

# The assessment of potentially actionable noise impact

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This article considers elements of noise impact; independent, or only partially reliant on the decibel level. It relates to sources of specific sound from one premises affecting another that is potentially ‘actionable’ in law.

**O**ne example of actionable noise in the UK is noise emitted from premises that is prejudicial to health or a nuisance regulated by a local authority.<sup>1,2</sup> Consideration is given to non-acoustic and situational factors (‘context’) and how they affect the perception, interpretation and reaction to actionable sound at the individual level.

## When is sound noise?

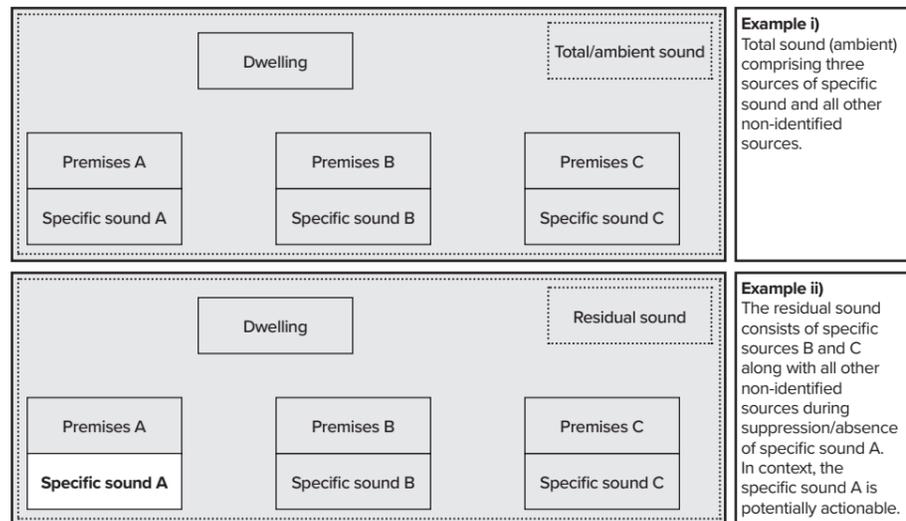
In air, sound is an aural sensation caused by pressure variations. The pressure variations are waves of energy. Sound is the human perception of those pressure waves via the hearing mechanisms located within the ear as interpreted by the brain. The pressure variations are transmitted via the middle ear (air), inner ear (fluid) and converted into nerve impulses mainly within the cochlea. The nerve impulses are detected and interpreted by the brain.

The perception of a sound, whether desired or unwanted will depend on a wide range of acoustic and non-acoustic factors, memories, associations, sensitivity and expectation. Sound can have positive psychological connotations such as a songbird reminding the 

**Main image:** Sound waves that are disruptive, alien, unwanted, occurring in the wrong place, at the wrong time or otherwise in an unexpected way (context), are usually considered noise

“The perception of a sound, whether desired or unwanted, depends on a range of acoustic and non-acoustic factors, memories, associations, sensitivity and expectation.”

Actionable/specific sound within the acoustic environment



Above: Figure 1

listener of nature. This provides a positive association with the acoustic environment. Where sound waves are disruptive, alien, unwanted, occur in the wrong place, at the wrong time or otherwise in an unexpected way (context), is usually considered noise.

Categories of noise and description of sound in context

In England, the Department for Environment, Food and Rural Affairs (DEFRA) within the Noise Policy Statement for England (NPSE) 2010 recognises noise as falling into three categories:

- ‘environmental noise’ which includes noise from transportation sources
- ‘neighbour noise’ which includes noise from inside and outside people’s homes; and;
- ‘neighbourhood noise’ which includes noise arising from within the community such as industrial and entertainment premises, trade and business premises, construction sites and noise in the street”

Noise affecting sensitive locations such as dwellings can fall into any of the categories both externally and/ or internally. The total (ambient) sound encompasses all categories of noise. Sources of actionable noise most commonly fall into the ‘neighbour’ and ‘neighbourhood noise’ category. The specific sound is emitted from a specific source and usually identifiable by the receiver within the acoustic environment as to where it emanates from and what

it is caused by. The total, specific and residual sound is illustrated in Figure 1 above.<sup>3</sup>

In Figure 1, example i shows a dwelling juxtaposed with premises A, B and C. The premises operate independently, and each emit a specific sound respectively, also as A, B and C. The grey area represents the total sound comprising all sources near and far. In the context of example ii, premises A emits a specific sound of noticeably different character. Premises B and C along with all other non-identified sources of sound within this example acoustic environment contribute to the residual sound, as observed when the specific sound from premises A is suppressed. The occupants of the dwelling consider the specific sound emitted from premises A to be unwanted (noise) and intrusive within the context of a residential receiver. Depending on the context and different approaches to analysis in each of these two examples, the specific sound can be considered as part of the residual sound or as specific sound that is intrusive and unwanted at the residential receiver. ‘Context’ can therefore have widespread interpretation and application.

The term ‘context’ is increasingly used within environmental management and noise assessment. A wider definition suggests context is “A set of physical (geographical, topographical, meteorological, and structural), social, psychological, cultural,

situational conditions, relevant to determine a particular individual or collective behaviour, attitude, emotion toward an environmental stressor”.<sup>4</sup> In relation to noise, the International Organization for Standardization (ISO) considers that context concerns the interrelationships between person, activity and place in space and time through auditory sensation, interpretation of that sensation and response.<sup>6</sup> Thus, generally, noise should not be considered in isolation but in the context of wider situational factors. However, for actionable noise those affected and regulators are often less concerned with factors such as wider societal benefit when assessing noise and focus on how it affects the individual based on the circumstances of impact.<sup>6,7</sup>

Situational factors and psychological reaction

Noise is commonly defined as unwanted sound or sound without value. Noise may arise in a variety of situations from a dripping tap, someone else’s loud telephone conversation, an intruder alarm or sound including unusual or otherwise irritating features that disrupt thought processes. Conversely, the greater our mental effort or concentration on a task, the less attention we pay to other stimulants such as noise. As a result, noise disrupts activity such as relaxation and rest to a greater extent than activities requiring higher concentration. For example, undertaking manual work tasks, concentrating on an important telephone call or cutting a hedge.

The term ‘noise’ introduces a subjective (emotionally based response) element to the individual’s decision of whether a sound is wanted or unwanted. It is normally an unconscious response. It is important to note, whether a sound is noise and whether that noise is expected or annoying is dependent upon the circumstances/situational factors in which sound is received. For example, a relatively quiet dripping tap may be thought of as not too annoying but can prevent/ disturb sleep if audible in a hotel bedroom at night when it is otherwise quiet. Likewise, an objectively loud audible intruder alarm sounding on the streets of towns and cities during the day may cause little annoyance to a transient

listener but with the same sound energy level can become a serious annoyance when repeatedly malfunctioning at 2am in a residential neighbourhood. ‘Noise annoyance’ can be defined as negative feelings of dissatisfaction, displeasure, disturbance or irritation caused by a specific sound.<sup>8</sup>

A loud telephone conversation of another passenger can be very annoying when trying to relax, read or concentrate on a long train journey. The speech content and use of language is likely to continuously trigger attention. However, the person making the call is less distracted by the noisy environment around them as they are concentrating on the call. These aspects of annoyance are far less determined by the decibel level other than in relation to audibility and possibly dominance, but by the constituents of the sound (character, message imparted to an inadvertent listener etc.) and how they are perceived (expectation, level of interruption etc.) in context.

The likelihood a sound is considered noise and will cause annoyance is multifactorial. The individual interpretation and reaction includes modifiers such as attitude/

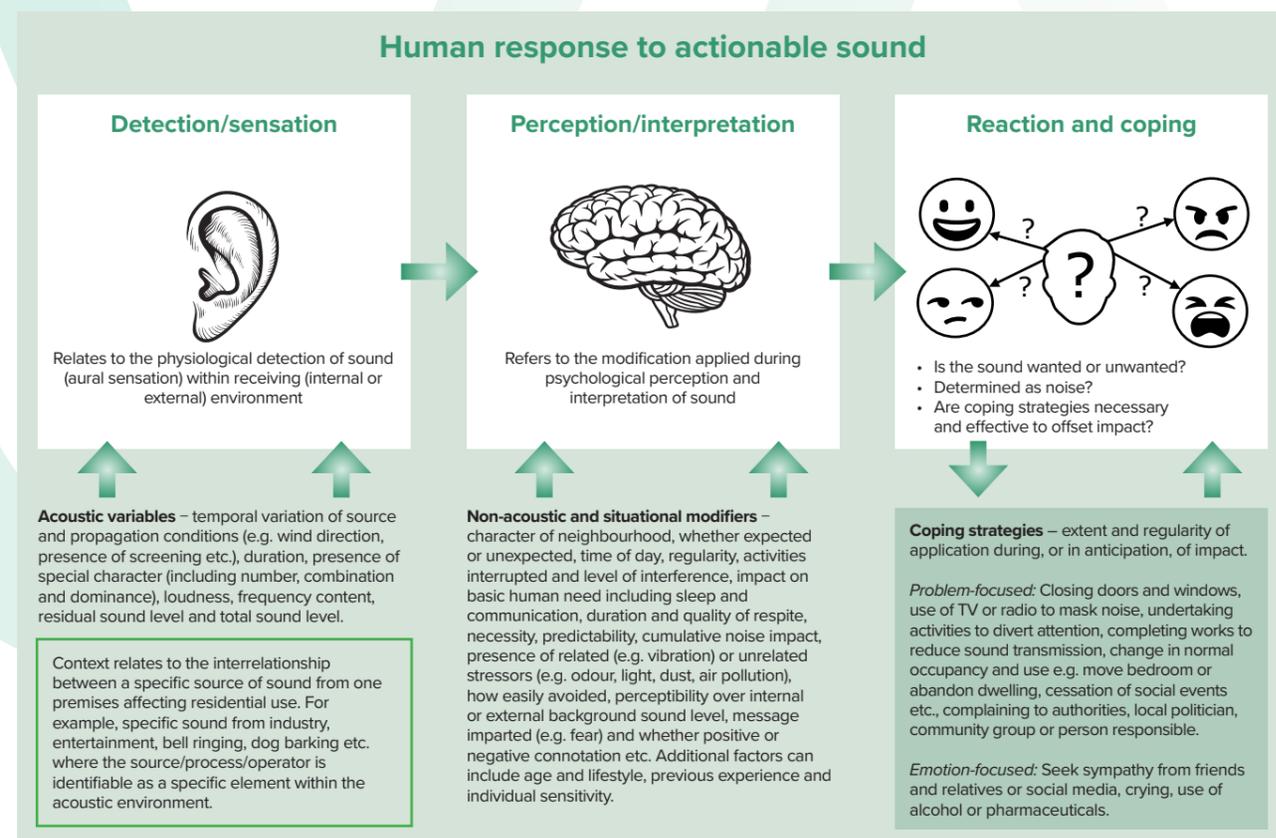
perception of the source and source operator, attitude to the message imparted, necessity to community life, perception of control over the specific source, individual sensitivity and sensitivity to any specific characteristics present that grab attention i.e. disrupt rest, relaxation or activities requiring concentration. This is shown diagrammatically in Figure 2 below.

Figure 2 shows the detection/ sensation, perception/interpretation and reaction/coping at the individual level.<sup>9</sup> Sensation relates to the physiological detection of sound and acoustic variables. Perception/ interpretation refers to modification due to non-acoustic and situational factors applied during the psychological processing of sound within an internal or external environment. Non acoustic factors can arise from unconscious or conscious responses. Reaction follows psychological processing and modification to determine whether the sound is wanted or unwanted. Problem-focused or emotion-focused coping strategies may then be applied which are multidimensional and situation specific.<sup>10</sup> Coping strategies can be maladaptive, for example, the use of

alcohol to sleep during repeat noise exposure. This form of maladaptive coping can lead to unintended adverse health outcomes. The aim of coping strategies is to counteract adverse impact arising from exposure to the noise stressor, usually in a way that disrupts desired lifestyle the least.

Interpretation also depends on related memories, for example, if a particular activity (neighbour’s party) led to disturbed sleep at an important point in lifetime then any related memories to noise from that neighbour could trigger emotive responses relating to the historical experience. One example would be a party affecting sleep the night before an exam and such recurrence is likely to more readily trigger negative response. The specific sound arising from industrial/commercial use is likely considered wanted by staff or those associated with the business as it informs on operations and imparts a positive (economic) message. However, it can be considered unwanted by residents when received in the context of a home environment where there is no equivalent positive message or perceived benefit. P52

Below: Figure 2



The aural experience will also depend on the condition of the ear and especially the inner ear which changes with age, exposure to excessive noise (sustained or sudden) and natural/genetic variation. Age introduces changes into this evaluation of noise both in terms of physiological and psychological changes where loss of hearing capacity due to presbycusis means generally there is less recognition of higher frequency intruding sounds.<sup>11,12</sup> Conversely the increased range of memory of different sounds, voices of individuals and exposure to societal experience introduces greater causes of distraction where attention is unconsciously drawn. Thus, a young child will recognise and be drawn by a parent's voice but not attracted by a wide range of sounds it has little experience of and therefore memory of. This has been demonstrated with smoke alarms where children who

have not experienced the alarm may sleep through it but those trained to respond and treat the noise as a sign of danger (imparts a message) or is based on a known voice will more readily awaken.<sup>13</sup>

### Cognition and habituation

Unlike other environmental stressors such as light, noise cannot be 'shut out' physiologically by the body.<sup>14</sup> However, habituation to some forms of noise does occur when the message interpreted by the brain is determined as not presenting a risk of the need for fight or flight (psychological and physiological stress response) such as road traffic noise. Humans typically habituate to noise that does not impart a message of concern. Similarly, a noise may not trigger psychological stress responses as there is no perceived threat but nevertheless draws attention because it triggers

unconscious responses such as recognition of the noise and what it represents.

Humans are continuously and unconsciously listening. Humans aurally observe the environment for threat even when asleep which may trigger awakening in response to salient, sudden or loud sounds. This appears a natural response meaning it is difficult to prevent either awakening where the brain perceives a response may be needed, or attention when awake for example, triggering a memory such as from a known voice. Equally, alien and unrecognised sounds will trigger attention and awakening as the brain will be seeking input from all senses in a conscious state to determine its source and, whether it carries a threat or other message. These responses do not require loudness but sufficient recognition or degree of unconscious concern to trigger awakening. As a result,

**Below:** Sources of actionable noise most commonly fall into the 'neighbour' and 'neighbourhood noise' category

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14. For example, where eyes are exposed to high levels of light the eyelids can close and the iris constricts. There is no alternative or comparative mechanism for aural protection albeit it is understood there is a physiological mechanism of dampening to muscles connected to bone within the ear in response to sudden loud noises e.g. the middle-ear reflex/stapedius reflex.



awakenings and distraction when awake arising from alien, unwanted or disliked sounds is not directly related to its loudness and more a factor of its detection, perception (audibility) and identification (interpretation) whether conscious or unconscious. An observer's auditory impression of the relative strength or intensity of the sound is less relevant once identified in a particular situation and humans do not normally relate to them in terms of their loudness in such cases. This is recognised in particular by the courts in nuisance cases.

Other effects include the 'irrelevant speech effect' which is an example of an effect that doesn't depend on the intensity of the noise. The irrelevant speech effect is the finding that performance on immediate serial recall tasks is impaired by the presence of background speech, even though the background speech is completely irrelevant to the task.<sup>15</sup>

In cases of continuous or constant noise exposure, for example distant road traffic noise, habituation occurs reducing adverse response at the individual level. However, in cases of repeat exposure to actionable noise, sensitisation occurs where the message causes increasing alertness or alarm due to the absence of physical or emotional coping.<sup>16,17</sup> The determination of sound as noise, depends upon which type of response is triggered, whether we habituate to it and thus

the negative response reduces and the consequence of the response such as awakening, disruption of activity, negative or positive interpretation.

As the disruption of brain activities by noise is an unconscious process, we cannot prevent its effect. It can be reduced by concentrating on the task we do not want disrupted but in turn this requires increased mental focus altering cognition. This in turn is a higher level of alertness and concentration which is not conducive with relaxation and rest. Thus, in the presence of noise on a train we will more readily be able to focus and respond to a message from a work colleague but when at home reading a novel for relaxation, will less likely be able to maintain the relaxation we are seeking to achieve.

**Below:** Sound can have positive psychological connotations such as a songbird reminding the listener of nature



**Noise impact on humans**

There are generally two categories of sound source. The first are commonly classified as anonymous sources such as road, rail and aircraft. They are anonymous as we do not unconsciously associate them with a particular person or operator. Thus, when heard they less often draw our attention. They are normally present daily without exception and thus become embedded in memories that do not trigger the need for conscious response.

Sound from transportation is generally considered unwanted and defined 'environmental noise' by national noise policy.<sup>18</sup> Impact is primarily related to energy dose and physiological effects of a high level of continuous sound energy causing sleep disturbance, annoyance and triggering hormone type responses. Adverse health effects from transportation noise (anonymous) arise primarily relative to their decibel level and transportation type causing impact (rail/road/air). It can be time specific such as where activity only arises at certain times, for example holiday traffic or operations of a port relating to ferry times. In most cases adverse impact follows a dose-response relationship and daily impact where an increasing decibel level of exposure increases the incidence of adverse health outcomes. A systematic review of evidence by the WHO (2018) identified different trigger levels for air, road and rail traffic.<sup>19</sup> Health effects including but not limited to annoyance and sleep disturbance are recognised to impact at certain trigger/onset levels of sound energy where a stepwise change occurs in the percentage of a population adversely affected.

Environmental noise affects everyone in society to varying degrees. Transportation noise can include special characteristics that require consideration (e.g. low frequency noise from aircraft) and reaction is influenced by non-acoustic and situational factors.

One outcome is the development of different guideline levels for aircraft, road traffic and rail noise as provided in the WHO 2018 and the necessity for

individual evaluation. There is a recognisable benefit of transportation sources, socially, for mobility and movement of goods. It is long recognised humans tend to habituate to low levels of distant or localised road traffic noise over time as it does not threaten safety (impart a message of danger) or trigger a fight or flight psychological stress response and is present virtually every day with no related adverse outcome (depending on context). It is noise that is ubiquitous within society, benign in terms of threat, acceptable as a social norm and characterless to the point it does not normally draw attention or directly relate to some other stressor. Such sources are not normally actionable in law and complaints do not result in direct regulatory action. Exceptions do occur such as a very noisy exhaust on a motorbike and military flying.

The second category is effectively actionable noise. This sound and its circumstances of impact typically contain acoustic and non-acoustic characteristics. Non-acoustic factors, generally, are considered to be all factors other than sound level alone which contribute to noise annoyance and similar effects.<sup>20</sup> This can include a wide range of sources such as music or noise from an industrial site associated with a particular identifiable activity, process or operator. If the responsible person (individual or business) can be identified it is more likely the resulting impact will be perceived as noise by the receptor. Related memories will increasingly be set down as the noise is experienced and reinforce negative responses increasingly over time. Sound with this character unconsciously draws attention associating adverse response with the source, process and person or organisation responsible. As a result, non-acoustic factors associated with the source add to impact (interpretation) and psychological stress caused by the noise (reaction) resulting in the application of coping strategies.

The source recognition and unconscious response, to the process or person responsible, become more readily identified in the brain resulting in increased sensitisation and drawing of attention. Over time, improved recognition develops in the same way a musician recognises faults with their instrument and a conductor recognises what part of the orchestra is at the wrong tempo or dominance. Heightened sensitivity is a normal human reaction following repeat exposure and should not be confused with individuals who may exhibit 'over-sensitivity', generally, to noise i.e. hyperacusis. This leads to a general principle that humans tend to habituate to environmental/ transportation noise but sensitise to noise with attention drawing character or that imparts an adverse message. Important parameters include lack of controllability, unpredictability and where a noise is considered unnecessary. Intermittent (non-continuous) noise can have a greater effect on reaction due to the modification attributable to these non-acoustic and situational factors.

Impact from actionable noise with specific/acoustic characteristics is determined more by non-acoustic factors such as regularity, times of occurrence, duration and quality of respite periods, message imparted and how individuals interpret it, character of the neighbourhood and what activities are affected. Audibility, dominance, attention grabbing, regularity, duration, times of occurrence and what is disturbed are important non-acoustic and psychoacoustic factors. One example is music bass beat from specific premises where music emissions are regularly audible. Regardless of decibel level, when observed inside the home they are widely recognised as unacceptable. Even when infrequently occurring at night it is recognised as unacceptable as it will disturb sleep. It does so not because of its decibel level but due to the detection and

interpretation by the receiver and human responses which trigger awakening or impede mechanisms which lead to the onset of sleep. In the case of bass beat within music, there are two primary effect multipliers including the low frequency content and regular modulation. There are generally multiple reasons for increased human response including expectation and message imparted (speech). In such cases assessment is based on the acoustic characteristics, the mechanisms by which it intrudes, when it occurs and its frequency and duration along with other non-acoustic factors. Other acoustic factors are also important and can include the spectral distribution, and changes in level along with the duration of such sound energy levels.

**Relationship of noise character and loudness or sound energy level**

The World Health Organization (WHO) attribute only one third of noise annoyance to the decibel level with non-acoustic factors demonstrating greater importance. Whether noise causes adverse or significant adverse impact depends on several factors as recognised in the UK courts in nuisance cases including how loud it is in relative terms, what sort of noise it is, where, when and how regularly it occurs, how long it lasts and its frequency/spectral content. Numerous other factors are also relevant.

Difficulty arises when trying to relate impact causing adverse psychological human response to sound energy level. Whilst loudness is a clear factor and is processed by different neurons to those triggering attention or emotional responses, the relevance and importance of loudness compared to factors such as attention drawing character in the noise is less well researched. The latter relates more to its audibility and dominance rather than loudness.

It is generally recognised within planning policy and noise guidance, **P56**

18. Exceptions exist where it is necessary for transportation to be heard for safety reasons e.g. train horn but it nevertheless remains unwanted by exposed residents, especially as many cases are avoidable but is convenient or financially beneficial to the operator. However, it would likely be considered noise when received in a home environment to a resident living close to a crossing and many complaints arise.  
 19. For example, those at a late-night party enjoying themselves at the cost and disregard of others losing a night's sleep.  
 20. Determined through experience of both authors and feedback from the training of local authority officers responsible for the investigation of noise complaints and enforcement.

## “It is generally recognised within planning policy and guidance, that once there is a high sound energy dose in an environment the tolerability of additional noise is reduced particularly where it has attention drawing character.”

that once there is a high sound energy dose in an environment the tolerability of additional noise is reduced particularly where it has attention drawing character.<sup>21</sup> It should be recognised quiet environments generally experience increased incongruity by intruding noise particularly where they are not expected. However, in a loud and cacophonous sound environment, low levels of additional noise may not increase attention disruption as there is already a wide range of ongoing attention-grabbing sounds triggering greater attention on tasks in order to avoid disruption. In that instance, the brain is flooded by such effects leading to more complex human responses including potentially a general increased unconscious avoidance of exposure.

Consider an evening environment impacted by a loud relatively steady roar of road traffic at levels of 65dB(Aeq,T) but with additional music noise emissions from an adjacent entertainment facility that is just audible. The music may increase adverse impact even when only just audible due to the total dose. Compare that to a busy vibrant city centre location with the same average noise level but composed of multiple sources.<sup>30</sup> Imposing the same music in this cacophony/sound environment is less likely to intrude due to the saturating cacophony of sounds.

The brain receives separate stimuli in terms of loud noise from multiple sources and has to determine directionality but also elements drawing attention and whether the sound contains a message e.g. threat. So the louder a noise that draws attention the more it will disrupt even higher mental focus except this could change having regard to the context and complexity of the sound

environment. Complex sound environments may affect discernibility of some minority sounds. Simply put, in environments with underlying anonymous noise not drawing attention the louder it is the more it would disrupt not just rest and relaxation activities but those in a workplace. In complex sound environments the noise is likely to disrupt and intrude at lower loudness levels, but the intruding noise may not trigger the same complex responses as these aspects of cognition are already in a state of stimulation.

The total level of sound can potentially be important, therefore, in situations where the total sound is high due to all sources near and far and where the specific sound forms one of many individual sources (low signal to noise ratio). Less attention is drawn to a single element of the acoustic environment and impact is more related to the continuous and high levels of noise plus the presence of any individual acoustic features and available coping subject to the complexity of the ambient sources. However, when considering the specific sound in areas of low noise, a high signal to noise ratio relative to the residual sound or background masking sound and minimal competing attention-grabbing character, it can make the sound incongruent focusing attention on that single element. In sound environments that impose a high dose but are not primarily dominated by a single continuous transport source, a more complex relationship can arise. Where community noise includes a range of attention drawing sources, for example the cacophonous sound environment described above, this can make assessment of any individual source complex. More

research is required as the various contributing factors and their importance remain unknown although it is considered these general principles are supported.

### Conclusion

For actionable noise, a noise assessment should consider factors such as audibility and dominance whether internally or externally, frequency and duration, the times it occurs and activities affected, the nature and character of the sounds that unconsciously draw attention and those other factors discussed above in relation to this type of noise. Additionally, impact will vary depending on what human activity is affected. If the noise cannot be escaped from anywhere within the dwelling, this would impact far more than a scenario where it only affects limited rooms used in a limited way such as bathrooms.

Whilst not considered here, audibility and dominance are not necessarily as simple as emergence above background and ambient sound levels, but this is clearly a factor.

In many cases of impact, the decibel level is insufficient to determine whether a specific sound is considered acceptable particularly where certain acoustic and non-acoustic characteristics are present. Whilst pressure variations in the air are a form of energy that can be measured using scientific instruments the reaction to sound is predominantly psychological. This includes within both source noise and residual and background sound environments. The assessment of actionable noise requires more than an understanding of acoustics particularly as knowledge and research into noise with special or specific characteristics is limited. It is possible complex noisy environments may exhibit a greater tolerability of additional characterful noise than less complex quieter environments and is an area for future research.

There are too many variables to provide precise levels or decibel ranges to such influencing factors, but we can draw reasonable conclusions. For example, where a noise is both loud and attention drawing, it does not become

acceptable by simply reducing its loudness when still above the point it continues to draw attention. The latter element is less related to loudness and more related to the acoustic characteristics or message imparted by that noise which do not disappear until it is no longer discernible.

When undertaking noise impact assessments, it should be remembered noise falls into distinct categories and the resulting level of annoyance or stress increase can be dependent on a variety of acoustic, non-acoustic and situational factors independent of the decibel level. Dominance, audibility, noisiness and

attention drawing elements need to be analysed along with all the other factors discussed such as message imparted, frequency and duration but which can be further complicated by the constituents of the existing sound environment. Other factors such as additional environmental stressors within the receiving locale are also important. ●

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### Advertising feature

## Secondary glazing enriches Art Deco revival of Hatfield's most iconic building



**The Comet Hotel is at the junction of the Barnet by-pass with St Albans Road in Hertfordshire, close to the Selectaglaze office and factory.**

Formerly known as the Ramada Hatfield, the Comet's multimillion pound refurbishment, which began in 2017, is now complete. A new three storey extension block annexed to the rear of the hotel has added a further 52 rooms, which reflects

and enhances the silhouette of the heritage building. This new extension is shared with a student residential development.

In addition, the hotel has also opened its own independent restaurant, 'Element Bar & Kitchen'. A replica of the Comet Racer, mounted on a 20ft high pylon stands tall outside the hotel.

The hotel had retained the building's original Crittal sash windows, but this did not provide the required level of noise insulation to a number of the guest rooms, restaurant and function spaces.

To remedy this, St Albans-based Selectaglaze installed 104 secondary glazed units. The secondary windows were made bespoke to ensure the best fit and included four different systems, specific to the project's needs. All units were finished in white to match the original external windows.

The new secondary glazing to this Hatfield landmark will help lower energy

and afford the guests a good night's sleep, and those visiting the hotel will be guaranteed a pleasant experience.

Hotel refurbishments are often fast-track projects requiring close cooperation between client, contractor and specialists. Selectaglaze has wide experience of working in buildings up to Grade I Listed and offers a technical advisory service and specification advice to ensure correct interface with other trades.

Established in 1966, Royal Warrant Holder Selectaglaze is the leading specialist in the design, manufacture and installation of secondary glazing and will be exhibiting at Future Build 2020 from 3rd – 5th March 2020. ●

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