks at the Saxon works and 3 stacks at the King's Dyke works. The model results were compared with the standards in Appendix 1.

The model results predict that the Air Quality Objective for 15 minute sulphur dioxide is likely to be exceeded within 4 km of the Whittlesey brickworks as a result of the emissions from the stacks as currently operated. Furthermore, the model results predict that there is a risk that the hourly and daily mean objectives may be exceeded in small areas within 2 km of the brickworks.

1.0 Background information

- 1.1 Evidence from ambient monitoring equipment in the vicinity of the fletton brickworks at Stewartby, Bedford and dispersion modelling for that site indicates that emissions from the works cause the air quality objectives for sulphur dioxide to be exceeded (data acquired from Hanson Building Products process records). Two kilns are currently operating at the Stewartby works.
- 1.2 Hanson Building Products operates two similar brickworks at Whittlesey within 1.5 km of each other, with a total of 5 kilns. This report assesses the combined impact of the two works against the Air Quality Objectives given in Appendix 1; 2 kilns discharging through 2 stacks at the Saxon works and 3 kilns discharging through 3 stacks at the King's Dyke works.
- 1.3 Due to the nature of the fletton brick process, the emissions from the stacks are inherently variable in temperature, exit velocity and pollutant concentrations. Very limited continuous monitoring data was available for the Whittlesey sites. Therefore, constant emission rates were used in the modelling based on values averaged from manual sampling reports over a number of years and the limited continuous monitoring dataset.
- 1.4 Ambient air monitoring data were not available in the vicinity of the Whittlesey brickworks.

2.0 Modelling assumptions

Dispersion Model

- 2.1 AERMOD Prime (02222) was used in the modelling study. ADMS 3.1 was also used for a comparative model run. They are both new generation models, which can model the dispersion effects under unstable meteorological conditions more

accurately than old generation models.

Meteorological data

- 2.2 Historical meteorological data are available for the Wyton station, approximately 23 km to the east-south-east of the Whittlesey brickworks, and Wittering, approximately 20 km to the west-north-west of the works. Complete sets of meteorological data for use in air dispersion modelling are available for 1993 and 1994 at Wyton and 1996 and 1997 at Wittering.
- 2.3 Appendix 2 shows the windroses for data used in the modelling. Wyton 1993 and 1994 were selected, *a priori*, for the sensitivity studies.

Emission characteristics and rates

- 2.4 The dispersion modelling of the emissions from the brickworks used constant emissions temperature, exit velocity and emission rate. Tables 1 and 2 show the stack emission characteristics used in the dispersion modelling.

Table 1. Saxon Stack emission characteristics

Parameter	S1	S2
Location of Stack	525570, 297020	525520, 297155
Stack height from base	91 m	91 m
Stack height above ground level	71 m	71 m
Diameter at exit	2.6 m	2.6 m
Exit Temperature	130 °C	130 °C
Exit Velocity	10 m/s	10 m/s

Table 2. Kings Dyke Stack emission characteristics

Parameter	KD1	KD2	KD3
Location of Stack	(524350, 297605)	(524340, 297750)	(524505, 297690)
Stack height from base	84 m	91 m	122 m
Stack height above ground level	71 m	79 m	109 m
Diameter at exit	2.9 m	2.6 m	3.7 m
Exit Temperature	130 °C	130 °C	130 °C
Exit Velocity	7.5 m/s	10 m/s	10 m/s

- 2.5 The emission parameters were derived from averaged data from manual sampling reports over a number of years (data acquired from Hanson Building Products process records). The basic modelling used stacks at the height shown as 'height above ground level'. The sensitivity to this assumption is examined later.
- 2.6 Tables 3 and 4 show the modelled emission rates of SO₂, for the stacks.
- 2.7 The emission rates used in the modelling of annual mean concentrations of SO₂ were derived from averaged data from manual sampling reports over a number of years.
- 2.8 Due to the variable emission characteristics of the fletton brick making process, it is not appropriate to model the short term impacts of the emissions using an averaged

emission rate. Appendix 3 describes the sensitivity tests used to estimate suitable constant emission rates for the modelling of short term impacts which take into account the observed variability in the stack discharges. The methodology used to derive the emission rates implies that the model results represent the *worst likely case*.

Table 3. Stack emission rates used in modelling of long term (annual mean) emissions (g/s)

Pollutant	S1	S2	KD1	KD2	KD3/4
Sulphur Dioxide	63	63	63	55	126

Table 4. Stack emission rates used in modelling of short term (15 minute, hourly and daily mean) emissions (g/s)

Pollutant	S1	S2	KD1	KD2	KD3/4
15 minute SO ₂	95	95	95	83	189
Hourly SO ₂	88	88	88	77	176
Daily SO ₂	82	82	82	72	164

Roughness length

- 2.9 The roughness length used in the modelling was 0.2 m which reflects the semi-rural nature of the land surrounding the brickworks.

Buildings

- 2.10 There are no buildings greater than 40% of the lowest stack height within 5L of the stacks, where L is defined as the lesser of the building cross-wind width and height on either site. Therefore building downwash effects were not included in the modelling.

Terrain

- 2.11 The general terrain in the vicinity of the brickworks is not significant in terms of dispersion; there are no significant scale slopes with gradients in excess of 1 in 10. However, the brickworks are located in large pits up to 20 m deep. The basic modelling was carried out with stacks at the height specified as above ground level in Tables 1 and 2 *i.e.* at the height at which the stacks protrude above the lip of the pits. The model sensitivity to the representation of this terrain is examined in Section 4.

Receptor Grids

- 2.12 Two nested grids were used in the modelling, centred at the stacks. The resolutions of the fine and coarse grids were 100m and 500m respectively; the domains were 4 km by 4 km and 20 km by 20 km respectively.

Background Concentrations

- 2.13 The background concentration of sulphur dioxide was estimated to be 4 µg m⁻³ using data on the www.airquality.co.uk website. To calculate the predicted environmental concentration, background concentrations were added to the modelled process contribution using the methodology outlined in Defra guidance LAQM TG4(00).

Other Assumptions

- 2.14 The 99.9th percentile of 15 minute SO₂ is assumed to be equal to 1.36 times the 99.9th percentile of hourly mean SO₂. This assumption is consistent with theoretical studies of peak to mean ratios (Turner, 1994) and Defra guidance LAQM TG4(00).

3.0 AERMOD Prime model predictions

- 3.1 Table 5 shows the predicted maximum ground level concentrations of SO₂, resulting from emissions from the 5 stacks at the constant emission rates shown in Tables 3 and 4. Appendix 4 shows the contour diagrams of the predicted annual mean, 99.9th percentile of 15-minute mean, 99.7th percentile of hourly mean and 99.18th percentile of 24 hour mean of SO₂ using the Wyton 1994 meteorological data.

Table 5. Predicted maximum ground level concentrations of SO₂ (µg/m³) for the emission rates shown in Tables 2 and 3.

Sulphur Dioxide	PROCESS CONTRIBUTIONS				TOTAL (PROCESS CONTRIBUTIONS + BACKGROUND ¹)			
	Wyton 1993	Wyton 1994	Wittering 1996	Wittering 1997	Wyton 1993	Wyton 1994	Wittering 1996	Wittering 1997
99.9 th ile 15min	516	510	475	504	524	518	483	512
99.73 th ile 1hr	325	326	307	312	333	334	315	320
99.18 th ile 24hr	111	100	116	104	119	108	124	112
Annual Mean	14	17	13	15	18	21	17	19

¹ Background concentrations included using the methodology outlined in LAQM TG4(00)

- 3.2 The contour plots in Appendix 4 show a general zone of exceedence of the 15 minute mean SO₂ air quality objective extending to approximately 4 km around the stacks in all directions. The modelling predicts that there is a risk of exceedence of the hourly and daily mean objectives for SO₂ in small areas close to the stacks.

4.0 Sensitivity Tests

Representation of Stack Locations in Pits

- 4.1 The brickworks at Whittlesey are located within large pits up to 20 m deep. The modelling represented this by reducing the height of the stacks by the depth of the pits. The sensitivity of the model predictions to the representation of this feature in this way were tested by running the model with:

- flat terrain and the stacks at their height above general ground level (as in modelling reported in Section 3);
- with flat terrain and the stacks at their height above the bottom of the pit; and
- with terrain included in the model runs and the stacks at their actual height but with a base elevation representing the bottom of the pit.

- 4.2 Table 6 shows the impact of these three scenarios for the Wyton 1993 meteorological data set. The most conservative results (i.e. those that result in the highest ground level

concentrations) are predicted when it is assumed, as in the basic modelling for this case, that the stack heights relate to their height above the lip of the pit *i.e.* the general ground level. The least conservative assumption is to assume that the stacks release at the stack height from the base given in tables 2 and 3. The maximum predicted ground level concentrations, using this least conservative scenario, are decreased by less than 10%, 15% and 25% in relation to the basic modelling for the 15 minute, hourly and daily averages respectively.

Table 6. Maximum predicted ground level concentrations for sensitivity tests to representation of stack locations in pit.

Sensitivity Scenario	PROCESS CONTRIBUTIONS			
	99.9 th ile 15 minute	99.73%ile 1hr	99.18%ile 24hr	Annual Mean
Flat terrain, release height set to height of stacks above lip of pits	516	325	111	14
Flat terrain, release height set to height of stacks above bottom of pits	479	274	85	11
Terrain, release height set to height of stacks above bottom of pits, base elevation of stacks reduced with respect to general ground level	483	274	83	11

Dispersion Model

4.3 The results presented in Section 3 above relate to model runs in AERMOD Prime. For comparison, a model run was set up in ADMS 3.1 for the emission rates shown in Tables 2 and 3 using meteorological data for Wyton 1994. The ADMS model results are consistent with the AERMOD Prime results. Table 7 shows the maximum predicted ground level concentrations using ADMS 3.1. Whilst the zone of predicted exceedence of the 15 minute mean SO₂ objective is similar between the two models, the maximum predicted by ADMS is higher than predicted by AERMOD. Appendix 5 shows the predicted annual mean, 99.9th percentile of 15 minute mean, 99.7th percentile of hourly mean and 99.18th percentile of daily mean SO₂ from the ADMS 3.1 model run.

Table 7. Maximum predicted ground level concentrations using ADMS 3.1.

Operating Scenario	PROCESS CONTRIBUTIONS			
	99.9 th ile 15 minute	99.73%ile 1hr	99.18%ile 24hr	Annual Mean
ADMS and Wyton 1994	796	364	113	18

Contribution from each works individually

4.4 Results were extracted from the basic model runs to identify the contribution to ground level concentration from the Saxon and Kings Dyke works separately. Table 8 below shows the results from a model run using Wyton 1994 meteorological data. The model results indicate that each works on its own may cause exceedences of the 15 minute air quality objectives for sulphur dioxide, but not the daily or hourly objectives.

Table 8. Maximum predicted ground level concentrations for each brickworks individually, modelled using meteorological data from Wyton 1994.

Operating Scenario	PROCESS CONTRIBUTIONS			
	99.9 th ile 15 minute	99.73 th ile 1hr	99.18 th ile 24hr	Annual Mean
Kings Dyke alone	424	276	100	15
Saxon alone	345	121	94	13
Combined	510	326	100	17

5.0 Predicted air quality impacts

Sulphur Dioxide

- 5.1 The model results predict that breaches of the 15 minute mean Air Quality Objective are likely to occur within a zone extending to around 4 km from the combined brickworks in all directions. Defra guidance document LAQM TG(03) states that the 15 minute mean objective applies in locations where members of the public might reasonably be exposed for a period of 15 minutes or longer. The model predicted region of exceedence of the 15 minute mean objective covers both farmland and residential areas and, therefore, includes locations at which the objectives apply.
- 5.2 Furthermore, the model results predict that the hourly and daily mean air quality objectives for SO₂ may be exceeded in small areas within 2 km of the brickworks. The areas of potential exceedence of the hourly and daily objectives include off-site locations.
- 5.3 The model results predict that the air quality objective for annual mean sulphur dioxide may be exceeded in the vicinity of the works. However, the region of potential exceedence is within 5 km of the works and, therefore, the limit does not apply (Appendix 1).

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References

Turner, D. B. (1994) Workbook of Atmospheric Dispersion Estimates.

Appendix 1. Air Quality Standards and Objectives for Sulphur Dioxide.

<i>Measured as</i>	National Air Quality Standard ¹	National Air Quality Strategy/Air Quality Strategy for England, Scotland, Wales and Northern Ireland		EU Daughter Directives ⁴	WHO Guidelines ³
		2000 Objectives ^{1,2}	2001/2003 Objectives ^{7,9,11}		
10-minute mean					500 µg/m ³ 188 ppb
15-minute mean	266 µg/m ³ 100 ppb	266 µg/m ³ 100 ppb by end of 2005 (max 35 exceedences a year)	266 µg/m ³ 100 ppb by end of 2005 (max 35 exceedences a year)		
1-hour mean		350 µg/m ³ 132 ppb by end of 2004 (max 24 exceedences a year)	350 µg/m ³ 132 ppb by end of 2004 (max 24 exceedences a year)	350 µg/m ³ 132 ppb by end of 2004 (max 24 exceedences a year)	
24-hour mean		125 µg/m ³ 47 ppb by end of 2004 (max 3 exceedences a year)	125 µg/m ³ 47 ppb by end of 2004 (max 3 exceedences a year)	125 µg/m ³ 47 ppb by end of 2004 (max 3 exceedences a year)	125 µg/m ³ 47 ppb
Annual mean					50 µg/m ³ 19 ppb
Annual & winter (1 Oct. to 31 March) values for protection of vegetation and ecosystems		*20 µg/m ³ 8 ppb by end of 2000.	*20 µg/m ³ 8 ppb by end of 2000.	20 µg/m ³ 8 ppb by 19 July 2001	

* The Protection for Vegetation and Ecosystems for NO_x and SO₂ as per the EU Directive has been defined by the Government as in reference 4 below, to apply only to those parts of the UK which are more than 20 km from a conurbation of more than 250,000 people; and greater than 5 km distance from industrial sources regulated under Part A of the 1990 Environment Act, motorways and built-up areas of more than 5000 people.