7B Noise and Vibration Impact Assessment Criteria and Methodology

7B.1 Introduction

This annex provides details of the basis for development of criteria for evaluating the significance of noise and vibration impacts for the Simandou Project and describes the methods used for predicting impacts from the Simandou Mine:

- Section 7B.2 reviews sources of international guidance relating to noise and vibration;
- Section 7B.3 explains the approach to prediction and evaluation of construction noise;
- Section 7B.4 explains the approach to assessing noise from mine operations; and
- Section 7B.5 explains the approach to assessing noise and vibration impacts from blasting.

7B.2 International Guidance

There are generally three types of guidance on noise levels that can be consulted for noise and vibration assessments:

- levels which represent the on-set of noise or vibration impacts (which are often contained in planning guidance for new projects, but which do not require any mitigation of noise);
- mitigation trigger levels where the potential noise or vibration impacts are considered to be sufficiently high to require mitigation to be considered at source taking account of local conditions and the benefits of a scheme; and
- levels at which regulations require noise mitigation at the receiver in the form of noise insulation or mitigation at the affected buildings due to the levels being unacceptable without such mitigation.

The World Health Organisation (WHO) together with the Organisation for Economic Co-ordination and Development (OECD) and the International Finance Corporation (IFC) are two of the main bodies that have collected data and developed their own assessments on the effects of the exposure to environmental noise. On the basis of these assessments, guideline values for different time periods and situations have been developed.

7B.2.1 WHO/OECD Guidance


- To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB LAeq for a steady, continuous noise.
- To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB LAeq.
- At night, sound pressure levels at the outside façades of living spaces should not exceed 45 dB LAeq and 60 dB LAMax, so that people may sleep with bedroom windows open. These values have been obtained by assuming that the noise reduction from outside to inside with the window partly open is 15 dB.

7B.2.2 IFC General EHS Guidelines

The IFC General EHS Guidelines differentiate between two principal receptor categories, residential and industrial, but are not specific to any particular source. The noise level guidelines for these receptors are summarised in Table 7B.1. They make reference to noise from facilities and stationary noise sources, and
are commonly applied as design standards for industrial facilities. Whilst they offer general guidance on noise effects, the IFC has indicated that they are not directly applicable to transport or mobile noise sources. Measurements are to be taken at noise receptors located outside the project property boundary.

**Table 7B.1 IFC Noise Level Guidelines (General EHS Guidelines Table 1.7.1)**

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Maximum Allowable Ambient Noise Levels, LAeq,1hr, dBA Free field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daytime</td>
</tr>
<tr>
<td></td>
<td>07:00 – 22:00</td>
</tr>
<tr>
<td>Residential, institutional, educational</td>
<td>55</td>
</tr>
<tr>
<td>Industrial, commercial</td>
<td>70</td>
</tr>
</tbody>
</table>

The guidelines also state that:

“Noise impacts should not exceed the levels presented in Table 1.7.1, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.”

**7B.2.3 IFC EHS Guidelines for Mining**

In addition to the General EHS Guidelines the IFC has developed industry specific guidelines including the EHS Guidelines for Mining (1). The EHS Guidelines are technical reference documents with general and industry specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the General EHS Guidelines.

The EHS Guidelines for Mining are applicable to underground and open-pit mining, alluvial mining, solution mining, and marine dredging. In summary, they state that the noise guidelines in the general EHS guidelines should be achieved and that:

“sources of noise emissions that may include noise from vehicle engines, loading and unloading of rock into steel dumpers, chutes, power generation, and other sources related to construction and mining activities. Additional examples of noise sources include shoveling, ripping, drilling, blasting, transport (including corridors for rail, road, and conveyor belts), crushing, grinding, and stockpiling”.

They go on to discuss the establishment of good practice in the prevention and control of noise sources based on the prevailing land use and the proximity of noise receptors such as communities or community use areas and recommend various mitigation strategies and techniques.

The guidelines also recognise that vibration and noise from blasting are also generated from mining but no standards are offered.

**7B.3 Construction Noise**

**7B.3.1 Introduction**

This section presents a review of current noise guidance to inform the development of construction noise impact assessment criteria for the Simandou Mine and describes the method used to predict construction noise.

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7B.3.2 Review of Construction Noise Guidelines

Construction sites have special characteristics compared with other major noise generators. Construction is generally undertaken in the open, is usually of a temporary duration, and varying levels of noise are produced by several different types of noise sources. Equipment can be stationary or mobile; stationary equipment operates in one place for one or more days at a time, and can have either fixed power operation (pumps, generators, compressors) or variable operation (pile drivers, pavement breakers), whereas mobile equipment will move around sites (bulldozers, mobile cranes, haul trucks etc). Noise levels created by construction equipment can vary greatly and depend on factors such as type of equipment, the specific model, the operation being performed, duration of the activity, and the condition of the equipment.

There are no standardised criteria for assessing construction noise impacts, and consequently such criteria are usually determined on a project-specific basis. Criteria should take into account the existing noise environment, the absolute noise levels during construction activities, and the receptor land use.

The current approaches taken to determining land use construction noise impact criteria in European Union (EU) countries including the UK, the USA, Australia, Japan, Korea and Hong Kong are all similar in that the noise sensitivity of various land uses is used to provide the primary indicator of an acceptable noise level attributable to construction activities for different times of the day (daytime, evening and night time). The other significant factor in assessing the effects of noise impacts is the duration of the impact.

A review of construction noise level impact assessment criteria, expressed as LAeq values normalised to preferable (minimum) and acceptable (maximum) values for day and night time periods, from these countries, is presented in Figure 7B.1. The ranges presented in Figure 7B.1 cover daytime and night time criteria, as well as some instances of 24 hour criteria.

![Figure 7B.1 Ranges of Residential Noise Limits for Construction (LAeq)](image)

7B.3.3 Construction Noise Impact Criteria

The basic rationale behind the proposed construction noise impact assessment criteria for the Simandou Project is one that will ensure the adequate protection of existing sensitive land uses whilst permitting the
construction works to be completed in a practical manner. The guidance summarised above has been reviewed to establish a suitable set of criteria for the Simandou Project. These are presented in Table 7B.2. The grades of significance are as defined in Chapter 1: Introduction of the SEIA. The duration of construction noise is accounted for by applying variable noise thresholds for significant impact.

A threshold for critical noise impact is defined based on the level at which it is generally considered that hearing damage could start to occur (Lmax 85dBA).

<table>
<thead>
<tr>
<th>Operating Period</th>
<th>Daytime Noise Level, dB L&lt;sub&gt;Aeq&lt;/sub&gt;, 1hr</th>
<th>Night time Noise Level, dB L&lt;sub&gt;Aeq&lt;/sub&gt;, 1hr</th>
<th>All Periods L&lt;sub&gt;Amax&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Significant</td>
<td>Minor</td>
<td>Moderate</td>
</tr>
<tr>
<td>Short term exposure &lt; 1 month</td>
<td>&lt;70</td>
<td>70-75</td>
<td>&gt;75-80</td>
</tr>
<tr>
<td>Medium term exposure 1 to 6 months</td>
<td>&lt;65</td>
<td>65-70</td>
<td>&gt;70-75</td>
</tr>
<tr>
<td>Long term exposure &gt; 6 months</td>
<td>&lt;55</td>
<td>55-60</td>
<td>&gt;60-65</td>
</tr>
</tbody>
</table>

**7B.3.4 Method for Predicting Construction Noise**

Bruel & Kjaer’s Predictor V8.01 noise modelling software has been used to calculate noise emissions from construction activities utilising the methods identified within British Standard, BS5228:2009 Noise and vibration control on construction and open sites. BS5228 provides guidance concerning methods of predicting and measuring noise and identifies indicative noise level outputs, in terms of Sound Power Levels (SWL or Lw) and activity L<sub>Aeq</sub> (the A-weighted equivalent noise level), for a wide range of construction plant. It also recommends methods of noise control for construction and open sites where work activities or operations generate significant noise levels.

The computer model incorporates identifiable noise source data, surrounding terrain characteristics and the barrier effects of nearby buildings and structures. It can be used to calculate noise levels at specified locations (single point calculation) or noise level contours over a defined area (contour calculation). Due to the expanse of the project and number of receptors, the contour calculation feature of was used to predict noise levels from the mine construction activities.

Factors such as meteorological conditions (eg wind speed and direction), atmospheric absorption, and ground attenuation can influence the level of noise received from day to day. However, predicting these effects is complex and instead a conservative approach has been adopted by assuming still air and no atmospheric absorption, which potentially over-predicts noise levels.

**7B.4 Operational Noise**

**7B.4.1 Introduction**

This section reviews current noise guidance on operational noise, details the evaluation criteria developed for mine operations and describes the prediction method. The guidance is generally derived from research into human response to noise or vibration and the criteria are developed taking into account the need to protect the wellbeing of the community and the opportunity for individuals to enjoy sleep, relaxation and conversation without unreasonable interference from intrusive noise.
7B.4.2 Evaluation Criteria for Operational Noise

The IFC General EHS Guidelines Section 1.7 Noise Level Guidelines (see Section 7B.2) are considered to be applicable to the Simandou Mine and have been adopted for the project. IFC EHS guidelines present two approaches related to overall ambient noise levels and changes in background noise levels.

Two sets of criteria are therefore established for operational noise:

- Firstly, the noise level from the mine is evaluated against threshold values based on the general wellbeing of people and the onset of annoyance; and
- Secondly, the potential for increase in noise caused by the mine is evaluated by comparing the contribution from the mine with the background noise without the mine.

The criteria for overall noise are based on the IFC guidance set out in Table 7B.1.

The change from background is evaluated by reference to Section 1.7 of the IFC EHS Guidelines – Environmental Noise Management which states that noise impacts should not result in a maximum increase in background levels of more than 3 dB at the nearest off-site receptor. This could be expressed either as a change in background noise levels (ie LA90) or as the difference between LA90 without the mine and LAeq with the mine. Because there is no direct means of calculating the mine contributed LA90 the LAeq is used.

Further guidance is available from BS 4142 (1) Method for rating industrial noise affecting mixed residential and industrial areas, and the NSW INP (2) relating to acceptable noise levels from industrial noise sources and industrial facilities where noise is generally of a continuous nature. These guidelines are based on the understanding that where the difference between the specific noise from the project (LAeq) and the background noise (LA90) is large enough, then the specific noise source can be sufficient to cause a significant increase (> 3 dB) in background noise levels.

The NSW INP suggest that noise may become intrusive if the LAeq, 15 minute is 5 dBA or more above the rating background level where:

- LAeq, 15 minute represents the equivalent continuous (energy average) A-weighted sound pressure level of the source over 15 minutes; and
- the rating background level is the background level to be used for assessment purposes as determined by the method outlined in Section 3.1 of the INP.

BS 4142 is based on a 1 hour daytime criteria and assesses the likelihood of complaints by subtracting the measured background noise level from the specific level and concludes the following:

- the greater this difference the greater the likelihood of complaints;
- a difference of around +10 dB or more indicates that complaints are likely;
- a difference of around +5 dB is of marginal significance; and
- if the specific level is more than 10 dB below the measured background noise level then this is a positive indication that complaints are unlikely.

Based on these sources, and taking into account the distance to receptors, a significant noise impact from the relatively steady and continuous noise generated by mine operations, is judged to occur when the mine noise exceeds the background noise level by more than 10 dB.

(1) BS 4142 Method for Rating industrial noise affecting mixed residential and industrial areas
(2) Australia - New South Wales Industrial Noise Policy
The resulting criteria proposed for evaluation of noise from operation of the Simandou Mine are set out in Table 7B.3. When assessing the background noise impact, and where baseline noise levels are very low, a minimum noise level of 30 dBA is adopted as the baseline.

Table 7B.3 Evaluation Criteria for Operational Noise affecting Residential Receptors

<table>
<thead>
<tr>
<th>Operating Period</th>
<th>Daytime, LAeq, 1hr dBA</th>
<th>Night time, LAeq, 1hr dBA</th>
<th>LAmx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significance</td>
<td>Not Significant</td>
<td>Minor</td>
<td>Moderate</td>
</tr>
<tr>
<td>Specific Noise Level</td>
<td>&lt;55</td>
<td>55-60</td>
<td>&gt;60-65</td>
</tr>
<tr>
<td>Difference (LAeq, 1hr minus LA90)</td>
<td>&gt;10</td>
<td>10-15</td>
<td>15-20</td>
</tr>
</tbody>
</table>

7B.4.3 Method for Predicting Operational Noise

Bruel & Kjaer’s Predictor V8.10, used for calculating construction noise, was also used to calculate noise emissions from operational activities, but in this case using the methods identified within ISO 9613 Part 2 for the propagation of noise. As before, the model incorporates identifiable noise source data, meteorological data, surrounding terrain characteristics and the barrier effects of nearby buildings and structures and was used to generate noise level contours. The effect of meteorological conditions was taken into account by modelling four different meteorological scenarios as described in Table 7B.4.

Table 7B.4 Meteorological Conditions for Noise Modelling

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Temperature (°C)</th>
<th>Humidity (%)</th>
<th>Wind Speed (m/s)</th>
<th>Wind Direction (deg from North)</th>
<th>Pasquill – Gifford Atmospheric Stability Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calm conditions</td>
<td>25 Daytime 15 Night time</td>
<td>80</td>
<td>--</td>
<td>--</td>
<td>C</td>
</tr>
<tr>
<td>Wet Season</td>
<td>20 80</td>
<td>3</td>
<td>SW (225)</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Dry Season</td>
<td>20 60</td>
<td>3</td>
<td>E (90)</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Night Time Temperature Inversion</td>
<td>15 80</td>
<td>0</td>
<td>--</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

7B.5 Blasting

7B.5.1 Introduction

This section presents the review of current guidance materials relating to blasting emissions to inform the development of operational blasting impact assessment criteria for the Simandou Mine.

Blasting from mining and construction activities can have impacts on surrounding people, wildlife and structures including plant, machinery, buildings and pipelines through airblast (air overpressure) and ground vibration.

Whenever blasting is carried out, energy is transmitted through the air from the blast site in the form of airborne pressure waves. These pressure waves comprise energy over a wide range of frequencies. Some is higher than 20 Hz and perceptible as sound, but the majority is below 20 Hz and hence inaudible, but can be sensed as concussion. The combination of sound and concussion that is known as airblast. Airblast can excite secondary vibrations at an audible frequency in buildings and it is usually this effect which has been
Energy is also transmitted through the ground as vibration. The effect of vibration on people is highly subjective, as one person may tolerate high levels that would be unacceptable to someone else. It is therefore difficult to offer advice on suitable levels of ground vibration because of the uncertainties in response. Appropriate limits need to take account of local conditions and the nature of the works.

7B.5.2 Review of Blasting Guidance

In the absence of Guinean or international blasting guidelines the following sources were reviewed:

1. Ontario Limits for Quarries (Canada);
2. Office of Surface Mining Reclamation and Enforcement (OSMRE), USA;
3. Australian and New Zealand Environment and Conservation Council (ANZECC) Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (ANZECC, 1990);
6. Minerals Technical Advice Note 2: Coal (MTAN), January 2009 (Wales);
7. Minerals Planning Guidance Note 9 (MPG), 1992 (UK) and Scottish Government Circular 26/1992; and

The guidelines are defined limits for airblast, measured in dBZ or dBLinear, and ground vibration, measured as Peak Particle Velocity (PPV) in mm/s. A summary is presented in Table 7B.5.

Table 7B.5 Common Blasting Emissions Criteria

<table>
<thead>
<tr>
<th>Emission Type</th>
<th>Receptor</th>
<th>Regional Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ontario⁵</td>
</tr>
<tr>
<td>Airblast dB(Z)</td>
<td>Residential</td>
<td>129 (&lt; 6Hz)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>133 (&lt; 2Hz)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>134 (&lt; 0. 1Hz)</td>
</tr>
<tr>
<td>Peak Particle Velocity</td>
<td>Recommended maximum ground vibration</td>
<td>5 (95%)⁶</td>
</tr>
<tr>
<td>(mm/s)</td>
<td>Offices, commercial &amp; industrial buildings</td>
<td>31 (&lt; 100m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 (&gt; 100m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 (&gt; 1500m)</td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td>2 (long term)³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 (max)³</td>
</tr>
</tbody>
</table>

Note: References are to the list of relevant blasting guidelines above.

Criteria for avoidance of structural damage from transient vibration from blasting are provided in Australian Standard AS 2187. 2 Explosives - Storage, Transport and Use (ANZECC 2006), British Standards BS 6472: 2008 and BS7385: 1993 and German standard DIN 4150-3: 1992-02. These are summarised in Table 7B.6. Thresholds for structural damage are generally above those specified in Table 7B.5.
Table 7B.6 Common Ground Vibration Limits for Structures

<table>
<thead>
<tr>
<th>Type of Structure</th>
<th>Ground Vibration Criterion (mm/s)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Transmission lines (overhead)</td>
<td>100</td>
<td>AS 2187,2 (ANZECC 2006)</td>
</tr>
<tr>
<td>Buried Pipework (steel)</td>
<td>100</td>
<td>DIN 4150-3: 1999-02 Table 2 Line 1</td>
</tr>
<tr>
<td>Roads</td>
<td>20</td>
<td>Conservative criteria 2 x ANZECC Guidelines</td>
</tr>
<tr>
<td>Site Buildings/ Offices/ Workshops</td>
<td>20</td>
<td>DIN 4150-3: 1999-02 (Table 1 Line 1)</td>
</tr>
<tr>
<td>Conveyors (standard construction)</td>
<td>100</td>
<td>Terrock Consulting (2008) [1]</td>
</tr>
</tbody>
</table>

Note:
[1] An investigation into the effects of blasting on the conveyors at Cumnock Colliery (NSW, Australia) undertaken by Terrock Consulting Engineers found that a peak particle velocity (PPV) of “100 mm/s would not cause overloading of the conveyor structure with the conveyor belt running” (Terrock Consulting Engineers, July 2008).

7B.5.3 Evaluation Criteria for Blasting

The guidance summarised above was used to establish criteria for evaluating the significance of emissions from blasting for the Simandou Project. These are set out in Table 7B.7. The criteria are designed to ensure adequate protection of sensitive land uses whilst permitting the operations to be conducted in a practical manner. The criteria are presented as 95 percentile limits for human comfort in occupied buildings and avoiding risk of cosmetic and structural damage to buildings from long term effects of vibration. Lower limits are set for the night time period. No distinction is made between minor and moderate significance because of the nature of impacts resulting from blasting and the response of receptors.

Critical impacts from airblast are identified where airblast noise from blasting exceeds 140 dBZ, generally accepted as the safe threshold for hearing.

Table 7B.7 Criteria for Evaluation of Impacts from Blasting

<table>
<thead>
<tr>
<th>Period</th>
<th>Airblast dB(Z) 95 percentile</th>
<th>Vibration PPV mm/s 95 percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Significant</td>
<td>Minor/ Moderate</td>
</tr>
<tr>
<td>Daytime</td>
<td>&lt;115</td>
<td>&gt;115-125</td>
</tr>
<tr>
<td>Night time</td>
<td>&lt;105</td>
<td>&gt;105-115</td>
</tr>
</tbody>
</table>

7B.5.4 Ground Vibration and Airblast Prediction Methodology

Ground vibration and airblast levels have been predicted using the methodology outlined in the ICI Blasting Guide (ICI 1995) to provide an understanding of the potential of impacts from blasting.

7B.5.4.1 Airblast Prediction

The 95th percentile airblast site law, which may be exceeded up to 5% of the total annual blasts is defined by the peak airblast level (SPL) measured in dB (Z) and is defined as:

\[
\text{Airblast OP (95\%) = 165.3 – 24 \log_{10} (SD)}
\]

where scaled distance

\[
SD = \frac{d}{\sqrt{MIC}}
\]

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MIC is the maximum explosive charge mass (kilograms) detonated per delay at any 8 millisecond interval; and

d is the distance between the charge (blast location) and receptor.

7B.5.4.2 Blasting Vibration Prediction

The Peak Vector Sum (PVS) ground vibration site law is defined as:

\[
PVS \text{ (mm/s)} = 1140 \text{ (SD)}^{-1.6}
\]

\[
SD = \frac{d}{\sqrt[3]{MIC}}
\]

where scaled distance

MIC is the maximum explosive charge mass (kilograms) detonated per delay at any 8 millisecond interval; and

d is the distance between charge and receptor.