INTRODUCTION

360° Testing Service has been retained to perform tests upon "Brand" ultrasonic emitting devices. Four samples, pictured at right, were supplied for these tests.

OVERVIEW

Over 100-dogs and a selection of cats were tested with the Brand pet devices,[1] some formally, more informally. In a few cases, test administrators were fortunate to catch related action in images; however, in many other instances a picture depicting the desired interaction was either too delayed or otherwise non-descriptive, thus not included.

Testing revealed that the Brand pet device was generally effective at commanding attention or acting as a repellant with dogs and cats, but only when used at closer ranges, 5 - 6 feet or less, and when no obstructions such as clothing obstructed the line of sight from the device's emitting front element (pictured at right). Brand pet device had the most notable effect when the tested animal was seemingly not preoccupied nor intent on a specific action, for example, casually walking around. Evident from testing is that some dogs, and perhaps breeds, are more sensitive than others to the Brand pet device emission.

Testing also revealed that some dogs, once exposed to the Brand pet device's ultrasound emission, appear to become less reactive to the device with additional use. Further, young puppies also proved a challenge, as they sometimes appear to be too distracted to pay attention to anything, including the Brand pet device.

Testing also showed that continued activation of the Brand pet device at increasingly closer range can prompt dogs and cats to get off couches, and stop jumping, etc. Brand pet device appears to act as a form of annoyance at greater distance, but becomes a potent repellant as the proximity increases to only several feet.

[1] All provided samples were used on some number of test trials. Test administrators did not notice an observable difference from one Brand ultrasonic sample device to the next.

Test subject: Dogs

- Dog is on a couch/seat less than 6' away. Test Procedure...
  1. Verbally prompted
  2. After unsuccessful prompt, the Brand pet device was activated

Findings:
With several dogs of varied types, and in differing locations, test administrators were unable to get the tested dogs to get down from the bench, sofa, or seat. Some dogs seemed indifferent to an activated Brand pet device such as the black and white spaniel below. Other dogs, seemed annoyed, or would flinch, but still did not leave the seat. Based on test responses, it would seem that some dogs may become responsive to a get down or get off the couch command with the use of Brand pet device, if for example the dog was told to get down followed by a pulse from Brand pet device, and then if need be, forcibly removed from the seat. We theorize this result because the Brand pet device was generally observed to command attention over a large number of animals and scenarios when used at close distances and without obstructions.

- Dog jumping at an approaching individual. Test Procedure...
    1. Verbally prompted
    2. After unsuccessful prompt, the Brand pet device was activated for 1-2 seconds

Findings:


Tested dogs did not stop jumping unless the dog jumping on the person was exposed to a Brand pet device at extremely close distance (1-2'), and then only sometimes did they stop, and not necessarily for very long. The tested jumping dogs were intensely jumping and in a highly excited state; thus, they did not seem to pay much attention to anything other than the individual they were jumping on.



- Response(s) of animals when Brand pet device was activated for 1-2 seconds within 6.'

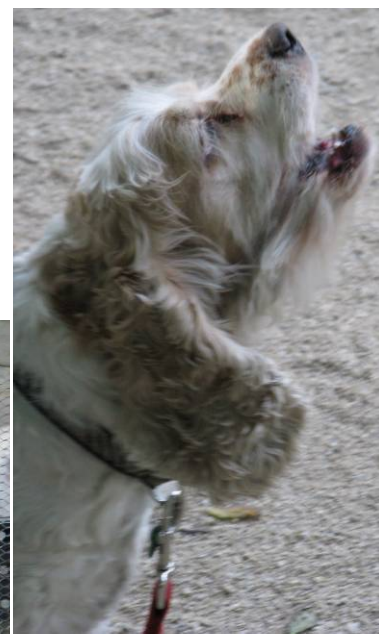
Findings:
Over a considerable number of test trials, estimated at greater than 50, dogs and cats within a few feet of an activated Brand pet device typically had an observable reaction that ranged from a call to attention to being startled to flinching to fleeing; that is, unless they were deeply pre-occupied such as a puppy playing, or more than a few feet away, or in some way obstructed (e.g., behind Plexiglas). In the below two rightmost pictures, puppies at play or behind Plexiglas seem unaffected by an active Brand pet device. Note that in the below left picture that one of two similar dogs and a third dog are pictured, yet, only the closest dog seems to have responded to the activated Brand pet

device. This image is consistent with the range practicalities observed with the tested devices.



- A continually barking dog within 6’ of test administrator. Test Procedure...
    1. Verbally prompted
    2. After unsuccessful prompt, the Brand pet device was activated for 1-2 seconds

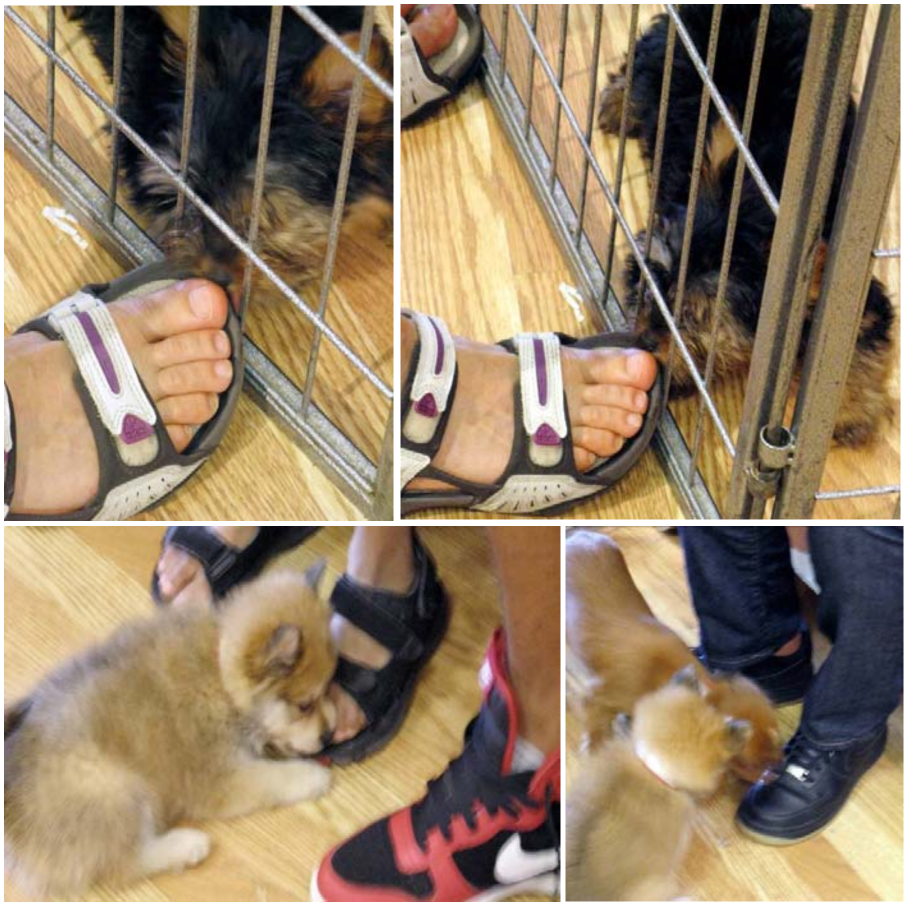
Findings:
When the Brand pet device was activated at close range to a barking dog, dogs did initially stop barking. At materially greater distances > 6’, no effect was observed on barking dogs. The white Bijon Frise looking dog show below (left), on the second trial fled into the house. Both times this dog stopped barking immediately. The spaniel shown barking below (right) did stop barking on the first use, and ignored the activated Brand pet device on the second attempt.

- A dog chewing a shoe within 6’ of test administrator. Test Procedure...
    1. Verbally prompted
    2. After unsuccessful prompt, the Brand pet device was activated for 1-2 seconds

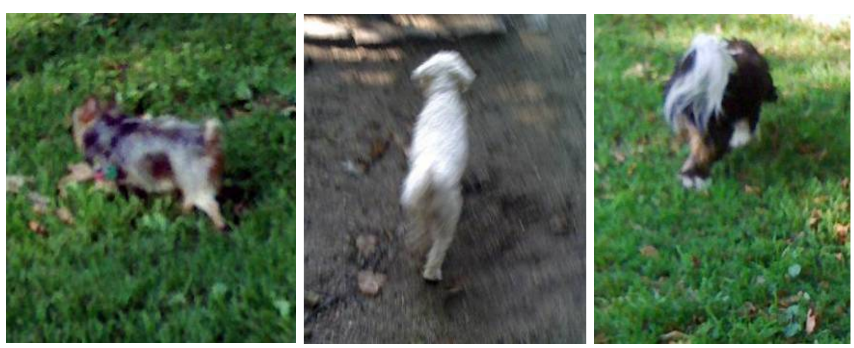
Findings:
Similar to jumping dogs, a tested dog chewing a shoe did not stop chewing until the dog chewing was exposed to a Brand pet device at a intimate distance (2 - 3’), and then only

temporarily. As with jumping dogs, the chewing dog was intensely chewing and in a somewhat excited state. Three tested chewing puppies, shown below, did not stop chewing when Brand pet device was activated. Puppies were at 3 to 6 foot distances.



- A dog fleeing test administrator within a 6-10' perimeter. Test Procedure...
    1. Verbally prompted
    2. After unsuccessful prompt, the Brand pet device was activated for 1-2 seconds

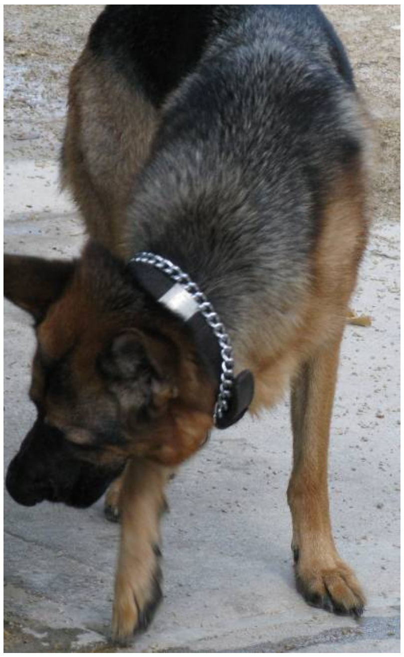
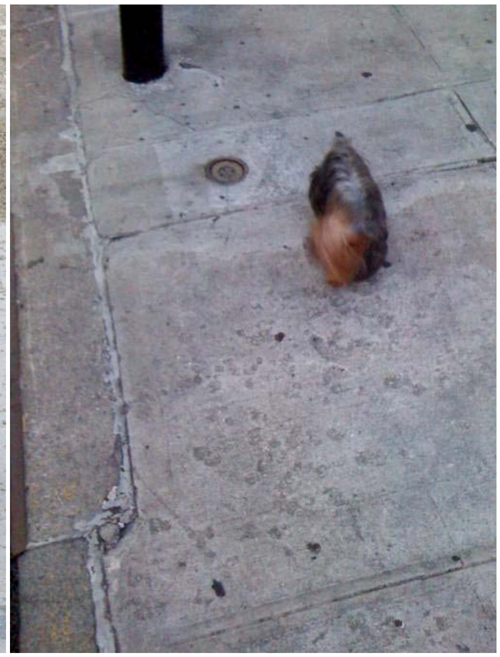
Findings:



As noted earlier, distances other than a few feet did not seem to have much effect in most circumstances and with most dogs. Thus, at test distances of 6-10', none of the testing fleeing dogs stopped due to Brand pet device. At a somewhat closer distance one dog, the center dog of the below pictured, accelerated his escape when the Brand pet device was activated. It appeared that this white dog wanted to get as far away from the emitting Brand pet device as far and as fast as possible.

- An unattended dog approaching test administrator. Test Procedure...
    1. Brand pet device was activated for 1-2 seconds at 20-25’
    2. Brand pet device was activated for 1-2 seconds at 6’

Findings:
At 6’, preferably less, a dog approaching casually, will typically turn away abruptly when the Brand pet device is emitting. The pictured Yorkshire Terrier and the dog pictured to its right both abruptly reversed direction at a 6’ range. Both of these dogs seemed startled by the Brand pet device.   However, the pictured German Shepherd was far more casual about changing course. At distances materially greater than 6’ little notable effect could be discerned over many trials with many dogs in many settings.


- Dog rummaging on tipped/loose garbage. Test Procedure...
    1. Verbally prompted
    2. After unsuccessful prompt, the Brand pet device was activated for 1-2 seconds

Findings:
At intimate distances (≤ 4’), tested rummaging dogs typically would abruptly move away from garbage or other foodstuffs on the ground, but sometimes they would return to their previous activity a short time later. However, at greater distances, the desire for the garbage seemed to outweigh the effects of an emitting Brand pet device, and rummaging dogs would continue to rummage as pictured at right and below.




Test subject: Cat

- Cat on a chair less than 6’ away. Test Procedure...
    1. Verbally prompted
    2. After unsuccessful prompt, the Brand pet device was activated for 1-2 seconds

Findings:
Cats proved responsive to an emitting Brand pet device. However, as was observed with dogs, at less than intimate distances, the Brand pet device did not seem to be enough of an incentive to induce the desired behavior, i.e., having the cat get down from a chair. However, as the Brand pet device is moved in towards a seated cat, e.g., 4 - 5’ or less, and activated, tested cats would promptly evacuate their position..., presumably to escape the Brand pet device’s ultrasound emission. The same proved true for a resting cat occupying a favorite perch or spot.



Audio:

Frequency and Power Level Measurements

The frequency and relative Sound Pressure Level (SPL) of each of the four Brand pet device samples were measured and shown in the following table. The SPLs shown were measured at a distance of about one meter, the SPL of unit #3 was not measured as it was in field-use at the time.

Unit #	Frequency, kHz	Relative SPL, dB
1	23.4	71.8
2	23.6	74.4
3	22.5, slightly unstable	?
4	23.2	72.8

One unit, #2, had measurably more output power than the other three units. One unit, #3, showed some frequency instability. The frequency of all units could be varied slightly depending upon how close the ultrasonic transducer was placed to an object.

Attenuation Measurements

We placed various types of materials between a unit and our SPL meter, then measured the apparent attenuation. However, ultrasonic waves can bounce off most hard surfaces, scattering some energy in other directions. We found, for example, that when a unit was placed into, and transmitting, into the open end of a cardboard box, that we could measure more energy being reflected from inside the box, back to the wall behind the open box. Thus, an apparent high-attenuation measurement should be taken with some caution since the SPL meter may have actually been measuring energy that was being reflected around the laboratory. If so, this would mean that the attenuation was actually higher than the measurement seemed to indicate.

The following table shows measured attenuation levels when a material was placed between unit #2 and the SPL meter, which was located ½ meter from the unit.

Material	Apparent Attenuation
Men's cotton dress shirt	negligible
Jeans pocket	20+ dB
Two sheets of paper towel	6 dB
Human hand	~10 dB
15"-cube open-end box	>30 dB
12" x 24" sheet of cardboard	~10 dB
3' x 3' x 1/8" Plexiglass sheet	35+ dB
12" x 12" x 0.2" cork sheet	~20 dB

Note that the men’s dress shirt did not appear to provide any attenuation, whereas placing the unit inside the pocket of a pair of jeans appeared to attenuate the signal very significantly.

Measurements of Attenuation with Distance

One of our more interesting discoveries occurred when we attempted to measure attenuation of unit #2’s signal over distance. We began by setting up a Behringer wideband measurement microphone, model ECM-8000, with a Shark DSP-110 preamplifier unit. This drove our laboratory data computer that was running True Audio’s spectrum analyzer TrueRTA.

We modified unit #2 to operate continuously by jumpering across the pushbutton switch and connecting it to a laboratory power supply. This allowed us to operate the ultrasonic source continuously from an external power supply without having to press the button, as well as avoided errors due to the 9 volt battery depleting due to the constant discharge into the operating unit. Unit #2 and the measurement microphone were then each mounted on their own tripods.

We started off attempting to measure attenuation of unit #2's signal up to a distance of 9 feet, and found the signal level had dropped only about 7 dB, if that. We also found that the ultrasonic transducer of unit #2 appears to radiate most strongly with a pattern apparently like that of a cone, wherein the most radiation seemed to occur along the walls of the cone. The cone angle appeared to be about 10 to 15 degrees. The signal level in the center of the cone (i.e.; when the unit was pointed directly at the microphone) appeared to be about 3 or 4 dB lower than when the unit was slightly offset toward the microphone.

Next, we extended the range to 23-1/2 feet and found the signal level had dropped by about 19 dB compared to 1 foot. This measurement was undertaken across the carpeted lobby of our offices, as seen in the following photos. We then moved the microphone further away, and around a 30-degree hallway corner, out to a distance of about 40 feet, and found the signal had dropped another 10 dB to a total of approximately 30 dB altogether… AND around a corner.

In addition, we found that the heavily-upholstered furniture in our lobby did not appear to attenuate the ultrasonic signal significantly… perhaps by several dB, if that.

The photos on the following page show unit #2 on its tripod, the lobby with the microphone cable running across the lobby and around the corner, and the location of the microphone.

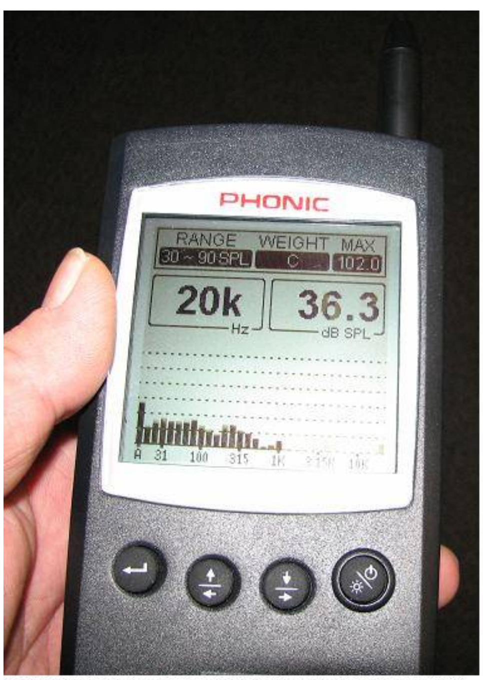
Next, we undertook a long distance test by placing unit #2, on its tripod, at the end of a hallway. We found the signal level had dropped by about 50 dB over 105 feet of hallway. This measurement should not be considered an actual long-distance test, however, since the sound waves are bouncing off the walls, sometimes coming together in phase at some point down the hallway and sounding louder than they normally would, and sometimes arriving out of phase and so cancelling one another out. A true distance test would have to be conducted in a totally open space. Photos of the long-distance hallway test are shown on the following pages.

Looking into the lobby from the doorway of our lab; Unit #2 is at the lower left.

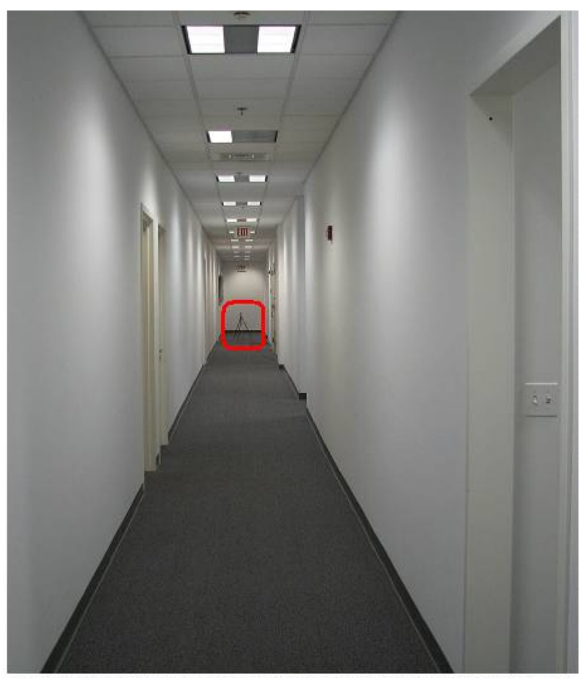
Looking into the doorway of the lab; unit #2 is on the tripod in the red rectangle

From the same vantage point, now looking toward the microphone on its tripod

Looking back into the lobby from behind the microphone



From 105 feet away, unit #2 measured about 36.3 dB SPL, about 50 dB down from one foot away.



A look down the hallway toward unit #2, sitting on its tripod about 105 feet down the hall in the red rectangle.

Sound Level

We conducted exhaustive research into the issue of what level ultrasonic sounds is considered dangerous, both for humans as well as animals. We found very little scientific research on that specific subject, but much research has been conducted and reported as to how, why, when, and where certain animals emit ultrasonic sounds, theirselves. It is well-known, for example, that bats use ultrasound to find insects as well as to navigate. One study found several species of bats generated ultrasound as loud as 120 dB SPL, a level that would be painful to human ears at lower, audible frequencies.

Ultrasound is generally considered to be 20 kHz and up in frequency. Dolphins and some bats use ultrasonic waves as high as 150 kHz, but most animals operate somewhere between 20 and 50 kHz. Most dogs and cats are able to discern ultrasound as high as 47 kHz.

We were unable to unearth any reputable studies or research into what level ultrasound causes pain to animals. There appears to be a considerable amount of controversy over whether ultrasound even makes some animals uncomfortable. There are numerous so-called "pest repellers" on the market that claim to emit sufficiently-loud ultrasonic noises as to cause animals to avoid the generator, but there are apparently numerous professional and scientific studies indicating that ultrasound generally has little effect on animals or insects.

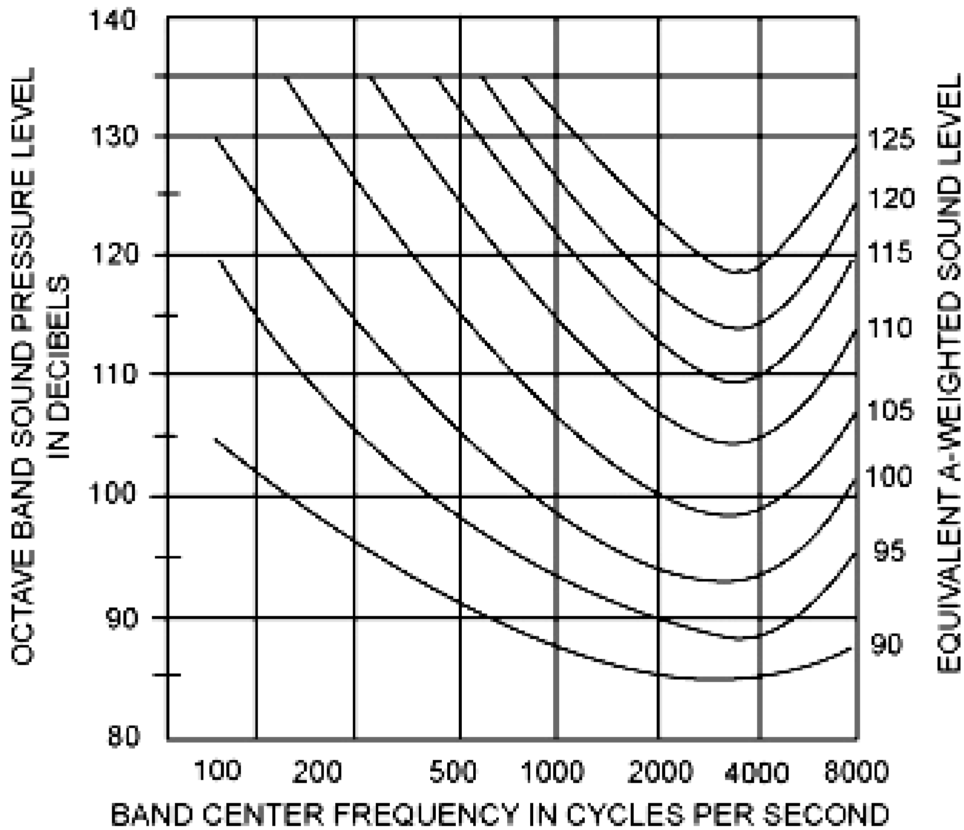
OSHA has long had a standard listing permissible noise levels for the workplace; this is given in Table G-16 of OSHA Standard 1910.95, and is reproduced below.

TABLE G-16 - PERMISSIBLE NOISE EXPOSURES (1)

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

Footnote(1) When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C(1)/T(1) + C(2)/T(2) C(n)/T(n) exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time of exposure permitted at that level. Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

The only reference to frequency that we found is the below chart, also from 1910.95.



Note that the highest frequency shown is just 8 kHz, far below the ultrasonic frequency range.

Some further searching on OSHA's web site found the following at http://www.osha.gov/dts/osta/otm/noise/health_effects/ultrasonics.html:

Appendix I:D. Ultrasonics Applicability of OSHA's Noise Standard, 1910.95

OSHA's noise 1910.95 addresses airborne ultrasonic noise because of OSHA's criterion parameters.

- At 20 kilo-Hertz (kHz), an A-weighted sound pressure level is 10 decibels (dB) below an unweighted sound pressure level.
- At 50 kHz, an A-weighted sound pressure level is 25 dB below the corresponding unweighted level.
    - Example: If an A-weighted instrument is used to measure a 50 kHz, 110-dB tone, the instrument will indicate 85 dBA.[2] Note that the American National Standards Institute's (ANSI) S1.4-1976 or S1.4-1983 standard, which sets the performance and accuracy tolerances that all OSHA sound-level meters must meet, requires a Type II microphone accuracy of only ±5 to 4 at frequencies above 10,000 Hz.

Health Effects and Threshold Limit Values (TLVs®)

[2] The Academy of Pediatrics and the National Campaign for Hearing Health states 85 dB is the threshold for dangerous levels of noise.

- Research indicates that ultrasonic noise has little effect on general health unless there is direct body contact with a radiating ultrasonic source. Reported cases of headache and nausea associated with airborne ultrasonic exposures appear to have been caused by high levels of audible noise from source subharmonics.
- The American Conference of Governmental Industrial Hygienists (ACGIH®) has established permissible ultrasound exposure levels. These recommended limits (set at the middle frequencies of the one-third octave bands from 10 kHz to 50 kHz) are designed to prevent possible hearing loss caused by the subharmonics of the set frequencies, rather than the ultrasonic sound itself.
  - These TLVs® represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech. Previous TLVs® for frequencies in the 10 kHz to 20 kHz range, set to prevent subjective effects, are referenced in a cautionary note below (1). The 8-hour time-weighted average (TWA) values are an extension of the TLVs® for noise, which is an 8-hour TWA of 85 dBA for sound below 10 kHz. The ceiling values may be verified by using an integrating sound level meter with slow detection and 1/3 octave bands. All instrumentation should have adequate frequency response and should meet the specifications of ANSI S1.4-1983 and International Electrotechnical Commission (IEC) 804.
  - Measuring any source suspected of producing sound at levels exceeding the ACGIH® recommended limits requires the use of a precision sound level meter, equipped with a suitable microphone of adequate frequency response, and a portable third-octave filter set. Consult with the Assistant Regional Administrator for Technical Support for guidance.

TLVs® for Ultrasound			
	One-third Octave-Band Level		
	Measured in Air in dB re: 20 µ Pa; Head in Air		Measured in Water in dB re: 1 µ Pa; Head in Water
Mid-Frequency of Third-Octave Band (kHz)	Ceiling Values	8-Hour TWA	Ceiling Values
10	105[A]	88[A]	167
12.5	105[A]	89[A]	167
16	105[A]	92[A]	167
20	105[A]	94[A]	167
25	110[B]	--	172
31.5	115[B]	--	177
40	115[B]	--	177
50	115[B]	--	177
63	115[B]	--	177
80	115[B]	--	177
100	115[B]	--	177

TLVs® for Ultrasound		
	One-third Octave-Band Level	
	Measured in Air in dB re: 20 µ Pa; Head in Air	Measured in Water in dB re: 1 µ Pa; Head in Water

[A]Subjective annoyance and discomfort may occur in some individuals at levels between 75 and 105 dB for the frequencies from 10 kHz to 20 kHz especially if they are tonal in nature. Hearing protection or engineering controls may be needed to prevent subjective effects. Tonal sounds in frequencies below 10 kHz might also need to be reduced to 80 dB.

[B]These values assume that human coupling with water or other substrate exists. These thresholds may be raised by 30 dB when there is no possibility that the ultrasound can couple with the body by touching water or some other medium. [When the ultrasound source directly contacts the body, the values in the table do not apply. The vibration level at the mastoid bone must be used.] Acceleration Values 15 dB above the reference of 1g rms should be avoided by reduction of exposure or isolation of the body from the coupling source. (g = acceleration due to the force of gravity, 9.80665 meters/second; rms = root-mean-square).

Source: ACGIH® Worldwide. 2003 TLVs® and BEIs®: Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices, p.107.

Controls

- High frequency noise is very directional and is relatively easily reflected or blocked by any type of barrier. The wavelength of a 16 kHz tone, for example, is about 3/4 inch, so a barrier of one to two inches higher than the source is generally sufficient to reflect noise of approximately the same frequency away from the nearby worker. Such barriers are inherent in some of the machines and surfaces themselves.
- High frequency audible noise is also easily absorbed by any of the so-called acoustical materials (for example, glass fiber or foam).

The Brand pet device operates at about 22.5 to 23.5 kHz; thus, the applicable "Ceiling Limit" from the table above would be the value at 20 kHz of 105 dB re: 20 µPa. A short explanation of the units of measurement is given below, taken from http://www.resonancepub.com/unwateracou.htm

The commonly used reference pressure level in underwater acoustics is 1 µPa while 20 µPa (which is roughly the human hearing threshold at 1000 Hz) is used as the reference level in air. The reference intensity in water is

$$I_{ref} = p^2_{\ ref} / (D_{water}\ c_{water}) = 6.7 \times 10^{-19}\ W/m^2$$

where reference pressure in water (p_{ref}) is 1µPa rms,

and the density of water (D_{water}) is about 1000kg/m^3,

and the speed of sound in water (c_{water}) is about 1500 m/s.

Historically, the reference intensity in air was the sound intensity barely audible to humans, 1 10^{-12}watts/m^2 or 1 pW/m^2. (A painful (airborne) sound to humans = 10 watts/m^2).

The Sound Pressure Level of the four Brand pet device samples at 10 cm was measured and found to be at least 96 to 99.5 dBA. This level appears to be within the limits above.