IPPC APPLICATIONS, A CONSULTANT'S EXPERIENCE

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1 INTRODUCTION

Integrated Pollution Prevention and Control (IPPC) is a regulatory system that employs an integrated approach to control the environmental impacts of certain industrial activities. The IPPC directive, on which UK legislation is based, was adopted by the EU Council of Ministers in September 1996 and took effect in England and Wales in August 2000 through the Pollution Prevention and Control Regulations[1] and through similar legislation in Scotland. It involves determining the appropriate controls for industry to protect the environment through a single permitting process. To gain a Permit, operators will have to show that they have systematically developed proposals to apply Best Available Techniques (BAT) and meet certain other requirements, taking account of relevant local factors. The control and management of noise (and vibration) from the prescribed industries has been included within the new legislation. This presentation considers the noise aspects of an IPPC application for a new gas-processing terminal from a consultant's perspective.

2 ENVIRONMENT AGENCY GUIDANCE

One of the most helpful aspects in preparing an IPPC application is the detailed guidance that has, and is still being prepared by the Environment Agency. In addition to general guidance for each industry sector, there are BAT Reference Documents (BREFs) that are being prepared at a European level. These are very long and complex documents, often extending to more than 500 pages. A short guidance section on noise and vibration is given in the IPPC General Sector Guidance[2], and also in the individual industry sector guidance documents, where this has been prepared. For example, the sector guidance for the Pulp and Paper Industry[3] has three pages of guidance for noise and vibration, half of which is fairly general in content but the rest is specific to that industry. This makes reference to particular items of plant and processes that are used in this industry, emphasising, for example, the importance of maintenance as a noise control technique for paper machines. Help is also given on guidance on balancing costs and benefits in this area. Reference is made in this specific sector guidance to the BREF for the pulp and paper industry[4] which includes case studies on noise control. However, it is clear from a perusal of this BREF, that noise has a very low emphasis as compared to all the other environmental aspects.

Of particular importance to the consideration of noise and vibration in IPPC applications are two Environment Agency *horizontal* guidance notes on noise, which apply to all industries. These are IPPC H3 Parts 1 and 2. Guidance Note[5] IPPC H3 Part 1 outlines the main considerations relating to the regulation and permitting of noise, and is aimed primarily at the information needs of regulators. Guidance Note[6] IPPC H3 Part 2, describes the principles of noise measurement and prediction and the control of noise by design, by operational and management techniques and by abatement technologies. It forms a background to Part 1, and is intended to assist in determining BAT for a given installation. It is aimed equally at regulators and at operators.

Included within the Part 1 guidance document are indicative permit noise limits. As a starting point, these suggest a night-time façade *rating* level of 45 dB, a daytime free-field rating level of 50 dB, and a $L_{Amax,F}$ level of 60 dB at the façade of bedrooms. But to be sure that there is no reasonable cause for annoyance, the rating level from the installation should be set equal to the background

noise level, although there is some concern expressed over creeping ambient levels. Thus, the implication is potentially to allow some increase on existing noise levels for a new development, subject to upper noise limits not being exceeded, but being aware of the danger of creeping ambient noise.

3 BEST AVAILABLE TECHNIQUES (BAT)

The Regulations require installations to be operated in such a way that "all the appropriate preventative measures are taken against pollution, in particular through the application of BAT". The definition of pollution includes "emissions which may be harmful to human health or the quality of the environment, cause offence to any human senses or impair or interfere with amenities and other legitimate uses of the environment". The guidance states that BAT is therefore likely to be similar, in practice, to the requirements of the Statutory Nuisance legislation which requires the use of "best practicable means" to prevent or minimise noise nuisance. It goes on to say that, in the case of noise, "offence to any human senses" may be judged by the likelihood of complaints. However a lack of complaints should not necessarily imply the absence of a noise problem and it may be possible, and desirable, to reduce noise emissions still further at reasonable cost. This *may*, therefore be BAT, for noise emissions.

The guidance summarises the aim of BAT as achieving the following:

- Underpinning of good practice, a basic level of which the operator should employ for controlling noise, including adequate maintenance of plant whose deterioration may cause increases in noise;
- Noise levels should not be loud enough to give reasonable cause for annoyance to persons in the vicinity (this is a more appropriate standard than that of Statutory Nuisance);
- Prevention of creeping ambient (creeping background), which is the gradual increase in ambient sound levels as industry expands and areas develop.
- There may be a requirement for noise surveys, measurement, and investigations to identify sound power of individual plant items for existing plant, and noise modelling for new or existing installations.

4 NOISE INFORMATION REQUIRED FOR IPPC APPLICATIONS

To apply for an IPPC permit, the operator must provide information relating to:

(i) the techniques employed to control noise;
(ii) the emission of noise from the installation;
(iii) an assessment of the impact of those emissions on the environmental receptors.

The application needs to identify the main sources of noise that fall within the IPPC installation, stating: whether noise is continuous or intermittent; the type of emission and any associated characteristics; the hours of operation; its contribution to the overall site noise emission; and the location of the installation. Information is also required on infrequent sources of noise (such as alarm testing). The noise sensitive receptors need to be identified, with details of the ambient noise environment, details of any relevant planning conditions and details of any complaints about noise within the previous three years.

The application should also contain details of any noise modelling work, describe the proposed position with respect to the techniques and technologies for noise measurement and control, as contained in IPPC H3 Part 2, and demonstrate that the proposals are BAT by confirming

compliance with the indicative requirements as previously stated. It should be noted that reference to noise is also taken to mean *vibration*, and the application should make reference to vibration, even it is only to declare that there are no significant environmental vibration issues associated with the installation.

5 IPPC APPLICATION FOR A NEW GAS PROCESSING TERMINAL

5.1 Background to Application

The following sections describe some of the considerations that went into the supporting noise report for an IPPC application for a new gas terminal to process natural gas from offshore installations. This new terminal is being built alongside existing gas processing facilities and will eventually be operated as part of these, but under IPPC it is being treated as a new installation, rather than as a "substantial change" to the existing gas terminal.

A planning application for the development had been made some two years prior to the IPPC application. The planning application included an environmental noise impact assessment report as a supporting document. The report identified that, with the scale of development proposed, an increase in ambient noise levels was inevitable, otherwise the project would not be viable. The planning application was subsequently granted with conditions. However, the new terminal was not conditioned separately with respect to noise, but rather the local authority took the view that the new terminal would be part of the existing complex and the pre-existing noise limits for the terminal, as a whole, would be increased by 3 dB to allow for the new facility.

The existing conditions generalised the applicability of the noise limits in that they applied to the noise arising from the existing facilities at *any* occupied building. Thus, allowing a general 3 dB increase from the terminal complex, has probably been generous to the operator, as the noise model for the new development, which was initially prepared at the planning application stage, indicated that a maximum increase of 2 dB would apply only at one or two of the properties nearest to the new development.

5.2 Description of Facilities

The gas from the offshore field to be processed by the terminal, contains hydrogen sulphide (H_2S) and significant quantities of nitrogen. It is known as "sour" gas. It is to be exported from the field via a 49 km long pipeline to the onshore reception facilities. This will receive the wet sour gas, separate the liquids, compress the gas to export pressure, sweeten the gas by removing the H_2S and forward the gas to the existing terminal for processing to the National Transmission System specification. The H_2S removed from the gas is to be converted to sulphuric acid. This is directed to a storage tank where it is exported from the terminal by tankers. Two flare systems are provided, a high and a low pressure system. Flaring of gas will not normally occur, and the flares will operate with a pilot flame only. Under emergency, or plant upset conditions, flaring of gas will occur with a concomitant increase in environmental noise levels.

The onshore facilities are being designed for 145 MMscfd inlet gas flow, 700 bpd condensate flow and 1000 bpd of free water. The new terminal will operate 24 hours per day, all year round, except whenever the plant is shut down for maintenance purposes. The movement of road tankers to and from the site will normally be a daytime operation only.

The site is bounded on one side by the sea and rural terrain in the other directions. The nearest occupied residential properties are typically 1 km from the centre of the new facilities.

5.3 IPPC Sector Guidance

Environment Agency sector guidance has not yet been prepared for the IPPC Directive Section 1.2 designated industries that the new gas processing terminal would come under (Gasification, Liquefaction and Refining Activities). The relevant period in England and Wales for making applications for existing facilities in this industry sector is June to August 2006. There is, however, a recent BREF[7] for Mineral Oil and Gas Refineries, dated February 2003. Unfortunately this contains only a passing reference to noise in its 500+ page document. Paragraph 4.23.10 of this document, entitled "Noise prevention and control techniques" states that: "*Flares compressors, pumps, turbines and air coolers require particular attention as regards sources of noise. Abatement measures in refineries usually focus on these types of equipment*"

This rather brief commentary on the issues of noise in refineries and related plants, whilst factually correct, does little to help in the definition of BAT for this industry, in relation to noise. It is suggested that the section on noise in the Environment Agency sector guidance for this industry, when prepared, should be more explicit than that given in the BREF, if it is to be of any real value.

5.4. Ambient Noise Levels

Although simple in concept, it can be relatively difficult to obtain a meaningful, and representative value for the ambient noise level in the vicinity of a process plant which operates 24 hours a day, 7 days a week. This is primarily due to the variation in noise levels that will occur with different meteorological conditions, as well as variations in plant operating conditions. To determine the existing downwind noise levels in the vicinity of the currently operating gas terminal in relation to noise generated by the terminal, a detailed test specification was prepared. This required noise measurements to be taken at night, between the hours of midnight to 4.00 am, with strict criteria on weather conditions, and for the wind speed and direction considered valid for a particular receiver location.

The noise limit condition for the existing terminal is 35 dBA at the nearest occupied dwelling, together with an additional restriction on noise characteristics (impulsive noise or predominant pure tones). Although standards such as BS4142[8] suggest that meaningful measurements can be measured in wind speeds up to 5 m/s, the wind speed has to be significantly less than this when trying to measure specific noise levels of 35 dBA, as there can be higher levels of noise from rustling leaves, for example. This does question, however, what should be taken to be the representative conditions under which background noise level should be obtained, for the purposes of setting permit limits in relation to background noise. BS4142, which is referenced widely in the Horizontal Guidance notes, is rather vague on the subject, and states that where background noise levels are significantly affected by meteorological conditions, it may be necessary to repeat the background noise measurements on a number of occasions to obtain a *representative* measurement sample. The standard does not offer any guidance as to how to manipulate the data, once obtained, to produce a representative value from the sample. Perhaps it is time to be thinking about use of parameters such as L_{den} and L_{night}, as given in the EC noise mapping directive[9], to give a more representative average value of existing ambient noise levels, from which any change can be assessed.

5.5 Operating Plant Noise Levels

5.5.1 General Philosophy

Right from the outset, noise control formed an integral part of the project design. Of importance in this regard was the delegation of the responsibility of achieving noise limit targets on individual plant items through contractual arrangements with the individual equipment or package suppliers, and then the verification that these target limits could be achieved. Where noise was to be controlled

through external means (such as acoustic enclosure, or pipe lagging), the responsibility for the design and implementation of these measures was clearly defined. This approach to noise control at the planning stage is fully endorsed in IPPC H3 Part 2, para 3.3.2.

5.5.2 Equipment Noise Limits

At an early stage of the project a preliminary noise model was constructed based on the EEMUA[10] sound propagation model. Use of this model is cited in IPPC H3 Part 2, para 2.5.1. From this model, equipment item noise limits were devised, such that if met, the resultant overall noise level would be satisfactory at the nearest residential property. These limits were generally given as octave band sound power levels. The frequency spectra of the individual plant item limits were devised to reflect expected values from the individual types of equipment, such that the overall characteristics of the noise will blend in with the frequency spectrum of the existing noise environment. In particular, care was taken to control low frequency noise from such sources as gas turbine exhausts and air cooler fans, and to limit tonal noise from compressors and control valves.

The noise model assumes attenuation over acoustically “soft ground” and the attenuation values are for sound propagation under light downwind conditions. The extra attenuation resulting from the soft ground is reduced in relation to the relative height of the noise source to the receiver distance, with an overriding factor that the ground effect attenuation becomes zero for source heights of 15 m or more above the ground. No additional benefit was ascribed to an earth bank on one side of the site, although this is likely to have some benefit in reducing the noise from low-level noise sources. For upwind conditions, over the distances between the new facility and the nearest residential properties, resultant noise levels would be some 10-15 dBA less than predicted.

The basic factors included in the propagation model are sound attenuation with distance (not frequency dependent), increased attenuation due to propagation over acoustically soft ground (frequency and source height/receiver distance geometry dependent) and sound absorption directly by the atmosphere (frequency and source/receiver distance dependent). Although the sound propagation parameters in this model are relatively simple, this propagation model has been found, in practice, to give good correlation between measured and predicted levels for the defined set of weather conditions, and probably as good for this application as more sophisticated models based on ISO 9613-2[11], for example.

5.5.3 Plant Item Noise Control

Field Gas Compressors

There are two 6.5 MW field gas compressors which will be driven by industrial gas turbines. Each gas turbine is to be located within a forced ventilated acoustic enclosure, with air drawn into the enclosure through an attenuator, approximately 1.8 m long, upstream of the ventilation fan. The air exhausts via attenuators approximately 1.4 m long. Each enclosure is free-standing and not attached to the skid of the gas turbine compressors. Combustion air for each gas turbine is drawn in via a filter and a 3 m long attenuator. The combustion gases from each gas turbine exhaust via a twin silencer arrangement. Both silencers are 4.5 m long, and are separated by a 90° elbow, with a separation distance of about 2.5 m. In normal circumstances, the hot gases will exhaust via a waste heat recovery system that will provide some additional attenuation of the exhaust noise. The waste heat recovery section can be by-passed, however, and the exhaust silencers have been sized for this eventuality.

The suction and discharge pipework associated with the compressors will be acoustically lagged with a system comprising 100 mm thick mineral wool, covered by a dense visco-elastic membrane together with an outer steel jacket. Where acoustic lagging has been applied, use is being made of vibration isolating support pads to reduce the transfer of residual high frequency noise into the support structure.

Provision has also been made in the design for inlet and discharge silencers in the compressor lines. A decision has been made, in principle, to delay the installation of the silencers until, and if, required by compressor duty later in the plant life, although they could be installed at an earlier stage if found to be necessary. The use of piping spool pieces will make this a relatively easy retrofit measure. Each gas turbine driven compressor will also have its own lube oil cooler, and noise data has been supplied for these.

Initially the compressors will operate as duty/standby, then in parallel, but later in the project as the field pressure decays, series operation is required. By 2010, recycling of gas will be a normal operation, but the recycle valve for each compressor has been chosen to be inherently quiet in operation, therefore this mode of operation should not be significantly noisier than the other modes of operation.

Control Valves

Control valves and associated piping systems can be major sources of noise at a gas terminal. A review has been undertaken of all valves for which the predicted sound pressure level is greater than 65 dBA , at a distance of 1 m from the pipe wall downstream of the valve. A total of 27 valves are being purchased with an expected sound pressure level of 65 dBA, with a tolerance of 5 dBA. In addition there are 6 valves being purchased from a specialist valve company, with a guaranteed sound pressure level of 65 dBA at 1 m from the downstream pipework. These include, in particular, the recycle valves associated with the field gas compressors.

A review has been undertaken of the major pipework associated with these valves and lengths of line identified from the computer model developed of the terminal. From this, radiation areas have been calculated leading to the determination of radiated sound power levels for each of the valves.

Air Coolers

In the gas and petrochemical industries, extensive use is made of fan assisted air cooling of gases and fluids. These consist of large horizontally mounted fans, typically 4m to 5m in diameter, driven by electric motors. For this terminal, inherently low noise, highly efficient fans are being used with low rotational speeds. Vendors can normally supply good test data for these types of fans.

Pumps and Motors

There are a large number of pumps driven by electric motors on the new gas terminal. Where noise levels have been found to be too high in relation to those specified, then the pumps and motors are being located within acoustic enclosures.

Sulphuric Acid Plant

A separate noise study has been undertaken for the sulphuric acid plant by the supplier's own noise consultant. A number of plant items will require treatment, especially the air blowers, which will be fitted with inlet and discharge attenuators, with the blowers themselves acoustically enclosed.

Pipework

Noise radiating from connecting pipework can be a significant source on a gas terminal. For the new facilities, pipework noise is being controlled through the selection of inherently quiet plant, the use of acoustic lagging on particular sections of pipes, and the limitation of in-pipe fluid velocities. For other sections of pipework, provision is being made for acoustic lagging if found to be necessary after plant start-up.

Flares

There are two flares located at one end of the site with the tips at an elevation of 32 m. These are designed to burn high pressure (HP) and a low pressure (LP) gas respectively. In normal operation the flares will be on pilot conditions only and radiate low noise levels. The highest noise level will occur under depressurisation of the HP flare, when gas flow rates to the flare could be as high as 335 MMscf/d. The flare vendor has predicted a noise level of 86 dBA at a distance of 800 m, although the likelihood of this occurring at all, is very low. The flare vendor was asked to review the possibility of achieving a sound pressure level of 70 dBA at a distance of 800 m for full flow conditions, but an inherently quieter flare tip would significantly affect toxic and odour emissions. Given the strictures of visual impact, and the limit on equipment height set by the planning permission, dispersion of toxic and noxious gas release was considered a greater priority on the surrounding population, forcing the noise issue to be a second priority.

5.6 NOISE MONITORING

Verification testing will take place to ascertain whether plant item noise limits have been achieved. For the larger items (e.g. the field gas compressors), noise testing cannot take place until the terminal is being commissioned, although for the smaller items, some testing will undertaken at the vendors' works. In principle, the purpose of the testing will be to determine the as-built octave band sound power levels of the various items of plant and equipment. The data will be obtained from a combination of sound intensity measurements, sound pressure level measurements and surface vibration level measurements, together with physical measurements to determine sound radiation areas.

The octave band sound power levels so obtained will be entered into the acoustic model of the terminal which was developed initially for the environmental noise impact assessment at the planning stage, and the model re-run to determine predicted community noise levels. In addition, it is anticipated that community noise measurements will be made once the new facilities is operational, in accordance with the survey methodology already specified.

5.7 ASSESSMENT OF BAT

The design of the new gas terminal facilities is employing basic good practice measures to control noise. This involves the use a noise model to set plant item noise limits; the selection of low noise plant and equipment (e.g. low noise fans on air coolers); the use of acoustic enclosures to reduce noise radiation from the gas turbine driven field compressors, and the larger pumps; the use of attenuators on air paths into and out of the enclosures; the use of acoustic lagging on potentially noisy pipework; the installation of control valves with low noise trims; the use of inherently quiet valves on critical fluid flow applications (e.g. compressor recycle lines); and the provision for additional acoustic lagging and silencing measures on compressor related and other pipework, should this be found to be necessary after plant start-up.

The predicted character of the noise from the gas processing facilities is anticipated to be without significant character and will blend into the existing ambient noise environment. The rating level of the noise (as defined in BS4142) will be less than the existing background noise level. The total noise level from the gas terminal as a whole will be significantly below the indicative night-time Environment Agency permit limit of 45 dB (façade rating level). Therefore it is not anticipated that any annoyance will be caused by noise from the new facility.

Although there will be an increase in existing ambient levels due to the new facilities, the increase will be nominal only (typically up to 2 dB at night at the nearest residential locations) and within the

EA guideline limit, but no increase at residential locations further away. Thus the degree of any "creep" in the ambient noise environment will be very limited (IPPC H3, Part 1, 2.5.6).

Noise modelling has been undertaken as part of the design of the new facility. When the terminal is commissioned, a detailed noise survey will be undertaken and the model populated, as far as possible, with actual sound power levels from the operating plant. As a longer-term measure, the model of the new facilities will be integrated into the noise model that exists for the existing gas terminal to form the basis of the noise management system for the terminals as a whole. The noise management system will also include a requirement for regular on-site and off-site noise monitoring to ensure ongoing compliance with statutory noise limits, to check for possible deterioration in noise control hardware or increased noise levels from machinery requiring maintenance (noisy bearings etc), and to check for variation in noise levels from plant and equipment as process conditions change with field depletion.

These elements comprise the indicative requirements of IPPC H3 Part 1, 2.2.1, to demonstrate achievement of BAT for the new gas terminal facilities, with respect to noise.

6 CONCLUSIONS

An overview has been undertaken of the IPPC application process which includes the demonstration of BAT for noise and vibration for prescribed industries. An example has been given of the noise considerations included as part of an IPPC application for a new gas processing facilities. Although similar in some ways to an environmental noise impact assessment that is produced at the planning stage of a new development, the IPPC application process is usually undertaken much later on in the design stage of a project. Thus the IPPC application can use "real" noise data, and not assumed levels, which is often the case at an early stage of design when an environmental assessment is made. Where such real data is not available, then it may be more difficult to demonstrate the application of BAT.

A brief review has also been undertaken of available guidance on noise and vibration for IPPC applications. Of most importance are the two horizontal guidance notes produced by the EA, although there is also some individual sector guidance on noise. Of limited value appear to be the BREFs, which are being produced at a European level, as noise is scarcely regarded in these documents. Any development of BREFs specifically relating to noise in different industry sectors could be of considerable use in the future, although it is not known whether this is being planned.

7 REFERENCES

1. The Pollution Prevention and Control (England and Wales) Regulations 2000/1973.
2. Sector Guidance Note IPPC S0.01, General Sector Guidance.
3. Technical Guidance Note IPPC S6.01, Technical Guidance for the Pulp and Paper Sector.
4. EC Reference Document on Best Available Techniques in the Pulp and Paper Industry, December 2001.
5. Horizontal Guidance for Noise, IPPC H3, Part 1 – Regulation and Permitting.
6. Horizontal Guidance for Noise, IPPC H3, Part 2 – Noise Assessment and Control.
7. EC Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries, February 2003.
8. BS4142:1997, Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas.
9. Directive 2002/49/EC, June 2002, Relating to the Assessment and Management of Environmental Noise
10. EEMUA, Noise Procedure Specification, Publication 140
11. ISO 9613-2, Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation