Application of noise guidance to the assessment of industrial noise with character on residential dwellings in the UK

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Highlights

I critically review the application of noise guidance to industrial noise
I compare four sources of industrial noise with BS8233, WHO 1999 & 2009 and BS4142
I demonstrate noise guidance for anonymous noise understates impact when applied to industrial noise with character

Abstract

British Standards are used to assist the assessment of noise impact from new or existing sources and assist judgements of acoustic acceptability. Standards may include provision for the assessment of noise with character whilst others are limited to anonymous noise. Noise guidance designed for the assessment of anonymous/characterless noise appears increasingly used to justify acceptable noise impact from industrial noise with character (non-anonymous noise). This results in comparison with inappropriate guideline values that ignore noise character and context in the assessment of noise acceptability at dwellings. This technical note conducts a critical review of noise guidance and considers four sources of industrial noise with character. Preliminary comparisons with the World Health Organization Guidelines for Community Noise (WHO 1999), World Health Organization Night Noise Guidelines for Europe (WHO 2009), BS8233 2014 Guidance on sound insulation and noise reduction for buildings (BS8233) and BS4142 2014 Methods for rating and assessing industrial and commercial sound (BS4142) demonstrate guidance designed for anonymous noise understates the impact of industrial noise with character on dwellings when compared to noise guidance for rating and assessing industrial sound accompanied with context based observations of noise impact.

Keywords:
Industrial noise annoyance
Anonymous noise
British Standards
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1.0 Introduction and background

Noise can be steady, benign and anonymous (distant road traffic) or contain specific inherent characteristics that attract attention or impart a message that is perceived to be unwanted depending on the circumstances (context) in which noise is received.

In the UK, British Standards are used in the design of new buildings to reduce internal and external intrusive noise, assess noise impact on amenity for planning and assist the determination of nuisance (statutory and common law) or pollution. The standards assist assessment of acoustic acceptability on new or existing dwellings.

BS8233 [1] is a design standard that considers noise control in and around buildings and suggests guidelines for different building types and room uses. Clear caveats exist within the guidance on use and application.

Noise guidance designed for assessing anonymous noise has been applied to the assessment of industrial noise with character[1] from existing sources on dwellings, proposed sources affecting existing dwellings and existing sources adjacent proposed dwellings. The comparison understates impact by ignoring noise character, context and subjective annoyance.

Industrial noise is emitted in different localities around the UK. An important consideration when town planning for new industrial development is noise impact from the use on noise sensitive receptors. Where dwellings are proposed adjacent existing industrial areas care is required to locate, separate, orientate and design (passive engineering measures[2]) residential development to adequately mitigate environmental noise impact.

Using preliminary data this technical note compares four sources of industrial noise against anonymous noise guidelines in BS8233 and WHO [2,3]. Three scenarios consider industrial noise affecting existing dwellings. One scenario considers proposed residential development adjacent existing industry. In all scenarios the industrial noise contains character. Annoyance responses inside and outside dwellings during the daytime and sleep disturbance within dwellings during night time are considered[3]. A comparative noise assessment using BS8233, WHO and BS4142 [4] with subjective observations is presented.

The UK Planning system allows applicants and regulators to minimise noise impact on new or existing dwellings. Finegold [5] advises it is logical to avoid placing noise sensitive areas near to noise producing land uses. It is important to prevent unreasonable noise immission from new development and the correct application of noise guidance is critical.

2.0 Industrial noise, psycho-acoustics and annoyance

'Noise' introduces a subjective element to an individual's decision of whether a sound has value. Thorne and Shepherd [6] describe reaction

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[1] Sources of noise emanating from industrial premises that contain noticeable characteristics e.g. impulsivity, tonality, unpredictability or other distinguishable characteristics. These sources cannot be considered 'anonymous' noise.

[2] Passive engineering measures refer to physical design to mitigate noise breakout or break-in (immission) at dwellings. Active measures rely on human action/inaction e.g. closing doors to prevent breakout, not sounding horns etc.

[3] Where night time measurement data is available from the selected sources of industrial noise.

modifiers to noise for individuals to include attitude to the source, attitude to the information content of the noise, perceived control over the noise, sensitivity to noise (in general and specific measures) and sensitivity to specific character of the noise (e.g. changes in pitch or modulation).

Thorne and Shepherd suggest noise is sound perceptible to an individual which has identifiable characteristics that modify an individual's response from pleasurable or neutral to adverse. Intrusive noise is sound whose character is adversely perceived compared to the character of the receiving environment in the absence of that sound. Reaction to sound varies based on sensitivity but also the receiving context. The sound may then be considered 'noise'. This perception of the sound and individual reaction modifiers by the receiver are known as the psycho-acoustical factors.

Finegold [5] identified many reasons for noise annoyance in different situations including interference with speech communication, other desired activities and sleep disturbance which can be very annoying and may lead to long-term health effects. Noise can be perceived as inappropriate in a particular setting without any objectively measurable effect. The context in which sound becomes noise can be more important than the absolute sound level itself.

Industrial noise has been recognised as a source of common law nuisance by the UK Courts since the 1800s. Methodologies recognisable within guidance applicable to the assessment of industrial noise emerged in the 1960s, most notably by Kosten and Van Os [7] Community Reaction Criteria for External Noises and the Committee on the Problem of Noise [8] with the simplified procedure for assessing reaction to industrial noise in mixed residential areas.

Both studies recognised annoyance from industrial noise is subjective and affected by many factors additional to the absolute decibel level. Kosten and Van Os [7] applied decibel penalties where noise was received in dwellings and considered the receiving room (context), pure tone perceptibility (character and sensitivity to specific character), impulsivity and/or intermittency (character, frequency and duration), occurrence during work hours only, percentage of time present (duration), any economic tie (benefit of noise to receiver and control over noise) and the character of the receiving locality (character of area). The simplified procedure for assessing reaction to industrial noise in mixed residential and industrial areas considered specific characteristics, time of occurrence, duration (minutes) of noise during one hour or half day and type of district and was the predecessor to BS4142 1967 [9].

Research projects into the assessment of industrial noise were undertaken by Berry and others [10-14]. Berry and Porter [10] highlighted compressor noise as more annoying than road traffic noise when played at the same LAeq level. Additional research by Berry, Porter and Flindell [12] evaluated acoustic features present in industrial noise. The study reconsidered the approach to the assessment of industrial noise by considering not only the absolute level of industrial noise but the acoustic features present (e.g. tonality and impulsivity). The emphasis was to not only objectively measure levels of noise but to objectively measure the acoustic features present [14]. The study showed annoyance scores were relatively independent of the traffic noise levels within the combination of noises to which subjects were exposed. Berry and Porter [14] suggested that features contained within the traffic noise component were much less dominant in determining an adverse response than features containing tonal and impulsive components. The research demonstrated the difference and affect of noise characteristics when considering comparable equivalent LAeq levels of noise i.e. road traffic noise compared with a source of impulsive industrial noise.

A literature review for DEFRA by Berry and Porter [15] of available evidence into industrial noise annoyance concluded that in general, there was no strong evidence that industrial noise produces a higher annoyance response than transportation noise but there had been extensive studies of transportation noise and annoyance but far fewer studies into the annoyance caused by industrial noise. This conclusion was based on a number of international sources but primarily on research completed by Henk Miedema who was considered the first to produce dose response relationships for combinations of transportation and industrial noise. As Berry and Porter [15] suggested, dose response relationships for transportation and industrial noise sources do apply but this was only relevant to industrial noise without impulsive, tonal or low frequency content. For industrial noises with these features, Miedema suggested corrections could be applied for the annoying character of these aspects [16,17,18]. The literature review by Morel et al [18] suggests that locally, industrial noise sources can cause great annoyance but the occurrence is less widespread than transportation noise and their heterogeneity of spectral features may explain the lack of studies on them. For example, steady flows of road traffic noise may be considered homogeneous compared to industrial noise which covers a wide variety and combination of noise sources that may include impulsive, cyclic, tonal, unpredictable, intermittent and contain combined effects (noise and vibration, noise and odour etc).

The study by Morel et al [18] builds on historical work by Miedema and Berry and Porter prior to 2004. The Morel et al [14] study identifies the specific and total annoyance when comparing different sources of industrial noise and the ability of specific acoustic characteristics to inhibit the annoyance of broad band industrial noise. The study found that the focus of annoyance shifts to the low frequency and 100Hz component noise inhibiting the annoyance from broad band industrial noise i.e. the psychological focus shifts to the most annoying characteristics of the noise.

The Morel et al study [18] is supported by work by Fritz van den Berg [19] in relation to health effects from wind turbines. When comparing dose relationship curves for wind turbine noise, annoyance follows a similarly shaped curve to road, rail, aircraft, industrial and shunting yards. In comparison to the above, Van den Berg [19] shows wind turbines appear to be a relatively annoying noise source as shown in figure 1 below:

Figure 1 shows wind turbine noise is more annoying than other environmental noise sources at lower dB(A) levels with the exception of shunting yards for various Lden dB(A) values. In the study by Miedema and Vos [17] the dose relationship curve for shunting yards and higher levels of annoyance appear to be due to the vibrations and impulsive characteristics of shunting. This supports work by Porter [20] demonstrating the under prediction of the BS4142 1990 [21] methodology to noise with combined effects e.g. noise and vibration experienced in combination at receiver.

3.0 Review of noise guidance

3.1 Applicability of the WHO to industrial noise

The WHO [2] guidelines relate to the onset of critical health effects from noise exposure based on the lowest levels of noise that affect health which includes sleep disturbance, speech intelligibility and annoyance responses. The guidelines for annoyance, 50dB or 55dB LAeq 12-16hr, represent daytime levels below which a majority of the adult population will be protected from becoming moderately or seriously annoyed.

Additional research into sleep disturbance by the WHO [3] for night noise suggests lower thresholds than the LAmax,internal of 45dB [3] for a number of effects. The WHO [3] conducted a review of scientific evidence and derived a number of guideline values for noise. The WHO [3] is considered an extension to and update of the previous WHO [2].

The WHO restrict LAeq,T and LAmax guidelines to critical health effects and steady, continuous noise only (LAeq,T). The WHO consider critical health effects with noise guideline values based on long term external average noise (LAeq) and short term (impulsive) internal guidelines (LAmax) based on research into sources of transportation noise and sleep disturbance. The internal LAmax guidelines are comparable to site specific industrial noise but relate to the onset point of critical health effects during sleep and not harm to amenity, annoyance or nuisance. This indicates any limit to assess harm to amenity (Town and Country Planning Act 1990) or contraventions of statute (Environmental Protection Act 1990) must be lower. For noise, neither regime considers critical health effects[4] as a benchmark for acceptability and are above what could be considered reasonable for planning or nuisance.

The WHO [2] reinforce good reasons for sleep with windows open and to prevent sleep disturbance to consider the equivalent sound pressure level (LAeq,T) and the number of sound events (LAmax) during sleep. The LAmax,inside parameter from the WHO [3] is used to characterise instantaneous effects, such as sleep disturbance and is better represented by maximum noise events than longer term averages. The WHO [3] suggest the LAmax parameter is useful to predict short-term or instantaneous health effects.

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[4] The National Planning Policy Framework 2012 refers to significant adverse impacts on health and quality of life and makes reference to the Noise Policy Statement for England 2010 which provides no quantitative noise guidance on noise acceptability for planning.

It is clear the WHO [2,3] restrict LAeq,T guideline values to critical health effects and steady, continuous noise only. For annoyance, the WHO [2] make a key distinction between anonymous noise and industrial noise and state:

"....it should be recognized that equal levels of different traffic and industrial noises cause different magnitudes of annoyance. This is because annoyance in populations varies not only with the characteristics of the noise, including the noise source, but also depends to a large degree on many non acoustical factors of a social, psychological, or economic nature"

The reference highlights the inapplicability of the WHO to the assessment of industrial noise and was identified in guidance to Local Authorities [22]:

"While sound can be measured with the help of acoustical instruments such as sound level meters, the actual extent of noise nuisance cannot be measured in this way. One of the negative effects is annoyance. Large-scale population studies show that only one third of noise annoyance can be accounted for through exposure to varying sound levels. Non-acoustical factors, including personal factors such as noise sensitivity, and social factors, can have as much effect as the sound level"

3.2 Applicability of BS8233[5] to industrial noise

BS8233 [1] is designed to ensure a suitable noise environment within rooms for steady external environmental noise. The guidelines apply to airborne and structure-borne noise in combination. Internal noise guidelines for resting in living rooms, dining in a dining room/area and sleeping/resting within a bedroom are provided. Caveats limit the use of guideline values to assessing steady external noise sources without character (anonymous noise). The standard cannot determine whether sound is pleasant or unpleasant, ignores the existing soundscape and applies to all areas. These omissions are significant when considering psycho-acoustical factors of noise character associated with site specific industrial noise and character of the area in which the noise is received. It ignores an individual's perception and expectation of noise, or freedom from noise, in the locality.

BS8233 provides guidelines for 'desirable' and 'reasonable' conditions within the receiving room. For external noise BS8233 suggests the main considerations for dwellings are the acoustic effect on resting, listening and communicating and the acoustic effect on sleep within bedrooms. BS8233 allows a relaxation of 5dB to the desirable guidelines where external noise levels exceed the WHO [2] guidelines on which they are based and advises reasonable internal conditions are achieved.

At 7.7.1 [1] an important caveat states:

[5] References demonstrating the inapplicability of the WHO are relevant to BS8233 2014 as that standard was formulated on scientific research by the WHO. See BS8233 2014 point 7.7.2 Note 2. Page 24.

"This sub clause applies to external noise as it affects the internal acoustic environment from sources without specific character, previously termed "anonymous noise". Occupants are usually more tolerant of noise without specific character than, for example, that from neighbours which can trigger complex emotional reactions. For simplicity, only noise without character is considered in Table 4..."

BS8233 states the guidelines should be used for 'anonymous noise' or 'noise without a specific character'. For industrial noise BS8233 refers the user to BS4142 [4]. BS8233 recommends 'desirable' guidelines for external amenity areas space of 50 dB LAeq,T, with an upper guideline value of 55 dB LAeq,T which would be acceptable in noisier environments.

The guidelines for external amenity space mirror the WHO [2] guidelines for moderate and serious annoyance. BS8233 refers to external noise levels and, as the criteria are based on critical health effects from the WHO [2], can only refer to all steady, ambient noise within the environment. The guidance does not consider noise character, psycho-acoustical factors and context which are significant when assessing noise impact, annoyance and acceptability.

3.3 Applicability of BS4142 to industrial noise

BS4142 uses a reference period of 1 hour for daytime and 15min for night time to reflect the impact of shorter LAeq,T periods of sound between 2300-0700hrs [4]. Historically BS4142 applied a threshold approach where noise is predicted to lead to complaints/community dissatisfaction when decibel penalties were applied and exceeded the background noise level by a certain margin.

BS4142 2014 [4] uses a context based procedure using outdoor sound levels to assess the likely effects of sound on people who may be inside or outside a dwelling. It applies separate and cumulative decibel penalties for tonality, impulsivity, intermittency and other sound characteristics which has specific features/characteristics. The standard advises the initial estimate of impact needs to be modified due to the context which includes consideration of additional factors including the absolute sound level, residual sound level, the character and level of the residual sound compared to the character and level of the specific sound, sensitivity of receptor and the incorporation of noise mitigation measures.

BS4142 is the primary guidance for assessing the impact of industrial sound with specific characteristics affecting dwellings. BS4142 considers the character of sound and background levels of the receiving locale to assist determine acceptability.

4.0 Preliminary results and data analysis

Four sources of industrial noise containing different inherent features were selected including a supermarket delivery, blanking press, metal fabrication and metals recycling.

4.1 Limitations

Measurement details are omitted due to the legal sensitivity of data. The periods chosen are considered representative of the specific sound with minimal extraneous noise affecting measurements. The data is from real-life situations where industrial noise causes impact (complaints) or is likely to cause impact following development.

To provide direct comparison with guidance [1,2,3] time periods were harmonised with BS4142 2014[6].

4.2 Comparison with BS4142, WHO and BS8233

A graph[7] for each source is provided with average (LAeq,T) and maximum (LAmax) sound levels shown. The X axis represents absolute time and Y axis A-weighted decibel level. Levels are of average sound over time labelled 'period LAeq'. The red line represents the LAeq over the entire monitoring period and includes all ambient sound. The background sound level for a measurement period, labelled 'period LA90', is denoted by the blue line. Custom LAeq,T periods are denoted with an orange line as identified in the key. The 125ms LAeq black trace shows the temporal variation.

4.3 Supermarket delivery

Figure 2 shows a 5 minute period from 0710hrs[8] demonstrating levels from a heavy goods vehicle (HGV) engine and manoeuvring with metal impacts from unloading activity. Noise levels increase at 0711hrs as the HGV engine starts. Time averaging 51dB,3min with 40 and 41dB LAeq,5min with an adjustment of -1dB for the residual sound gives a specific sound level of 44dB LAeq,15min. A BS4142 assessment applying a penalty of +9dB for highly perceptible impulsive and +3dB for intermittency characteristics gives an excess of rating level over background of +19dB. This level of difference with observations of context indicates significant adverse impact.

The 44dB LAeq,15min exceeds the desirable internal bedroom guideline by 2dB but meets the reasonable guideline. The WHO is exceeded externally by 4dB. Supermarket deliveries typically occur for 20 minutes and were proposed between 0600-0700hrs. Conversion to an LAeq,8hr night period gives an external free field level 35dB LAeq,8hr. Therefore, one supermarket delivery every morning 365 days a year would meet the BS8233 internal and WHO 2009 external guidelines.

Typical worst case LAmax noise levels varied between 57-61dB from impact noise and vehicle manoeuvres with the LAmax criteria for awakenings within the bedroom exceeded by 3-7dB.

4.4 Blanking press

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[6] LAeq,1hr between 0700-2300hrs and LAeq,15min between 2300-0700hrs.

[7] Graphs and audio available at www.masenv.co.uk/noiseguidancepaper

[8] Deliveries were proposed prior to 0700hrs and the specific sound level considered over 15min.

Figure 3 shows 5 minutes between 0633-0638hrs on a Saturday. The graph shows rapid operation of a blanking press dominating the soundscape. The press impacts occur every 0.875secs. This is equivalent to 300 press impacts over 5 minutes. The specific sound level is 50dB LAeq,15min with an adjustment of -1dB for residual sound. A BS4142 assessment applying a penalty of +9dB for highly perceptible impulsive and +3dB for intermittency characteristics gives an excess rating level of +19dB indicating significant adverse impact. For daytime background sound levels are higher resulting in an excess rating level of +14dB indicating a significant adverse impact.

The impulsivity is shown in figure 4. The graph shows the rate of change in decibels between the initial noise and 'peak' LAeq,125ms. The first six blanking press impacts show the rate of decibel change varies between 44-101dB per second demonstrating highly impulsive characteristics.

For night time, the 50dB LAeq,15min levels exceed the desirable BS8233 guideline by 5dB but meet the reasonable guideline. The external WHO guideline is exceeded 10dB. The blanking press occurs sporadically and was observed operating for 30 minutes prior to 0700hrs. Conversion to LAeq,8hr gives an external façade level of 38dB LAeq,8hr. Assuming 30 minutes of blanking press activity prior to 0700hrs every morning for 365 days per year would meet the BS8233 internal and WHO 2009 external guidelines.

Typical worst case LAmax noise levels varied between 53 and 56dB and meet the internal LAmax guidelines.

For daytime, the 50dB LAeq,1hr meets BS8233 and the WHO internally and externally within amenity areas. The blanking press occurs sporadically and was observed for periods of a few minutes to upwards of an hour during daytime. A typical worst case of 4 hours per day has been assumed. Conversion to LAeq,16hr gives an external façade level of 44dB LAeq,16hr. Assuming 4 hours of blanking press activity every day would meet the BS8233 and WHO 1999 internal and external guidelines. The blanking press could operate continuously for 16 hours per day and still meet the BS8233 and WHO 1999 daytime guidelines.

4.5 Metal fabrication

Figure 5 shows 5 minutes of metal fabrication. A number of activities occur including metal impacts, muffled music, angle grinding, loud clangs and the continuous drone of a fan. The fan is shown with the green line on the graph (labelled 400Hz). LAmax levels were measured between 47-61dB.

Time averaging 45dB,5min and 44dB LAeq,10min provides a specific sound level of 44dB LAeq,15min. A BS4142 assessment applying a penalty of +6dB for clearly perceptible impulsive and +4dB for tonal characteristics gives an excess of rating level over background of +25dB indicating significant adverse impact.

The LAmax criteria for awakenings is exceeded internally by up to 4dB.

The 44dB LAeq,15min meets the desirable and reasonable internal guidelines from BS8233. The WHO 2009 guideline is exceeded by 4dB. Metal fabrication was observed sporadically through the night for approximately 3 hours (periods including impact noise[9]) between 2300-0700hrs. Conversion to LAeq,8hr gives an external façade level of 40dB LAeq,8hr. Assuming 3 hours of metal fabrication per night for 365 days per year would meet the BS8233 internal and WHO 2009 external guidelines.

4.6 Metals recycling

Figure 6 below shows 15 minutes of metals handling and represents an hour of noise. The graph shows large peaks of metal impacts, tipping and reverse bleepers.

The specific sound level was 47dB LAeq,1hr including a -1dB adjustment for residual noise. A BS4142 assessment applying a penalty of +9dB for highly perceptible impulsive characteristics gives an excess of rating level over background of +16dB. This level of difference indicates a significant adverse impact.

The 47dB LAeq,1hr noise level meets the BS8233 and WHO internal and external noise guidelines. A comparison shows metals handling could occur continuously for 16 hours everyday and meet the BS8233 and WHO 1999 guidelines.

4.7 Summary findings

Tables 1 and 2 show a summary of industrial sound levels for night and daytime compared with BS8233, WHO and BS4142 with context related observations of impact.

4.8 Night time

In all cases the BS8233 reasonable internal guideline for bedrooms is met. The desirable guideline is exceeded for the supermarket delivery and blanking press. The WHO 2009 Lnight,outside is exceeded in all cases when the guideline is considered over 15min but time averaging noise impact over an 8hour night time period meets the guideline. The LAmax,internal for awakenings is exceeded when applying typical worst case LAmax noise levels from the supermarket delivery and metal fabrication. The LAmax guideline is met for the blanking press.

Applying BS4142 indicates significant adverse impact in all cases supported by context related observations of impact. Observations of impact demonstrate unreasonable noise.

4.9 Daytime

[9] Fan noise was audible for longer periods than the 3 hours considered in the assessment.

In both cases the WHO 1999 and BS8233 desirable and reasonable internal guideline for living rooms and amenity areas is met. Applying BS4142 indicates significant adverse impact in all cases supported by context related observations of impact that demonstrate unreasonable noise.

For night and daytime the results show comparison with BS8233, WHO 1999 and 2009 internally and externally (LAeq,T) does not correlate with assessments using BS4142 with context based observations. The LAmax,internal guideline is exceeded for the supermarket and metal fabrication when the highest events are considered.

Table 1 - Comparison of NIGHT TIME industrial sound with BS8233, WHO 2009 and BS4142 with context based observations					
Source (typical worst case sound levels)	**Noise guidance and criteria for night time / bedrooms**				**Context related observations of impact**
	BS8233 2014	**WHO 2009**		**BS4142 2014 assessment of impacts**	
	Desirable 30 and reasonable 35dB LAeq,8hr (internal)	**40dB Lnight, outside (1 year)**	**Critical health effect (awakenings) 42dB LAmax (internal)**	**Greater difference (+ve dB value) = greater magnitude of impact**	
Supermarket delivery (44dB LAeq, 15min and 57-61dB LAmax)	44-12=32 (2dB above desirable, 3dB below reasonable)	44-40 = 4dB above	(57-61)-12 = 45 to 49 (3 to 7dB above)	+19dB indicates significant adverse impact	Loud impulsive impacts and engines dominate soundscape at dwelling. Character of area semi rural with distant road traffic and natural sounds audible. Character distinguishable with impact occurring during sensitive night time periods with low background noise levels. Deliveries proposed with erosion of respite from noise at sensitive times and incongruous with residual sound environment. Considered subjectively unreasonable as predicted to occur early from 0600hrs indicating sleep disturbance and harm to amenity.
Blanking press (50dB LAeq, 15min and 53-56dB LAmax)	50-15=35 (5dB above desirable, meets reasonable)	50-40 = 10dB above	(53-56)-15 = 38-41 (1-3dB below)	+19dB indicates significant adverse impact	Loud impulsive and repetitive impacts, unpredictable and sporadic occurrence of presses prior to 0700hrs. Character of the area mixed residential and commercial/industrial adjacent significant source of single lane road traffic noise. Clearly audible within all rooms of the dwelling and remains audible with windows and doors closed. Likely to cause sleep disturbance and considered subjectively annoying due to repetition and impulsivity considered unreasonable and a statutory nuisance (criminal law).
Metal fabrication (44dB LAeq,15 min and 47-61dB LAmax)	44-15=29 (1dB below desirable, 6dB below reasonable)	44-40 = 4dB above	(47-61)-15 = 32-46 (10dB below and up to 4dB above)	+25dB indicates significant adverse impact	Loud impulsive impacts of metal, hammering, angle grinding, clangs and the presence of tonal fan noise at 400Hz clearly audible within bedroom with window ajar. No other industrial noise audible within locality. Considered subjectively unreasonable and at a level likely to prevent and disturb sleep and considered to be a nuisance (common law).
Note, a correction of 15dB has been applied to convert LAeq and LAmax façade levels to internal levels through a partially open window for the blanking press and metal fabrication. A correction of 12dB has been applied to supermarket delivery noise and is assumed to be a free field level at the façade.					

Table 2 - Comparison of DAYTIME industrial sound levels with BS8233, WHO 1999 and BS4142 with context based observations						
Source (typical worst case sound levels)	**Noise guidance and criteria for day time internal and external**					**Context related observations of impact**
	BS8233 2014		**WHO 1999**		**BS4142 2014 assessment of impacts**	
	Living rooms desirable 35 and 40dB reasonable dB LAeq,16hr (internal)	**amenity areas desirable = 50 to 55dB LAeq,T (external)**	**speech intelligibility and moderate annoyance 35dB LAeq,12-16hr (inside dwelling)**	**serious annoyance 55dB and moderate annoyance 50dB LAeq,12-16hrs (Outdoor living area)**	**Greater difference (+ve dB value) = greater magnitude of impact**	
Blanking press (50dB LAeq,1hr)	(50-15=35) meets desirable and 5dB below reasonable	meets desirable and 5dB below desirable upper guideline	(50-15=35) meets guideline	50dB meets guideline for moderate annoyance and 5dB below serious annoyance	+14dB indicates significant adverse impact	Unpredictable but repetitive impact from presses, fork lift truck and tonal noise from fans. Significant source of road traffic noise adjacent dwelling but does not mask noise of press impacts. Clearly audible outside dwelling. Considered subjectively unreasonable even in a high daytime (LAeq) noise environment. Noise from press impacts penetrates dwelling and audible in all rooms making escape from noise impossible when in the home. When operating is the only source of industrial noise audible at residential dwelling. Considered subjectively unreasonable and a statutory nuisance.
Metals recycling (47dB LAeq,1hr)	(47-12=35) meets desirable and 5dB below reasonable	3dB below desirable and 8dB below desirable upper guideline	(47-12=35) meets guideline	3dB below moderate annoyance and 8dB below serious annoyance	+16dB indicates significant adverse impact	Loud impulsive impacts of metal on metal with associated tipping, clangs, clatters, reverse bleepers, mobile Character of metals recycling noise considered incongruous with other transport related noise in the locality. Considered an unreasonable noise environment for new dwellings.
Note, a correction of 15dB has been applied to convert LAeq façade levels to an internal level through a partially open window for the blanking press. A correction of 12dB has been applied to metals recycling noise and a free field level at the façade.						

5.0 Discussion

Whether sound is perceived to be unwanted depends on many factors including individual sensitivity and context. Inherent noise character and context are more important than absolute decibel levels. Annoyance from industrial noise is affected by the features present and message imparted, individual sensitivity, duration, intermittency, character of receiving area and level of control over or economic tie. Industrial noise causes annoyance but is less widespread than transportation sources with less research into its effects.

The literature review highlights the significance of acoustic features within industrial noise, notably impulsivity and tonality. Significantly guidelines for anonymous noise (BS8233 and WHO) ignore inherent acoustic features and apply in every context allowing increased impact than shown to be acceptable when compared to BS4142 with context related observations.

The preliminary results show a noise assessment comparing steady anonymous noise guidelines from BS8233 and the WHO against industrial noise with character understates impact. This is shown for night and day time noise. A comparison with BS8233 and the WHO guidelines does not correlate with the level of impact shown when BS4142 is applied with context related observations. The results show the assessment using BS8233 and the WHO to be inappropriate.

It is unlikely simple 'dose relationship' response curves could be produced for industrial noise annoyance in all cases due to the heterogeneity of sources, different noise characteristics and different combinations of noise characteristics.

5.1 Implications of inadequate noise characterisation and assessment

The UK experiences increasing anonymous noise from transportation particularly road traffic, aircraft and HS2 rail project. Modern living standards are high with greater expectation of freedom from pollution including noise.

Population growth increases housing need resulting in construction and pressure to build on brownfield land. This results in encroachment into historic sites of industrial use and reduces separation distances between existing industry and proposed housing. The reverse is true for industrial development. The recession and general decline in industry means it is important to preserve industrial uses and carefully consider the placement of new dwellings and industrial development to prevent land use conflicts.

Applying inappropriate noise guidelines results in incompatible land uses. Introducing housing to an industrial area changes the character of the area from industrial to mixed industrial and residential. Complaints to a local authority or EA can restrict future industrial operation and viability. It does not create communities where people want to live due to annoyance/nuisance from noise. Introducing new industrial development into residential areas can introduce new noise incongruous with the soundscape. Depending on the specific characteristics of the new industrial noise and context of noise impact, there is a potential for annoyance and complaints. This may result in annoyance to the local community and lead to the demise of industry.

6.0 Conclusions

BS8233 and the WHO guidelines are often applied to the assessment of industrial noise and other noise sources with character. The guidance confirms it cannot be used in this way and fails to consider noise character and psycho-acoustical factors of whether the sound is pleasant or unpleasant which are significant when assessing impact from industrial noise.

Response to noise is subjective and the likelihood a noise will cause annoyance is multi-factoral. Guidelines for anonymous noise applied to site specific industrial noise understate the true impact and is inappropriate. Careful reading of BS8233 and the WHO is necessary to understand their limitations of application to steady anonymous noise and not industrial noise with character.

The misapplication of BS8233 and the WHO is counterproductive to the long term sustainability of constructing housing and protecting UK industry. Using inappropriate guideline values to assess noise impact from industrial noise with character does not benefit industry or communities.

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Figure 1: Van den Berg [15] p.2

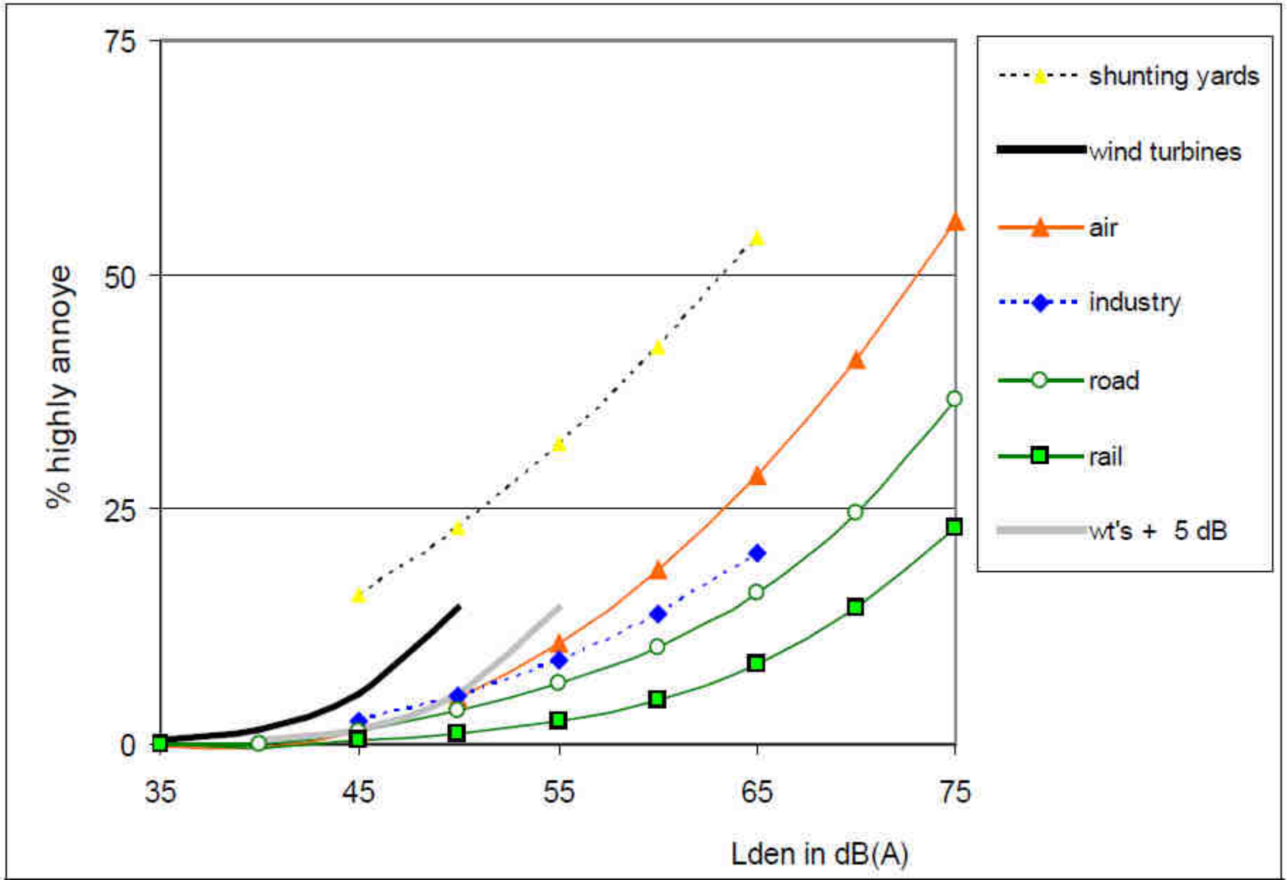

Figure 1: percentages of respondents that are highly annoyed when exposed indoors to noise from wind turbines or other

Figure 2: Measured noise levels from supermarket delivery

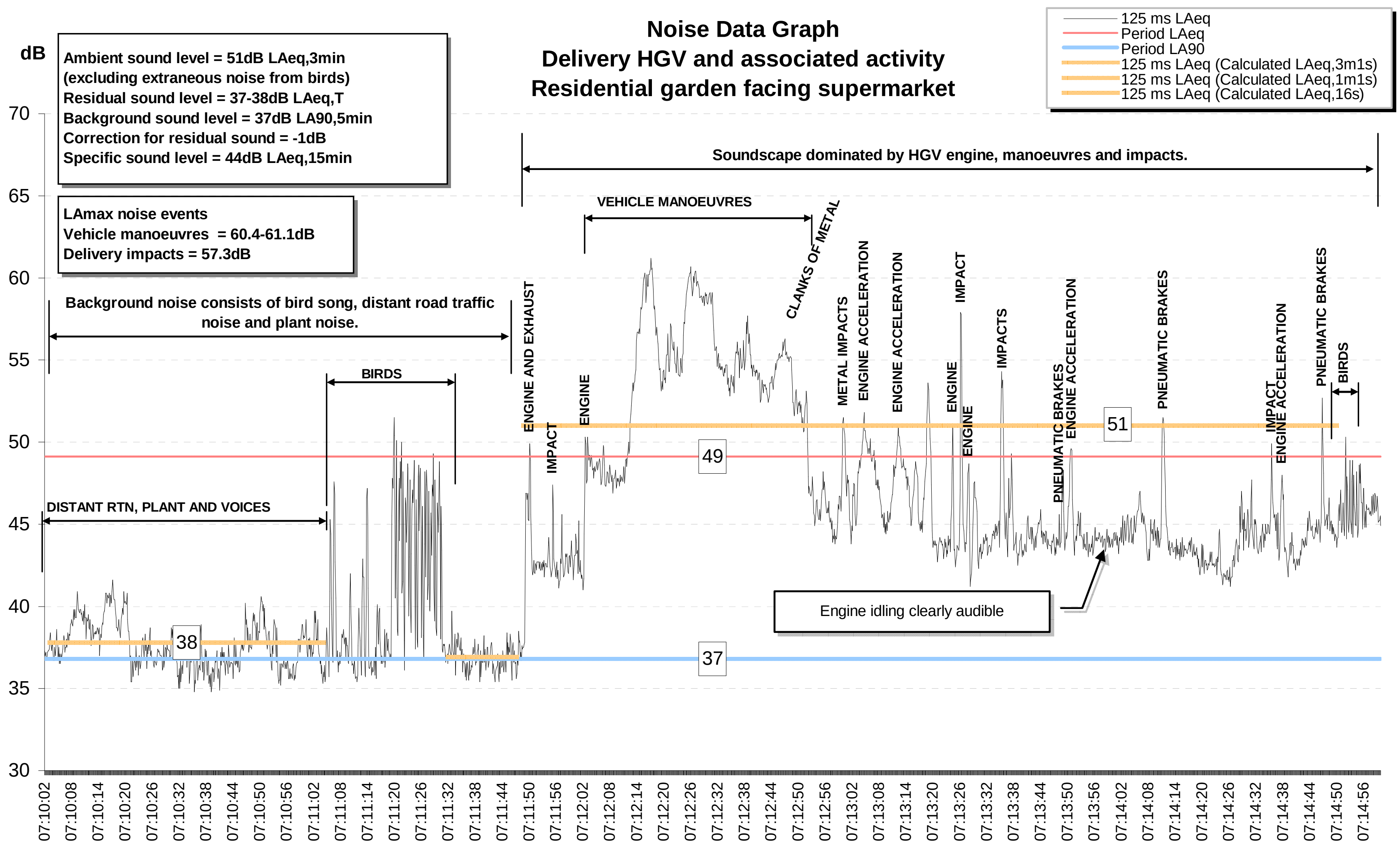

Figure 3: Measured noise level from blanking press

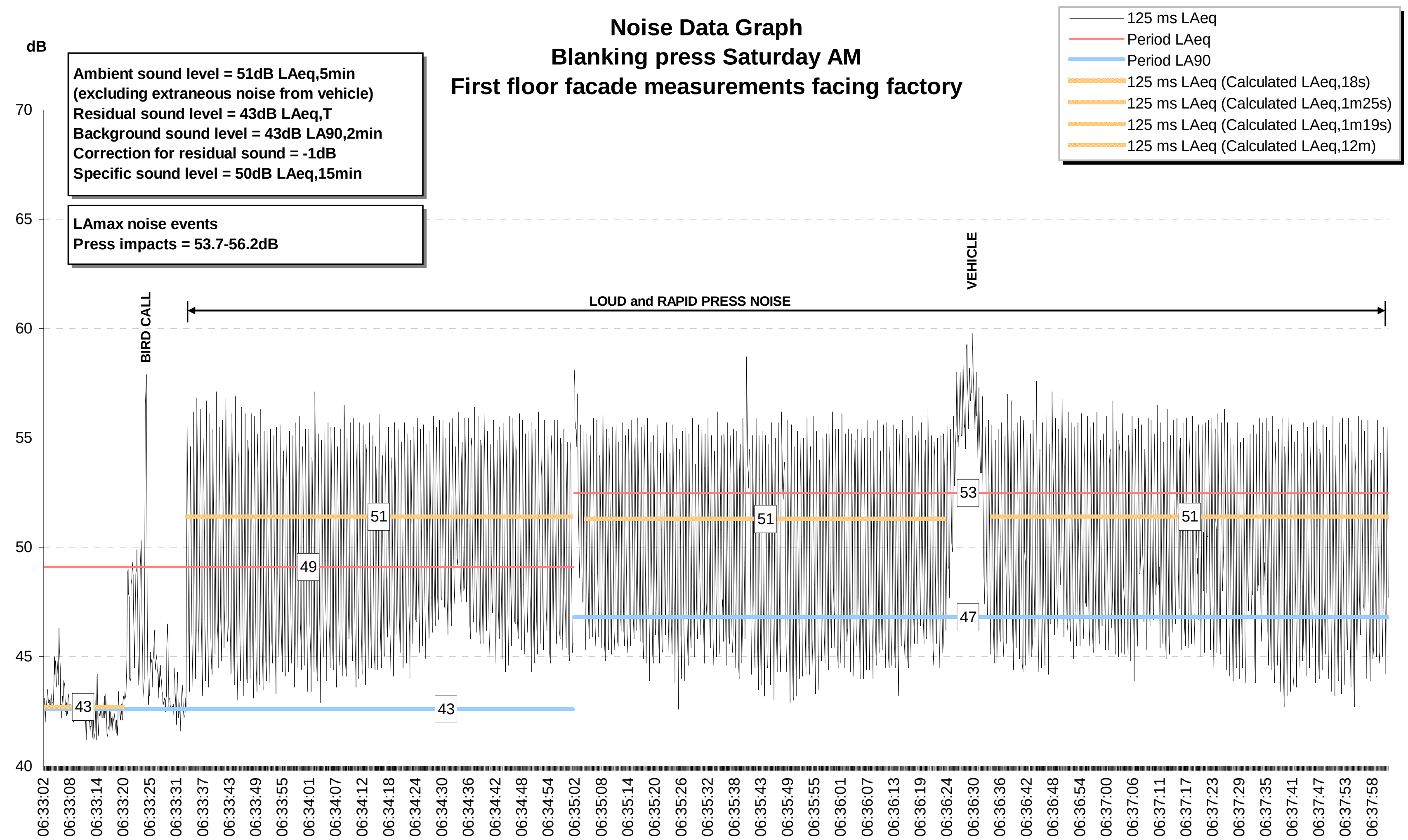

Figure 4: Blanking press impulsivity

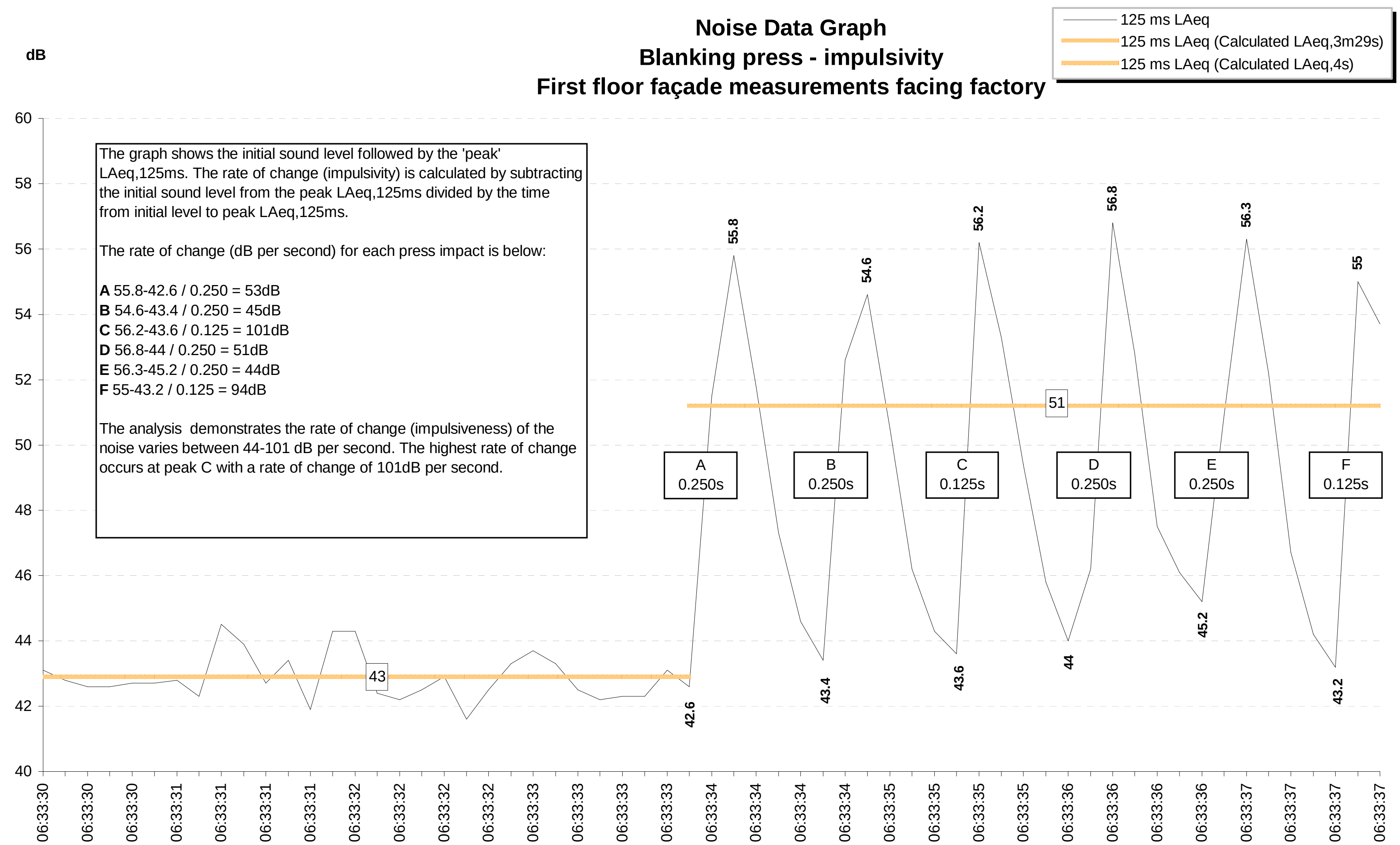

Figure 5: Measured noise level from metal fabrication

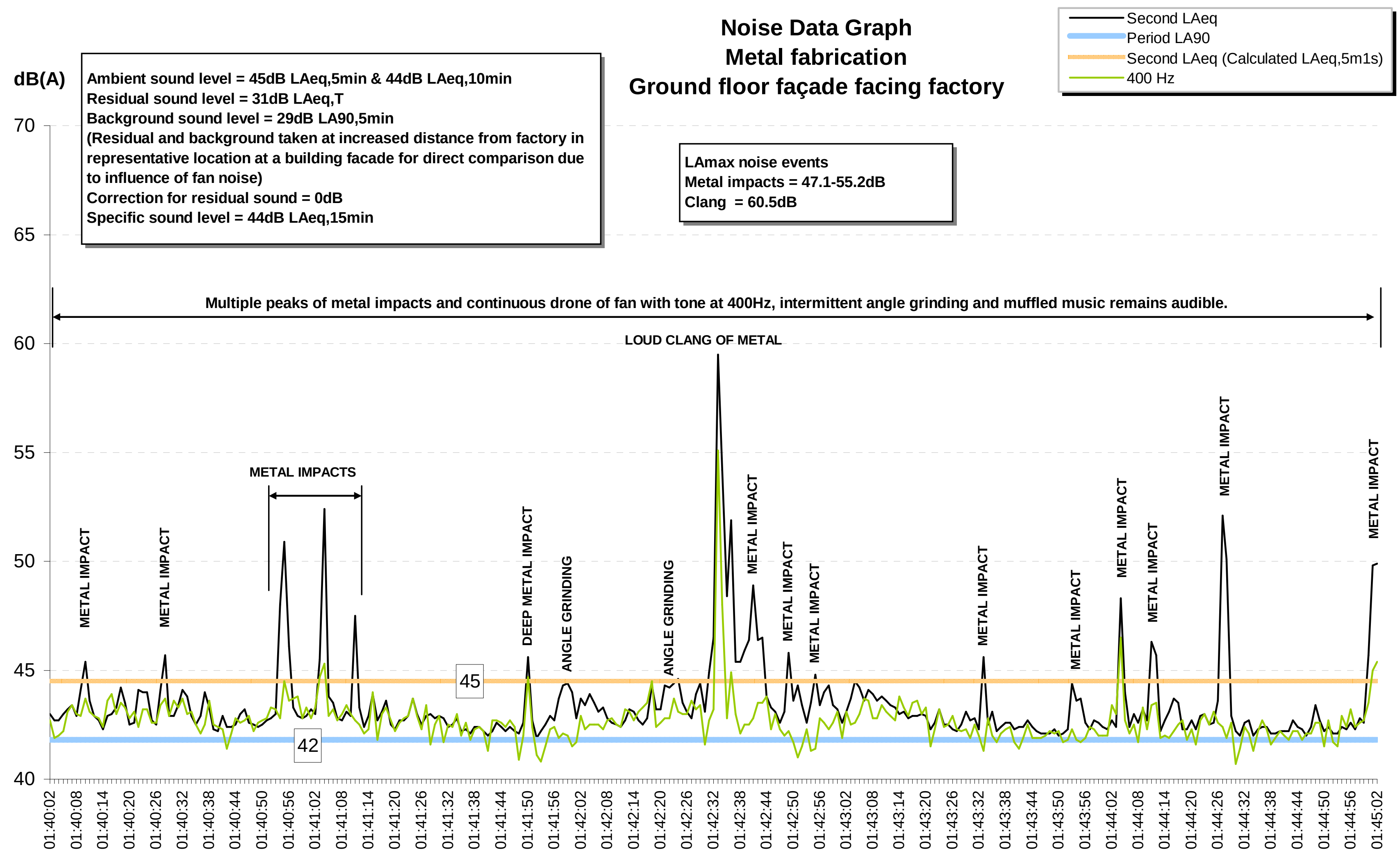

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Figure 6: Measured noise level from metals recycling