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PROPAGATION OF NOISE FROM PETROCHEMICAL WORKS

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Economic control of neighbourhood noise from a works demands simple but reliable methods for determining sound power level and estimating attenuation. These needs, and proposals for fulfilling them, were set out by the author in 1968 (1). This formed the basis for the OCMA Noise Specification NWG1 in 1970. Extracts from the 1972 revision of NWG1 (2) (3) were incorporated in other guidance documents (4) (5). Revision 2, 1980 (6) retains the atmospheric and ground effects attenuation curves from (1) only slightly modified. The German VDI 2714 (7), still in draft, is the only other Standard document in the world (as far as the author knows) for calculating works-to-neighbourhood noise attenuation.

The new CONCAWE study

CONCAWE (The Oil Companies' International Study Group for Conservation of Clean Air and Water - Europe) is funded by the oil refining companies in Europe, and includes noise in its area of interest. It saw a need for a more detailed study of propagation effects relevant to neighbourhood noise from refineries and petrochemical plants. CONCAWE commissioned Acoustic Technology Ltd. to carry out a study in two phases

(i) Review of theoretical studies and experimental data in the literature (1977) (8)

(ii) Field study to determine actual attenuation. This was to be derived from source sound power data and neighbourhood noise levels measured at three petroleum plant sites (1978-9) (9) (10).

A propagation model was derived from phase (i), then modified and tested in phase (ii).

The model was written in the same basic form as that used by OCMA and by VDI:

$$L_p = L_w + D - \Sigma K$$

where L_p is sound pressure level
L_w is sound power level
D is directivity index
ΣK is sum of attenuation factors

all quantities expressed in dB in octave bands from 63 H_z to 4k H_z

Seven attenuation factors were used:

1. Geometric Spreading (K_1)

Spherical propagation was assumed so that ground reflection would be incorporated in K_3.

2. Atmospheric Absorption (K_2)

Over the practical range of atmospheric temperature and humidity, there is fairly good agreement between authorities. The ANSCA data is used. (For full reference list consulted in deriving K values see CONCAWE Report (8).

3. Ground Effects (K_3)

Parkin & Scholes is still the most comprehensive published work and was used as a basis for this model; this has some theoretical justification.

4. Meteorological Effects (K_4)

Temperature gradient and wind shear effects were considered theoretically, and published experimental data was reviewed. It was considered reasonable to group these meteorological conditions into six categories which can be summarised:-

Cat 1. maximum attenuation effect unstable atmosphere and -ve vector wind >3 m/s.
Cat 4. assumed zero effect neutral and zero wind (< 0.5 m/s).
Cat 6. maximum enhancement effect (-ve attenuation) stable atmosphere and +ve vector wind > 3 m/s.

5. Source Height Effect (K_5)

This modifies the values of K_3 and K_4 and is expressed as a function of source and receiver heights and distance.

6. Barrier Effect (K_6)

This takes into account not only the geometrical propagation effect of the barrier itself but also the interrelation of meteorological and ground effects with the barrier effect.

7. In-plant Screening (K_7)

This was indicated in the literature as significant but the field study suggested that this would not normally be so.

Reliability of the CONCAWE Model

The model was tested using the field data. The CONCAWE Report should be referred to for a full explanation. In summary, the neighbourhood sound pressure levels calculated in dBA showed a mean error of 0.5 dBA and 95% confidence limits of $\pm$ 6 dBA approx. The model is applicable over a distance up to about 1,500m. It may be applicable at greater distance.

Several simplified models (K_4 independent of frequency, K_4 independent of distance, K_4 set for +ve, zero, or -ve vector wind only) and also the OCMA model were tested and found to have not much poorer accuracy.

Some areas for argument

The VDI model was tested with the field data and showed a mean error of 2.7 dBA and confidence limits of ± 9 dBA approx. One major difference between CONCAWE and VDI models is in the spectrum shape of groundeffects attenuation - in particular the dip at 250 and 500 H_z in the CONCAWE model. The real existence of this dip is shown clearly in the CONCAWE field data and also in data relating to several locations in the neighbourhood of two refineries in different terrain surveyed by the author.

A recent extensive survey by Müller-BBM (11) over distances up to 2km has shown a mean error in the VDI model of 0.5 dBA with 95% confidence limits of ± 3 dBA. The octave band data did not show the 250 & 500 H_z dip. All the measurements in this survey were taken downwind (± 45°) which is the condition for which VDI 2714 is particularly designed. It may well be that the interaction of ground and meteorological effects is such as to account for some of the difference between these two sets of observations.

The CONCAWE study can be criticised as being too ambitious and for trying to quantify too many variables with too little data. It can also be credited with being unusual in making available both an extensive commentary on the literature and its own field survey data, and reporting on the reliability of its own conclusions as determined by fieldwork.

With regard to overall accuracy of prediction, it may be felt that confidence limits of ± 6 dBA are not very good. However, if we compare state-of-the-art of atmospheric dispersal of noise with atmospheric dispersal of gases (which has been studied more intensively by more people over the last 50 years) we can take heart. Many people calculate ground level concentration of gases using complex formulae, and commit substantial sums of money as a result. Very few go out after the plant has been built to measure the glc. The author has done both, and he would assure readers that if mean values of measured glc's at different locations and under different meteorological conditions agree with calculated values to within a factor of 4 (6 dB) one can feel well satisfied (14). Unfortunately, neighbourhood noise level is much easier to measure than glc of a gas.

Conclusion

The CONCAWE Report is not by any means final, but it is a substantial contribution to the published literature on the propagation of noise relevant to process works. It deals with the range of meteorological conditions common in western Europe. Probably the most important area for further study is downwind propagation, particularly where the receiver is within an arc of 45° either side of the wind direction downwind (12) (13).

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