



# Fireworks: noise levels and impacts on health and the environment

## 1 Document purpose

This document is intended to provide information on the noise levels and impacts on health and the environment of fireworks to the Office for Product Safety and Standards (OPSS). This is to support the creation of an evidence base on fireworks to identify and consider if gaps in knowledge exist, assess if there is a problem and determine if current legislation is fit for purpose. This document is intended to provide a baseline of current scientific knowledge on fireworks.

## 2 Key findings

- The impacts of noise depend on the decibel (dB) level, the frequency (Hz), the proximity to the source of noise, and the time of exposure.
- A-weighted decibels, or **dBA**, are **noise levels adjusted relative to frequency**. This is because the human ear is more sensitive to some frequencies than others.
- Fireworks have a **limit of 120 dBA** at the approved distance; the World Health Organisation (WHO) recommends that children are not exposed to more than 120 dB peak noise pressure. Adults have a higher limit of 140 dB peak noise pressure (WHO, 2018).
- As long as the operating instructions for fireworks are observed, there should be no permanent damage to hearing. This is however distinct from mental health issues such as stress and anxiety.
- **Misuse** of fireworks is a problem, with around 990 injuries attributable to fireworks in 2005.
- **Air pollution** increases significantly around the time of fireworks events such as Guy Fawkes and Diwali (London Air, 2019). Fireworks also result in the release of toxic chemicals (McClendon, 2018); however, research has not concluded whether the amounts are enough to cause an impact on human health.
- Evidence around the impacts of fireworks on **animal health** is inconclusive. Although they are unlikely to suffer physiological damage as a result of firework noise levels (apart from incidences of malicious use) there is evidence that fireworks can cause noise distress. Different species of animals have different sensitivities and responses to noise. The Welfare of Farm Animals Regulations (WOFAR) state pigs should not be exposed to noise levels of above 85 dB on a farm.

### 3 Firework standards

Fireworks sold for domestic use are divided into three categories following different conditions, a summary of which is provided in Table 1.

**Table 1: Summary of different categories of firework from BS EN 15947**

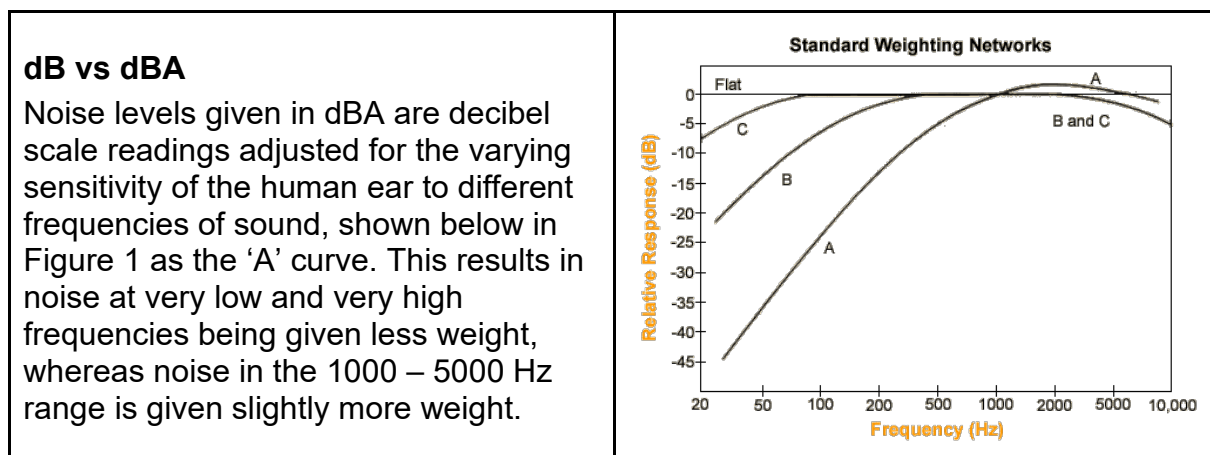
Category	Standard	Noise pressure level
1	Suitable for use inside domestic buildings; should not cause injury to people standing 1 m or more away. For hand-held fireworks, the person holding them should not be injured.	Below 120 dBA; noise pressure measured 1m horizontal distance at a height of 1m above ground.
2	Suitable for outdoor use in relatively confined areas; fireworks should not cause injury to people standing 5 m or more away. For hand-held sparklers, the person holding them should not be injured.	Below 120 dBA; noise pressure measured 8m horizontal distance at a height of 1m above ground.
3	Suitable for outdoor use in large open spaces; should not cause injury to people standing 25 m or more away.	Below 120 dBA; noise pressure measured 15m horizontal distance at a height of 1m above ground.

### 4 Noise

#### 4.1 Noise level

- The **decibel (dB)** is the unit for measuring the intensity of noise. Each increase in 10 dB means that the noise is 10 times more powerful than previously; for example, a noise at 90 dB is 10 times louder than a noise at 80 dB.
- Noise levels are often quoted in A-weighted decibels, or **dBA**; as human ears are more sensitive to some frequencies than others, this is the actual noise level adjusted for the frequency of the noise.
- **Frequency** is the number of vibrations per second of the noise and is measured in **Hertz (Hz)**.

**Figure 1: Weighting of noise depending on the frequency (Noise Help, 2018)**



## 4.2 Proximity

- The further away you are from the source of noise, the more the noise level is reduced.
- A **doubling** of distance from a noise source will **reduce** the noise pressure level by 6 dB (The Engineering Toolbox, 2005).
- A study in 2018 found that **indoor-outdoor noise levels were reduced** by a median of 10-28 dB depending on whether the household in question had open, tilted or closed windows (Locher et al., 2018).

## 4.3 Time

The longer you are exposed to a noise, the more chance there is of damage. Table 2 displays max exposure rates depending on the noise level.

**Table 2: Noise levels and exposure times**

Noise Level (dBA)	Maximum Exposure Time per 24 Hours
85	8 hours
91	2 hours
97	30 minutes
103	7.5 minutes
109	112 seconds
115	28 seconds
121	7 seconds
127	1 second
130–140	less than 1 second
140	NO EXPOSURE

## 5 Fireworks and health

### 5.1 Noise limits

- Fireworks are limited to producing noises of 120 dBA or lower as long as the observer is standing the recommended distance away (BSI, 2012).
- The WHO recommends that adults are not exposed to 140 dB peak noise pressure, with children having a lower limit of 120 dB (WHO, 2018).
- **As long as the operating instructions for fireworks are observed, physiological damage will not result.** This is however distinct from mental health issues such as stress and anxiety.

### 5.2 Misuse

- An ADAS report for Defra found that anecdotal evidence presented by BBC News in 2000 suggested that **almost 830 people in Britain were treated for firework injuries in 1998. In 2005**, a report by the Royal Society for the Prevention of Accidents stated that some **990 injuries were attributable to fireworks.**

### 5.3 Pollution

- Fireworks events such as Guy Fawkes night and Diwali have been found to result in higher concentrations of air pollution detrimental to human health (London Air, 2019). **This is due to both fireworks and bonfires.**
- Fireworks also produce heavy metal particles and toxins which can be detrimental to human health. Further research is required to determine whether the amounts produced are more than negligible (McClendon, 2018).
- Firework housing can be a significant cause of litter because of the inclusion of non-biodegradable parts.

## 6 Fireworks and animal health

- The effects of noise on animal behaviour depends not only on its intensity (dB), its frequency (Hz), and its duration and pattern (including vibration potential), but also on the hearing ability of the animal species and breeds, the age and physiological state of the animal at the time of exposure. It also depends on the noise exposure history of the animal and to the predictability of the acoustic stimulus (United States Environmental Protection Agency, 1980).
- The noise threshold expected to cause a behavioural response by cattle is 85 to 90 dB (J Brouček, 2014). Domestic animals exposed to aircraft noises of 120-135 dB showed no injury, and became accustomed to intermittent levels of aircraft noise at 120 dB – apart from a raised heart rate at the time of stimulus, no other effects were noted (United States Environmental Protection Agency, 1980), although this has been questioned in more recent studies (J Brouček, 2014).
- Dogs were used as a reference in the RSPCA report below; the auditory systems of humans and dogs are similar, so it is likely that noise levels that damage human hearing will have the same effect on dogs (Garvey, Stella, & Croney, 2006).
- Dogs can however hear across a much greater frequency range and can therefore are exposed to a greater risk of noise distress. The bark of a dog can reach 100 dB, with noise levels recorded at between 85-122 dB in kennels (Garvey et al., 2006). Previous studies have shown that noise blasts of 120 dB are particularly stressful to dogs, although this did not seem to result in chronic stress (Haverbeke, Diederich, Depiereux, & Giffroy, 2008).
- The Welfare of Farm Animals Regulations (WOFAR) state, in Schedule 5 (laying hens) and Schedule 8 Part 2 (pigs) that those animals must not be exposed to a sudden noise. Pigs should not be exposed to noise levels of above 85 dB. Regulation 1099/2009 on the welfare of animals at the time of killing also requires that in Article 3.1 that Animals shall be spared any avoidable pain, distress or suffering during their killing and related operations.
- In the past 9 years the BHS has received incident reports describing 272 fireworks related incidents, 98 horses injured and 20 horse fatalities (BHS, 2019).

## 7 Noise level comparison

Comparisons of noise levels can be seen below in Table 3.

**Table 3: Noise Navigator comparison. These ranges are indicative only; some sounds may have highs and lows outside of the range** (Berger, Neitzel, & Kladden, 2015).

Noise level (dBA)	Source
70 - 80	Home: Laundry, Dishwasher Home: Baby crying
80 - 90	Farm: Milkhouse Home: Hedge clippers Home: Alarm clock Home: Hair dryer Home: Ringing telephone
90 - 100	Farm: Pig squeals Farm: Tractor (diesel powered) Home: Food processor Home: Dog bark
100 - 110	Farm: Combine harvesters Home: House door slamming
110 - 120	Peak London Underground (Furby, 2018) Car horn Chainsaw Pneumatic drill
120 - 130	<b>Fireworks (max)</b> Thunderclap (Noise Help, 2018) Police sirens (The Telegraph, 2008)
130 - 140	Jet engine, 30m away

## 8 RSPCA report

The RSPCA asked vets to log firework-related cases between October and November of 2004, of which they reported 682 cases. However, it is unclear as to whether this is due to stress caused by increased noise levels or anti-social/criminal behaviour.

The report included a comparison of household noises with Category 3 fireworks at 8m distance. This comparison is invalid as safe distance for Category 3 is recommended to be 15m, and a direct comparison should not be made as it is likely that household noises will be heard at a closer distance (therefore the decibel level will be greater).

As responsible pet owners will generally keep their animals indoors on firework night, noise levels will be reduced to levels below 120 dBA before reaching the pet due to the distance from the source of noise and the noise-lessening effects of walls and windows (see above in 4.1).

For comparison, a category 3 firework detonating at 60m distance could see its noise reduced to about 80 dBA in a property with closed windows (Locher et al., 2018; The Engineering Toolbox, 2005), about the same as a ringing telephone (Centre for Hearing and Communication, 2019); the same firework detonating at 15m distance in a property with fully open windows could see noise levels of 110 dBA, about the same as a car horn.

As explained previously in section 6, animals generally have heightened hearing sensitivity when compared to humans, so extra care should be taken to isolate pets from the source of noise.

## 9 Bibliography

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