

Sonic Focus Processing Evaluation White Paper

CSA 08-7036 ARC Audio

Goal of the study

This paper presents the results of a study by independent consultants Charles Salter Associates (“CSA”). The study investigates the sound pressure level difference to achieve equal loudness with and without the use of the Sonic Focus (SF) algorithm for Windows Media Player audio playback. It was determined that there is a “Loudness advantage” using Sonic Focus. This means that, for an equivalent sound pressure level of Sonic Focus-processed and unprocessed music, the loudness is higher for Sonic Focus. Stated another way, the same loudness between Sonic Focus-processed and unprocessed music could be achieved using a lower sound pressure level at the loudspeakers for SF-processed music.

We conducted three different types of ‘test’ evaluations. The first evaluation calculates the *objective measure of sound level* based on equal-loudness adjustments made by SF personnel. The second evaluation was a *subjective test for equal loudness*. In this evaluation, 5 different subjects adjusted the level of the SF-processed music to be equally loud as non-SF-processed music. The difference in sound level is reported and contains the accuracy of the equal loudness adjustment in the first test. The third evaluation uses objective sound level data and calculates an *objective measure of loudness in sones* using an American National Standard method based on a model of hearing.

Data are shown that indicate an average “loudness advantage” when using Sonic Focus processing. In brief, the loudness advantage ranges from approximately **0.9-2.6 dB**, depending on the type of measurement and the musical material tested. Details and explanations for interpreting these data are given below. Using the more conservative sone loudness calculation the loudness advantage equates to 1.3 decibels.

Since the same loudness can be achieved using a lower sound pressure level with SF, then there are potential advantageous implications for power management and hardware configuration of the computer. These potentially include:

- lower demand on amplifier
- lower power requirements from batteries
- power requirements and physical size of the loudspeakers

Note that this report provides loudness calculation measurements, and does not provide calculations for power or hardware requirements. These calculations can be made based on the data provided.

Details of the study

A single computer (Hewlett-Packard “TouchSmart”) provided by Sonic Focus (SF) was used for all tests. The settings of the SF processing were provided by SF personnel. This includes the playback level as set in Windows Media Player (slider level set to 78). See Appendix “A” for screenshot picture of settings in the “Blackhawk Production Tool” that is part of the SF processing.

Testing was done under “reference” (SF ‘off’) and “test” (SF ‘on’) conditions. Nine representative genres of music provided by SF personnel were evaluated. A representative segment of 7-15 seconds of each musical genre was extracted and continuously looped.

A sound-isolated room at CSA’s testing facility is used for testing. ANSI¹ Type-1 compliant measurement instrumentation (microphones, pre-amps, measurement software-hardware) was used for all testing. The microphone was located at the approximate center of a computer user’s head (43” height, 27” distance from loudspeakers).

For the current study, the interest is in the **relative difference** in loudness (the “loudness advantage”) between the reference and test condition. Absolute loudness calculation will vary as a function of program material, but this is not important since the variation will remain fixed in the calculation of the loudness change.

What is loudness? How is it measured and how does it relate to sound level?

It is important to understand the difference between perceived loudness and sound level. *Loudness* is a subjective term; it refers to the *perceived* level of a sound source, and therefore is a perceptual phenomenon. By contrast, *sound level* refers to an objective measure of sound pressure level; it is a physically-measurable phenomenon. It is important to keep this distinction in mind when evaluating the loudness advantage of SF processing.

When comparing Sonic Focus (SF) processed versus non-SF processed sound, we held either loudness or sound level constant and examine the difference in the other variable. The loudness advantage occurs because, for a given *sound level*, SF processing will be subjectively *louder*. Consequently, for a given loudness, a lower *sound level* was measured if SF processing is used.

Under controlled conditions, a measurement of sound level is both repeatable and predictable. On the other hand, human perceptual response is more variable. It can depend on the type of sound, its timbre, and a number of other human factors.

Results of test evaluation 1: objective measure of sound level

The Sonic Focus processing was pre-adjusted for equal loudness to delivery by SF personnel. What is the difference in level for unprocessed and SF-processed sound, with reference to the unprocessed condition? Figure 1 shows both A-weighted and Linear level differences. The average A-weighted sound pressure level difference is **2.4 dB lower** with a range of 1.8 – 2.8 decibels, depending on the specific music example. For linear sound pressure level differences, the average is **1.7 dB lower** with a range of 0.9-2.6 decibels, depending on the specific music example.

¹ American National Standards Institute

Figure 2 shows the sound pressure level in 1/3 octave bands. SF processing has a lower level over most of the musical octaves above middle C (250 Hz- 4 kHz) but results in a boost at lower bass frequencies (80- 250 Hz).

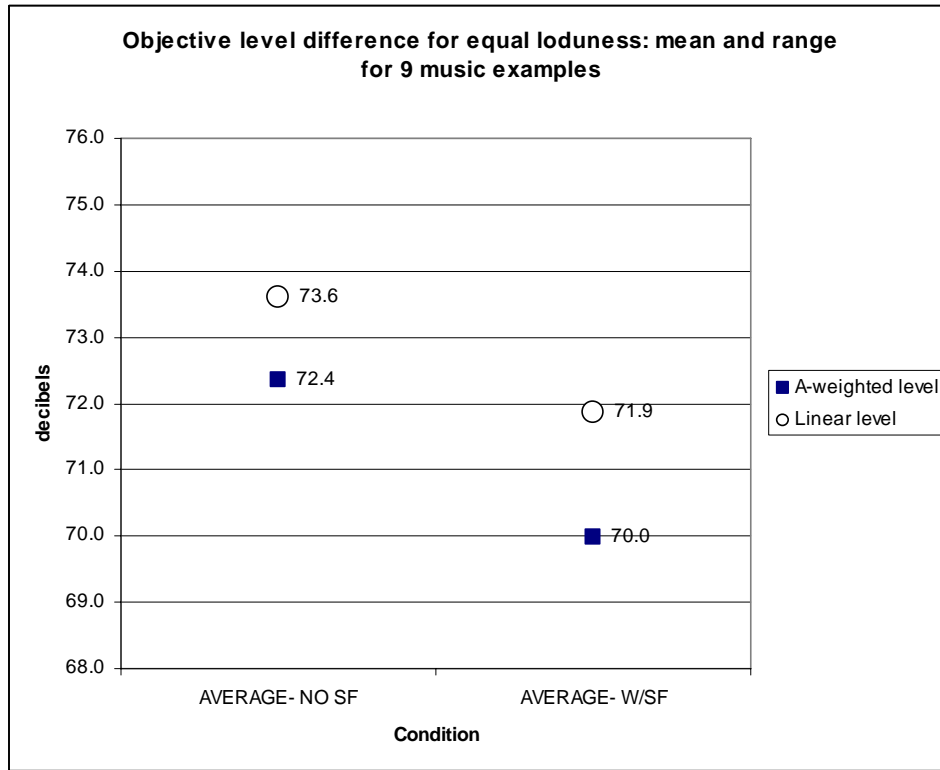


Figure 1. The measured objective levels (Linear and A-weighted) without and with SF processing. The difference is:

In Figure 1, we refer to “A-weighting”. This is a frequency spectrum level adjustment to make sound levels better correspond to human loudness perception, as defined by ISO and ANSI standards. This is the most commonly used metric, but is a simplification of human loudness perception. Figure 3 shows an A-weighting (the linear measurement corresponds to a straight line horizontally at “0” on the y axis).

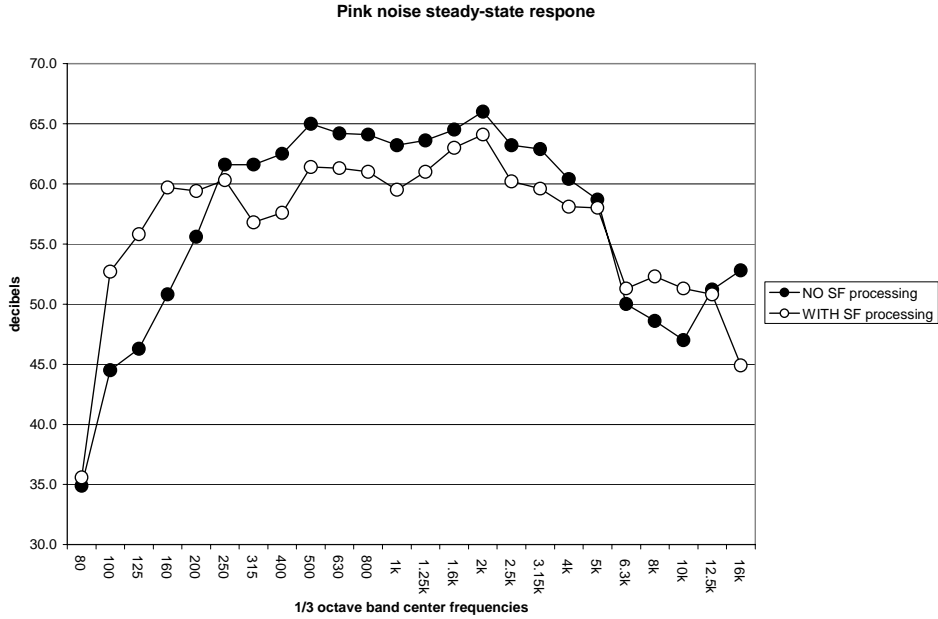


Figure 2. One-third octave band comparison of SF processing, pink noise when set for equal loudness.

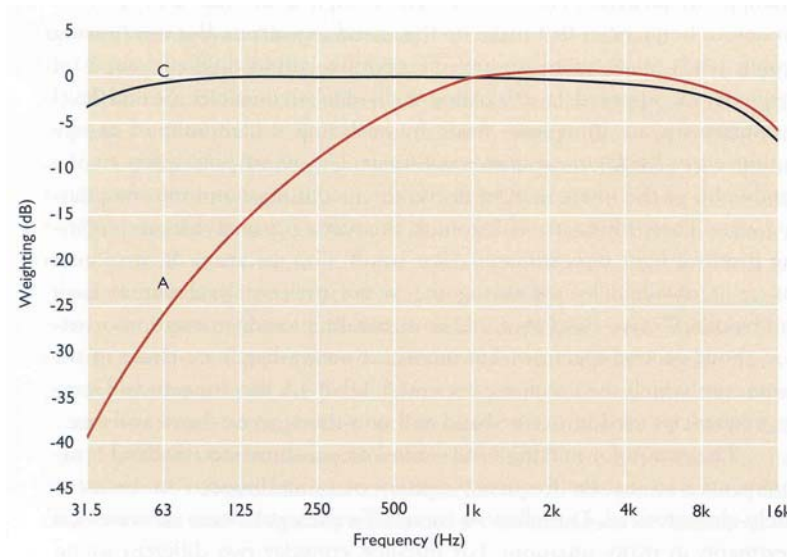


Figure 3. Frequency weightings. The “A” frequency weighting is commonly used to estimate loudness.

Results of test evaluation 2: subjective data

In this test, four subjects adjusted the level of the SF-processed music (the ‘test’ stimuli) to be the same loudness as non-SF-processed music (the ‘reference’ stimuli) in our testing facility. We wanted to determine what difference, if any, there would be in the loudness set by SF personnel and for representatives of the ‘general public’.

The instructions to the subjects were to “compare the reference and the test stimuli for overall loudness, and then ask an assistant who ran the test to adjust the level higher or lower so as to make the reference and test sample have the same overall loudness.” They were asked to “not focus on any single instrument or voice”, but instead to rate their overall impression of loudness. Both the subjects and the experimenter were ‘blind’ to purpose of the experiment and had no interest in the results of its outcome. To prevent any possible visual bias effect, the subjects could not see any numerical indications associated with the change in level of the test material.

The nine test stimuli (musical material loops) were randomized across subjects, as well as the starting level for the test material. The presentation levels were varied using a method similar to that used for an audiogram (a “hearing test”: a quasi-adaptive staircase adjustment that converges from larger to smaller sound level intervals). Each subject could listen to the looped sound example as long as they liked and freely switch between SF-processed and unprocessed sound. They would then tell the lab assistant to adjust the level upward or downward, until they felt the loudness was equal within one decibel.

The results were very consistent amongst the four subjects as seen in Table I. The average level was within **0.15 dB**, or virtually identical, to the level of **2.4 dBA** difference used by SF personnel.

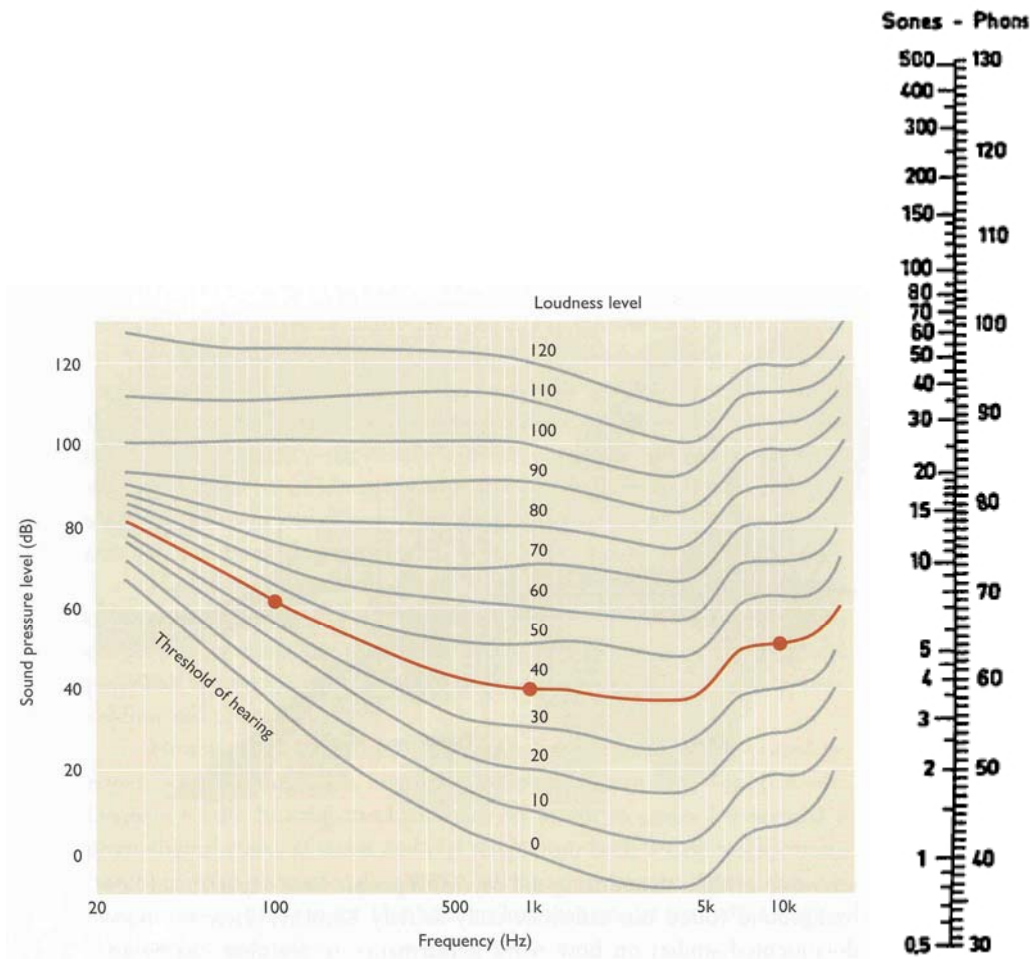
SEQUENCE		SUBJECT				AVERAGE
		1	2	3	4	
1	every breath	-1	0	1	0	0
2	fever	1	2	0	0	0.75
3	dreams	2	0	-2	1	0.25
4	cold heart	-1	2	0	0	0.25
5	sweet emotion	0	0	0	-1	-0.25
6	rollin and tumblin	0	0	1	0	0.25
7	damaged	0	1	-1	0	0
8	clocks	0	1	-1	0	0
9	fly me to the moon	-1	1	0	0	0
10	don't stop_1	0	0	1	0	0.25
	AVERAGE	0	0.7	-0.1	0	0.15

Table 1: subjective results

Results of test evaluation 3: “objective loudness” measurement in sones

It is also possible to measure loudness using a standard unit termed a *son*, as specified in ANSI S3.4-2007 “Procedure for the Computation of Loudness of Steady Sounds”. A Sone is a unit of loudness referenced to a frequency of 1 kHz and a sound level of 40 dB. A doubling of sones corresponds roughly to a doubling of loudness, or 10 dB in sound level.

Figure 5, left, indicates ‘equal loudness contours’ referenced to numerically-indicated levels at 1 kHz known as *phons*. For example, sound frequencies at the location of the dots along the line labeled 40 would sound equally loud. The left dot at 100 Hz is at a 60 dB is as loud as the middle dot at 40 dB, etc. At right is a nomograph for converting phons to *sones*. One can see from the nomograph that, for a 1 kHz tone, each doubling of sones corresponds to a 10 dB increase; for instance, 1 sone = 40 phons = 40 dB; 2 sones = 50 phons = 50 dB; etc.



The calculated loudness was an average of 2.3 sones higher for sonic focus-processed material, compared to non-processed material (range: 1.5 - 3.2 sones across the music material tested). To make the unprocessed material equally loud as Sonic Focus-processed material in sones, the level of unprocessed material would be reduced by an average of 1.3 decibels (range: 0.8 – 1.8 decibels, across the music material tested). This 1.3 decibel value represents the average calculated ‘loudness advantage’.

The advantage is more modest than that observed in the subjective testing since the model is based on a simple model of the relatively complex auditory system’s interpretation of a steady state sound, and is therefore conservative. It does not account for any changes in loudness that might be influenced by the time-varying characteristics of musical material, including differences contained within the stereo signal. Nor can it account for the contribution of factors such as ‘clarity’ or ‘bass enhancement’ that may contribute to a subjective impression of loudness. Nevertheless, it provides further confirmation of the loudness advantage of Sonic Focus that has been presented via the subjective data and the objective measurement of sound pressure level.

Appendix A: Specified settings of Sonic Focus software used in tests

