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PLANT NOISE CONTROL ENGINEERING

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1. INTRODUCTION

The technical advice provided by Shell Global Solutions to clients, both within the Shell Group and to other industrial customers, is supported by a large number of technical specifications, called Design and Engineering Practices. One of these specifications has been used as a basis for the development of an international standard on plant noise control. The contents of the ISO standard 15664, at this moment issued by Working Group 48 to the ISO secretariat as a final draft standard, constitutes the backbone of this paper. A schematic flow-chart, reviewing the noise control process, is presented in Figure 1.

When the design of a new plant is started or when engineering work for a plant expansion or modification commences, the following parties are usually involved:

- the end-user and future operator of the plant,
- the engineering contractor, who makes the detailed design, and often does the plant construction and purchasing of equipment,
- the local authorities, who specify and enforce environmental and occupational health criteria,
- consultants, who may be called upon by the above parties to assist in various studies.

At the beginning of a project it is very important to make clear who is responsible for what part of the work, especially in the relationship between end-user and engineering contractor. Discussions with authorities and environmental reviews may be performed by the end-user or may be delegated to the engineering contractor or to an external consultant.

Furthermore, the process to ensure that noise control engineering will be adequately addressed and that appropriate progress review checks are carried out during the project, have to be agreed upon. This paper will discuss the proposed process that may be applied.

The ultimate goal of the use of noise control procedures in a project is to specify noise limits for individual equipment items such that, once installed and running, the plant noise levels meet the specification(s). A methodology to arrive at proper equipment limits is also touched upon in this paper.

2. SETTING OF NOISE LIMITS

Noise control requirements are needed for the following reasons:

- to prevent noise-induced hearing loss,
- to reduce work, speech and concentration interference,
- to provide quiet living accommodation for personnel,
- to protect the environment,
- to prevent annoyance to the neighbouring community.

These requirements can often be achieved by establishing two noise limits: one limit related to the work area and one related to the environment.

The work area limit can be specified as a maximum sound pressure level at a minimum distance (usually 1 m) to all noise sources. Alternatively, noise limits could be related to a position and the time that personnel is present at that position. The limit is then given as a maximum noise dose or exposure level.

For many years Shell Global Solutions have adopted a maximum noise dose for operators and maintenance personnel of 85 dB(A) for an eight hour working period. However, the noise dose principle makes it difficult to determine a noise limit to be specified when a piece of equipment is to be purchased. During the design and engineering phase maintenance requirements and operator rounds are not known yet.
Initially it was assumed that a conversion of the noise dose limit of 85 dB(A) to a work area noise limit of 90 dB(A) at 1 m from the equipment would be representative, since personnel typically visit many locations with lower noise levels and would not be present in a high noise area for long periods.
Tests carried out on installations built according to the above principle however, revealed that measured noise dose levels often exceeded the limit of 85 dB(A), primarily due to the fact that staff performing their jobs are often nearer to equipment than the 1 m limit assumed , thereby being exposed to higher noise levels.
Presently the standard specification for work area noise is set at 85 dB(A) at 1 m. This limit has also been adopted by several governmental bodies, although in many countries higher levels are considered acceptable.

Environmental noise limits are often imposed upon a project by local authorities, in the form of a maximum sound pressure level in the nearest residential area or at the boundary fence of the site. In those cases where authorities do not enforce environmental noise requirements, normally a representative noise limit is adopted so as to become a "good neighbour".

3. DETAILED ENGINEERING

During detailed engineering all noise limits and additional requirements imposed upon that project have to be translated into noise limits for individual equipment items which will have to be purchased from equipment suppliers. Normally two limits are specified for equipment: the maximum sound pressure level at 1 m from the equipment and the total sound power level radiated from the equipment. These two limits need not to be interrelated, e.g. the sound power level of an electric motor is based on the average sound pressure level around the motor while the maximum sound pressure level is found in front of the cooling fan and may be considerably higher than the average noise level.

3.1 Sound pressure limit

The sound pressure limit imposed on the equipment supplier is usually derived from the plant work area noise limit. However, the work area limit cannot be simply adopted as the equipment limit. The noise level generated by each piece of equipment has to be considered against that generated by adjacent noise sources (e.g. neighbouring equipment or noisy piping), with full account taken of whether reverberation effects may influence the overall level. The individual equipment limits shall be such that the total noise level in the work area does not exceed the limit.

3.2 Sound power limit

An environmental noise limit is often given as a maximum sound pressure level at a particular distance from the plant. When the governing receptor points are far enough from the plant to consider the plant as a single or a few point sources, it is most appropriate to translate the immission sound pressure limit into an emission sound power limit of the plant or main component parts of that plant. Recognised noise propagation models to make this conversion (prediction) are available (e.g. ISO 9613-2).
Once the overall sound power limit for a plant or part of a plant has been established, the very important and detailed job starts of assigning sound power limits to individual equipment items in such a way that the overall plant limit is not exceeded. The allocation of sound power limits in an early stage of a project can best be performed using vendor data, noise declarations, data bases and experience, taking into account type, size and operation conditions of equipment.

At this stage it is very important to take economics into account. It is more cost effective to allocate higher sound power limits to large or high powered equipment, than to simply allocate the same sound power level to each equipment item.
In the iterative process of making the sum of equipment sound power levels fit the overall limit, decisions also have to be made concerning where noise abatement measures are required or where special demands have to be put on suppliers for low-noise designs. In most cases it is technically more reliable and more cost-effective in the longer-term to reduce noise at source.

Drastic abatement measures, such as the erection of large acoustic enclosures or installing equipment in acoustically-treated buildings, may be required to meet the noise limits. These expensive measures may pose a heavy financial burden on the project, and may even make the project economically less attractive, but may also impose additional hazards. From a safety point of view it is generally preferable to have equipment installed in the open atmosphere, such that, if a leak occurs and hydrocarbons escape from the process equipment there is less chance of an explosion due to natural dispersion effects. Acoustic enclosures can be equipped with gas detectors, fire alarms and fire extinguishing systems, but the risk (and capital cost!) is still increased .
It should also be realised that, in terms of life-cycle costs, the erection of e.g. acoustic enclosures increases future maintenance costs. Not only for maintenance of the enclosure itself and its accessories but also for additional handling when the insulated equipment has to be accessed.

For the acoustic design of refineries, petro-chemical plants or gas plants the important contribution of piping noise should not be underestimated. As a rule of thumb, half of the noise radiated from a plant originates from pipelines, particularly those associated with high powered compressors, pressure letdown valves and (to a lesser extent) pumps. All such linework shall be considered in the acoustic design of a plant.
Acoustic insulation is the main abatement measure available for reducing piping noise. In ISO Working Group 48 a standard on acoustic insulation has been developed, for which a Shell specification formed the skeleton.

3.3 Equipment requisitions and feedback

The sound pressure and sound power limits which have been determined for equipment to be procured, shall be clearly communicated to the relevant manufacturers/suppliers. For this purpose, data requisition sheets are used to provide the supplier a standard format for response with guaranteed noise spectra for the equipment.
Based on the feedback of the equipment suppliers, the initial acoustic design has to be reviewed. Guaranteed noise levels from suppliers may be higher or lower than the required limit. If guaranteed noise levels exceed the limit and no alternative equipment is available, it may be

necessary to modify the acoustic design by applying additional acoustic measures or modifying the limits of other equipment. In this way the acoustic design again becomes an iterative process.

Once the majority of data from equipment suppliers is available, the acoustic design of a plant (still on paper at this stage), starts to become clear. This design should be formally documented in a 'Noise Control Report'.

4. VERIFICATION

When the plant has been built and is up and running, the time is there to investigate whether the plant is performing to acoustic specification. Measurements shall be carried out to evaluate compliance with maximum sound pressure limits, sound power limits and possible additional requirements like noise exposure levels and noise levels in residential areas.
Work area sound pressure levels can be checked in critical areas but it is Shell's recommendation to determine noise contour plots showing noise levels of 75 dB(A) and above with incremental steps of 5 dB(A).
Sound power levels are normally verified by enveloping measurements (ISO 8297) of the plant or substantial parts of the plant.

When a plant is not meeting the design criteria, investigations will be initiated to determine why the plant is not performing. If equipment items are not meeting their individual design and guaranteed limit, the supplier shall be expected to rectify the problem.

5. CONSIDERATIONS

The setting of noise limits at the onset of a project is of prime importance. Even if no limits are set explicitly, the consideration of noise control issues during the design of a plant means that a criterion for acceptable noise levels has to be adopted implicitly.
Once a level of noise limitation has been selected it is often very difficult to achieve lower noise levels without rigorous noise abatement measures and replacement of equipment, usually at very high costs.

Work area noise levels are normally designed not to exceed 85 dB(A), such that operators and maintenance personnel are not required to wear ear protection. In some areas, especially where large high powered equipment is installed it is neither technically feasible nor economically justified to reduce the levels below 85 dB(A). In those areas, called restricted areas, personnel are obliged to wear ear protection.

Figure 1 Noise control flowchart