AUC
Alberta Utilities Commission
Fifth Avenue Place, 4th Floor, 425 - 1 Street SW
Calgary, Alberta Canada T2P 3L8
Phone (403) 592-8845
www.auc.ab.ca

Rule 012

Noise Control

The Alberta Utilities Commission (Commission) has approved amendments to this rule on February 23, 2010.

Contents

Tables

Figures

1 General Provisions

1.1 Definitions

In this rule,

(a) "Commission" means the Alberta Utilities Commission;

(b) "facility" means a gas utility pipeline, hydro development, power plant, substation, and transmission line;

(c) "gas utility pipeline" has the same meaning as in the *Gas Utilities Act* (*GU Act*);

(d) "hydro development", "power plant", "substation", or "transmission line" has the same meaning as in the *Hydro and Electric Energy Act* (*HEE Act*); and,

(e) "licensee" means the holder of a licence or approval for a facility in accordance with the records of the Alberta Utilities Commission.

1.2 Rule Application

Subject to section 2.3, this rule applies to a facility and the operation of a facility including noise related to construction of a facility.

1.3 Permissible Sound Level

A facility must meet the permissible sound level (PSL) determined in accordance with section 2 where there are dwelling(s) within 1.5 km from the facility fence line.

Where there is no dwelling near the facility, a PSL of 40 decibels absolute energy level equivalent (dBA Leq) nighttime must be met at 1.5 km from the facility fence line.

For the purpose of determining compliance with this rule, noise is measured at a distance of 15 m from the nearest or most impacted dwelling, rather than at the property line of the land on which the dwelling is located.

1.4 Existing Facility

When requested, a licensee must communicate existing noise levels to a person proposing to build near a facility, using existing noise survey data or modeling data extrapolated to the proposed building site.

A licensee must keep documentation of communication between the licensee and any person proposing to build near the facility.

Where a dwelling is built near an existing facility, a licensee must comply expeditiously with the requirements of this rule once it is aware that new dwelling will result in the facility exceeding the permissible sound level stipulated in section 1.3.

2 Permissible Sound Level (PSL)

2.1 Determination of Permissible Sound Level

(1) The PSL is determined for the nearest or most impacted dwelling(s) within 1.5 km from the facility and is the value assigned to that dwelling unit. The PSL is based on summertime conditions.

(2) The PSL is calculated as follows:

Permissible sound level (PSL)	=	Basic sound level (BSL) (Table 1)	+	Daytime adjustment (Item 4 below)	+	Class A adjustment (Table 2)	+	Class B adjustment (Table 3)

(3) Nighttime basic sound levels (BSLs) are determined from Table 1. The BSL is determined to be 40 dBA Leq (5 dBA Leq above ambient) to generate the minimum PSL. Moving down each column in Table 1, an adjustment is made to the BSL for proximity to transportation noise sources. Moving across each row, an adjustment to the BSL is made for higher population density.

Table 1 - Basic sound levels for nighttime*

	Dwelling unit density per quarter section of land		
Proximity to transportation	**1 - 8 dwellings; 22:00 - 07:00 (nighttime) (dBA Leq)**	**9 - 160 dwellings; 22:00 - 07:00 (nighttime) (dBA Leq)**	**>160 dwellings; 22:00 - 07:00 (nighttime) (dBA Leq)**
Category 1	40	43	46
Category 2	45	48	51
Category 3	50	53	56

*Notes:

- The average rural ambient noise level is 5 dBA less than the BSL.
- Category 1—dwelling units more than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.
- Category 2—dwelling units more than 30 m but less than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.
- Category 3—dwelling units less than 30 m from heavily travelled roads and/or rail lines and/or subject to frequent aircraft flyovers.
- Density per quarter section—refers to a quarter section with the affected dwelling at the centre (a 451 m radius). For quarter sections with various land uses or with mixed densities, the density chosen is then averaged for the area under consideration.
- See Appendix 1 for more definitions.

(4) Daytime adjustment means the daytime adjustment of 10 dBA Leq above the nighttime PSL and daytime is the period between 07:00 am to 22:00 pm.

(5) Class A adjustments are based on the nature of the activity and/or the actual measured Ambient Sound Level (ASL) in an area and referred to in Table 2.

Table 2 Class A adjustments*

Class	Reason for adjustment	Value (dBA Leq)
A1	Seasonal adjustment (wintertime conditions)	+ 5
A2	Ambient monitoring adjustment See Figure1 below	-10 to +10

*Class A adjustment = Sum of A1 and A2 (as applicable), but not to exceed a maximum of 10 dBA Leq.

a. A1—Seasonal adjustment for wintertime noise complaints must not be added when determining the PSL for design purposes. With prior approval from the Commission, the PSL may be modified to reflect site-specific conditions for a wintertime noise complaint. If it is demonstrated that the facility may affect a winter recreation area where a quiet environment is a key aspect, the seasonal adjustment might not be allowed.

b. A2—An adjustment to the ASL which is the average sound environment in a given area without the contribution of noise from any energy-related industry. An adjustment for an incremental change to the BSL is applicable only when BSLs (Table 1) are thought not to be representative of the actual sound environment and when ASLs have been measured. Two cases where it may be necessary to determine the ASL are:

   - areas considered to be pristine (defined in Appendix 1); and
   - areas with non-energy industrial activity that would impact the ASLs.

   In either case, the licensee must obtain an approval from the Commission to apply an ambient sound adjustment.

   Licensees may conduct a background survey to determine the total noise levels that currently exist in an area for information purposes, such as energy-related industry, non-energy industry, and transportation.

c. An ambient sound monitoring survey consists of a 24-hour continuous sound monitoring survey, with measured ASL presented for the daytime and nighttime periods that is conducted 15 m from the nearest or most impacted dwelling unit and under representative conditions. The 15 m requirement may be altered if it is physically impossible or acoustically illogical. If the affected dwelling unit is not in an acceptable location, another suitable measurement site may be chosen. An ambient sound survey must be conducted without any energy-related facility components.

d. A licensee must use Figure 1 to determine the appropriate adjustment value, A2, which will be added to any other applicable Class A adjustment factor.

To use Figure 1:

1. Determine the difference between the BSL (Table 1) for the appropriate dwelling density and transportation proximity and the measured ASL to the nearest whole number.
2. Look up this difference on the x-axis of Figure 1.
3. Move up on the figure until the plotted line is intersected.
4. Move left on the figure and read off the applicable A2 adjustment factor; it may be positive or negative.
5. Add this adjustment factor to any other applicable Class A adjustment factor(s) to arrive at the Class A adjustment. If the sign of A2 is negative, you will be adding a negative number to arrive at the Class A adjustment.

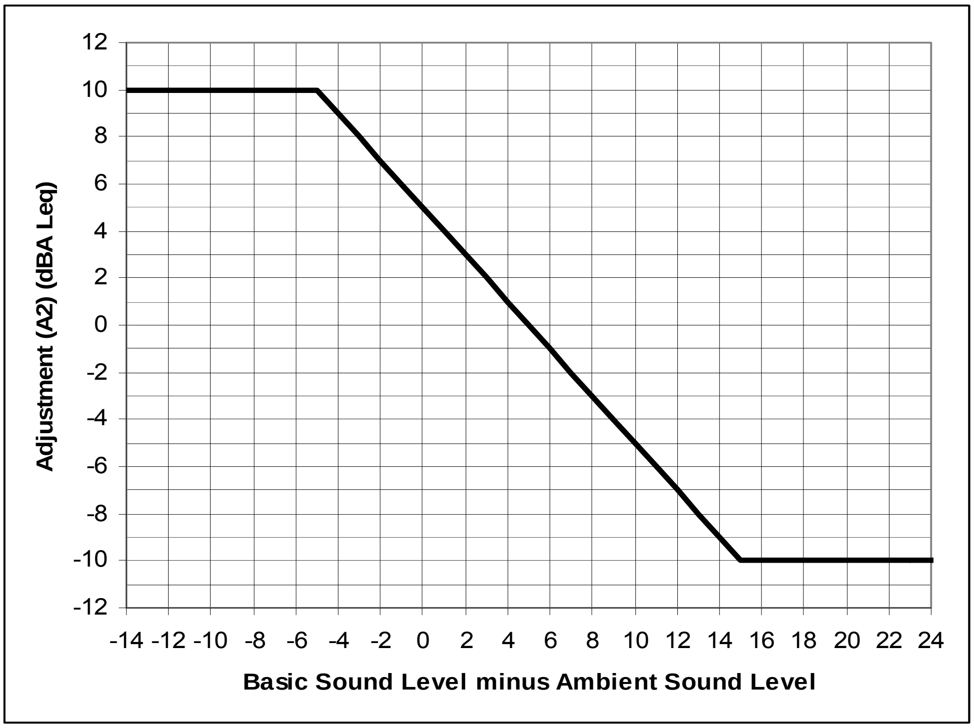

Figure 1 Ambient monitoring adjustment, A2

6. Class B adjustments are values intended to permit adjustments to the BSLs based upon people’s responses to temporary noise generating activities which means activities lasting 60 or less days. In order to use this adjustment, the licensee must fully inform the potentially impacted residents of the duration and character of the noise.

Table 3 Class B adjustments

Class	Duration of activity	Value (dBA Leq)
B1	1 day	+ 15
B2	7 days	+ 10
B3	≤ 60 days	+ 5
B4	> 60 days	0

7. A licensee must keep technical information to support the licensee's use of any of the adjustments to the BSL.

2.2 Exceptional situations

(1) For exceptional situations or areas, the Commission assesses the PSL on a site-specific basis.

(2) The PSL determined under this rule does not apply in an emergency which is an unplanned event requiring immediate action to prevent loss of life or property. Events occurring more than four times a year at a facility are not considered unplanned.

2.3 PSL Determination for pre-1988 Facilities

(1) A facility constructed and in operation before October 17, 1988 is considered to be a deferred facility, meaning that it does not have to demonstrate compliance in the absence of a noise complaint.

(2) If a noise complaint is filed with the Commission, the licensee must calculate the PSL in accordance with sections 2.1 and 2.2.

(3) The pre-expansion or pre-modified PSL will become the PSL for any expansion or modification to the facility subsequent to 1988 if the PSL is currently above the PSL determined in accordance with section 2.

(4) A licensee must reduce existing noise from sources at the facility to make room for the introduction of new noise sources so that there is no net increase in total noise emitted from the facility.

(5) Effective October 17, 2018, the Commission will eliminate the deferred status for facilities built and in operation prior to 1988.

3 Noise Impact Assessments

3.1 Preparation of a Noise Impact Assessment

(1) An applicant for a facility must prepare a noise impact assessment that includes the potential noise impacts of the proposed facility under normal facility operating conditions and is to be filed with the Commission as one document attached to the application.

(2) A noise impact assessment is conducted to predict the sound level from the proposed facility at the nearest or most impacted dwelling unit.

(3) As part of its public consultation for the proposed facility in an area, an applicant must discuss noise impacts of the proposed facility with nearby area residents and design the facility to meet the PSL.

(4) If a noise complaint is filed by a resident near the facility after the facility is in operation, the licensee must meet the PSL as determined in accordance with section 2.

(5) An applicant planning a facility in an area where there is an energy-related facility present, must ensure that its facility will not cause the overall sound levels to exceed the PSL. If the existing noise levels are acceptable to residents even though the noise levels may be higher than the PSL (only for deferred facilities), the applicant must ensure that its facility will not cause an increase in overall sound levels.

3.2 Noise Impact Assessment Requirements

(1) Where it deems it necessary, the Commission may require a noise impact assessment for a proposed facility.

(2) An applicant must complete a noise impact assessment before submitting an application for a new facility or modification to an existing facility, and submit the noise impact assessment with the application.

(3) If the noise impact assessment indicates noncompliance with the PSL, the applicant must:

- provide for additional attenuation measures, or
- submit reasons why the measures proposed to reduce the impacts are not practical.

3.3 Comparing Predicted Noise Level to the PSL

The predicted sound pressure level emanating from a facility is added to the ASL. The average rural ASL is 5 dBA less than the BSL (Table 1). The predicted noise levels of the facility plus the ASL must be compared to the PSL. A dwelling may have only one PSL.

3.4 Cumulative Noise Environment

(1) The cumulative noise level of the ASL including existing energy-related facilities and the predicted noise from proposed facilities when combined must not exceed the PSL.

(2) Licensees must use accepted acoustical practices, equipment, and techniques when measuring or modeling sound levels.

(3) The method for measuring sound must meet the requirements set out in this rule.

(4) The simplified method of reducing 6 dBA per doubling of distance is only acceptable under the circumstances set out in section 2.5 of Appendix 2. In cases where the simplified approach is not acceptable, a licensee must use an acoustical practitioner to predict the cumulative noise level. When requested, a licensee must make available to the Commission all noise modeling documentation.

3.5 Noise Models

(1) The noise model must incorporate the following parameters:

- geometric spreading;
- barrier effects;
- atmospheric absorption;
- ground attenuation; and
- specific wind speed/direction.

Consideration must be given to:

- source identification;
- source size, location, and elevation;
- isolation analysis;
- sound power level (PWL) and/or sound pressure level (SPL) spectral data;
- intermittency; and
- mild downwind and/or temperature inversion conditions.

(2) The following input parameters must be used in modeling summertime conditions for an acceptable noise impact assessment:

- wind speed: 5.0 to 7.5 km per hour (km/hr) (see section 3.7 for wind turbines);
- wind direction: from the facility to the dwelling(s);
- temperature: 0 to 25 degrees Celsius;
- relative humidity: 70 to 90 percent; and
- topography and ground cover: consistent with site conditions.

Models must meet accepted protocols and international standards (e.g., CONCAWE or ISO 9613).

3.6 Low Frequency Noise

If available, C-weighted sound pressure level (dBC) minus the A-weighted sound pressure level (dBA) is to be considered in the noise modeling of new facilities or facility modifications or expansions to identify and minimize the potential for low frequency noise impacts (see Appendix 5).

3.7 Wind Turbines

(1) When selecting the locations of wind turbines, licensees must limit noise levels at any dwelling to the PSL determined in accordance with section 2.

(2) For any new wind turbines, an applicant must prepare a noise impact assessment that meets the criteria set out in sections 2 and 3.4.

(3) Wind turbine noise must be modeled using wind speeds of 6 to 9 m per second (m/s) or 21 to 32 km per hour (km/h) to predict a worst-case condition. At these wind speeds, the wind turbine noise may be greater than or equivalent to the wind noise.

(4) The modeling must also include cumulative effects of adjacent wind turbines and adjacent energy-related facilities. The predicted noise levels must be compared to the PSL (predicted noise level from wind turbines, existing energy-related facilities and ASL).

3.8 Requirements for an Acceptable Noise Impact Assessment

An acceptable noise impact assessment must include the following information:

(1) Permissible Sound Level:

Identify the PSL and the direction and distance to the nearest or most impacted dwelling unit(s). This includes all details on how the PSL was calculated and any adjustments claimed.

(2) Sound Source Identification:

Identify all major sources of noise such as transformers, Heat Recovery Steam Generators, exhaust and pump noise, ventilation openings or other equipment from the energy-related facilities and their associated sound power/pressure levels in octave bands.

Indicate whether the sound data is from vendors, field measurements, theoretical estimates, or another source. Note that use of any theoretical data or extrapolation techniques can lead to inaccuracies and therefore is less reliable than actual field measurements made once the equipment is in place.

(3) Operating Conditions:

When using manufacturer's data for expected performance, it may be necessary to modify the data to account for actual operating conditions (indicate design conditions, such as operating with open or closed compressor building windows and doors).

(4) Noise Model Parameters:

The following must be clearly stated within the noise impact assessment:

- type of model used (models or hand calculations may be used to obtain the predicted sound level);
- standards followed;
- source directivity considerations;
- ground absorption conditions;
- meteorological parameters;
- terrain parameters selected;
- reflection parameters; and
- any adjustments made (documentation of power level calculation assumptions made must be provided, e.g., source size considerations).

(5) Outline of Study Area:

Include a figure, map, area plan or drawing showing the proposed facility, study area and the nearest or most impacted dwelling(s).

(6) If sound levels are determined using estimates as outlined in section 2.5 of Appendix 2, the noise impact assessment must clearly show that the conditions in that section are met.

(7) Predicted Sound Level/Compliance Determination:

Identify what the predicted cumulative sound level will be at the nearest or most impacted dwelling unit(s). If there are differences between day and night operations, both levels must be calculated. Indicate whether the facility is in compliance with requirements.

(8) Non-compliance Determination/Attenuation Measures:

If the predicted sound level indicates noncompliance with this rule, identify the attenuation measures that the applicant/licensee is committing to and the timeline to implement measures to attain compliance.

If the predicted sound level indicates noncompliance with this rule and further attenuation measures are not practical, the noise impact assessment must include the reasons why the measures proposed to reduce the impacts are not practical.

(9) Acoustical Practitioner's Information:

Provide the name(s) and describe the role(s), directly related training and experience of the person(s) who prepared the noise impact assessment as well as the professional affiliations of the person(s).

3.9 Records

A licensee must keep all supporting information relating to a noise impact assessment in the event that the Commission requests the information, and for reference if a noise complaint is filed. See Appendix 3 for a Noise Impact Assessment Summary form.

4 Noise Complaint Investigations

(1) Licensees must make every reasonable attempt to resolve any noise-related complaint in a timely manner.

(2) When investigating a noise complaint, licensees must first attempt to resolve the issue through direct contact with the complainant to understand the concerns and establish a dialogue.

(3) When a noise complaint is filed with the Commission, the Commission may require the licensee to conduct a comprehensive noise survey to determine the compliance with this rule.

(4) If a facility is found to be noncompliant, the licensee must provide both a detailed noise control mitigation plan and a timeline for when compliance will be met.

(5) When the facility meets the requirements in this rule, the Commission ends its investigation.

(6) If conditions at the facility change, a new complaint may be filed.

(7) A noise complaint cannot be filed against a deferred facility as a result of gathering noise emission data as part of an application for modification of the facility.

4.1 Process for Comprehensive Sound Level (CSL) Survey

(1) If a comprehensive sound level survey is to be performed, the licensee and the complainant must complete Part 1, and if possible Part 2 of the Noise Complaint Investigation Form in Appendix 4 to identify the conditions that exist when noise is affecting the resident. If the complainant does not participate in the completion of the Noise Complaint Investigation form, the licensee must submit documentation of its attempts to directly engage the complainant in the completion of the form.

In the noise impact assessment, if a facility was modeled to operate with doors and windows closed, this is a condition of operation to ensure that the PSL is met.

(2) In Part 1 of the Noise Complaint Investigation Form, the licensee must enter information from the resident(s) about the quality and characterization of the noise to help determine the source of the noise. Part 1 also examines the weather

and ground cover conditions that exist when the noise is most annoying to the resident(s). With this information, the licensee, or its representative, can establish the typical representative conditions that exist under which sound level monitoring should take place. If the complainant has highlighted specific weather conditions, facility operating conditions, or seasons, the monitoring should take place under these representative conditions.

Representative conditions do not constitute absolute worst-case conditions or the exact conditions the complainant has highlighted if those conditions are not easily duplicated. In order to expedite complaint resolution, sound measurements should be conducted at the earliest opportunity when sound propagation towards the impacted dwelling is likely and representative conditions might exist. An extended-duration survey (more than 24 hours) may be considered to ensure that representative conditions have been met (see section 4.5).

(3) Part 2 of the Noise Complaint Investigation Form, the event log, is designed for use by the resident(s) concerned about the noise generated by the Commission regulated facilities. Residents complaining about noise are encouraged to record details about environmental and facility operating conditions under which noise adversely affects them.

(4) CSL surveys must encompass a representative portion of the time of day or night when the noise causing the complaint typically occurs. The surveys should be conducted at the first opportunity when the representative conditions can be reasonably met.

(5) A licensee must provide a copy of the completed Noise Complaint Investigation Form to the complainant and include a copy in any CSL reports to demonstrate that the representative conditions were met.

(6) If the complainant does not complete Part 2 of the Noise Complaint Investigation Form, the licensee must use best judgment to determine representative conditions, and provide an explanation in the report for the absence of the form. In addition, the licensee must explain how the representative conditions were determined.

(7) A monitoring period may vary from 9 to 24 hours, depending on the type, time, and duration of the noise. There must be at least 3 continuous hours of acceptable data (after isolation analysis) for the nighttime period and 3 continuous hours for the daytime period (if required) for the survey to be considered valid. The measurements are to be conducted 15 m from the complainant's dwelling in the direction of the noise source. The 15 m requirement may be altered if it is physically impossible or illogical from an acoustical consideration.

(8) If the PSL was established for deferred facilities using modeling results, the outcome of the CSL must be adjusted if necessary, taking into account the input conditions used to generate the modeled results. For example, if the PSL was determined by inputting calm summer conditions in the model, the CSL must be measured under similar seasonal and meteorological conditions.

(9) When the measured CSL exceeds the PSL but noise from the facility and its related activities is not considered to be responsible for the excess, a further assessment using an appropriate isolation analysis technique to separate the facility noise contribution from the measured CSL may be carried out (see section 4.7 (2)). This method will separate noises not related to the facility. The isolated facility contribution can then be compared to the PSL for compliance.

4.2 Low Frequency Noise in CSL Survey

A-weighting measurements typically discount the lower frequencies. Therefore, Low Frequency Noise (LFN) may be an issue in some situations where the dBA value is satisfactory but the concern is a dominant low frequency that increases annoyance levels at dwellings. Due to the complexity of determining LFN, this is a specialized investigation. The procedure outlined below and in Appendix 5 is only completed in specific response to an LFN complaint identified through the complaint investigation process and as a second-stage investigation.

(1) If the potential for LFN exists, measurements must be conducted in both C and A weighted scales concurrently. Measurements may be made using two monitoring sound level meters, a dual-channel capable sound level meter, or other equipment capable of obtaining both the C and A weighting sound levels simultaneously.

An LFN condition may exist when:

- the isolated (i.e., non-facility noise, such as wind noise, has been removed) time-weighted average dBC – dBA value for the measured day or nighttime period is equal to or greater than 20 dB; and
- a clear tonal component exists at a frequency below 250 hertz (Hz).

(2) If LFN is confirmed to exist, a 5 dBA Leq penalty will be added to the CSL results. If this value exceeds the PSL, the licensee must identify the potential source and outline an action plan to address the issue in a timely way.

Once LFN noise control measures have been installed, a follow-up CSL and complaint investigation must be conducted to confirm that the LFN condition has successfully been addressed.

Wind generates high levels of low frequency sound that can mask the assessment for LFN. Measurements of LFN should only be taken when atmospheric conditions are favourable for accurate measurement (see Table 4 and Appendix 5).

4.3 Determination of Tonal Component

The following conditions indicate the presence of a low frequency pure tone in the noise measured at a dwelling.

For the 1/3 octave frequency bands of 250 Hz or below:

(a) the linear sound level of one band must be at least 10 dB or more above one of the adjacent bands within two 1/3 octave bandwidths; and

(b) there must be at least a 5 dB drop in level within two bandwidths on the opposite side of the high frequency band.

The presence of a pure tone, as defined above, is required in order to declare that there is LFN. Where a clear tone is present below 250 Hz and the difference between the overall C-weighted sound level and the overall A-weighted sound level exceeds 20 dB, remedial action may be required to reduce the impact of the LFN (see Appendix 5).

4.4 Wind Turbines and CSL Survey

Generally, the "cut-in" wind speed (minimum wind speed required to start the turbines) for a wind turbine exceeds the maximum wind speeds for typical comprehensive sound surveys. Therefore, to accurately measure the true noise output from the turbine, it is necessary to minimize the impact of wind noise on the results. For wind turbines, noise measurements, including CSLs, are recommended to be conducted for wind speeds between 4 and 6 m/s (about 14 and 22 km/hr) measured between a height of 1.2 and 10 metres above grade. Wind speed must be measured in the vicinity of the microphone in a manner that does not affect the noise measurement.

4.5 Multiple Nights or Single Night of Monitoring

(1) In order to ensure that representative conditions have been monitored, multiple nights of noise monitoring may be required to address uncertainty regarding what representative conditions might be prior to monitoring or what they have been during monitoring.

(2) The following are some of the reasons to conduct multiple-night monitoring:

- conditions not representative of the complaint;
- requirement for minimal hours of valid data not achieved;
- changing weather conditions;
- changing atmospheric conditions (such as inversions);
- changing plant operating conditions;
- variable seasonal effects;
- significant contamination from distant noise sources;
- insufficient local meteorological data; and
- prior agreement on an extended monitoring period in order to satisfy mutual concerns between residents and licensees.

(3) The following are reasons for accepting single-night monitoring or for concluding a multiple-night survey:

- favourable and stable weather conditions (see section 4.6);

- "achievement" of representative conditions, as described in the Noise Complaint Investigation Form;
- agreement from complainant that survey conditions were appropriate; and
- licensee acknowledgement that compliance is not achieved.

(4) Each night result for multiple-night monitoring must be evaluated against the requirements of this rule. If multiple nights are deemed to be representative, the worst-case condition (highest nighttime Leq) is compared to the PSL.

4.6 Noise Monitoring Conditions

(1) The completed Noise Complaint Investigation Form is used to determine conditions representative of the complaint. If this completed form is not available, Table 4 outlines the recommended noise monitoring conditions. Measurements should be conducted when sound propagates towards the nearest or most impacted dwelling unit.

(2) Invalid data (except in the case of wind turbine noise monitoring) may result if wind speeds are greater than those shown in Table 4. Wind gradients can greatly affect the sound levels measured. Table 4 is less applicable in situations where hills exist between the facility and the measurement location. Judgment must be used in determining the applicability of the table; short-term wind gusts less than five minutes in duration and up to 20 km/hr may be acceptable.

(3) Note that the limits for wind speed (measured at a height between 1.2 and 10 m based on the judgment of the acoustical practitioner) and precipitation apply in the vicinity of the measurement, not at a remote sensing position many kilometres away. While data from a nearby meteorological station may serve as an indicator, that data does not guarantee the same conditions at the measurement position.

Table 4 Favourable summertime weather conditions

Parameter	Preferred condition
Ground cover	No snow, water, or ice (frozen) ground cover
Precipitation	No steady precipitation, monitoring invalid
Wind speed	Wind speed limits (noise data may be invalid if limits are exceeded): **Less than 500 m from noise source:** Upwind: 10 km/hr limit Crosswind: 15 km/hr limit Downwind: 15 km/hr limit **500–1000 m from noise source:** Upwind: 5 km/hr limit Crosswind: 10 km/hr limit Downwind: 10 km/hr limit **Greater than 1000 m from noise source:** Upwind: less than 5 km/hr limit Crosswind: 10 km/hr limit Downwind: 10 km/hr limit 24-hour noise sampling period: there should be at least 3 hours of wind blowing directly to the complainant in the nighttime sampling period (22:00 to 7:00) and 3 hours in the daytime sampling period (7:00 to 22:00)

4.7 Noise Survey

4.7.1 Methodology for Assessing Multiple Noise Sources

(1) The methodology for assessment of multiple noise sources or isolation techniques relies on the judgment of an acoustical practitioner and must be documented in the noise investigation report.

(2) Techniques that may be used:

- If the sound levels at the receiver are due to the cumulative contributions from several sources or energy-related facilities, the relative contributions of each source or energy-related facility at the nearest or most impacted dwelling unit must be determined in order to address noise control options. This is most commonly done by assessing the PWL of each contributor or a measured sound pressure level (SPL) at a standard distance where each individual source is dominant.
- If the facilities are separated, the relative sound emission of each can be determined by taking measurements in the direction of the receiver at points where each source or facility, in turn, is completely dominant. Usually, these measurements are conducted at a common distance in the far field.
- If the facilities are in close proximity to each other causing the sound fields to overlap, or if there are elevated sound sources that may not be adequately taken into account at the fence line due to vertical directionality of the sources, judgment must be used when assessing the sound levels.

(3) At points where two or more sources contribute to the total SPL, the relative contributions must be explained in the report.

For example, extensive near-field diagnostic surveys can be conducted at the various noise sources using computer-aided modeling to predict the source contributions at the dwelling.

4.7.2 Isolation Analysis

(1) Isolation analysis techniques are used to separate out sound sources and obtain the sound level from the source of interest alone. During a comprehensive noise survey, all sound levels are captured for the survey period. However, in a compliance survey, noise contributions from the licensee's facility are evaluated.

(2) Invalid or abnormal data not typical of an average ASL should be extracted from the measured CSL. Invalid data can include periods with unacceptable meteorological conditions or non-representative ground cover. Temperature inversions or lapse conditions1 are excluded unless they are considered a frequent occurrence (that is, they occur more than 10 percent of the time for a particular season) and can be captured at the dwelling site. Such conditions affect the dwelling's perception of noise, but unless the event occurs with regularity due to local topography or other factors, the condition is dismissed. The extraction of data from the measured CSL must be justified and supported by an acceptable reference, such as a digital or analog audio recording, operational log, or event log. The accumulated isolated facility contribution data must encompass the previously stipulated minimum time period.

(3) Criteria for removing data may include:

- maximum wind speed exceeded;
- measurement periods when precipitation is present;
- measurement periods where the monitor is upwind of the source;
- periods of noise dominated by biological activity, typically at dawn or dusk, such as birdcalls, frogs;
- abnormal noise events, including aircraft flyovers and off-plant site vehicular traffic; and
- other non-energy related sources of noise.

[1] Temperature inversions or lapse conditions are defined as situations when temperatures in the atmosphere (usually measured at a height of 10 m) are 1°Celcius or more higher than at ground level (usually measured at a height of 2 m).

4.8 Comprehensive Noise Survey Report

Reports summarizing results of a noise survey used to show compliance with this rule must include the following information:

- completed Noise Complaint Investigation Form (parts 1 and 2) identifying the representative conditions for monitoring—if not available, an explanation for why it was not used,
- distance and direction of dwelling from the facility (include a map),
- record of calibration results,
- environmental conditions during monitoring period (wind speed and direction) and the source of the data,
- operating conditions for energy-related facilities included in the survey,
- graphs showing measured sound levels and any isolation analysis (with noise sources identified),
- summary table including the PSL for dwelling, measured sound level, isolation analysis results, and valid hours of the survey, and
- in cases where LFN was identified as a potential problem, the analysis and results.

4.9 Measurement

4.9.1 Instrumentation

Instrumentation used to conduct sound monitoring surveys must be able to measure the A-weighted (dBA) and/or C-weighted (dBC) continuous energy equivalent sound level (Leq) of steady, intermittent, and fluctuating sounds. It must be able to accumulate the data and calculate the Leqs over the time periods required and must meet the minimum technical specifications in the International Electrotechnical Commission (IEC) *61672-2 Ed.01.0 2003*for Type II sound level meters.

The sound measurement instrumentation necessary to conduct the 1/3 octave band sound pressure level measurements to characterize the presence of tonal components must meet the minimum technical specification in IEC publication 225-1966 or American National Standards Institute (ANSI) publication S1.11-1966 for Class II filter sets used in conjunction with conventional sound level meters that meet the minimum technical specifications in IEC publication 651-1979 or ANSI publication S1.4-1983 for Type II sound level meters.

4.9.2 Calibrator Certification Requirements

Calibrators must be recertified in accordance with ANSI publication SI.40-1984 (or latest revision), which requires that a calibrator be recalibrated at least once a year.

4.9.3 Sound Level Meter Calibration Requirements

The sound level meters used for noise measurements made under this rule must:

- meet the requirements in ANSI S1.4-1983 and S1.4A-1985 or latest revision;
- be calibrated immediately prior to the measurement with a sound calibrator meeting the requirements of ANSI S1.40-1984 or latest revision;
- have their calibration confirmed immediately after the measurement using the same calibrator and a record of calibration results must be included in the report; and
- be calibrated by the instrument manufacturer, an authorized instrument calibration facility, or another agency acceptable to the Commission within a two-year period immediately preceding the measurements. Records of calibration must be maintained, although formal calibration certificates are not necessary. Meters which fail a pre-use or post-use calibration test (i.e., the meter does not read within ±1 dB) must not be used until re-calibrated for accuracy, applicability, and cause of deviation. Data collected from noise meters that fail at pre-use or post-use field calibration test (i.e., the meter does read within ±1dB) must not be used.

4.9.4 Measurement Techniques

General guidelines for sound measurement techniques are found in the following publications: Alberta Environment's A Method for Conducting and Reporting Noise Surveys at Industrial Plants, March 1978; Ontario Ministry of the Environment's Model Municipal Noise Control By-Law, 1978; ANSI publication S1.13-1971: Methods for the Measurement of Sound Pressure Levels; and International Organization for Standardization (ISO) publication Assessment of Noise with Respect to Community Response, 1996. Users must also ensure that the instrumentation is working within manufacturer's specifications and limitations.

5 Noise Complaints and Noise Management Plans

In unique cases where traditional comprehensive sound surveys are not practical, as determined by the Commission, compliance may be demonstrated through the development and implementation of detailed regional noise management plans.

A facility is in compliance if a CSL survey conducted at representative conditions has results equal to or lower than the established PSL, taking into consideration any LFN. Alternatively, if the Commission agrees that a CSL survey is not practical, a detailed Noise Management Plan approved by the Commission may be used.

The Commission may conduct random comprehensive sound surveys of facilities. The Commission requires sound levels to be compliant and noise impact assessments to be complete and accurate.

5.1 Noise Management Plans (NMP)

(1) An NMP must include:

- identification of noise sources;
- assessment of current noise mitigation programs;
- performance effectiveness of noise control devices;
- methods of noise measurement;
- best practices programs; and
- continuous improvement programs.

(2) In all cases, a NMP must be discussed with and incorporate input from all affected persons, such as nearby residents, regulated and non-regulated industries, and local government. The Commission may assist in the process if requested by the licensee.

(3) Appendix 6 shows examples that outline the process to determine compliance.

6 Construction Noise

(1) Licensees must take the following mitigating measures to reduce the impact of construction noise on nearby dwellings:

- conduct construction activity between the hours of 07:00 and 22:00 to reduce the duration impact of construction noise;
- advise nearby residents of significant noise-causing activities and schedule these events to reduce disruption to them; and
- ensure that all internal combustion engines are fitted with muffler systems.

(2) Should a noise complaint be filed during construction, the licensee must respond expeditiously and take action to ensure that the complaint has been addressed.

Appendix 1 - Glossary

Some of the terms used in this rule are defined for this particular context; these definitions are not necessarily the same as the generally accepted broader definitions of the terms.

Abnormal noise events	Noises that are sufficiently infrequent as to be uncharacteristic of an area or that occur so close to the microphone as to dominate the measurements in an unrealistic manner. Consideration must be given to deleting occurrences of abnormal noise from the measurements to obtain a reasonably accurate representation of the sound environment. Examples of abnormal noises include a dog barking close to the microphone, a vehicle passing nearby, people talking in the vicinity of the microphone in a quiet environment, or a passing road grader.
Ambient sound level (ASL)	The sound level that is a composite of different airborne sounds from many sources far away from and near the point of measurement. The ASL does not include any energy-related industrial component and must be measured without it. The ASL can be measured when the sound level in an area is not believed to be represented by the basic sound levels in Table 2. The ASL must be measured under representative conditions. As with comprehensive sound levels, representative conditions do not constitute absolute worst-case conditions (in this case, the most quiet day) but conditions that portray typical conditions for the area. Also see *Representative conditions*.
A-weighted sound level	The sound level as measured on a sound level meter using a setting that emphasizes the middle frequency components similar to the frequency response of the human ear at levels typical of rural backgrounds in mid frequencies. See Figure 2.
Background noise	The total noise from all sources that currently exist in an area. Background noise includes sounds from the energy industry, as well as other industrial noise not subject to this rule, transportation sources, animals, and nature.
Bands (octave, $^{1}/_{3}$ octave)	A series of electronic filters separate sound into discrete frequency bands, making it possible to know how sound energy is distributed as a function of frequency. Each octave band has a centre frequency that is double the centre frequency of the octave band preceding it. The $^{1}/_{3}$ octave band analysis provides a finer breakdown of sound distribution as a function of frequency.

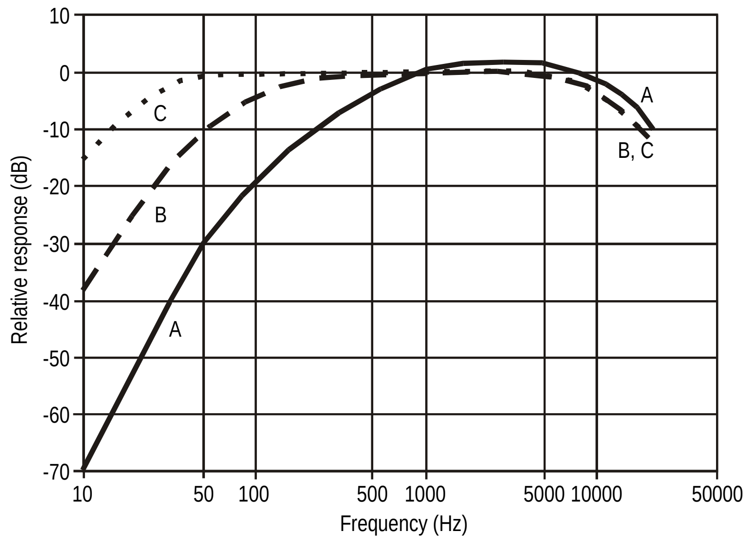

Figure 2 - Weighting network curves

Basic sound level (BSL) — The nighttime A-weighted Leq sound level commonly observed to occur in the designated land-use categories with industrial presence. The BSL is assumed to be 5 dBA above the ASL and is set out in Table 1.

Calibration — The procedure used for the adjustment of a sound level meter using a reference source of a known sound pressure level and frequency. Field calibration must take place before and after the sound level measurements.

Category — A classification of a dwelling unit in relation to transportation routes used to arrive at a BSL.

Category 1 — Dwelling units more than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers. Also see Category.

Category 2 — Dwelling units more than 30 m but less than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers. Also see Category.

Category 3 — Dwelling units less than 30 m from heavily travelled roads and/or rail lines and/or subject to frequent aircraft flyovers. Also see Category.

Class A adjustment — Consists of the sum of adjustments that account for the seasonal nature of the noise source (cannot be used for design state) and the actual ambient sound level in an area. It cannot exceed +10 dBA. The Class A adjustment is added to the BSL, the daytime adjustment, and the Class B adjustment to arrive at the PSL.

Class B adjustment — An adjustment based on the duration of a noisy activity that recognizes that additional noise can be tolerated if it is known that the duration will be limited. An adjustment of B1, B2, B3, or B4 may be selected as

	applicable.
Comprehensive sound level (CSL)	The sound level that is a composite of different airborne sounds from many sources far away from and near the point of measurement. The CSL does include energy-related industrial components and must be measured with them, but it should exclude abnormal noise events. The CSL is used to determine whether a facility is in compliance with rule 012. Also see Representative conditions.
Cumulative noise level	The sound level that is the total contribution of all industrial noise sources (existing and proposed) from Commission regulated facilities at the dwelling.
C-weighted sound level	The C-weighting approximates the sensitivity of human hearing at industrial noise levels (above about 85 dBA). The C-weighted sound level (i.e., measured with the C-weighting) is more sensitive to sounds at low frequencies than the A-weighted sound level and is sometimes used to assess the low-frequency content of complex sound environments.
Daytime	Defined as the hours from 07:00 to 22:00.
Daytime adjustment	An adjustment that allows a 10 dBA increase because daytime ambient sound levels are generally about 10 dBA higher than nighttime values.
dB (decibel)	A unit of measure of sound pressure that compresses a large range of numbers into a more meaningful scale. Hearing tests indicate that the lowest audible pressure is about 2 x 10-5 Pa (0 dB), while the sensation of pain is about 2 x 102 Pa (140 dB). Generally, an increase of 10 dB is perceived as twice as loud. $$\text{Sound pressure level (dB)} = 10 \log \left(\frac{p^2}{p_o^2} \right) = 20 \log \left(\frac{p}{p_o} \right)$$ p = root-mean-square sound pressure (Pa) po = reference root-mean-square-sound pressure, generally 2 x 10-5 Pa The decibel is a linear weighting and can also be used when referring to differences in weightings.
dBA	The decibel (dB) sound pressure level filtered through the A filtering network to approximate human hearing response at low intensities. Also see *dB* and *A-weighted sound level*.
Deferred facility	Energy-related facilities constructed and in operation prior to October 1988. These facilities do not have to demonstrate compliance in the absence of a complaint.

Density per quarter section — Refers to a quarter section with the affected dwelling at the centre (a 451 m radius). For quarter sections with various land uses or with mixed densities, the density chosen must be factored for the area under consideration.

Dwelling — Any permanently or seasonally occupied residence with the exception of an employee or worker residence, dormitory, or construction camp located within an energy-related industrial plant boundary. Trailer parks and campgrounds may qualify as a dwelling unit if it can be demonstrated that they are in regular and consistent use during the applicable season.

Dwelling unit — The nearest or most impacted dwelling as the nearest dwelling may not necessarily be the one most adversely affected because of factors such as topography or man-made features. For example the nearest dwelling to a facility may be behind an intervening ridge, while a more distant dwelling may be in direct line of sight of the facility.

Emergency — An unplanned event requiring immediate action to prevent loss of life or property. Events occurring more than four times a year are not considered unplanned.

Energy equivalent sound level (Leq) — The Leq is the average weighted sound level over a specified period of time. It is a single-number representation of the cumulative acoustical energy measured over a time interval. The time interval used should be specified in brackets following the Leq—e.g., Leq (9) is a 9-hour Leq. If a sound level is constant over the measurement period, the Leq will equal the constant sound level. If the sound level shows a variety of constant levels for different intervals, then fi is the fraction of time the constant level Li, is present.

$$\text{Leq} = 10 \log \left(\sum_{i=1}^{n} f_i \times 10^{L_i/10} \right)$$

See Appendix 2 for more detail on the Leq concept.

Far field — The far field is that area far enough away from the noise source that the noise emissions can be treated as if they come from a single point or line source and the individual components of the noise source are not apparent as separate sources. This is typically at a distance of at least three to five times the major dimensions of the noise source.

The far field may consist of two parts, the free part and the reverberant part. In the free part, the sound pressure level obeys the inverse-square law (6 dBA loss per doubling of distance for a point source). The reverberant part exists for enclosed or semi-enclosed situations where there are many reflected sound waves from all directions. An example of a reverberant field is industrial equipment enclosed in a room.

Filter — A device separating the components of an incoming signal by its frequencies.

Frequent aircraft flyovers	Used in the assessment of categories as part of a site-specific analysis for dwellings that lie within a NEF contour area with a noise exposure forecast (NEF) 25 or greater, as designated by Transport Canada. In the absence of any NEF contours for a local airport, Transport Canada is to be contacted for current air traffic statistics. In this case, to qualify for the BSL adjustment, a dwelling must be within 5 km of an airport that has a minimum of nine aircraft takeoffs or landings over the nighttime period. Also see Noise exposure forecast.
Heavily travelled road	Generally includes highways and any other road where the average traffic count is at least 10 vehicles/hour over the nighttime period. It is acknowledged that highways are sometimes lightly travelled during the nighttime period, which is usually the period of greatest concern. The Commission will use the 10 vehicles/hour criterion to determine whether highways qualify as heavily travelled during the nighttime period.
Isolation analysis techniques	Various sound measurements and analytical skills used to separate out various sound sources and obtain the sound level from the source of interest alone.
Leq	See Energy equivalent sound level.
Linear weighting (or Z weighting)	The sound level measured with the linear weighting measures the acoustic pressure without any adjustment for the sensitivity of human hearing. It is a direct measure in decibels of the variation in air pressure and is often referred to as the "Sound Pressure Level." This level is sometimes called the "linear weighted level" or "the unweighted level," as it includes no frequency weighting beyond the tolerances and limits of the sound level meter being used for the measurements.
Low Frequency Noise (LFN)	Where a clear tone is present below and including 250 Hz and the difference between the overall C-weighted sound level and the overall A-weighted sound level exceeds 20 dB.
Near field	The region close to the source where the inverse-square law (6 dBA loss per doubling of distance for a point source) does not apply. Usually this region is located within a few wavelengths of the source and is also controlled by the dimensions of the source.
Nighttime	Defined as the hours from 22:00 to 07:00.
Noise	Generally associated with the unwanted portion of sound.
Noise exposure forecast (NEF)	The NEF contours are site specific to each airport and take into account such factors as traffic levels, proximity to runways, flight paths, and aircraft type and size.
Noise impact assessment	A noise impact assessment identifies the expected sound level emanating from a facility as measured 15 m from the nearest or most impacted permanently or seasonally occupied dwelling. It also identifies what the permissible sound level is and how it was

calculated.

Permanently occupied dwelling	A fixed residence occupied on a full-time basis.
Permissible sound level (PSL)	The maximum daytime/nighttime sound level that a facility must not exceed at a point 15 m from the nearest or most impacted dwelling unit. The PSL is the sum of the BSL, daytime adjustment, Class A adjustment, and Class B adjustment.
Pristine area	A pure, natural area that might have a dwelling but no industrial presence, including energy, agricultural, forestry, manufacturing, recreational, or other industries that already impact the noise environment.
Rail lines	Includes any rail line where there is a minimum of one 25-car train passage during every nighttime period.
Representative conditions	Those conditions typical for an area and/or the nature of a complaint. For ASLs, these are conditions that portray the typical activities for the area, not the quietest time. For CSLs, these do not constitute absolute worst-case conditions or the exact conditions the complainant has highlighted if those conditions are not easily duplicated. Sound levels must be taken only when representative conditions exist; this may necessitate a survey of extensive duration (two or more consecutive nights).
Seasonally occupied dwelling	A fixed residence that, while not being occupied on a full-time basis, is occupied on a regular basis. A regular basis does not imply a scheduled occupancy but implies use of six weeks per year or more. The residence must not be mobile and should have some sort of foundation or features of permanence (e.g., electrical power, domestic water supply, septic system) associated with it. Summer cottages or mobile homes are examples of seasonally occupied dwellings, while a holiday trailer simply pulled onto a site is not.
Slow response	A standardized detector response on a sound level meter that dampens the movement of displays so that rapidly fluctuating sound levels may be read. Slow response has a time constant of 1 second, which helps average out the display fluctuations.
Sound level meter	An instrument designed and calibrated to respond to sound and to give objective, reproducible measurements of sound pressure level. It normally has several features that would enable its frequency response and averaging times to be changed to make it suitable to simulate the response of the human ear.
Sound monitoring survey	The measurement and recording of sound levels and pertinent related information over a given time period.
Sound power level (PWL, SWL, or L_W)	The decibel equivalent of the rate of energy (or power) emitted in the form of noise. The sound power level is given by:

$$\text{Sound Power Level} = 10 \log_{10} \left(\frac{\text{Sound as Power}}{W_O} \right)$$

By international agreement, $W_O = 10^{-12}$ watts (W)

However in some older data (roughly pre-1975), the value of W_O was set as 10^{-13} W (no longer used). The sound power level is an inherent property of a noise source.

Sound pressure level (SPL or L_P)	The decibel equivalent of the pressure of sound waves at a specific location, which is measured with a microphone. Because human reaction and material behaviours vary with frequency, the sound pressure level may be measured using frequency bands or with an overall weighting scale such as the A-weighting system. The sound pressure level depends on the noise sources, as well as on the location and environment of the measurement path.
Spectrum	A wide range or sequence of frequencies.
Summertime conditions	Ground cover and temperatures that do not meet the definition for wintertime conditions. These can occur at any time of the year.
Tonal components (low frequency)	The test for the presence of tonal components consists of two parts. The first must demonstrate that the sound pressure level of any one of the slow-response, A-weighted, 1/3 octave bands between 20 and 250 Hz is 10 dBA or more than the sound pressure level of at least one of the adjacent bands within two 1/3 octave bandwidths. In addition, there must be a minimum of a 5 dBA drop from the band containing the tone within 2 bandwidths on the opposite side. The second part is that the tonal component must be a pronounced peak clearly obvious within the spectrum. An example of tonal component determination is shown in Appendix 6.
Wind turbine	A machine for converting the kinetic energy in wind into mechanical energy, which is then converted into electricity.
Wintertime conditions	There is snow, ice, or frozen ground cover and temperatures are below 0°C.

Appendix 2 - Sound Level Descriptors

2.1 dB and dBA

The human ear is capable of hearing a large range of levels of sound pressure from 2 x 10^{-5} pascals (Pa) (just audible, 0 dB) to 2 x 102 Pa (sensation of pain, 140 dB)—a difference of seven orders of magnitude. The decibel is a logarithmic scale and is used to compress the range of sound pressure levels into a more meaningful scale. The symbol used to represent the linear decibel scale is dB (Lin), or simply dB.

The subjective or perceived loudness of a sound is determined by several factors, including the fact that the human ear is not equally sensitive to all frequency ranges. The ear emphasizes middle frequency sounds. The A-weighted decibel scale approximates the way the human ear hears different frequencies and is represented by dB(A) or dBA (see Appendix 1: Glossary for A-weighted sound level and Figure 2 Weighting network curves).

Low frequency sounds (hum) are harder for the human ear to hear than higher frequency sounds (whine). This means a low frequency sound would have a higher sound pressure level on the linear scale (dB) than a high frequency sound and yet would be perceived to be equally loud to the ear. These two sounds would have the same dBA rating on the A-weighting scale because they are perceived to be equally loud.

2.2 Leq Concept

This rule uses Leq measurements, which represent energy-equivalent sound levels. The Leq is the average weighted sound level over a specified period of time—a single-number representation of the cumulative acoustical energy measured over the interval. The time interval used should be specified in brackets following the Leq (e.g., Leq (9) is a 9-hour Leq). If a sound level is constant over the measurement period, the Leq will equal the constant sound level. Figure 3 illustrates this concept.

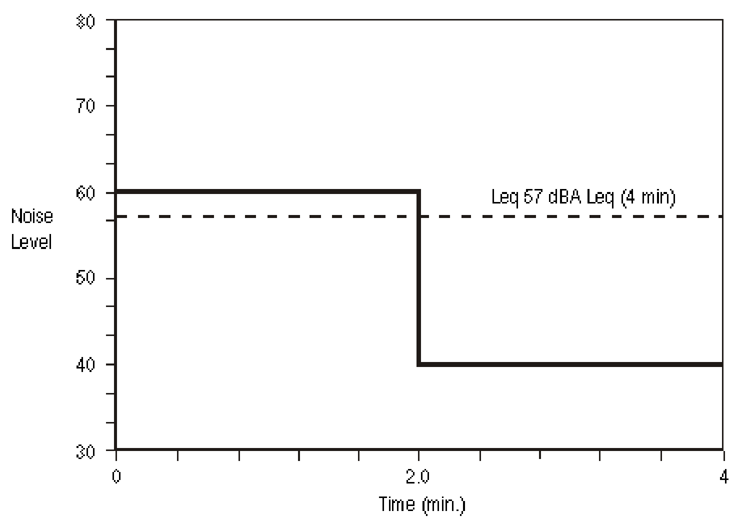

Figure 3 - Illustration of Leq concept

In Figure 3, the equivalent energy during the 4-minute period is not 50 dBA, as one might expect, but 57 dBA. This is due to the way in which sound energies are added, which is logarithmical rather than arithmetic. A quick look at the mathematics shows this:

For Figure 2.1 that has 4 minutes of 1-second Leq values:

$$\text{Leq} = 10 \log \left(\sum_{i=1}^{n} f_i \times 10^{L_i/10} \right)$$

$$\text{Leq} = 10 \log \left(\sum_{i=1}^{n} f_i \times 10^{L_i/10} \right)$$

where: f_i = fraction of total time the constant level L_i is present

L_i = sound level in dBA

$$= 10 \log \left(\sum_{1}^{240} f_i \times 10^{L_i/10} \right)$$

$$= 10 \log \left(\frac{120}{240} \times 10^{60/10} + \frac{120}{240} \times 10^{40/10} \right)$$

$$= 10 \log (505\ 000)$$

$$= 57 \text{ dBA Leq (4 min)}$$

In these calculations, we are adding numbers that are proportional to the corresponding sound energies. For example, the energy associated with the 60 dBA level is 100 times greater than the energy associated with the 40 dBA level (10^6 versus 10^4).

Another example of a Leq calculation is useful in demonstrating how a loud noise event, such as a train passing by, can alter the Leq value. Assume the sound level is measured for 1 hour. For 59 minutes, the sound level is 40 dBA (fairly quiet), and for 1 minute it is 90 dBA while a train passes:

$$\text{Leq} = 10 \log \left(f_1 \times 10^{L_1/10} + f_2 \times 10^{L_2/10} \right)$$

$$= 10 \log \left(\frac{59}{60} \times 10^{40/10} + \frac{1}{60} \times 10^{90/10} \right)$$

$$= 10 \log (0.98 \times 10^4 + 0.02 \times 10^9)$$

$$= 73 \text{ dBA Leq (1 hour)}$$

This example demonstrates how loud noise events, such as trains passing, can dominate the Leq values.

2.3 Sound Power and Sound Pressure Levels

A sound source radiates power, which results in a sound pressure. Sound power is a physical property of the source alone and is an important absolute parameter used for rating and comparing sound sources. Sound power levels for specific equipment may be obtained from the manufacturer or by modeling the source using near-field sound pressure level measurements.

Sound pressure levels can be calculated using sound power levels. For sound levels in a free field, the formula is:

$$L_{pressure} = L_{power} + 10 \log_{10} Q - 20 \log_{10} r - 10.8 - A_{NC} - A_{air} - A_{ground} - \ldots.$$

Where r = distance in metres

Q = directivity factor of source, composed of inherent directivity of the source, Q_s, and the geometry of location, Q_g

A = attenuation from noise control, air absorption, ground effects, etc.

For simplicity, with an exposed source in a free field (e.g., the distance, r, is greater than 5 times the size of the source and there are no significant reflections of sound) where additional attenuation factors are to be neglected, this calculation can be done using A-weighted power and pressure levels. This gives a conservative estimate of the sound pressure level at a distance, but not necessarily the "worst-case" level that may occur under weather conditions favouring noise propagation in a given direction, which can be considered as a negative attenuation.

If any noise control measures are to be added to the source (such as a silencer or a building that will enclose the source) or if environmental conditions (such as the barrier effect of the topography) are to be included, the calculations must be done using octave or 1/3-octave frequency bands and the sound pressure levels added together and A-weighted afterwards. Noise controls and environmental effects are strongly frequency dependent, and a calculation using A-weighted data is not adequate.

The directivity factor, Q, can be thought of as the portion of a sphere into which the source radiates its sound energy. Some sources radiate uniformly in all directions, while others, notably fans, are very directional. For example, a fan in a vertical plane radiates most of the sound energy in a narrow beam to the front: (Qs □ 5 - 8).

The directionality of the source is also affected by the geometry of its immediate surroundings, largely due to the presence of reflecting surfaces. The directivity of the location may or may not be significant due to the inherent directivity of the source. How the directivity factors Qs and Qg combine depends on the layout of the equipment and its surroundings. Table 5 gives examples of values of Q for a variety of location geometries.

Table 5 - Q Values

Q	Radiation pattern	Examples
1	Spherical	Elevated sources, flares, aircraft
2	Hemispherical	Source near or on ground surface
4	¼-spherical	Source on ground beside taller building
8	$^1/_8$-spherical	In a corner of three surfaces

2.4 Addition of Sound Power or Sound Pressure Levels

A similar formula to the one used in section 2.2, Leq Concept, can be used to add sound levels together both for the A-weighted levels and in frequency bands. This formula is useful for adding together sound power or sound pressure levels from different components of a plant, for example, to arrive at a composite sound level for the plant.

Sound pressure levels can be added together in this way only if they are measured or calculated for the same location.

Sound power levels can be added together and the composite source can be thought of as being at the acoustic centre of the individual sources (similar to the concept of the centre of mass of an object).

The formula for the addition of sound levels is:

$$L_{TOTAL} = 10 \log_{10} \left(\sum_{i=1}^{n} f_i \times 10^{L_i/10} \right)$$

where Li = individual component sound levels (power or pressure).

Example Calculation of Addition of Sound Power Levels

You are building a simple facility and are told by the manufacturer that the A-weighted sound power levels (referred to as 10^{-12} watts, also written 1 picowatt, or 1 pW) for the different components are as follows:

Engine exhaust, with muffler 106 dBA
Aerial cooler (nondirectional) 113 dBA
Piping noise 79 dBA

$$L_{power,\ total} = 10 \times \log_{10} \left(\sum_{i=1}^{n} f_i \times 10^{Li/10} \right)$$

$$= 10 \times \log_{10} \left(10^{106/10} + 10^{113/10} + 10^{79/10} \right)$$
$$= 10 \times \log_{10} \left(10^{10.6} + 10^{11.3} + 10^{7.9} \right)$$
$$= 10 \times \log_{10} \left(2.394 \times 10^{11} \right)$$
$$= 10 \times 11.38$$
$$= 113.8 \text{ dBA (ref 1 pW)}$$

When adding sound pressure levels, these levels are only valid for the specific location. To add the sound pressure levels, they must all be calculated or measured at the same location.

2.5 Estimate of Sound Pressure Levels for Different Distances

2.5.1 Point Sources

This estimate assumes hemispherical spreading of the sound waves and equates to a 6 dB loss per doubling of distance from the sound source. The calculation does not account for any attenuation (or loss) due to atmospheric or ground absorption.

This method of calculation can only be used in the following circumstances:

1) Simplified or other informal calculations are only acceptable for a smaller stationary single source facility without any existing industrial infrastructure and with flat ground between the facility and a single dwelling at a close distance or in remote areas where there are no dwellings within 1.5 km of the facility.

2) An acceptable distance for applying the inverse square law depends on the sound source dimensions and the wavelength of the sound. The formula is usually safe to use as long as R_1 and R_2 are about five times the size of the source. Alternatively, a minimum distance of 50 m can be used as a rule of thumb.

3) The inverse square law (6 dB loss per doubling of distance) for sound dissipation over distance does not apply for “near-field” measurements. The near field is the area where the dimensions of the source are significant; it applies to sound pressure levels measured at distances less than about five times the size of the source object. The data supplied by manufacturers are often provided as sound pressure levels measured very close to the equipment (i.e., in the near field) and are intended for use under occupational hearing requirements rather than for environmental assessment. Note that such measurements are often conducted using conditions that may not reflect field or operational conditions. Therefore, this type of measurement cannot be used in the equation below. However, given additional information about the dimensions of the equipment and the conditions of the measurement, the sound power level of the equipment can be determined, and the equation from Appendix 2 and section 2.3, Sound Power and Sound Pressure Levels, can be used instead.

In other circumstances, it may be advisable to contact an acoustical practioner.

The basic equation is:

$$L(R_2) = L(R_1) - 20 \log_{10}\left(\frac{R_2}{R_1}\right)$$

with R_1 = distance R_1 in metres
R_2 = distance R_2 in metres
L = sound level in dBA

Note that if R_2 is less than R_1, the second term in the equation is negative and $L(R_2)$ is higher than $L(R_1)$. Also, under certain source-receiver configurations, the loss per doubling of distance can be less than 6 dB.

Example Calculation of Determining the Sound Level at a Different Distance

The sound level specification you are given is 75 dBA for the simple facility at 50 m away. You have a dwelling 800 m away from your facility. What is the facility sound level measured at the dwelling?

You know that L (50 m) = 75 dBA.

$$L(R_2) = L(R_1) - 20 \log\left(\frac{R_2}{R_1}\right)$$

$$L(800\ m) = L(50\ m) - 20 \log\left(\frac{800}{50}\right)$$

$$L(800\ m) = 75\ dBA - 20 \log\left(\frac{800}{50}\right)$$

$$L(800\ m) = 75\ dBA - 24\ dBA$$

$$L(800\ m) = 51\ dBA$$

So the sound level contribution due to the compressor is 51 dBA at 800 m.

A simpler, more intuitive way to do the calculation is illustrated below.

Alternative Method of Determining the Sound Level at a Different Distance—Simple Table Approach

A simplified way to estimate the sound level is based upon using the rule of 6 dB lost per doubling of distance. With this method, you simply make a table and subtract 6 dB each time you double the distance from the noise source.

If we use the 75 dBA at 50 m specification:

Distance (m)	Sound level (dBA)
50	75
100	69
200	63
400	57
800	51
1600	45

From this simple method, you get 51 dBA at 800 m. This matches the calculation above. The simple table method only allows you to get sound values at discrete distance points. If sound values between the distance points are required, use the calculation method.

2.5.2 Line Sources

Where a long, narrow source radiates noise, the radiation pattern is that of a cylinder, not a sphere. Examples include pipes, conveyor belts, and transportation corridors, such as roads. Calculations using the spherical spreading of sound from point-like sources would involve a final step of integration over the length of the sound. It is more convenient to treat the sound as a line radiating into a cylinder. The pressure level at distance R is considered below. If the length, L, of the line source is limited, once the distance, R, exceeds three to five times the length, the source can be considered as a point source, and the equations in Appendix 2, section 2.3 and section 2.5.1 can be used.

For a line source, the sound spread equates to a 3 dB loss per doubling of distance. Similar conditions apply for the line source equation as for the point source equation. The formula for noise levels at different distances from a line source is as follows:

$$L(R_2) = L(R_1) - 10 \log_{10}\left(\frac{R_2}{R_1}\right)$$

with R_1 = distance R_1, in metres
R_2 = distance R_2, in metres, and
L = sound level in dB (for octave bands) or dBA

Note that if $R_2 < R_1$, the second term in the equation is negative, and $L(R_2)$ is higher than $L(R_1)$.

Appendix 3 - Noise Impact Assessment Summary Form

Licensee: ____

Facility name: ________________________ Type: ____________________

Legal location: ____

Contact: ________________________ Telephone: ______________________

1. Permissible Sound Level(PSL Determination (*Rule 012,* section 2)

(Note that the PSL for a pre-1988 facility undergoing modifications may be the sound pressure level (SPL) that currently exists at the dwelling if no complaint exists and the current SPL exceeds the calculated PSL from section 2.1.)

Complete the following for the nearest or most impacted dwelling(s):

Distance from facility	Direction from facility	BSL (dBA)	Daytime adjustment (dBA)	Class A adjustment (dBA)	Class B adjustment (dBA)	Nighttime PSL (dBA)	Daytime PSL (dBA)

2. Sound Source Identification

For the new and existing equipment, identify major sources of noise from the facility, their associated sound power level (PWL) or sound pressure level (SPL), the distance (far or free field) at which it was calculated or measured, and whether the sound data are from vendors, field measurement, theoretical estimates, etc.

New Equipment	Predicted or ☐ PWL (dBA) ☐ SPL (dBA)	Measured ☐ PWL (dBA) ☐ SPL (dBA)	Data source	Distance calculated or measured (m)

Existing Equipment/Facility	Predicted or ☐ PWL (dBA) ☐ SPL (dBA)	Measured ☐ PWL (dBA) ☐ SPL (dBA)	Data source	Distance calculated or measured (m)

3. Operating Conditions

When using manufacturer's data for expected performance, it may be necessary to modify the data to account for actual operating conditions (for example, indicate conditions such as operating with window/doors open or closed). Describe any considerations and assumptions used in conducting estimates:

____

____

____

4. Modeling Parameters

If modeling was conducted, identify the parameters used (see section 3.5 (1)):

____

____

(continued)

5. Predicted Sound Level/Compliance Determination

Identify the predicted overall (cumulative) sound level at the nearest or most impacted dwelling. Typically, only the nighttime sound level is necessary, as levels do not often change from daytime to nighttime. However, if there are differences between day and night operations, both levels must be calculated.

Predicted sound level to the nearest or most impacted dwelling from new facility (ASL + new facility + existing energy-related facilities):

______________________ dBA (night) Permissible sound level: _______________ dBA (night)

If applicable: ____________ dBA (day) Permissible sound level: _______________ dBA (day)

Is the predicted sound level less than the permissible sound level? Yes ___________ No ___________
If **YES**, go to number 7.

6. Compliance Determination/Attenuation Measures

(a) If 5 is **NO**, identify the noise attenuation measures the licensee is committing to:

____

____

____

____

Predicted sound level to the nearest or most impacted dwelling from the facility (ASL + new facility **with** noise attenuation measures + existing energy-related facilities):

______________ dBA (night); if applicable: ______________ dBA (day)

Is the predicted sound level less than the permissible sound level? Yes ___________ No ___________
If **YES**, go to number 7.

(b) If 6 (a) is **NO** or the licensee is not committing to any noise attenuation measures, the facility is not in compliance. If further attenuation measures are not practical, provide the reasons why the measures proposed to reduce the impacts are not practical.

____

____

____

____

____

7. Explain what measures have been taken to address construction noise.

____

____

____

____

____

8. Acoustical Practioner's Information (See section 3.8 (9)):

____

Company: ____

Title: ____

Telephone: ____________________________ Date: ____________________________

Appendix 4 - Noise Complaint Investigation Form

AUC
Alberta Utilities Commission

PART 1

Date (D/M/Y):_______________________________

Resident: _______________________________ Licensee representative: _______________________

Legal location: ___________________________ Licensee: _______________________________

Address: ________________________________ Address: _________________________________

________________________________ _________________________________

Telephone:________________________________ Telephone: _______________________________

Noise Characterization

Identify the quality and characteristics of the noise.

Distance to source:________________ (m) When is noise a problem (day/night)? _______________________

Pitch (high/low): ____________________ Where is noise most annoying (inside/outside)? __________________

Is there a noticeable tone? _____________ Describe: ____

Is noise steady/intermittent/pulsating? ______ Describe: ____

Is the noise heard and/or a vibration felt? ____ Describe: ____

What is noise comparable to? ____

Other comments: ____

Weather Conditions

Identify the weather conditions under which the noise is most noticeable.

Temperature: ________________Direction wind is coming from: ______________________________________

Wind speed (km/h): ___________ Cloud cover: ___________Precipitation: ____________________

Ground cover between dwelling and facility (snow, water, grass, crop, trees, ice, etc.):

____

Other comments: ____

____

____

Representative Conditions

From the above, identify the conditions that should exist as closely as possible during a comprehensive sound survey.

____

____

____

____

____

(continued)

EVENT LOG
PART 2

Resident: ______________________________ Licensee contact: ______________________________

Telephone: ______________________________ Telephone: ______________________________

List any details related to the sound from the energy-related facility that is annoying you. Refer to the descriptions at the bottom for assistance in providing information.

Date (D/M/Y)	Time a.m./p.m.	Noise characteristics	Weather conditions	Ground cover	Receiver location

Noise characteristics: Describe the sound as a high or low tone, steady or pulsing. What would you compare the sound to?

Weather conditions: If possible, provide details on temperature, wind direction and speed, cloud conditions (clear or cloudy), and existence of precipitation when the sound is a problem.

Ground cover: Describe what is covering the ground between you and the facility; for example, is it snow, water, grass, crop, trees, ice?

Receiver location: Note where you were when the sound was annoying (outdoors, such as on the deck or in the yard or corrals, or indoors, such as in the bedroom or living room).

Appendix 5 - Determination of Low Frequency Tonal Component

5.1 The methodologies

The methodologies shown below are intended as guidelines only and should not restrict the methods of an acoustical practitioner. The Commission will review the proposed methodology and approve the techniques or require other methods, as deemed appropriate. As the PSLs are typically higher in the daytime than during the night, the methods described focus on the nighttime periods. However, the LFN concerns may be due to activities during the daytime only. The methodologies remain similar.

As part of the pre-evaluation of a potential issue with LFN, the investigator should determine the quality of the noise that has raised concerns from the affected resident(s) and assess whether the noise issue is intermittent or continuous.

5.1.1 Continuous LFN

If there is an LFN concern and it is continuous, the levels should be measured over the entire nighttime period in terms of the 1/3 octave Leq and statistical levels (L10, L50, L90, or some combination). The difference in the Leq (equivalent-continuous) levels for adjacent spectral bands should be graphed in order to demonstrate whether there is a pure tone, as defined in section 4.2. If the difference in the levels varies over the nighttime, this will be evident from such a graph.

When measurements are taken over the entire period of the nighttime, the measurement subinterval should be a maximum of one minute. In this case, the statistical levels are valuable to show any shorter term fluctuations in levels.

5.1.2 Intermittent LFN

If the suspected LFN is intermittent, then short-term measurements should be taken at times when the low frequency sound is present, and the assessment of the presence of a tone should be restricted to times when the sound is present. A high-quality audio recording of the sound over the period of concern may need to be taken for later analysis and identification of the duration and intensity of the LFN. If the timing of the intermittent periods is not regular, a continuous measurement may be required to obtain sufficient evidence of the presence or absence of a pure tone.

In this case, the spectral analysis can be done in terms of a short-term Leq or a “slow” weighted sound level. Many instruments do allow simultaneous measurements of the 1/3 octave Leq levels. If meters cannot track all the 1/3 octave frequency bands at the same time, the tonal components can be assessed by running a taped signal through an analyzer a number of times to get the levels of all the frequency bands of interest. The analyzer would be for “slow response” and the recordings run with different 1/3 octave band settings until all bands between 20 and 250 Hz have been analyzed.

5.1.3 Importance of Wind Conditions

In all cases where LFN may be a consideration, measurements of the local wind conditions must be taken throughout the assessment period at a height of 1.2 m to 10 m above ground in the vicinity of the sound monitoring location(s) based on the professional judgment of the acoustical practitioner. Wind generates high levels of low-frequency (and infrasonic) sound energy, which can mask or confuse the assessment of industrial LFN.

Example

The table below shows how the presence of low frequency tonal components is determined. For example, a tonal component is evident at 250 Hz (≥10 dBA within 2 bandwidths on one side and ≥5 dBA drop within 2 bandwidths on the other side, in addition to being pronounced within the spectrum).

		Part 1		Part 2
Band (Hz)	**Sound level (dB)**	**Maximum Δ dB within 2 bandwidths**	**≥5 dB on other side?**	**Pronounced within the spectrum**
20	10	-4	n/a	n/a
25	12	-2	n/a	n/a
31.5	14	4	n/a	n/a
40	13	-4	n/a	n/a
50	14	-3	n/a	n/a
63	17	4	n/a	n/a
80	14	-6	n/a	n/a
100	15	-8	n/a	n/a
125	20	-8	n/a	n/a
160	23	-11	n/a	n/a
200	28	8	n/a	n/a
250	34	11	**yes**	**yes**
315	31	3	n/a	n/a
400	28	-6	n/a	n/a

Figure 4 - 1/3 octave band frequency spectrum analysis for tonal components

The figure below shows some examples of tonal components. There is clearly a tonal component (pronounced peak) within the spectrum at 250 Hz and 2000 Hz (≥10 dBA within 2 bandwidths on one side and ≥5 dBA drop within 2 bandwidths on the other side); however, the second is at a frequency greater than 250 Hz and would not be considered low frequency noise.

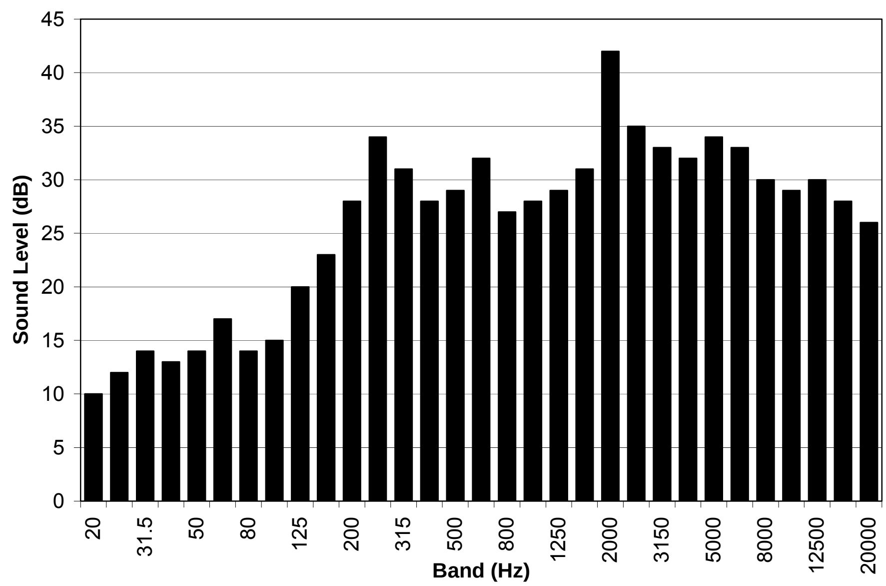

Figure 5 - 1/3 octave band centre frequency (Hz)

Appendix 6 - Examples

The examples below show a step-by-step process to determine compliance or noncompliance for any new or existing facility.

Example 1

A new facility is proposed for the area shown in Figure 6. What sound levels should the facility be designed for?

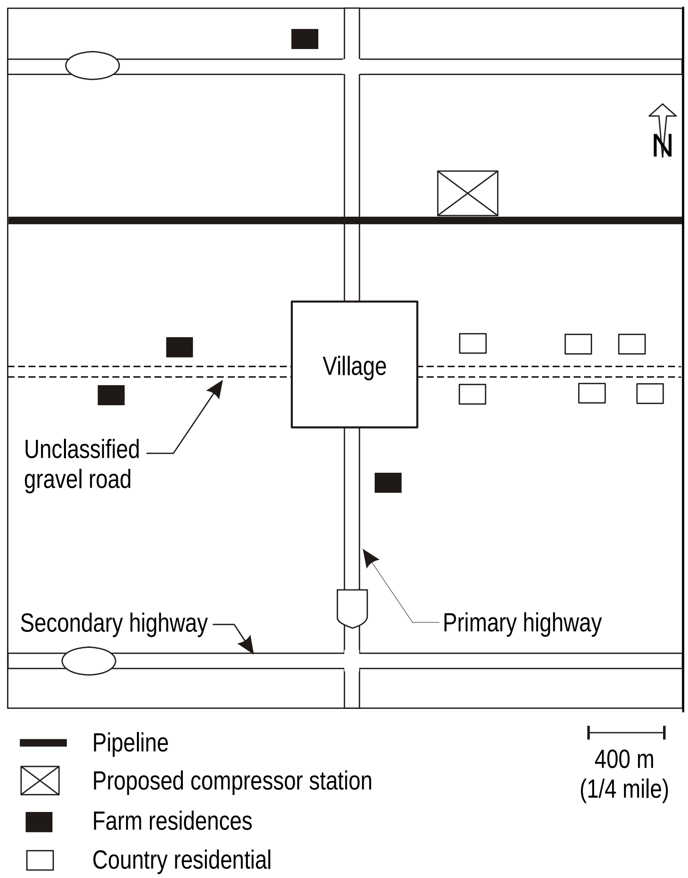

Figure 6 - Area sketch for example 1

Example 1 – Solution

Step 1 Designing a new facility. Determine PSL.

All three possible dwelling unit densities are represented in this area. The four 8.1 ha (20 acre) country residential dwellings factored over a quarter section fall into the 1-8 dwellings range, as do the farmhouses. The two country residential dwellings closest to the village and a portion of the village are in the 9-160 dwellings range, while the body of the village is in the greater than 160 dwellings range.

Regarding the transportation proximity category: the presence of the primary highway causes the adjacent farmhouses to fall into category 2, while the dwellings in the village fall into category 2 or 3, depending on the distance from the highway. Some of the country dwellings fall into category 2 (those closest to the highway), while others fall into category 1 (farther along the gravel road). The farmhouses on the gravel road are category 1.

It appears that the country dwellings to the south of the proposed facility are probably the most sensitive, being category 1 units. This gives a nighttime BSL of 40 dBA Leq, from Table 1.

Some preliminary calculation of expected sound levels and attenuation may be useful in determining the worst-impacted dwelling. For instance, the nearest dwelling unit may be a category 2, while a more distant dwelling unit may be category 1. Some elementary calculations may be necessary to determine the worst case.

Step 2 Are daytime sound levels required?
No, as the lower sound level is the one that must be designed for and the nighttime level is usually lower.

Step 3 Seasonal Adjustment?
No, because this adjustment cannot be added when determining the PSL for design purposes.

Step 4 Is the BSL appropriate for this area?
Assume no, because of presence of non-regulated noise source in area (feedlot that operates 24 hours). The licensee of this proposed facility has taken some spot measurements with a hand-held sound meter. The levels recorded ranged from 35 dBA at night to 55 dBA during the day. Consult with the Commission and obtain approval for using the A2 adjustment.

Step 5 A 24-hour ambient sound monitoring study 15 m from the nearest acreage dwelling unit prior to construction of the facility must be conducted to claim adjustment A2. The results of the survey are

Daytime ASL:	53 dBA Leq
Nighttime ASL:	37 dBA Leq

After receiving approval for using the A2 adjustment. Claim adjustment A2 from Figure 1. First, subtract the ASL measured in this step from the BSL in step 2.

Daytime BSL - daytime ASL = 50 - 53 = - 3
Nighttime BSL - nighttime ASL = 40 - 37 = +3

For each in turn, locate this difference on the horizontal axis of Figure 1, read upward until the adjustment line is intersected, and read to the left to find the applicable adjustment A2.

Daytime adjustment:	A2 = +8 dBA Leq
Nighttime adjustment:	A2 = +2 dBA Leq

Step 6

Sum of adjustments:	A1 + A2 (call it A)
Daytime:	0 + 8 = 8 dBA Leq
Nighttime:	0 + 2 = 2 dBA Leq

Step 7 Is A greater than 10 dBA Leq?
In either case, no.
Class A adjustment = 8 dBA daytime

Class A adjustment = 2 dBA nighttime

Step 8 Is noise temporary in nature?
No; the facility will operate all year.
Class B adjustment: B = 0 dBA

Step 9 Determine the PSL (PSL).

Daytime						Nighttime					
PSL	=	BSL	+ Day	+ A	+ B	PSL	=	BSL	+ Day	+ A	+ B
PSL	=	40	+ 10	+ 8	+ 0	PSL	=	+ 40	+ 0	+ 2	+ 0
PSL = 58 dBA Leq						PSL = 42 dBA Leq					

Step 10 Daytime PSL = 58 dBA Leq
Nighttime PSL = 42 dBA Leq

as measured 15 m from the nearest acreage dwelling unit.

Example 2—Noise impact assessment

A new facility is proposed for the area shown in Figure 7. What is the predicted sound level at the nearest or most impacted dwelling?

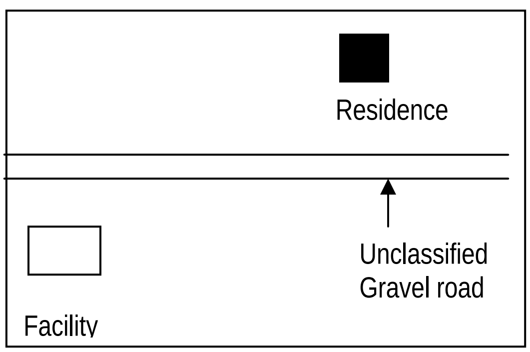

Figure 7 - Area sketch for example 2

Example 2 - Solution

The designer must calculate the maximum sound output of the facility. In this case, for example, the dwelling unit is about 600 m from the facility. Assuming a theoretical 6 dBA drop in sound level per doubling of distance, the facility must have a sound level of no more than 60 dBA Leq measured 75 m from the facility in order to have a sound level of 42 dBA at 600 m. This can be seen from the following table:

Distance (m)	Sound Level (dBA)
600	42
300	48
150	54
75	60

Note that since this is a small, stationary, single source facility without any existing energy-related industrial infrastructure and with flat ground between the facility and a single dwelling at a close distance, the 6 dBA loss per doubling of distance is used.

The 6 dBA loss per doubling of distance is a very rough estimate, and more site-specific methods should be used if possible. A more accurate way to determine the sound attenuation with distance is to measure similar equipment at a topographically similar location. This is done by measuring the sound levels at specified distances away from the facility (for example, 100 m, 200 m, 400 m, etc.) to determine the actual attenuation with distance. It is not uncommon for this attenuation to vary between 5 and 10 dBA for each doubling of distance.

For a design situation, notice how it is the nighttime sound level that must be met. Most permanent facilities create the same amount of noise whether it is day or night, and so the most stringent criterion is the nighttime sound level.

The noise impact assessment developed from these findings would include the following:

1) The major sources of noise in this facility include cooler fans and exhaust noise. The manufacturer of this equipment has stated that the maximum sound level from all the equipment is 60 dBA measured at 50 m in front of the cooler fan.

2) The sound levels at the nearest dwelling have been predicted using only the theoretical 6 dBA loss per doubling of distance. No additional losses for air absorption, excess ground attenuation, or facing the cooler fan away from the dwelling have been calculated. The only input is the 60 dBA criterion at 50 m.

3) The distance to the most impacted dwelling is 600 m to the south. This also happens to be the closest dwelling. If we extrapolate the 60 dBA value out to 600 m, using the theoretical 6 dBA loss per doubling of distance:

$$L(R_2) = L(R_1) - 20 \log\left(\frac{R_2}{R_1}\right)$$

$$L(600\text{ m}) = 60 - 20 \log\left(\frac{600}{50}\right)$$

$$L(600\text{ m}) = 60 - 21.6$$

$$L(600\text{ m}) = 38.4\text{ dBA}$$

So the predicted facility sound level at the dwelling is 38.4 dBA. Adding this to the typical rural ambient sound level (35dBA Leq) would give a combined predicted sound level of 40.0 dBA Leq.

As well, we have measurements at a similar facility with similar topography to the one being applied for. Those measurements indicate short-term sound levels of 55 to 60 dBA at a distance of 75 m. These measurements indicate that the 6 dBA loss per doubling of distance may be conservative. As another measure to ensure compliance of the facility, the cooler fan will be faced in a southwest direction, so that dwellings are not located in front of it.

4) The most impacted dwelling is along an unclassified gravel road, so it is in category 1 proximity to transportation. The dwelling density falls into the 1-8 dwellings range.

Based upon these two factors, the BSL is 40 dBA at night, from Table 1. No other adjustments are being used, so the PSL is 40 dBA Leq nighttime.

5) The assessment indicates that the predicted sound level is 40.0 dBA. This meets the PSL of 40 dBA during the nighttime, calculated above. The assessment indicates that the facility will meet the requirements in this rule. If the facility receives any complaints, they will be investigated promptly, and if the facility is not meeting the rule's requirements, remedial action will be undertaken to rectify the situation and bring the facility into compliance with this rule.

6) No further attenuation measures need to be considered at this time.

7) This noise impact assessment was conducted by Acoustical Practitioner, of XYZ Company. Also see other requirements set out in section 3.8 (9).

Appendix 7 - Standards

Standard	Latest Revision	Description
ANSI SI.1-1960 (RI976)	ANSI S1.1-1994 (R2004)	ACOUSTICS An Introduction to Its Physical Principles and Applications, Allan Pierce (renamed Acoustical Terminology)
ANSI SI.11-1986 (Rl993)	ANSI S1.11-2004	Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters
ANSI S1.40-1984	ANSI S1.40-2006	American National Standard Specifications and Verification Procedures for Sound Calibrators
ANSI S1.4A-1985 ANSI S1.4-1983	ANSI S1.4-1983 (R2006)/ANSI S1.4a-1985 (R2006)	American National Standard Specification for Sound Level Meters
ANSI SI.26-1978	ANSI S1.26-1995 (R2004)	Method for the Calculation of the Absorption of Sound by the Atmosphere
ANSI S1.13-2005	ANSI S1.13-2005	Measurement of Sound Pressure Levels in Air
ASTM Designation E1014-84 (reapproved 2000)	ASTM E1014 - 08	Standard Guide for Measurement of Outdoor A-Weighted Sound Levels
ISO 1996-1 (2003)	ASTM E1686 - 03	ASTM E1686 - 03 Standard Guide for Selection of Environmental Noise Measurements and Criteria
ISO Standard 9613	ISO 9613-1:1993 and ISO 9613-2:1996	Attenuation of sound during propagation outdoors – Part 1 Calculation of the Absorption of Sound by the Atmosphere; and Attenuation of sound during propagation outdoors – Part 2 General method of calculation
IEC 651-1979	Replaced by IEC 61672-1 Ed. 1.0, 2002	Electroacoustics – Sound Level meters Part 1: Specifications
IEC 225-1966	Replaced by IEC 61260 :1995 Amended 2001	Electroacoustics – Octave Band and fractional-octave-band filters
IEC 61672-2 Ed.01.0 2003	IEC 61672-2 Edition 1.0 (2003)	Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests
CSA Z107.0-1984		Definitions of Common Acoustical Terms used in CSA Standards
CSA Z107.55 – M1986	CAN/CSA-Z107.55-M86 (R2001)	Recommended Practice for the Prediction of Sound Levels Received at a Distance from an Industrial Plant