Appendix 3

PM_{10} Air Quality Modelling

PM_{10} Modelling undertaken by Corus UK Limited

NORTH LINCOLNSHIRE COUNCIL

Dispersion Modelling Details

The Royal Meteorological Society has published guidelines[1] to promote best practice in the use of atmospheric dispersion modelling. Their statement lists ten areas to be considered, and this Appendix addresses all but the two related to results and conclusions, which are included in the main report.

4.1.A3.1 Objectives of Dispersion Modelling Exercise

This modelling was undertaken in the context of the application for an IPPC Permit for the integrated iron and steelmaking plant in Scunthorpe, operated by Corus. In order to address the requirement within an application to "provide an assessment of the potential significant environmental effects of the foreseeable emissions" (Question B4.1 on the application form), a staged approach was used. For emissions to atmosphere, an initial impact assessment for each individual source was undertaken (see Appendix 4.1.2) to screen out insignificant releases. For the remaining releases, further assessment was required and so the modelling described here was used to determine the short-range (up to about 10 km) dispersion of pollutants within the lower layers of the atmosphere.

The modelling results reflect the contribution of emissions from the Corus installation, and the overall pollutant levels will be the sum of this contribution and the contributions from road transport, other industry, domestic sources and natural sources in the area. Relevant background pollutant concentrations were obtained (see Appendix 4.1.1) to allow the estimation of overall pollutant levels (including contributions from both Corus and other sources) in the main report. The resulting concentrations and deposition rates were then compared to the relevant Environmental Assessment Levels (EALs) to complete the assessment.

4.1.A3.2 Software and Justification

The model used for this study was the commercially available Atmospheric Dispersion Modelling System (ADMS) version 3.1 (Beta 1), made available to Corus in July 2001. ADMS 3 is a "new-generation" model based on a detailed understanding of the structure of the atmospheric boundary layer and represents an up-to-date approach to dispersion modelling. There are still many sources of possible error, and a report commissioned by Her Majesty's Inspectorate of Pollution and published in 1996[2] concluded that :

> "The ADMS results ... indicated that, on average, the difference between predicted and observed maximum ground level concentrations in conditions similar to those investigated is unlikely to be more than a factor of two. This is acceptable for most practical purposes and is unlikely to be bettered by other modelling methods"

These conclusions related to a previous version of ADMS (version 1.35), but the current version would be expected to have similar basic accuracy (though the treatment of factors such as multiple sources has been much enhanced since the earlier version). Further validation studies[3] of ADMS 3 have been undertaken by the model developers against several different data sets and are reported on their web site. The American Petroleum Institute also undertook a comparison[4] of the performance of ADMS and two models developed by the United States Environmental Protection Agency (AERMOD, another "new-generation" model, and the older ISC3 model) against five different sets of field observations and concluded that :

> "... ISC3 typically overpredicts, has a scatter of about a factor of three, and has about 33% of its predictions within a factor of two of observations. The ADMS performance is slightly better than the AERMOD performance and both perform better than ISC3. On average, ADMS underpredicts by about 20% and AERMOD underpredicts by about 40%, and both have a scatter of about a factor of two. ADMS and AERMOD have about 53% and 46% of their predictions within a factor of two of observations, respectively. Considering only the highest predicted and observed concentrations, ISC3 overpredicts by a factor of about seven, on average, while ADMS and AERMOD underpredict by about 20%, on average."

It should be noted that the inclusion of additional factors in the modelling reported here, such as buildings effects, is likely to increase the uncertainty of the modelling results. A study recently published by the United Kingdom Environment Agency[5] compared the AERMOD, ADMS and ISC models with each other and concluded that :

> "... there are significant differences between the outputs of the models but these do not follow any consistent pattern. It is not practicable to make generalised recommendations on the use of one or the other model. The choice of model(s) should be considered for each specific application depending on the particular dispersion situation and on the merits of different models in that situation ... the results of the study demonstrate that the new generation models are still in a state of development."

ADMS 3 represents a state-of-the-art tool for dispersion modelling and has been validated against several sets of field observations. The model takes account of a variety of factors that are expected to be significant in assessing the impact of emissions from this site, such as multiple sources, the effect of large buildings, plume rise for buoyant releases, and local meteorology. Average pollutant concentrations for both long and short averaging periods can be output from the model, consistent with the averaging periods and compliance objectives (i.e. percentiles) specified in UK legislation. Hence ADMS 3 is fit for the purpose of dispersion modelling in relation to the objectives detailed in section 4.1.A3.1.

4.1.A3.3 Modelling Set-Up

There are a variety of optional modules available within ADMS 3, for instance to model the effect of complex terrain and buildings, and the options used in this exercise are discussed in the following sections. Following the initial modelling exercise, some of these options were altered to determine the sensitivity of the results to assumptions made in the set-up. The sensitivity analysis is further discussed in Section 4.1.A3.5 of this Appendix.

4.1.A3.3.1 Buildings

Guidance[6] issued to Local Authorities in the UK suggests that buildings exceeding 40% of the height of a source and within five stack heights may affect dispersion. On Corus' Scunthorpe site many of the sources are close to large buildings and hence buildings effects have been included in this modelling. The latest version of ADMS 3 permits the selection of different main buildings for different sources, allowing the inclusion of multiple widely-spaced buildings over a large area. Table 4.1.A3.1 lists the parameters of the buildings included in the dispersion model.

4.1.A3.3.2 Complex Terrain

Guidance published by the Environmental Analysis Co-operative[7], suggests that hills may significantly affect dispersion if slopes of greater than 1:10 are found within 100 stack heights of a source. The tallest source on Corus' Scunthorpe site is the Sinter Plant Main Stack (107 metres) and since there are no hills rising above the level of this stack within 10 km, it has been assumed that the surrounding terrain can be classified as flat and Complex Terrain effects have not been included in the modelling.

4.1.A3.3.3 Surface Roughness

Surface roughness is the characteristic roughness length that generates turbulence in the air passing over the surface of the Earth, and is dependent on land use. For the modelling reported here, a roughness length of 0.3 metres, characteristic of agricultural area, was used.

4.1.A3.3.4 Deposition

If particles larger than about 40 µm diameter are released from a source, their downward velocity superimposed on the downwind spread of the plume may significantly affect dispersion[7,8]. In the case of emissions from Corus' Scunthorpe installation, most of the particulate material is much smaller than this (over 80% of the mass of particulate emitted from each source is below 10 µm in diameter with the exceptions of the sinter plant stacks, emissions from the blast furnace hoppers and fugitive emissions from the stockyards). For the purposes of calculating dispersion, it has been assumed that all particles are small enough that the downward velocity (terminal velocity of a 10 µm particle is 6.2 mm/s) does not significantly affect dispersion and they disperse in the same way as gases.

When pollutants come into contact with the ground, dry deposition may occur, which removes material from the plume. The initial impact assessment (see Appendix 4.1.2) used an overall deposition velocity of 0.01 m/s, taken from the Environment Agency's methodology(9), and it has been assumed that this value is representative of the deposition velocity for particles and gases in this dispersion modelling exercise. In addition to dry deposition, washout of material during rainfall and subsequent wet deposition may occur. The same methodology suggested multiplying the dry deposition rate by a factor of three to account for this, and the same approach has been used here. Annual average concentrations have been calculated with no allowance for deposition, and subsequently the deposition rate has been calculated from:

DR = (AA * DV * 3 / 1000) * 3600 * 24 - equation from section 6.6.6 of reference 9

where DR = deposition rate (mg/m²/day)
AA = annual average concentration (µg/m³)
DV = dry deposition velocity (assumed 0.01 m/s after reference 9)
3 = estimated ratio of total deposition to dry deposition
1000 = conversion from µg to mg
3600 * 24 = conversion from mg/m²/second to mg/m²/day

This approach will somewhat overestimate concentrations and deposition rates, as it doesn't account for the loss of material from the plume, but this error will be small and is discussed further in section 4.1.A3.5. Deposition rates have only been calculated for those pollutants that have an EAL for deposition to land (see Appendix 4.1.2, Table 4.1.A2.1).

4.1.A3.3.5 NO_x Chemistry

The term NO_x is used to describe a mixture of different oxides of nitrogen. The species most commonly emitted (typically making up over 90% of the total NO_x) from industrial sources is NO, but the species of most concern in the environment is NO_2. Within the atmosphere, NO will slowly oxidise to NO_2 and ADMS 3 includes a simplified model of NO_x atmospheric chemistry to account for this. This requires knowledge of the background ambient concentrations of total NO_x, NO_2 and ozone in the vicinity of the installation.

Previous experience with the use of the NO_x Chemistry module in ADMS 3 has shown that, at least in situations where the concentration of NO_x attributable to the modelled emissions from steelworks is much lower than the background concentration, the final results are very sensitive to the assumed levels of ozone. Ozone is not measured at the local authority air quality monitoring station in the vicinity of the installation and because the final results are so sensitive to this term, it was decided not to use the NO_x Chemistry module in this instance.

Instead, NO_x emissions were expressed as total NO_x for the purposes of estimating the Process Contribution and the resulting overall NO_2 concentrations were estimated using a methodology suggested by DETR(10).

4.1.A3.3.6 Fugitive Sources

Not all the emissions from Corus' Scunthorpe installation are released from stacks. Some fume not captured by local extraction systems escapes from vents on the roof of the BOS Plant and particulate material from the raw materials stockyards may be entrained by the wind and carried off-site. These fugitive sources are difficult to characterise for dispersion modelling; in particular, pollutant emission rates cannot easily be measured and are likely to be very variable.

Fugitive emission sources may effectively be a lot of point sources, a line source (BOS Roof Vent) or a group of large area sources (stockyards), but in the modelling reported here, each of these sources has been approximated as a point source. Section 4.1.A3.5 includes a discussion of the sensitivity of the final results to this approximation, but the uncertainty in the emissions estimates is likely to be far greater than the possible error introduced by assuming that fugitive sources can be represented as point sources in the dispersion model.