Tools of the Trade: A Review of NZ Acoustic Standards - 1977 to 2010

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An original contribution to New Zealand Acoustics

1. Introduction

This is the first of two technical papers which reviews the Standards New Zealand series for environmental acoustics, the 'NZS 680X series' between 1977 and 2010. The aim of the paper is to introduce the reader to environmental acoustics standards, discuss their overall purpose while setting out fundamental areas of service and restrictions.

2. Noise, Sound and Vibration

The terms 'noise' and 'sound' appear in the title of all environmental acoustics standards [the NZS 680X series]. The term 'noise' is considered by most to mean 'unwanted sound' and in the NZS 680X series, the term 'noise' is commonly defined as unwanted sound and for that reason has limits attached to it, for example noise limits prescribed in District Plans. The term 'sound' is mostly employed within the NZS 680X series to refer specifically to the sound source[s] being assessed.

Importantly, the Resource Management Act 1991 [RMA] defines noise as "includes vibration." This leaves noise along with other pollutants as something to be assessed as an environmental effect under the RMA. The RMA describes 'excessive noise' in Section 326 as "any noise that may unreasonably interfere with the peace, comfort, and convenience of any person [other than a person in or at the place from which the noise is being emitted], but does not include noise emitted by cars, vehicles, aircraft and trains." Section 16 of the RMA imposes duties on all persons using land or water for activities "to adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level." Section 17 of the RMA imposes duties to avoid, remedy, or mitigate any adverse effect whether or not the activity is in accordance with a rule in a plan.

3. Who is "Standards New Zealand"?

The first national standards organisation was created in New Zealand in 1932. "Standards New Zealand" is a user-funded, independent Crown entity, responsible for overseeing development and distribution of New Zealand Standards across a range of sectors, including environmental acoustics. Standards New Zealand is governed by the "Standards Council". Members of the Standards Council are appointed by the Minister of Commerce under the Standards Act 1988. Standards New Zealand facilitates the work of expert committees who prepare draft standards, and review public comments on drafts before voting on the final draft. When the committee reaches consensus on the final draft, it goes through an editing process before finally being approved for publication by the Standards Council.

4. What is a New Zealand Standard?

A 'New Zealand Standard' means a standard promulgated by the Council as a New Zealand Standard under the Standards Act. In essence, Standards are documents that provide requirements, specifications, and guidelines or benchmarks that, when applied correctly; promote consistency to ensure an agreed way of doing something, i.e. "standardisation". For example, standardised methods of measuring and assessing sound, if applied correctly, should produce consistent results. Standards New Zealand has a catalogue of 16 past and present NZS 680X series standards. Standards are generally developed by expert committees with consensus required before being formally approved by the Standards Council in accordance with the Standards Act. New Zealand Standards do not have any 'regulatory force' by themselves. Compliance with standards is voluntary unless cited as a means of compliance in a statutory document such as a regulation, a National Environmental Standard, a District Plan rule or, for example, as a condition of a Resource Consent.

5. Measurement and Assessment of General Environmental Sound

The science of acoustics describes sound by various functions including the level of sound, its frequency spectrum and duration. Many different sound descriptors [or metrics] have been defined and the traditional standard unit of a sound level descriptor is the decibel [dB]. For example, the time-average, A-frequency weighted sound level [L_{Aeq}(t)dB] or the exceedance sound pressure level [L_{AN}dB]. Some of the most commonly used descriptors for environmental sound within the NZS 680X series of Standards are the L_{A90}, L_{A10}, L_{Aeq}(t), L_{AFmax}, and L_{dn}. There are many other descriptors in use internationally for environmental sound assessments used for specialist assessment including but in no way limited to Pascal-squared seconds (Pa^2s), L_{Cpeak} or L_{Zpeak}, for example. The two core environmental standards for the measurement and assessment of environmental sound are NZS 6801 and NZS 6802. These two standards should be read in conjunction, as 6801 prescribes how sound is measured while 6802 prescribes the method for assessment of sound

and guidelines for setting noise limits. The following sections discusses 6801 and 6802, 1977 to 2008 versions, with emphasis being provided on the most recent and technically advanced 2008 versions of these standards.

6. NZS 6801 and NZS 6802 - The First General Environmental Noise Standards

The first official environmental noise standards to be promulgated in New Zealand by the then Standards Association of New Zealand [SANZ], now Standards New Zealand, were 'NZS 6801:1977 Methods of Measuring Sound' and 'NZS 6802:1977 Assessment of Noise in the Environment'. These 1977 standards were declared on 16th December 1977 by the Standards Council to be 'standard specifications' pursuant to Section 23 of the Standards Act 1965. The two standards had been prepared by a special noise sub-committee of SANZ, following the recommendation 3[b] of the Board of Health Series No 21, Noise, HMSO Wellington 1974. Prior to the introduction of these standards, Department of Health guidelines published by National Audiology Centre were used nationwide.

The 1977 standards used the L_{95} noise descriptor, defined by NZS 6801 as the 'background noise level' as the primary descriptor for environmental noise. In that era it was "background plus 10 dB" that was used in most "District Schemes" as the sole descriptor for noise limits. The standard also defined 'nuisance' noise and introduced the L_{10} noise descriptor.

The 1977 standard also refers to 'single event noise', which although not referred to directly in the standard as the maximum A-frequency weighted sound pressure level, L_{Amax} noise descriptor, this is precisely what it was. The 1977 standards were prepared before integrating sound level meters were in common use. NZS6801 provides for measurement methods based on visual observation of analogue meter displays and manual [read-write] survey methods and statistical analyser results to determine "percentile levels." Visual or manual calculation was mostly conducted post measurement, as there were few statistical analysers available. This was quite different to modern assessment methods where sound level meters log the data and incorporate analysis and processing firmware providing the user with a host of instant noise descriptor information at their finger-tips.

6.1 NZS 6801 and NZS 6802: 1991 and 1999

NZS 6801:1977 and NZS 6802:1977 were superseded by 'NZS 6801:1991 Measurement of Environmental Noise' and 'NZS 6802:1991 Assessment of Environmental Noise'. In a decision of the Planning Tribunal AC52/85 Vision Wall Coverings Ltd. versus Papatoetoe City Council, the Court held the 1977 standard was "in many respects outdated and due for revision." By that era the science of environmental acoustics had rapidly advanced and international acoustic standards and British Standards had been revised. The project to revise the 1977 editions began in 1985 with a committee of the Acoustical Society of New Zealand. This committee became the Standards New Zealand Committee which prepared the standard eventually approved by the Standards Council in 1992.

As with the 1977 version of NZS 6802, the 1991 version retained the use of L_{95} defined by this standard, but to conform with international standards, changed the name to 'background sound level'. The standard also clarified that the descriptor for "intrusive noise" [referred to as 'nuisance noise' in NZS 6801:1977] was the L_{10} noise descriptor together with L_{max}. The 1991 standards defined L_{max} as the 'maximum A-weighted sound pressure level'. Further change in the noise descriptors was introduced in the 1999 revision eight years later when the L_{10} nuisance noise descriptor was superseded with the new L_{Aeq} noise descriptor for assessment of intrusive noise. 'NZS 6801:1999 Acoustics – Measurement of Sound' and 'NZS 6802:1999 Acoustics – Assessment of Environmental Sound' were published in 1999. The revision of the series in 1999 was designated as a New Zealand only project.

Although both the 1991 and 1999 versions were later identified as containing defects and deficiencies, it was not until December 2005 that a scoping workshop held by Standards New Zealand identified a number of areas requiring revision in both NZS 6801 and NZS 6802. The year following the workshop held by Standards New Zealand saw Standards New Zealand release a report entitled; "Report on the future options for New Zealand Standards – NZS 6801: Measurement of Environmental Sound and NZS 6802: Assessment of Environmental Sound". The key objective of the scoping project was to determine and agree options/scope for future solutions to environmental sound Standards in New Zealand. The report concluded Standards New Zealand position at this time was to recommend that Standards New Zealand only review and revise NZS 6801:1999 Measurement of Sound and NZS 6802:1999 Assessment of Environmental Sound which subsequently occurred.

There are many noteworthy issues about the 1999 standards editions which include NZS 6802:1999 adopting L_{Aeq} as the main descriptor for intrusive noise and clarifying the assessment methods by incorporating adjustments factors which had been omitted from the 1977 and 1991 editions. New meteorological effects provisions were incorporated and the modern 'Rating Level' assessment method adopted from ISO1996 was introduced.

The revision of most District Plans were substantially complete by time of the 1999 version was published and they had already incorporated the NZS 6802:1991 as the basis for assessment. Only the few "late" District Plan reviews were able to incorporate the 1999 edition. By the time of the 2008 edition the second generation plan reviews had commenced and these were mostly able to start incorporating the 2008 editions.

6.2 NZS 6801:2008 and NZS 6802:2008

In 2008 the most recent environmental noise standards for NZS 6801 and NZS 6802 were released, the scope of both standards remained the same, but noticeably the names were simplified being NZS 6801:2008 Acoustics – Measurement of Environmental Sound and NZS 6802:2008 Acoustics – Environmental Noise.

The majority of issues addressed within the updated standards are set out within the Forward of NZS 6801:2008 which states that the changes made in NZS 6801:2008 were "relatively minor corrections, clarifications and updates". Nevertheless in terms of NZS 6802:2008 the Foreword of this standard tells us that

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the 2008 version addresses "several significant changes" in the revision of NZS 6802:1999. The change or at least the overall appearance in the 2008 versions can be viewed as major; the 2008 standards are technically superior and include enhanced detail and guidance to assist the user. Like the 1999 version, they align closely to ISO 1996-2:2007 Acoustics - Description, measurement and assessment of environmental noise—Part 2: Determination of environmental noise levels.

What becomes obvious with the 2008 standards is the user must have a firm understanding of environmental acoustics. Such advances between standards is due to many issues including advances in the science of acoustics for both measurement and assessment, and related advances in 'tools', such as sound level meters and 'methods', such as computer modelling. It is considered appropriate by most acousticians that NZS 6801:2008 Acoustics Measurements of Environmental Sound and NZS 6802:2008 Acoustics Environmental Noise should be incorporated by reference into District Plans at the relevant point in time of that Plan's life-cycle as these versions are most up-to-date technically, and are considered current best practice. It is generally agreed among practitioners that the 1991 and 1999 versions of the standards are now out-of-date with known technical, legal defects and no longer reflect best practice in the field of environmental acoustics.

6.2.1 Terminology and Interpretation

The 2008 standards modify past terminology used in earlier standards and conform to international standards. Uncertainty about use of the historic term "ambient" was clarified in NZS6802:2008 by adopting from ISO 1996-2:2003 the terminology and definitions. It is noted that the term "ambient" has distinctively different meanings in Europe and the USA and as noted, it is replaced in New Zealand by "total sound" and "residual sound", as relevant. The term 'background sound level' remains in NZS 6802:2008 but the metric changed from L_{95} to $L_{90}(t)$. NZS 6802:2008 describes the background sound level as the level in decibels [dB] equalled or exceeded for 90% of the measurement interval and is the component of residual sound that subjectively is perceived as continuously present.

The term 'total sound' is introduced meaning the total encompassing sound from all sources, near and far including the 'specific sound', while the 'specific sound' is a component of the 'total sound' best defined as a being associated with a specific sound source. The 'residual sound' can be viewed as the sound remaining when the specific sound under consideration are suppressed or are an insignificant part of the total sound. The concepts defined separately may be confusing, however applying them to the example of the noise of a heat pump which is being investigated, the sound the heat pump itself makes would be described as the specific sound, while residual sound could relate to local traffic on an adjacent busy road next to the site which the heat pump is located. The total sound would include both the heat pump and local traffic.

6.2.2 Assessment Methods, Measurements Interval and Rating Level

In the ISO standard ISO 1996-2:2007 'Acoustics – Description, assessment and measurement of environmental noise – Part 2: Determination of environmental noise levels', the "Rating Level" is a derived level used for comparison with a noise limit. The Rating Level is used to rank the potential subjective response to the sound environment.

Assessment under the 2008 standard of NZS 6802 is as in the 1999 version based on a "Rating Level" which is derived from assessment via two methods described in the standard as the "simple assessment method" or "detailed assessment method". The Rating Level is denoted within ISO 1996-2:2007 and NZS 6802 as 'L_R.'

The Rating Level process has three main steps. The first step in the process is to obtain the Rating Level from measured L_{eq} sound levels via the applicable 'simple' or 'detailed' method, outlined below. This provides an overall magnitude of the sound. The second step is to apply any applicable adjustments to the L_{eq}. NZS 6802:2008 contains adjustments to the L_{eq} for features which are likely to affect the subjective acceptability of the sound. The third and final step is to compare the Rating Level to the permitted noise limit.

NZS 6802:2008 sets out standardised adjustment provisions including [but not limited to] sound contamination, special audible characteristics [SACs] and duration. Where NZS 6802:1991 specified a measurement period of 'between 10 and 15 minutes and up to an hour in duration,' NZS 6802:2008 sets a standardised "reference time interval" of 15 minutes. Under NZS 6802:2008, the 'simple' method is to directly measure a representative L_{Aeq}(15 min) or equivalent value. For varying sounds a 'detailed' assessment method in Appendix B is described and examples are for the user are included in Appendix A. The difference between the two methods is that the detailed method allows for post-measurement calculations to arrive at a representative L_{Aeq}(15 min) value, while the simple method enables direct use of the measured levels.

NZS 6802:2008 recommends that in order to determine the Rating Level of a noise source, it is necessary to establish the level of the sound, the frequency of the sound, and occurrence of the sound, if it is intermittent. It also recommends the residual sound level be determined where relevant. Appendix A, Table A1 of NZS 6802:2008 provides suggested measurement time intervals and numbers of measurements relative to the nature of the sound for example steady, fluctuation and impulsive.

6.2.3 Averaging

Averaging is the process of finding the arithmetic mean of a data set, in the case of acoustics this is normally the "energy average". This averaging involves calculating the RMS [Root Mean Square] mean of data set and to do this the logarithmic effect of working in decibel units needs to be 'undone'. Thus the result is not the linear arithmetical "mean" of the decibel values as most people would know or would assume from everyday mathematical applications.

Prior to NZS 6802:2008, those in the acoustics profession in New Zealand had diverse opinions about averaging of sound levels, intermittency, duration and events, and the application of adjustments for averaging. NZS 6802:1991 allowed averaging if done as an energy average, and where the averaged L_{10} did not exceed the relevant limit, with all cases the limit must not be exceeded by more than 5 dB when averaged. The 1991 standard

states if comparison is to be made with night time noise limits no averaging shall be allowed at any time. Prior to the 2008 revision of NZS 6802, acousticians were in some cases applying differing methodologies to averaging which was contrary to the purpose of the standard which in very general terms mean potentially allowing for two different assessments of as well as solutions to the same problem. The 2008 versions solved this issue by specifying averaging only over the "Prescribed time frame" which is a time period representing 'Daytime', or 'Evening' specified in any rule or national environmental standard. The averaging effect was limited by capping averaging at a maximum 5 dB with no averaging during night time hours.

6.2.4 Sound Level Descriptors

One of the main consequences of updating NZS 6801 and NZS 6802 was a change in measurement descriptors. Background sound level [previously L_{A95}] was changed to L_{A90} in the 1999 version. The change was an update consistent with international usage in BS4142:1997 -- Method for rating industrial noise affecting mixed residential and industrial areas and ISO 1996-2:2007. The difference between the L_{A95} unit and L_{A90} is generally small [typically about 1 dB or less] depending upon the noise source being assessed.

The 1999 revision replaced the L_{10} descriptor with L_{Aeq}, technically referred to in the 1999 and 2008 versions as the 'time average sound level', being denoted as $L_{Aeq}(t)$). What is vital about the $L_{Aeq}(t)$ is the measurement or assessment period [t = time] is required by both the 1999 and 2008 versions to be stated. The key difference between the 1999 version and the 2008 version was the standardising of a reference time interval as 15 minutes. The BS 4142:1997 L_{Aeq}(1h) daytime and L_{Aeq}(5min) night-time criteria had been abandoned in favour of 15 minutes. The L_{10} descriptor was originally adopted as it was demonstrated to have a reasonably good correlation with the degree of annoyance experienced by a typical person and was easy to calculate. Furthermore L_{10} could be determined from analogue sound level meters by the visual mean maxima estimation method acceptable at the time.

The introduction of L_{Aeq} was considered to be on a 'firmer foundation' and appropriate as international research had shown that the L_{Aeq} descriptor has a greater degree of correlation to noise annoyance than L_{10}, and for this reason was widely accepted as being the preferred noise descriptor for use in environmental noise standards and noise limits. Furthermore the L_{Aeq} level, being unrelated to the statistical variation in sound levels, is more readily predicted, which is a considerable advantage over L_{10}. As noted above, by its very nature, L_{Aeq}, is related to a specific time interval and will only provide a valid description of a sound environment if the measurements cover the range and variability of that sound environment. The L_{Aeq} noise descriptor is used internationally and from an acoustician's point of view it can be readily used to combine, separate or average sound from various noise sources. The L_{Aeq} metric is an energy average and is affected by all sounds measured at all levels, in proportion to their sound pressure level, duration and spectrum. The difference between the L_{10} unit and L_{Aeq} will depend upon the sound under investigation, in particular its frequency spectrum and the variability or intermittency. It is generally accepted that the difference would typically be 2-3 dB for "common" sounds but may be much larger for some specific situations. In the case of simple constant sound sources with a fix spectrum, such as a fixed speed fan, all descriptors would be treated as the same, that is $L_{10} = L_{eq} = L_{90} = L_{max}$. For more complex variable sound sources such as wind farm sounds or the sounds of passing road traffic, the difference between L_{Aeq} and L_{90} for the same reference time interval is around 2.5 dB at receiver locations when all data with extraneous measurement noise is removed.

A difference of 2-3 dB may appear insignificant, however two sound sources of equal power [thus with the same sound level] only increases the received sound pressure level by 3 dB. For example two sources each with an output of 50 dB, when they are combined result in a level of 53 dB. While an increase in received sound of +3 dB is detectable, it is not usually a significant increase in an environmental noise context and is significantly less than a doubling of perceived loudness [which for simple sources typically occurs when a sound level is increased by 10 dB]. The single event L_{Amax} sound level descriptor remained in the 2008 standard, being denoted as L_{AFmax} in accordance

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Table 1: Example of Applying SAC under NZS 6801:1991 and NZS 6802:2008

Permitted Noise Limit = 60 dB Measured Sound Pressure Level = 58 dB Measured sound is assessed as having special audible characteristics	
1991 Method	**2008 Method**
Assessment under 1991 +5 dB Adjustment to applicable Noise Limit	Assessment under 2008 Adjustment to Sound Level
Measured Sound level = 58 dB Noise limit = 60 dB - 5 dB = 55 dB [for SAC] Sound Level is 3 dB over Noise Limit	Sound Level = 58 + 5 dB adjustment [for SAC] = Rating Level 63 dB Noise limit = 60 dB Rating Level is 3 dB over Noise Limit

with ISO 1996:2007 usage. NZS 6802:2008 states that the L_{AFmax} is the maximum A-frequency weighted, F-time weighted sound pressure level in decibels. Typically obtained with an A-frequency weighting and Fast [exponential]-time weighting on a sound level meter [SLM]. However, as modern SLMs produce short-L_{Aeq} values [commonly set to a 1 second integration period [L_{Aeq}, 1s] per data point] there may be a difference between a L_{AFmax} value and L_{Amax} based on the maximum short-L_{Aeq} for the 15 minute measurement period. The L_{AFmax} criteria is set for night-time hours only to protect from disturbance to the onset of sleep and awakening thresholds for the average person. Note: L_{Amax} must not be confused with the descriptor L_{peak}.

6.2.5 Notation

Correct use of noise conventions is important so that persons using the current notation are clear on which particular noise descriptors is being used. For example whether the noise descriptor uses A, C or Z-frequency weighting. NZS 6801:2008 states that in accordance with international conventions, where a sound level is A-frequency-weighted this shall be denoted by an 'A' subscript in the descriptor, for example, L_{Aeq}(15 min). Previous conventions of adding an 'A' to the units [for example dBA] shall not be used according to 2008 series when reporting sound levels in accordance with the Standard. The "F" [is included to make it explicit that "F" time-weighting applies for example in L_{AFmax}. The expression dBA or dB(A) should not be used. NZS 6801:2008 states the sound levels shall be reported in the format 'value-unit-descriptor-sample time', for example, 65 dB L_{Aeq}(15 min).

6.2.6 Adjustments

Assessment under the 2008 standards is based on a "Rating Level" obtained from the measured sound levels via the simple or detailed method with adjustments applied as appropriate. The following discusses some [but not all] relevant adjustments under NZS 6802:2008.

6.2.6.1 Duration Adjustments

The standard states that for prescribed time frames other than at night, subjective response is related to both the level and the duration of a sound. A duration adjustment for intermittency may be applied [subtracting up to 5dB from the measured and adjusted sound level] to account for the "lesser annoyance" generally caused by an intermittent sound compared to the same sound if it were continuously present. No adjustments are allowed for night time. Essentially the more the sound source is present, the less the duration adjustment allowed. An example is a permitted adjustment of 5dB when the percentage duration of specific sound in the prescribed time frame is less than 30%.

6.2.6.2 Special Audible Characteristics [SAC]

Adjustment for Special Audible Characteristics [SACs] has been a feature of past standards and continues its important role in the 2008 standards. The standard states that the intrusiveness of a sound is not just a function of its sound pressure level but also affected by its character such as tonality or impulsiveness which is likely to cause adverse community response at lower sound levels. If justified, the representative sound level determined over the reference time interval shall be adjusted to take into account the character of the specific sound[s] under investigation.

NZS 6802:2008 requires that the adjustment for special audible characteristics, where warranted, is added to the adjusted measured sound level before determining the Rating Level, as opposed to the 1991 version where special audible characteristics if present required the adjustment [5dB] to be subtracted from the specified numerical noise limit. In any event, there is no difference in the product of the two methods in terms of the final outcomes - as shown in the following example where the permitted noise limit is 60 dB and the measured sound pressure level is 58 dB, the example shows that using either the 1991 or 2008 method the sound level is 3 dB over the permitted noise limit.

The change to adjust the Rating Level as opposed to the sound limit was made so that if multiple sound sources are present and only one source was assessed as having special audible characteristics this could be addressed, but keeping the same fixed limit the sources with special audible characteristic are penalised under the 2008 version, as under the 1991 version for example the limit was penalised if only one sound source triggered assessment of special audible character being present.

The 2008 version can allow an adjustment in the range 1.0 to 6.0 dB, in the case where the reference method is used to determine tonality. This is different to the zero or +5 dB adjustment possible under the 1991 version assessment method which applied a 5 dB penalty to the specified noise limit making it more stringent by 5 dB. Appendix B of NZS 6802:2008 [Table B2] specifies how SACs are to be assessed providing guidance on the simplified test for tonality. It should also be noted that the symbol "k_2" after heading B4.5 "Adjustment" is an error and should be drafted as "K_t" as found in ISO 1996-2:2007 Annex C.

6.2.6.3 Residual Sound Contamination Adjustment

When measuring a specific sound source the microphone will also sense the contribution from other sound sources and include their contribution as the total sound pressure level. NZS 6802:2008 recommends that where appropriate, measured sound levels shall be adjusted to take into account the contribution of residual sound inadvertently included within the reading. Adjustments up to 3 dB are permitted if the difference between the total measured sound and residual sound difference is at least 3.0 dB. The adjustment in this case allows for the adjustment value K_1 to be subtracted from the total measured level. The correct level of the sound under investigation may not be possible where this sound level is within 3 dB of the residual sound level. This adjustment had not been specifically provided for in the 1991 version and was introduced in the 1999 version. NZS 6802:2008 provides guidance of the permitted adjustments, if the difference between measured total sound [referred to in Table B1 as L_{Meas}] and residual sound [referred to in Table B1 as L_{Resid}] is <3.0 dB no valid assessment can be done.

6.2.6.4 Facade Adjustments

The standard states that an adjustment to measurements so as to approximate free-field conditions at the microphone shall be made if there are reflections from structures other than ground, as in the 1999 version the 2008 version provided for a single 3 dB façade correction to be applied. No similar provision for an adjustment was included in the 1991 version, but it was implied.

6.2.6.5 Comparison of Adjustments and Methods under NZS 6802

The table in Appendix A compares the various adjustments and methods in all versions of NZS 6802 and predecessor documents.

6.2.7 Guideline Limits for the Projection of Health and Amenity Value

The NZS 6802 series have since the 1977 versions always provided recommended criteria or noise limits for the protection of Health and Amenity. These recommended guideline limits are provided as guideline residential upper noise limit values using L_{AFmax} and L_{Aeq} in the latest 2008 version of NZS 6802. The standard states the guidelines are generally acceptable noise limits and communities can make more or less stringent limits to suit their particular circumstances. The standard states such limits when adhered to provide "reasonable" protection of health and amenity. The 2008 version of the standard introduced an evening time frame with limits between the day and night limits if Local Authorities wished to incorporate such in their rules. NZS 6802 sets out the recommended Guideline Residential Upper Noise Limits. A daytime level of 55 dB L_{Aeq} (15 min) is set while a night time level of 45 dB L_{Aeq} (15 min) and 75 dB L_{AFmax} is set for the protection of health and amenity

The limits recommended above from NZS 6802:2008 are consistent with the guideline values for community noise in specific environments published by the World Health Organization [WHO] in 1999 which states that during the daytime, few people are seriously annoyed by activities with levels below 55 dB L_{Aeq} (16h). The night-time limit recommended should not exceed 45 dB L_{Aeq} (8h) outside dwellings so that people can sleep with windows open for ventilation and achieve the desirable indoor 30 to 35 dB L_{Aeq} (8h) level as a design level to protect against sleep disturbance. The WHO recommends various guidelines for specific environments. In the case of bedrooms the critical effect is sleep disturbance, where guideline indoor limits are 30 dB L_{Aeq} (8 hr) for continuous noise and 45 dB L_{AFmax} for single sound events. The WHO does however acknowledge that lower levels may be annoying depending on the nature of the sound source.

To protect the majority of people from being 'moderately annoyed' during the daytime, the outdoor sound level should not exceed 50 dB L_{Aeq} (16 hrs). The night time sleep disturbance threshold set were re-examined by the WHO Regional Office for Europe in a document entitled 'Night Noise Guidelines for Europe' [NNGfE]. In this "Interim targets" were defined to encourage countries to gradually reduce the percentage of the population exposed to levels above specified targets expressed as $L_{night, outside}$, but these values are yearly averages and should not be directly compared with L_{Aeq} (8h) values. NNGfE guidelines are considered by WHO to be an extension of the WHO 2000 guidelines, but not yet formerly adopted as an international WHO guideline. WHO guidelines have always been used in New Zealand Standards as the basis for protection of health and amenity values for an 'average' person's sensitivity but currently New Zealand does not use the $L_{night, outside}$ noise descriptor.

6.2.8 Objective versus Subjective Assessment

The World Health Organization [WHO] defines annoyance as 'a feeling of displeasure evoked by noise'. Annoyance can relate to both acoustic and non-acoustic factors, including social, psychological and economic issues. There are considerable differences in individual reactions to the same sound. Annoyance is generally a subjective assessment influenced by a number of 'social moderators' including the source and type of noise, and an individual's ability to control the source, affecting how an individual reacts to it.

The New Zealand Standards, including NZS 6802:2008, set objective recommended assessment limits to protect health and amenity. One key issue is the subjective response to a change in noise level is widely variable between the populace. It would be very difficult [if not impossible] and impractical to set noise limits based on subjective assessment alone due to the number of confounding non-acoustical variables such as annoyance evaluation factors.

A typical subjective 'annoyance evaluation factor' commonly mentioned is if a specific sound source under investigation can be heard, that is the sound is audible with the human ear at a

receiver location. It is however important to note that even if the specific sound was audible above background sound level this does not automatically mean when evaluating this sound source that it is above permitted objective recommended assessment limits to protect health and amenity. It is therefore important to consider that audibility based on subjective assessment and compliance based on objective assessment are two different issues.

6.3 NZS 6801:2008 Overview - See Table 2.

6.4 NZS 6802:2008 Overview - See Table 3.

Table 2: Overview of NZS 6801:2008 Acoustics – Measurement of Environmental Sound

Full Name	NZS 6801:2008 Acoustics – Measurement of Environmental Sound
Abbreviation	NZS 6801:2008
Supersedes	NZS 6801:1977 NZS 6801:1991 NZS 6801:1999
Copyright	Copyright of the document is the property of the Standards Council
Purpose	This Standard sets out quantities to be used for the description of sound in community environments and describes procedures for the consistent measurement of these sound descriptors. The Standard may be cited in local authority rules, plans, and consent conditions or in National Environmental Standards to avoid the need for inclusion of technical information while ensuring national consistency in sound measurement methods
Key function[s]	Assessment Procedures Measurement Procedures √ Prediction Methods √ Guideline Noise Limits √ Management Methods and Procedures √ Compliance Methods and Procedures Land Use Planning Reporting Requirements √
Inclusions	NZS 6801 Foreword specifically states that the standard's methods and procedures for the measurement of sound are intended to be applicable from all sounds, individually or in combination.
Further Information **Related Documents**	-ANSIS12.181994. Procedures For Outdoor Measurement of Sound Pressure Level Describes procedures for the measurement of sound pressure levels -ISO 9613-1:1993 Acoustics -- Attenuation of sound during propagation outdoors -- Part 1: Calculation of the absorption of sound by the atmosphere -ISO 9613-2:1996. Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation -ISO 1996-1:2003 Acoustics -- Description, measurement and assessment of environmental noise -- Part 1: Basic quantities and assessment procedures -ISO 1996-2:2007 Acoustics - Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels -ISO 80000-8:2007 - Quantities and units - Part 8: Acoustics
Key Noise Descriptor	L_{A90} $L_{Aeq(t)}$, $L_{Aeq\ (15\ minute)}$, L_{AFmax}
Proficiency Level	Persons using the standard are assumed to have an understanding of the science of environmental acoustics and be proficient in and have experience in acoustic measurement.

Table 3: Overview of NZS 6802:2008 Acoustics – Environmental Noise

Full Name	NZS 6802:2008 Acoustics –Environmental Noise
Abbreviation	NZS 6802:2008
Supersedes	NZS 6802:1977 NZS 6802:1991 NZS 6802:1999
Copyright	Copyright of the document is the property of the Standards Council
Purpose	This Standard sets out procedures for the consistent assessment of noise for compliance with noise limits. The standard provides guidance for the setting of noise limits for consent conditions, rules or national environmental standards
Key functions	Assessment Procedures √ Measurement Procedures Prediction Methods Guideline Noise Limits √ Management Methods and Procedures Compliance Methods and Procedures √ Land Use Planning √ Reporting Requirements √
Inclusions	This Standard sets out procedures for the assessment of nose for compliance with noise limits and provides guide for setting noise limits. Sound from rail yards not attributable to vehicle on rails and sound from airport activities except from aircraft taxing and in-flight are within the scope of NZS 6802 Light aircraft flight and ground movements not at airports which are outside the scope of other standards are within the scope of NZS 6802 Where sound from transportation or construction is part of ongoing day to day sound emissions it shall be assessed using NZS 6802. Where the residual sound level is required for the purpose of this standard all sources of sound are included whether or not they are subject to assessment by another standard.
Restrictions	NZS 6802 does not apply to sound where the source is within the scope of and subject to the application of any other New Zealand Standard including -Road and rail transport -Flight operations of fixed or rotary wind aircraft associated with airports or helicopter landing areas -Construction noise -Port Noise -Vehicles on Public Roads -Wind Turbine Generators -Impulsive sounds [blasting and gun fire]
Further Information Related Documents	NZS 6801:2008 Acoustics – Measurement of Environmental Sound
Key Noise Descriptor	L_{A90} $L_{Aeq(t)}$, $L_{Aeq\ (15\ minute)}$, L_{AFmax}
Proficiency Level	Persons using the standard are assumed to have an understanding of the science of environmental acoustics and be proficient in interpreting acoustic measurement data as well as proficient in acoustic assessment and analysis.

Continued on Page 26...

...Continued from Page 23.

7 NZS 6803 Measurement and Assessment of Construction Noise

'NZS 6803:1999 Acoustics – Construction Noise' is the current standard for construction noise assessment. The Standard was prepared by the 'Acoustics Construction Noise Committee' [EV/10/9] for the Standards Council established under the Standards Act 1988 as a "New Zealand" only project. The provisional version of NZS 6803 entitled 'NZS 6803P:1984 The Measurement and Assessment of Noise From Construction, Maintenance and Demolition Work' was first issued in 1982 but withdrawn due to errors and re-issued in 1984 as a provisional standard seeking comments from users of the new 1999 standard. Noise from construction projects generally cannot comply with the day-to-day permitted operational noise limits set out within District Plans or those recommended in standards such as NZS 6802. Although this may mean that the noise produced is undesirable by some parties it does not mean that the noise is unreasonable when all the relevant factors such as the limited duration, time of operation and mitigation measures, are taken into account.

This standard covers construction work of limited duration only. Projects such as demolition of a structure, alterations or additions to buildings, road reconstruction or re-alignment for example represent temporary noise sources and are assessed differently than noise from ongoing activities from a site, for example quarrying, landfill or the ongoing construction of pre-fabricated buildings or building components. The standard provides methods for the measurement, assessment, prediction and management of construction noise and should be read and used in conjunction with NZS 6801 and NZS 6802. While the versions of these standards referenced pre-date the 2008 versions, best practice should be followed to apply the latest versions unless there is a specific legal imperative requiring a specific edition be applied. NZS 6803 states that it should be used for the setting of noise limits to reduce the likelihood of annoyance, nuisance and adverse health effects to people in the vicinity of construction work. The standard recommended limits based on duration of works, time of day and if the activity occurs on a weekday or holiday. The standard provides two key tables; the first one is for noise sensitive residential areas and the second for industrial or commercial areas. The three categories are described for work duration as "short", "typical" and "long". This 1984 provisional standard was extensively reviewed in 1997-99 as NZS 6803:1999 and remains the current standard for the measurement and assessment of construction noise. Changes from the 1984 to 1999 version included the use of the L_{Aeq} noise descriptor for assessment of noise. Sound from construction work is usually highly variable. Therefore care must be taken to ensure that the measurements are representative of the sounds under investigation. The standard also states that measurement sample time should not exceed one hour and 15 minutes will often be adequate. Interestingly, unlike other standards [in particular the base standard 6801] or District Plans, the permitted noise limits NZS 6803:1999 requires noise assessment 1 metre from any exposed wall of a building used for a noise sensitive activity and not at the site boundary or notional boundary if the applicable assessment location. The construction standard is also unique in that the measured levels when compared against applicable limits in the standard are not adjusted for special audible characteristics as would occur under NZS 6802 all versions for example.

NZS 6803 is one of the larger standards, being over 70 pages; however the majority of these pages are Annexes, with Annexes B, C and D being reproduced from British Standard 'BS 5228-1:1991 Noise and vibration control on construction and open sites. Code of practice for basic information and procedures for noise and vibration control'. Both Part 1 and Part 2 of BS 5228 have now been superseded, the first updated version being 1997 and the latest versions being BS 5228-1:2009 and BS 5228-2:2009. The main change from the previous versions is Part 1 of the standard covers noise while Part 2 covers vibration. Updated databases for equipment noise values referred to in the NZS 6803 annexes are available on-line.

Section 1.4 of NZS 6803 specifically states that the standard

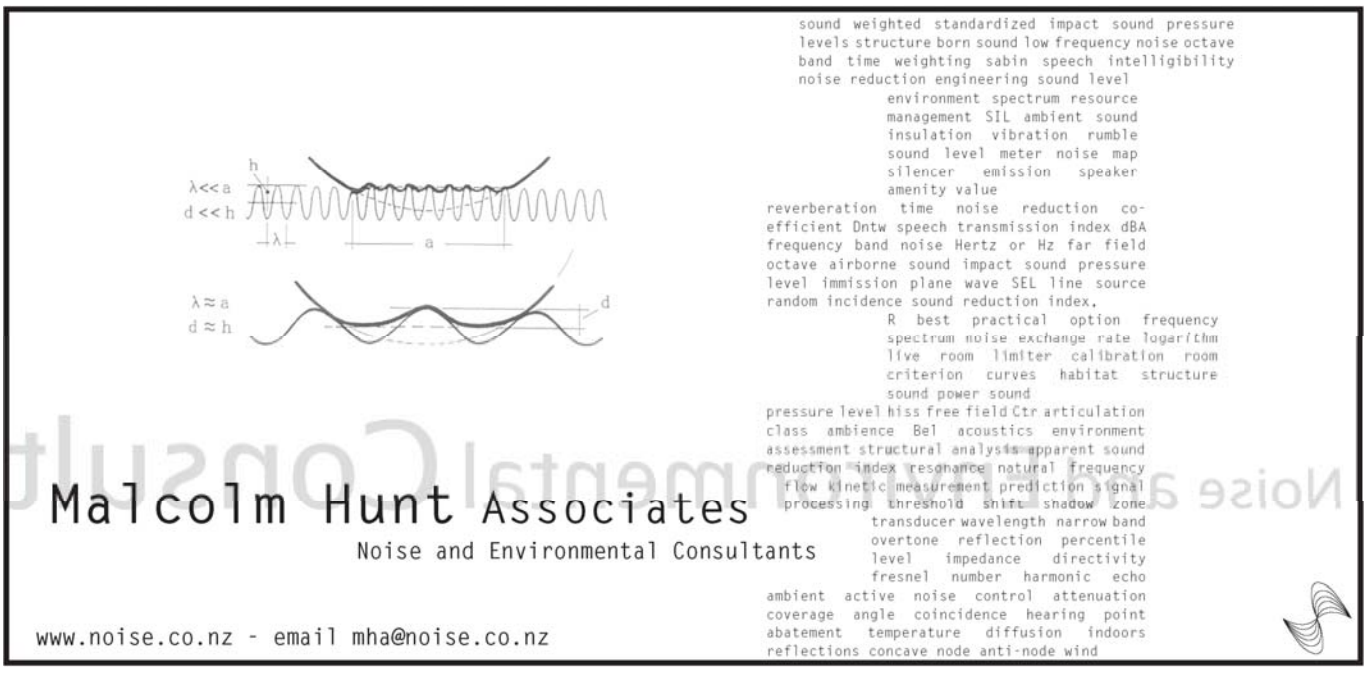

Table 4: Overview of NZS 6803:1999 Acoustics – Construction Noise

Full Name	NZS 6803:1999 Acoustics – Construction Noise
Abbreviation	NZS 6803:1999
Supersedes	NZS 6803:1984P
Copyright	Copyright of the document is the property of the Standards Council
Purpose	This Standard sets out procedures for the measurement and assessment of noise from existing and proposed construction work, including maintenance and demolition work. The standard recommends noise limits and provides guidance of prediction and management of construction noise. The standard is intended to assist Local Authorities, developers, architects, engineers, planners, designers, and contractors to control noise on and from construction, maintenance and demolition sites.
Key functions	Assessment Procedures √ Measurement Procedures √ Prediction Methods √ Guideline Noise Limits √ Management Methods and Procedures √ Compliance Methods and Procedures Land Use Planning Reporting Requirements √
Inclusions	Applies only to construction noise on temporary duration
Restrictions	NZS 6803 does not apply to -Vibration or blasting, noise induced hearing loss, or effects of noise upon wildlife, stock, or domestic animals. -NZS 6803 does not apply to 'emergency works' as defined in the Resource Management Act 1991.
Further Information **Related Documents**	-NZS 6801:2008 Acoustics – Measurement of Environmental Sound -AS2187.2-2006 Explosives - Storage and use -British Standard BS 5228-1:1991 Noise and vibration control on construction and open sites. Code of practice for basic information and procedures for noise and vibration control. -BS5228-1:2009 Construction Noise. Code of practice for noise and vibration control on construction and open sites. -BS5228-2:2009 Vibration. Code of practice for noise and vibration control on construction and open sites. -ISO 2631-2:2003 Mechanical vibration and shock - Evaluation of human exposure to whole body vibration — Part 2: Vibration in buildings [1 Hz to 80 Hz] -BS 6472:1992. 'Evaluation of Human Exposure to Vibration in Buildings [1Hz to 80Hz]
Key Noise Descriptor	$L_{A90,}$ $L_{Aeq(t)}$, L_{AFmax}
Proficiency Level	Proficiency of this standard depends upon which part of the standard is being applied. Generally the standard can be used without any immense knowledge or background science of acoustics in terms of the noise management side, however regarding assessment or measurement of construction noise the person using the standard are assumed to have an understanding of science of acoustics and related construction activities being assessed.

Table 5: Past and Present Environmental Acoustic Noise Standards NZS 680X Series.

NZS 6801:1977 Methods of Measuring Sound	Superseded
NZS 6802:1977 Assessment of Noise in the Environment	Superseded
NZS 6801:1991 Measurement of Environmental Noise	Superseded
NZS 6802:1991 Assessment of Environmental Noise	Superseded
NZS 6801:1999 Acoustics – Measurement of Sound	Superseded
NZS 6802:1999 Acoustics – Assessment of Environmental Sound	Superseded
NZS 6801:2008 Acoustics – Measurement of Environmental Sound	Current
NZS 6802:2008 Acoustics –Environmental Noise	Current
NZS 6803P:1984 The Measurement and Assessment of Noise From Construction, Maintenance and Demolition Work.	Superseded
NZS 6803:1999 Acoustics – Construction Noise	Current
NZS 6805:1992 Airport Noise Management and Land Use Planning	Current
NZS 6806:2010 Acoustics – Road Traffic Noise – New and Altered Roads	Current
NZS 6807:1994 Noise Management and Land Use Planning for Helicopter Landing Areas	Current
NZS 6808:1998 Acoustics – The Assessment and Measurement of Sound From Wind Turbine Generators.	Superseded
NZS 6808:2010 Acoustics –Wind Farm Noise	Current
NZS 6809:1999 Acoustics – Port Noise Management and Land Use Planning	Current

"does not cover vibration". Generally this is because although vibration is a common by–product of construction work, vibration itself is separate expert field for both assessment and measurement. The effects of vibration may relate to potential damage to buildings [structural damage] and human response [annoyance and subjective response]. NZS 6803 also does not specifically assess air-blast noise. Airblast noise is another type of potential effect from construction noise and can be described as the pressure wave that radiates out from the blasting area of an explosion hence 'noise' from explosives or 'blasting' is often described as "airblast" noise. Section 8.1.4 of NZS 6803 however states that noise from explosives is a special case and that the practice of good blasting should be adopted with the provisions of such documents as AS 2187.2-2006 Explosives - Storage and use, is referenced by NZS 6803:1999. AS 2187.2 provides a table with limits to avoid structural damage and to maintain human comfort. It is important to understand that 'modern blasting' is generally small scale controlled blasting which lasts a few seconds in duration and is assessed and conducted by suitable qualified and experienced engineers – noting that acoustical, geotechnical and blasting engineering are three distinct professional areas.

7.1 NZS 6803:1999 Overview - See Table 4.

8 NZS 6804:0000

There is no actual NZS 6804, this is the only standard designated between 01 and 09 that does not exist. It is noted that the NZS 6804 designation was left vacant for what was at the time going to be a planned New Zealand standard for Acoustics and electro-acoustics standards specifically sound level meters. NZS 6801:1977 related documents section tells us that this was going to be designated ' NZS 6804: Sound Level Meters'. However it is understood that a decision was made around 1984 not to produce this New Zealand standard.

9 List of NZS 680X: Past and Present

See Table 5.

10 List of Supplementary New Zealand Standards

The following list of standards are not NZS 680X series standards but are examples of those referenced within the series [the list is not exhaustive]

- AS/NZS2107:2000 Acoustics Recommended Design Sound Levels and Reverberation Times For Building Interiors.
- AS/NZS 2460:2002 Acoustics Measurement of the reverberation time of rooms
- ISO 1996-2:2007 Acoustics - Description, measurement and assessment of environmental noise — Part 2: Determination of environmental noise levels
- ISO 9613-1:1996 Acoustics - Attenuation of sound

during propagation outdoors - Part 1: General method of calculation of the absorption of sound by the Atmosphere

- ISO 9613-2:1996 Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation
- ANSI S12.18-1994 Procedures For Outdoor Measurement of Sound Pressure Level Describes procedures for the measurement of sound pressure levels.

Note IEC standards, such as those related to instrumentation, have been omitted from this list – A list can be found in NZS 6801:2008.

11 Qualifications of Review

This paper review is intended as a guide only, it is not intended to be surrogate for any person using a NZS 680X standard or expert advice from a professional acoustician or acoustic engineer. The reader and users should further understand that the information within this review does not attempt to cover all areas and applications of the NZS 680X standards and therefore there will be omissions. While all care has been taken in the preparation of this work and the information which is included is believed to be correct at the time of preparation, users of this paper should apply discretion and rely on their own judgements regarding the use of the above information. It may be necessary to obtain independent professional advice from a suitably qualified and experienced acoustician or acoustic engineer. It is not considered appropriate for the user to simply rely on the contents of this note without reading the contents of NZS 680X standards themselves.

12 Copyright and Further Information

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Appendix A - Differences in methods of applying adjustments to NZS 6802 Editions 1972-2013

The methods for making adjustments for special audible characteristics, duration and intermittency, background contamination, reflections and facade adjustments or corrections are different in most editions of NZS 6802. The table below summarises the differences. Note the differences in terminology, metrics and the different methods of application to measured or derived values. ¶

Table 6: Adjustment Methods - Environmental Acoustic Noise Standards NZS 680X Series.

<table>
<tr><th colspan="2">Which version?</th><th colspan="6">Methods of adjustment</th></tr>
<tr><th>Edition</th><th>Defined terms</th><th>Applies to</th><th>Intermittency / duration
daytime only
dB</th><th>Background contamination
[residual sound]
Method</th><th>Special audible characteristics
dB</th><th>Reflections method</th><th>Microphone sound field
method</th></tr>
<tr><td>MOH guide
Pre-1977</td><td rowspan="2">Corrected noise level</td><td rowspan="2">Measured level
L_{10} dBA</td><td>tabulated
0 to -30</td><td rowspan="2">Not stated</td><td rowspan="4">0 or - 5</td><td colspan="2" rowspan="2">Not stated</td></tr>
<tr><td>1977</td><td>tabulated
0 to -20</td></tr>
<tr><td>1991</td><td>Adjusted sound level</td><td>Noise limit
L_{10}(t) dBA</td><td>0 or -5</td><td>Referred to but method undefined</td><td colspan="2">Referred to but method undefined</td></tr>
<tr><td>1999</td><td rowspan="2">Rating Level</td><td>noise limit
L_{Aeq}(t)</td><td>Not applicable</td><td rowspan="2">Calculated method or nomogram</td><td colspan="2">Not included in Rating Level calculation</td></tr>
<tr><td>2008</td><td>Measured level
L_{Aeq}(t)</td><td>Tabulated</td><td>0 or - 5
[0 to - 6 for reference method]</td><td colspan="2">Included in Rating Level calculation</td></tr>
</table>