Guideline

Noise Assessment

Prescribing noise conditions for environmental authorities for petroleum activities

This guideline is intended to assist in the assessment of noise impacts and the development of noise conditions for petroleum activities within the general framework provided by the Environmental Protection Act 1994 (EP Act).

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1. Purpose and scope

This document establishes the noise management theory and considerations that are necessary for the administering authority to:

1. Assess impacts on environmental values from noise impacts as part of an application for an environmental authority for resource activities other than mining; and
2. Develop noise conditions, including measured noise limits, to best achieve the object of the *Environmental Protection Act 1994* (EP Act).

2. Background

Resource activities other than mining include petroleum activities and generate various sources of noise from permanent installations such as well head equipment and compressor stations; intermittent operations such as drilling, work over and hydraulic fracturing; and ancillary operations such as rig movements, water tankers and gravel trucks. These noise sources may impact upon environmental values, in particular, the wellbeing of an individual, including the individual's opportunity to have sleep, relaxation, and conversation without unreasonable interference from intrusive noise.

It is reasonable to expect that the holder of an environmental authority for a resource activity other than mining carries out activities in a manner that prevents the emission or likelihood of emission of intrusive noise and not give rise to situations where noise nuisance can be caused.

This guideline should be read in conjunction with the DES's guideline "*Application requirements for petroleum activities*" and is applicable to all petroleum activities and all environmental authority application types.

3. Regulatory framework

The EP Act and the *Environmental Protection (Noise) Policy 2008* (EPP Noise) provides for the management and regulation of commercial and industrial noise that could adversely impact on noise sensitive areas. Under the EP Act, noise is considered a contaminant and noise nuisance is considered environmental harm.

Noise is broadly defined in the EP Act as a vibration of any frequency, whether emitted through air or another medium. The term "noise" is a subjective quality and is often used to refer to unwanted or intrusive sound. Noise becomes a nuisance when there is an unreasonable interference with an acoustic value. Nuisance noise can be continuous or intermittent, but the effect is such that there is a material interference with property or the personal comfort or quality of life of persons.

The purpose of the EPP Noise is to protect Queensland's acoustic environment according to the principles of ecologically sustainable development established in the EP Act. The purpose of the EPP Noise is achieved by:

(a) Identifying environmental values that are to be enhanced or protected;

(b) Stating acoustic quality objectives for enhancing or protecting the environmental values; and

(c) Providing a framework for making consistent, equitable and informed decisions about the acoustic environment.

Noise management hierarchy

Section 9 of the EPP Noise sets out a management hierarchy for all activities involving noise:

- Firstly, **avoid**;
- Secondly, **minimise**, in the following order of preference
    (i) firstly, orientate an activity to minimise noise;

(ii) secondly, use best available technology;

- Thirdly, **manage.**

Examples of the application of the noise management hierarchy for avoidance would be to locate an activity that has the potential for nuisance noise emissions away from sensitive receptors. For the purposes of petroleum activities, this intent could be achieved by employing a minimum buffer distance between the noise source and the sensitive receptor.

In the event that this option was not possible (e.g. due to land use constraints), noise sources should be orientated away from sensitive receptors. This is because noise travels in waves similar to the way ripples propagate on the water's surface. By orientating equipment away from sensitive receptors, noise will similarly move away from that receptor.

Orientation may not be possible with certain noise sources (e.g. top drive drilling rigs used to drill petroleum or gas wells). If orientation is not possible, then best available noise abatement measures must be used to minimise nuisance noise emissions. The lowest preference in the management hierarchy, and therefore, the last resort, is to implement operational controls on noise emissions such as only operating noisy equipment during certain hours.

4. Noise characteristics

Noise occurs by sound waves. A sound wave has the following characteristics:

- Velocity – sound travels through the air at a constant velocity. Velocity can be influenced by climatic conditions such as wind speed.
- Amplitude – equates to sound pressure and is the magnitude of disturbance in the air pressure relative to normal atmospheric pressure. Amplitude is variable and decreases over distance.
- Wavelength – is the distance between repeating sound pressure peaks within the sound wave and is not a variable characteristic but unique to the sound pressure being emitted.
- Frequency – when a noise is emitted, the atmospheric pressure varies periodically and the number of pressure variations per second is called the frequency. Frequency is measured in Hertz (Hz). Noise of high frequencies has short wavelengths and spans the ultrasound range above 2 KHz. Middle frequency noises are audible sounds which span 200 Hz to 2 KHz. Low frequencies have long wavelength and spans infrasonic and audible ranges from about 10 Hz to 200 Hz.
- Pressure – the amplitude of the sound wave equates to the sound pressure detected by the human ear. The sound pressure is produced by the source, can be measured and varies depending on many factors such as distance, orientation of the receiver and climatic conditions. Sound pressure is measured in Pascals (Pa) and is represented by the descriptor L_p.
- Power – the particular quantity and flow of energy which is radiated by a noise source per second and can not be measured. It is a physical property of the source and does not vary. Sound power level is represented by the descriptor L_w.

Typical sound power levels for petroleum activities

The sound power level of typical noise sources relevant to petroleum activities are provided in Table 1. There are many different noise sources associated with petroleum activities. The noise sources described as having a continuous noise output over time (indicated by use of L_{Aeq} in Table 1) could generally be described as being tonal. Most of these tonal noise sources are from plant and equipment that is powered by internal combustion engines. This engine-powered equipment is generally fitted with proprietary exhaust silencers, but apart from

these silencers, additional noise control treatments, whilst readily available are not typically manufactured with the engines as standard. Accordingly, these major tonal noise sources all have a similar shape of noise spectrum which is characteristic of a large diesel engine. Only the overall sound power levels differ. Noise sources which can be described as impulsive (indicated by the measure L_{Amax} in Table 1) are more varied and managing these noise sources requires varied solutions such as changing operator behaviour (e.g. controlled braking of vehicles) or installation of specialised low noise equipment (e.g. broadband reverse beepers).

Table 1 – Typical sound power levels of petroleum activity noise sources

Noise source	Overall sound power level (L_{WA})	Metric
Drill Rig (hydraulic pack)	95-100 dB(A) $_{W}$	L_{Aeq}
Drill Rig (air compressor)	95-100 dB(A) $_{W}$	L_{Aeq}
Drill Rig (mud pump)	100-105 dB(A) $_{W}$	L_{Aeq}
Field Compressor Station (screw drive engines)	110-115 dB(A) $_{W}$	L_{Aeq}
Central Compressor Station (reciprocating engines)	120-125 dB(A) $_{W}$	L_{Aeq}
Well Head Power Pack	95-105 dB(A) $_{W}$	L_{Aeq}
Generator (500kVA)	100-110 dB(A) $_{W}$	L_{Aeq}
Stimulation Activity (fraccing) (combined sources)	110-120 dB(A) $_{W}$	L_{Aeq}
Impacts of Drill Rods / Casings	100-110 dB(A) $_{W}$	L_{Amax}
Cavitation / Air Release	115-120 dB(A) $_{W}$	L_{Amax}
Engine Brakes	110-115 dB(A) $_{W}$	L_{Amax}
Reversing Beeper	100-105 dB(A) $_{W}$	L_{Amax}

To understand the sound power levels in Table 1, they can be compared to more common, every day noises as follows:

- Four propeller airliner 150 dB
- Car on a motorway 100 dB
- Shouting 90 dB
- Normal conversation 70 dB

- Very soft whisper 30 dB
- Calm breathing 10 dB

The following can be used to understand differences in sounds by decibel level:

- 1 dB - Not noticeable
- 3 dB - Barely noticeable
- 5 dB - Clearly noticeable change
- 10 dB - About twice as loud
- 20 dB - About four times as loud

Noise frequency weightings

Noise is measured at different frequency weightings to more accurately represent the way a noise is heard by the human ear. In order to do this, the frequency response of noise meters is tailored in such a way as to simulate the ear's perception of sound. Using frequency weightings allow noise meters to hear sound the same way a human ear does. When a frequency weighting is used, the noise level is called the weighted sound pressure level.

Some common frequency weightings and their applications are as follows:

- A-weighting, denoted as L_{pA}, measured in dB(A) – most commonly used to measure environmental and industrial noises of all sound pressure levels but cuts off very high, infrasound and low frequency noises that the human ear cannot hear. This weighting most accurately reflects the response of the human ear to noise but can devaluate noises at very high and low frequencies.
- C-weighting, denoted as L_{pC}, measured in dB(C) – used to measure environmental noise of highest and lower frequencies and provides a flat and specified frequency response similar to what is heard by the human ear at these frequencies. Can also be used for measuring peak sound pressure level.
- G-weighting, denoted as L_{pG}, measured in dB(G) – commonly used to measure infrasound and low frequency noise.
- Z-weighting, denoted as L_{pZ}, measured in dB(Z) – is a flat and specified frequency response between 10 Hz and 20 kHz ± 1.5 dB which replaces the "unweighted" or "linear" responses (which did not define any frequency range.

A large (e.g. 20 dB) difference between the A and C weighting levels generally indicates that there is a high, low frequency or infrasound component to the noise.

5. Application requirements

The decision to approve an environmental authority for a resource activity other than mining is an environmental management decision for the purposes of the EP Act. In making such a decision, the administering authority must consider:

1. The standard criteria; and
2. The regulatory requirements, which include Chapter 4 Part 2 of the *Environmental Protection Regulation 2008* (EP Reg) which covers consideration of the EPP Noise including the noise management hierarchy, environmental values, quality objectives and the management intent for the acoustic environment.

Under the requirements of the EP Act, supporting information must accompany an application for a resource activity other than mining to enable the administering authority to decide the application via an assessment against the regulatory requirements. This is in the context, for example, of identifying what the potential impact on environmental values from noise may be, and then addressing the use of the noise hierarchy in relation to

these impacts. The supporting information also enables conditions to be prescribed which appropriately regulate the noise activities and limit the potential for noise nuisance at sensitive receptors. For site-specific applications and variation applications (where relevant), supporting information must be provided as part of the application documents.

The administering authority has developed a guideline "*Application requirements for petroleum activities*" which is to be used to assist proponents to identify and include the necessary information with their application.

The basic concept of determining whether or not the noise from petroleum activities is likely to cause nuisance impacts is to compare the existing noise levels to the expected noise levels from the proposed activities. The determination must compare the background noise level (the average of the minimum sound levels without the petroleum activities) to the measured sound level at all potentially affected sensitive receptors when the petroleum activities are being carried out. This assessment is typically carried out by noise impact modelling or calculation. The noise levels used in the noise model or calculation must be indicative of the noise environment, and be an accurate representation of the noise environment at the activity location.

The noise management measures used in the model or calculation must be in accordance with the EPP Noise hierarchy: avoid, minimise and manage. Where noise modelling is used, the input parameters to the noise model, assumptions and modelling output should support the application for an environmental authority for a resource activity other than mining. Input parameters should include:

- Meteorological conditions such as wind (gradient and drainage-flow), temperature, humidity and temperature inversions at the activity and sensitive receptor locations;
- Distances to sensitive receptors;
- Background noise levels which truly represent the ambient environment where the activities are to be carried out;
- All noise sources and their locations, including those external to the site but that still contribute to noise levels. All noise levels must be a true representation of the noise source.

Noise modelling must be carried out for various scenarios and include a scenario of worst case meteorological conditions. Whilst different scenarios can be run through a noise model, it will rarely be possible to factor in all possible situations that may present themselves over time with accuracy. For this reason, assumptions must be made in applying the noise model. Assumptions will typically relate to the technical aspects of the model (e.g. statistical methods, data distribution, algorithms) however assumptions can also relate to noise behaviour such as propagation, attenuation and the assumed influences of typography and/or meteorology. All assumptions must be clearly stated so that any limitations resulting from those assumptions can be considered when assessing the impacts of the different scenarios.

The model output must also be included with the application and should be accompanied by maps for each of the scenarios that identify the location of noise sources, sensitive receptors, land features, prevailing climatic conditions and the predicted noise levels along defined map contours. For more information about DES's requirements for noise modelling, refer to DES's guideline *"Planning for Noise Control".*

The noise level contours on the model output must be checked against the acoustic quality objectives relevant to the protection of the identified acoustic environmental values in Schedule 1 of the EPP Noise. The predicted noise level at any sensitive receptor must protect identified acoustic values by demonstrating that the relevant acoustic quality objective is going to be met. If not, acoustic values will not be protected and as such, the activities proposed are too noisy. Additional noise management is required such as relocation or re-orientation and/or installation of noise abatement measures. These additional noise management measures can be

subsequently incorporated into the noise model to reassess noise impacts and demonstrate that the acoustic values will be protected.

Where predicted noise levels are below acoustic objectives and there is minimal risk of background creep and/or cumulative impacts, the input parameters used in the model can be transferred into the environmental authority as noise limits. However, the conditions of an environmental authority must be able to serve for the life of the activity; this may be over a long period of time, where development may change the acoustic values of the surrounding area. As such, noise limits must be able to protect the surrounding acoustic values both now and in the future.

The locations where petroleum activities are being carried out, such as the Surat Basin gas fields, feature large open rural spaces with low ambient noise levels. Activities in these areas will continue to expand and this will potentially result in an increased number of noise sources and noise emissions. Over time this could result in a louder acoustic environment (i.e. background creep) and as such there is the potential for cumulative impacts from the petroleum sector in these areas.

In summary, an application must be supported by, as a minimum:

- An inventory of all noise sources and sound power levels associated with all activities and plant and equipment (reference can be made to Table 1 to ensure all noise sources are listed);
- Identification of all sensitive receptors in the surrounding environment (preferably indicated on maps);
- Details of background monitoring data measured over time and across different locations, including at sensitive receptors;
- An assessment, preferably by noise modelling and contour maps, of expected noise emissions at different locations, including at sensitive receptors; and
- A description of the extent to which the predicted noise emissions will protect acoustic values.

In addition, it is ideal that the supporting information contains a noise management plan to enable efficient and effective response to noise management issues such as handling of complaints. The noise management plan should include the following information:

- A commitment by the Chief Executive Officer for the holder of this environmental authority, or their delegate, to ensure adequate allocation of staff and resources to the establishment and operation of the Noise Management Plan;
- Definition of roles, responsibilities and authorities within the staffing of the Noise Management Plan;
- Delivery of training to staff and contractors and maintenance of competencies;
- Risk/constraint analysis methods to be undertaken prior to any new operation (e.g. drill site) or installation of new equipment that has the potential to create noise nuisance;
- Procedures and methods to undertake assessments to determine compliance with best practice noise limits in the event of a valid complaint being received and when there are no alternative arrangements in place, taking in to account any tonal or impulsive noise impacts;
- Procedures for handling noise complaints;
- Community liaison and consultation procedures including but not limited to consultation for when night time petroleum activities (i.e. between 10:00 pm and 6:00 am) are likely to exceed 25 dBA;
- Procedures for managing records associated with all aspects of the Noise Management Plan including standardised forms for recording monitoring results and complaints;

- Details of petroleum activities and measured and/or predicted noise levels of noise sources associated with those activities;
- Reasonable and practicable control or abatement measures (including relocating the activity, altering the hours of operation, or having an alternate arrangement in place with any potentially affected person) that can be undertaken to ensure compliance with best practice noise limits;
- The level of noise at sensitive receptors that would be achieved from implementing reasonable and practicable control or abatement measures; and
- Mediation processes to be used in the event that noise complaints are not able to be resolved.

In the absence of adequate supporting information accompanying an application for an environmental authority for a resource activity other than mining, the administering authority may specifically request the information under section 140 of the EP Act. Information requests should only be made once and clearly detail the exact information required.

Background noise levels

Noise levels become difficult to regulate where an area has exceptionally low background noise levels, such as some isolated rural areas which may have backgrounds as low as 15-20 dB(A) at certain times of the year. This is particularly relevant to the management of noise for petroleum activities because many are located in isolated rural areas.

In relation to noise nuisance, experience has shown that when noise is greater than the background noise level, the noise is likely to be discernible. If the difference is substantial enough, the noise will be annoying. Differences of less than 5 dB may be of marginal significance with respect to annoyance. However, noise levels greater than 5 dB above the background noise levels are likely to cause annoyance (Bassarab et al, 2009).

In circumstances of exceptionally low background noise levels (e.g. 15 -20 dB(A)), the usual approach of limiting intrusive noise to not more than 3 dB above background during night periods would lead to unreasonably low emission limits. Imposing such limits would not be consistent with achieving the necessary balance between economic development and environmental protection required by the object of the EP Act. This is because achievement of very low noise levels when using equipment such as drill rigs is not practicably achievable. In these cases it is considered reasonable to deem the background noise level a relatively low level of 25 dB(A) for the night time period (10 pm to 6 am) as the minimum background level on which compliance is evaluated (Rumble, 2011).

The deemed background noise levels to be used for noise impact assessments for petroleum activities carried out in isolated rural areas are provided in Table 2. Note that a different deemed background level has been specified for the dawn period (6:00 am – 7:00 am) which is 5 dB(A) higher than that for night time (10:00 pm – 6:00 am). This is different to the times of the day specified in the EPP Noise where night time is defined as 10:00 pm – 7:00 am. This additional deemed background level is considered necessary in this instance as there is generally a significant difference between the background noise level before dawn and the background noise level after dawn in rural areas (e.g. early morning bird song) (Rumble, 2011).

Table 2 – Deemed background noise levels

Time period	Deemed background noise level (dB(A))
7:00 am – 6:00 pm	35
6:00 pm – 10:00 pm	30

10:00 pm – 6:00 am	25
6:00 am – 7:00 am	30

In the event a proponent is carrying out an activity in a rural or isolated area and considers the background noise level to be greater than the deemed levels in Table 2 or when the petroleum activities are carried out in louder environments, the assessment procedures for establishing background noise levels provided in DES's "*Noise Measurement Manual 3rd edition* (2000)" and AS1055.1 "*Acoustics—Description and measurement of environmental noise*" (as amended from time to time) must be followed. To vary the deemed background levels, DES will require proponents, in the supporting information accompanying an application to clearly identify the acoustic environment and the acoustic values to be protected. DES will also require that site specific monitoring is carried out at sensitive receptor locations across all times of the day, preferably using a data logger over multiple days, so as to yield sufficiently representative data.

Given the large spatial scale of petroleum activities, there may in fact be more than one background noise level that is relevant to the environmental authority. In the event a proponent considers there to be two different background noise levels, DES will require that the supporting information accompanying an application clearly identifies the different acoustic environments (including referencing these areas in a map) and the different acoustic values to be protected for each acoustic environment. DES will also require that site specific monitoring is carried out at sensitive receptor locations across all times of the day and across any acoustic environments of major difference.

In regulating noise emissions from petroleum activities, DES will not be prescribing an unspecified background value (*i.e.* a limit of "Background + X dB(A)") on environmental authorities. Therefore, where it is demonstrated that there is more than one background noise level for a petroleum activity, the conditions of the environmental authority will need to be amended to provide for both standards whilst clearly identifying the application of each (e.g. by use of area maps).

Considering multiple noise sources

The proponent must identify all noise sources that could impact on sensitive receptors. Establishing the individual noise sources is also important for monitoring and compliance in the event that DES receives nuisance complaints. Depending on the location of the sensitive receptor, it may be affected by noise emissions from two or more sources. Therefore multiple noise sources need to be identified, including those sources off tenure which may potentially impact on sensitive receptors (e.g. power stations), in the supporting information. When there are multiple noise sources, individual noise levels should be such that when all noise sources are combined together, the overall noise limit will be met. These levels should be identified so that in the event there is a nuisance impact from the activity, compliance for each source can then be assessed against its recorded noise level. Any non-compliance can then be directly attributed to the offending noise source and abatement measures can be implemented.

In assessing the noise levels from multiple noise sources, each noise source can be considered separately and its individual contribution to the noise emission level determined at a sensitive receptor. The overall noise emission level at a sensitive receptor which results from several sources can be found by logarithmic addition of the individual contributions. Alternatively, they can be combined using Table 3 (Sharland, 1972). To use Table 3, list the decibel levels in ascending order, combining the lowest two using the table and progressively add the result to the next one up the list.

Table 3 – Addition of sound levels

Difference between the two levels (dB)	Add to higher level
0	3
1	2.5
2 - 3	2
4	1.5
5 – 7	1
8 – 9	0.5
≥ 10	0

Example - adding the decibel levels 34, 33, 38 and 39

1. Arrange in ascending order (i.e. 33, 34, 38, 39)
2. Add the two lowest levels using the table (i.e. 33 + 34). The difference between the two noise sources is 1 dB therefore add 2.5 dB to the higher of 33 and 34. This gives 36.5 dB
3. Add to the next highest level (i.e. 36.5 + 38). The difference between the two noise sources is 1.5 dB therefore add 2 dB (rounding up) to the higher of 36.5 and 38. This gives 40 dB.
4. Add to the next highest level (i.e. 40 + 39). The difference between the two noise sources is 1 dB therefore add 2.5 dB to the highest level to get the final combined noise level of 42.5 dB.

Combination of background and component noise

It is important to consider the component noise from a noise source in addition to the background noise level in order to fully understand the expected measured noise level at a sensitive receptor. The component noise can be defined as the source noise only (i.e. without the contribution of background noise). To achieve any measured noise limit that may be prescribed in an environmental authority for a resource activity other than mining, the component noise must be considered in addition to the background noise using the methodology described above.

For example, if the background noise limit is 35 dB(A) and the component noise level from the source is 28 dB(A), then the total measured noise level is expected to be 36 dB(A) (because the difference between 35 dB(A) and 28 dB(A) is 7 dB(A), requiring an addition of 1 dB(A) to the higher of the two values).

6. Benchmarking of noise management standards

A review of noise management and regulation of the petroleum sector in Australia and the United States of America showed a variety of approaches to ensuring acoustic environmental values are protected from these activities. The variations are likely due to differences in legislative and land use planning frameworks and the acoustic values where the activities are carried out. In Queensland, many petroleum activities are carried out in isolated rural areas, or at least, areas with low population densities and low background noise levels. When

carrying out a benchmarking exercise, the unique circumstance must be taken into account when drawing comparisons or contrasts.

Australia

The regulation of noise from petroleum activities in New South Wales, South Australia and Victoria rely on a predetermined background noise level, relevant to the acoustic environment (e.g. non-residential area, industrial area, commercial area). In NSW, industrial noise in general is regulated by the *NSW Industrial Noise Policy (2000)* which sits under the *Protection of the Environment Operations Act 1997*. This policy requires that industrial noise shall generally not generate noise at a non-industrial premises which exceeds background plus 5 dB(A) during day time hours. This is supplemented by recommended noise levels across different acoustic environments. For example, in rural areas, noise from industrial activities must not exceed 50 dB(A) in the daytime, 45 dB(A) in the evening and 40 dB(A) at night time, measured as $L_{Aeq,\ 15\ mins}$.

In South Australia, the regulation of industrial noise is governed by the *Environmental Protection (Noise) Policy 2007* which sits under the *Environmental Protection Act 1993.* This policy does not specifically deal with petroleum activities but for construction, the policy sets out various management requirements for construction activities including hours for noise impacts and specified reasonable and practicable measures to minimise noise. The policy also espouses that noise from construction activities will not be considered a nuisance if such noise does not exceed 45 dB(A), measured as $L_{Aeq,\ 15\ mins}$ at a residential sensitive receptor. The framework does not consider rural areas with low background noise levels. The South Australian Environmental Protection Agency is addressing this issue by developing a code of practice for noise from industrial and commercial activities in rural areas (currently in development).

There is no specific policy for noise that applies in country Victoria but the Victorian Environmental Protection Agency has recently published the guideline - "Noise from Industry in Regional Victoria" (October 2011). The guideline provides recommended noise levels and limits based on planning scheme zones. Based on this guideline, the proponent is required to meet recommended maximum noise limits from gas plant operations at a residential sensitive receptor of 46 dB(A) in the day time, 41 dB(A) in the evening and 36 dB(A) at night time, measured as $L_{Aeq,\ 30\ mins}$.

Construction activities are specifically guided by information contained in the Victorian Environmental Protection Agency "Noise Control Guidelines", a part reproduction of its previous publication known as "TG 302/92", includes various management requirements for construction activities including hours for noise impacts and specified reasonable and practicable measures to minimise noise. The former TG 302/92 sets out specific noise limits for activities relevant to the petroleum sector. Noise limits for pipeline construction as per TG302/92 at a residential sensitive receptor are 55 dB(A) in the day time, 37 dB(A) in the evening and 32 dB(A) at night time, measured as $L_{Aeq,\ 30\ mins}$. Noise limits for the operation of a gas plant as per TG302/92 at a sensitive receptor are 45 dB(A) in the day time, 37 dB(A) in the evening and 32 dB(A) at night time, measured as $L_{Aeq,\ 30\ mins}$.

United States of America

There are many examples of noise regulation for the petroleum industry in the United States. The Federal Energy Regulatory Commission has previously imposed a 55 dB(A) day and night time limit at a sensitive receptor for compressor stations and gas wells, measured as L_{DN} . The Fort Worth City Council in Texas has issued the "Zoning Ordinance – Gas Drilling Regulations" (2009) with similar requirements for compressor stations with a 55 dB(A) and 50 dB(A) limit at a residential sensitive receptor for day time and evening respectively. Noise from gas wells is required to meet background plus 5 dB(A) for day time and background plus 3 dB(A) for the evening and cannot exceed 65 dB(A), measured as L_{DN}. Activities such as construction and vehicle movements are prohibited at night time and on Sunday and the Ordinance requires various noise abatement measures to be adopted to reduce noise emissions (e.g. mandatory engine mufflers).

A background plus 5 dB(A) for day time and background plus 3 dB(A) for the evening, measured as L_{DN} has also been applied to other petroleum operations in Texas including Arlington and Southlake and in Mansfield, Ohio. The State of Louisiana imposes a slightly more lenient background plus 7 dB(A) for day time and background plus 5 dB(A) for the evening, measured as L_{DN} . Generally in Texas, stimulation activities such as fraccing are not permitted at night time. During the day time, stimulation activities must not exceed background plus 10 dB(A), measured as L_{DN}. The pumping of flow back wastewater post stimulation has no specified noise limit during the day time or evening period but must meet between 3 – 5 dB(A), measured as L_{DN} for night time.

A summary of the noise level limits for petroleum activities at residential sensitive receptors in various locations of the Unites States of America are as follows:

Table 4 – Various noise emission limits in United States of America

Regulation	**Petroleum activity**	**Day time noise level limit L_{DN}**	**Night time noise level limit L_{DN}**
Fort Worth City Council, Texas	Compressor stations	55 dB(A)	50 dB(A)
	Gas wells	Background + 5 dB(A)	Background + 3 dB(A)
Arlington, Southlake and Mansfield, Texas	Petroleum operations	Background + 5 dB(A)	Background + 3 dB(A)
Various, Texas	Stimulation activities	Background + 10 dB(A)	Not permitted
	Pumping wastewater	N/A	3 – 5 dB(A)
Mansfield, Ohio	Petroleum operations	Background + 5 dB(A)	Background + 3 dB(A)
Louisiana	Petroleum operations	Background + 7 dB(A)	Background + 5 dB(A)

7. Best practice noise emission limits

In making an environmental management decision such as issuing an environmental authority for a resource activity other than mining, consideration must be had to the imposition of conditions. It is essential that any conditions on an environmental authority are final, certain and reasonable and reflect best practice environmental management standards. Conditions, relevant to noise management, can include:

- the imposition of distances between activities and sensitive receptors;
- installing and operating stated plant or equipment in a stated way within a stated period;
- taking stated measures to minimise the likelihood of environmental harm being caused;
- restricting the type, characteristics of, and way in which noise is released into the environment; and
- the imposition of conditions requiring noise monitoring.

When considering conditions to manage noise, consideration should be had to ensuring those conditions are outcome (i.e. performance) based, rather than prescriptive (i.e. conditions that specify how the outcome should be achieved. Refer to DES's guideline "W*riting effective and enforceable conditions"* for more information). For example, the imposition of buffer distances, the specification of plant/equipment and stating the measures to be implemented would be overly prescriptive for the purposes of managing noise from petroleum activities (given the broad range of options and solutions available) and more than likely result in ineffective conditions to manage noise impacts. Accordingly, conditions for managing noise impacts from petroleum activities should

focus on restricting the type, characteristics of, and way in which noise is released into the environment and requiring noise monitoring in the event there are nuisance complaints.

In this regard, DES has developed a suite of model conditions for coal seam gas (CSG) activities which address noise management and include best practice measured noise emission limits for CSG activities in rural or isolated areas. Conditioning the activity as per the model conditions should take into consideration the specific activity and surrounding environmental values and objectives. Due to the similarities in noise sources across resource activities other than mining (where essentially all noises are generated from engines used to drive the various pieces of equipment), these model conditions can also be applied to other resource activities such as petroleum and conventional oil and gas operations.

The best practice measured noise limits are set out in Table 5 includes a deemed background noise (indicated in Table 5 by the superscript "^") and component noises (indicated in Table 5 by "+ X" dB(A)).

The limits in Table 5 are considered to protect the acoustic values of a sensitive receptor in rural or isolated areas and achieve acoustic quality objectives in the EPP Noise whilst considering cumulative impacts and background creep. Background creep occurs when an activity is approved that permits an increase in noise levels above the background noise level. If this is allowed for several activities, there is a resultant increase in the overall background noise level. The consideration of cumulative impacts and background creep is particularly important in Queensland given the rapid growth and increasing density of petroleum activities in its key resource areas.

In Queensland, the EPP Noise deals with controlling background creep and states that the management intent for any activity involving noise, to the extent that it is reasonable to do so, is that noise from an activity, for noise that varies over time (measured by $L_{Aeq,adj,T}$) must not be more than 5 dB(A) greater than the existing acoustic environment (measured by $L_{A90,T}$). The long term component noise limits in Table 5 achieve the management intent in the EPP Noise for controlling background creep in the dawn, day time and evening periods. A more stringent component noise limit is specified for long term activities that occur in the night time period due to the very low ambient noise levels in rural and isolated areas during the night. The long term component noise limits in Table 5 are also consistent with the noise limits in the United States of America which has experienced similar growth and high density of petroleum activities.

Table 5 - Best practice measured noise emission limits

Time period	Metric	Short term	Medium term	Long term
7:00 am – 6:00 pm	$L_{Aeq,\ adj,\ 15\ mins}$	45 dB(A) (35^ + 10dB(A))	43 dB(A) (35^ + 8dB(A))	40 dB(A) (35^ + 5dB(A))
6:00 pm – 10:00 pm	$L_{Aeq,\ adj,\ 15\ mins}$	40 dB(A) (30^ + 10dB(A))	38 dB(A) (30^ + 8dB(A))	35 dB(A) (30^ + 5dB(A))
10:00 pm – 6:00 am	$L_{Aeq,\ adj,\ 15\ mins}$	28 dB(A) (25^ + 3dB(A))	28 dB(A) (25^ + 3dB(A))	28 dB(A) (25^ + 3dB(A))
	Max $L_{pA,\ 15\ mins}$	55 dB(A)	55 dB(A)	55 dB(A)

6:00 am – 7:00 am	$L_{Aeq,\ adj,\ 15\ mins}$	40 dB(A) (30^ + 10dB(A))	38dB(A) (30^ + 8dB(A))	35 dB(A) (30^ + 5dB(A))

(^) Deemed background noise level

A short term noise event is a noise exposure, when perceived at a receptor premise, which persists for an aggregate period not greater than eight hours and does not re-occur for a period of at least seven days. Reoccurrence is deemed to apply where a noise of comparable level is observed at the same receptor location for a period of one hour or more, even if it originates from a different source or source location.

A medium term noise event is a noise exposure, when perceived at a receptor premise, which persists for an aggregate period not greater than five days and does not re-occur for a period of at least four weeks. Reoccurrence is deemed to apply where a noise of comparable level is observed at the same receptor location for a period of one hour or more, even if it originates from a different source or source location.

A long term noise event is a noise exposure, when perceived at a receptor premise, which persists for a period of greater than five days, even when there are respite periods when the noise is inaudible within those five days.

There is a clear relationship between the degree of annoyance to a person and the overall duration of the noise and there are varying levels of tolerance that apply which accord to the duration of noise exposure - the longer a person is exposed to noise, the more sensitised they become to that noise and in turn, the less tolerable their situation (Rumble, 2011). The person becomes frustrated by the fact that their amenity is being adversely impacted and this is when complaints are made. The application of short, medium and long term noise limits reflects this philosophy. For example, the short term day time limit in Table 5 is higher than the medium term noise limit because a person will have more tolerance to a louder noise if it occurs for a short duration.

During the day time and evening period, there is no limitation on the maximum noise level, measured as Max L_{pA}. Over this time, the relevant noise emission level is the A-weighted equivalent continuous sound pressure level over 15 minutes, measured as L_{Aeq} which applies to continuous audible noise. However, during the night time, it is necessary to also have a limit that applies to short term, impulsive noises which have the tendency to wake a person from sleep. Therefore, in order to preserve sleep, an additional limit of 55 dB(A) as Max $L_{pA,\ 15\ mins}$ is recommended and this applies regardless of whether the activity is short, medium or long term. This limit is consistent with that recommended by the World Health Organisation's *"Guidelines for Community Noise*" (1999) and is comparative to the outdoor acoustic quality objective in the EPP Noise for health and wellbeing in relation to the ability to sleep.

Application of best practice noise emission limits to petroleum activities

The limits in Table 5 should be applied to all environmental authorities for resource activities other than mining as these limits reflect best practice noise attenuation of tonal noise sources associated with petroleum activities and will help ensure that the acoustic values in the EPP Noise are being protected despite cumulative impacts and background creep.

The best practice measured noise emission limits apply outside at or near the façade of any habitable part of a residence, but do not include any correction for façade reflection (Rumble, 2011). As previously discussed, there may be circumstances where the deemed background levels can be increased (see Background Noise Levels, page 8) however the component noise should not be increased as this would authorise below best practice noise management.

In certain instances, basic noise abatement will be able to achieve compliance with the limits in Table 5. In other instances, more advanced abatement measures will be required. In the event that advanced abatement measures still do not bring about compliance with the best practice limits, other management options must be implemented as the highest priorities such as relocating the noise source so that it is a greater distance from the

sensitive receptor or implementing alternative arrangements with that receptor. Some examples of how noise emissions from different tonal noise sources can be managed so as to comply with best practice limits are provided below. The examples are derived from an electronic calculator which calculates sound pressure at a nominated distance using sound power or sound pressure levels in combination with various attenuation options (Rumble, 2011).

Example 1 – Well head power pack (long term noise event), 500 m from a sensitive receptor

Un-attenuated overall sound power level at well head power pack: 95 dB(A)

Predicted component sound pressure level at sensitive receptor for un-attenuated drill rig: 30 dB(A)

Requires noise abatement technology to comply with night time limit of 28 dB(A).

Noise source levels are required to have a component level of 25 dB(A) so that when this component is combined with the background noise level for night time of 25 dB(A), the combined noise sources equal the measured noise limit of 28 dB(A).

Installation of basic attenuation package (e.g. sealed steel enclosures ≥ 1 mm thickness, single stage acoustic louvers at the inlet and discharge and upgraded engine exhaust mufflers on engines).

Resultant predicted component sound pressure level at the sensitive receptor: 16 dB(A)

When this component sound pressure level is combined with the background noise level of 25 dB(A), the measured noise level at the sensitive receptor is expected to be 26.5 dB(A), meeting the night time limit of 28 dB(A).

Lesser attenuation measures could be used if the activity was not going to occur at night.

Example 2 – Fraccing activity (medium term noise event), 300 m from a sensitive receptor

Un-attenuated overall sound power level of fraccing activity: 110 dB(A)

Predicted component sound pressure level at the sensitive receptor for un-attenuated fraccing activities: 50 dB(A)

Requires noise abatement technology in order to comply with limits for all time periods.

Installation of high level attenuation package (e.g. sealed steel enclosures ≥ 1.6 mm thickness, 75 mm sound absorbing internal lining on enclosures, 1500 mm long splitter attenuators at inlet and discharge and dual exhaust mufflers on engines).

Resultant predicted component sound pressure level at the sensitive receptor: 25 dB(A)

When this component sound pressure level is combined with the background noise levels of 25 dB(A), 30 dB(A) and 35 dB(A), the measured noise level at the sensitive receptor are expected to be 28 dB(A), 31 dB(A) and 35 dB(A).

Lesser attenuation measures could be used if the activity was not going to occur at night.

Example 3 – Field Compressor Station (long term noise event), 200 m from a sensitive receptor

Un-attenuated overall sound power level of compressor station: 115 dB(A)

Predicted component sound pressure level at sensitive receptor for un-attenuated compressor station: 59 dB(A)

Requires noise abatement technology in order to comply with limits for all time periods.

Installation of best practice attenuation package (e.g. sealed steel enclosures ≥ 2 mm thickness, 75 mm sound absorbing internal lining on enclosures, 1800 mm long splitter attenuators at inlet and discharge and dual exhaust mufflers on engines).

Resultant predicted sound pressure level at the sensitive receptor: 31 dB(A)

When this component sound pressure level is combined with the background noise levels of 25 dB(A), 30 dB(A) and 35 dB(A), the measured noise level at the sensitive receptor are expected to be 32 dB(A), 33.5 dB(A) and 36.5 dB(A).

In this example, the field compressor station still does not comply with the night time limit of 28 dB(A) despite best practice abatement measures. Compliance at night can be achieved by ensuring the field compressor station is located an additional 200 m away from the sensitive receptor (bringing down the component sound pressure level at that receptor to an estimated 26 dB(A), which when added to 28 dB(A) gives a total measured level noise of 28 dB(A). Another option would be to implement permanent alternative arrangements with that receptor.

8. Noise measurement and reporting noise levels

Noise measurement and reporting for audible, low frequency, blasting and vibration must be carried out in accordance with DES's "*Noise Measurement Manual*" (2000), any applicable Australian Standard and the conditions of any relevant environmental authority for resource activities other than mining.

9. Definitions

- L_{WA} is the A-weighted sound power level in dB(A)w.
- *Max* $L_{pA\ ,\ 15mins}$ is the maximum A-weighted sound pressure level, measured over a time interval of 15 minutes using Fast ("F") meter time response.
- L_{AMax} is the average of the maximum noise excursions in a representative sample of the same intermittent, repetitive noise event such as vehicle reversing beepers or engine brake applications.
- $L_{Aeq,\ 15\ mins}$ is the equivalent or energy-averaged, A-weighted sound pressure level, averaged over a time interval of 15 minutes.
- L_{A90} is the A-weighted sound pressure level, equal to or exceeded for 90 % of the sample time ("T") measured using Fast ("F") meter time response.
- $_{Adj}$ is a penalty adjustment which is applied to a measured or calculated noise emission level, to account for annoying characteristics such as tonality or impulsiveness. It is assessed subjectively in accordance with DES's "*Noise Measurement Manual*" (2000) and has values of either zero, 2 dB(A) or 5 dB(A).
- L_{DN} is the day night average sound level and is the 24 hour average sound level, in decibels, for the period from midnight to midnight, obtained after addition of 10 dB to sound levels in the night from midnight to 7 am and from 10 pm to midnight. This is a measureable quantity and can be measured directly at a specific location. When it is measured it is not necessary that the measurement begin at midnight.

10. References

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Version history

Version	Effective date	Description of changes
1.00	15 March 2013	First publication of the document.
2.00	15 March 2013	Minor content updates.
2.01	10 July 2018	The document template, header and footer have been updated to reflect current Queensland Government corporate identity requirements and comply with the Policy Register.

[1] This is the publication number, which can be used as a search term to find the latest version of the publication at www.des.qld.gov.au.