T E S T R E P O R T

ISO 7779:2010 *Acoustics -- Measurement of airborne noise emitted by information technology and telecommunications equipment*

Orfield Laboratories Inc

Design Research Testing
Acoustics / Vibration / Vision / Lighting / Architecture / Market Research

DEVICES
Puget Systems Serenity PC with:

- Fractal Design R5 solid panel case
- Fractal Design R5 window panel case
- No case (Test Bench PC)

Report Date: 06/25/2015
Test Date: 12/17/2014

TEST SPONSOR
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METHODS
ISO 7779: 2010
ISO 3744: 2010
ISO 11201: 2010
ECMA-74: 2012

The information included in the following report presents the results of sound pressure and sound power testing.

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METHODS

This report presents the results of sound emission testing in accordance with international standards, as follows:

Referenced Standards

ISO 7779: 2010 *Acoustics -- Measurement of airborne noise emitted by information technology and telecommunications equipment*

ISO 3744: 2010 *Acoustics -- Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane.*

ECMA-74: 2012 *Measurement of Airborne Noise emitted by Information Technology and Telecommunications Equipment*

ISO 11201: 2010 *Acoustics -- Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections*

Sound Power Methods

The sound power testing was performed in full conformance with ISO 7779:2010 and ISO 3744:2010. For the sound power testing, the measurement surface selected was the hemispherical surface described in Annex B of ISO 3744:2010. The microphone positions used those with coordinates described in Table B.1. The measurement hemi-sphere radius was 1 meter resulting in a measurement surface area of 6.28 m^2. A diagram of the hemispherical array used is found in Appendix B of this document.

All sound measurements are time-averaged over a period of 30 seconds. Measured values in this report are for use in planning or in determining declared values. They are not to be confused with the declared values.

Operator Sound Pressure Methods

The operator sound pressure testing was performed in full conformance with ISO 7779 and other referenced standards. For the sound pressure testing, the operator position was selected to represent a user seated at a computer keyboard/screen with the central CPU (device under test) placed on the floor next to the device. This arrangement is described in ECMA-74 § C.15.2 and specifically in ECMA-74 figure C.4c. A diagram of the set up is found in Appendix B of this document. An additional bystander position was located at 1 meter out from the front panel of the device under test at a height of 1 meter above the floor (device placed on reflecting plane). This location was selected as the test sponsor indicated that this is a common microphone test location used in the quiet PC industry.

All sound measurements are time-averaged over a period of 30 seconds. Measured values in this report are for use in planning or in determining declared values. They are not to be confused with the declared values.

Measurement Uncertainty

The uncertainty declared for the measurement is based on information in the referenced standards. Since we have no prior knowledge of the standard deviation of reproducibility (σ_{omc}) for the family of machines under consideration, the values for σ_{omc} will be assigned as 0.5 dB. This value is suggested as appropriate for machines with "small variations in time" according to § 9.2 of ISO 3744:2010. The standard deviation of the method (σ_{ro}) is expressed as 1.5 dB in ISO 7779:2010 § 7.2 for the A-weighted values measured. The total standard deviation (σ_{tot}), is calculated from equation 25 in ISO 3744:2010, § 9.1

$$\sigma_{tot} = \sqrt{\sigma^2{}_{RO} + \sigma^2{}_{omc}}$$

where: σ_{ro} = 1.5 dB

σ_{omc} = 0.5 dB

The total expanded uncertainty (U), in decibels is expressed as:

$$U = k\ \sigma_{tot}$$

where: k = 2.0 dB[1]

σ_{tot} = 1.6 dB

Expanded Uncertainty: U = 3.2 dB

SPECIMEN DESCRIPTION

Several devices were tested. The devices were personal computers (PCs). The following is the abbreviated description of the devices tested:

- Puget Systems Serenity Desktop PC with Fractal Design R5 Case and solid side panel
- Puget Systems Serenity Desktop PC with Fractal Design R5 Case and window side panel
- Puget Systems Test Bench PC: Identical operational hardware to Puget Serenity except without any case

Detailed specimen descriptions are found in Appendix A at the end of this document.

[1] The coverage factor k=2 gives a level of confidence of 95% for the expanded uncertainty

OPERATING CONDITIONS

The systems were tested at idle and at CPU workload of 50% using a common CPU test application. Additional tests were carried out at 100% CPU workload as noted. This was described as running the Prime95 Torture Test (100% CPU) while simultaneously running Unigine's Heaven Benchmark to place a workload on the graphics card. The standard CPU load is expressed as 50% in ISO 7779:2010. The devices were connected to a standard 120 VAC, 60 Hz power receptacles.

In accordance with the sound power test method ISO 3744, the device was placed on the center of the reflecting plane.

For operator sound pressure level testing, the device was placed on the floor next to a "standard test table" as specified in ECMA-71 figure C.4c.

RESULT SUMMARY: SOUND PRESSURE LEVELS

OPERATOR POSITION				
MEASURED SOUND PRESSURE LEVEL VALUES IN ACCORDANCE WITH ISO 7779:2010				
		Puget Systems Serenity PC		
		Fractal Design R5 Case with solid side	Fractal Design R5 Case with window side	Test Bench (no case)
Measured A-weighted sound pressure level in decibels (0 dB=20μPascals)	dBA @ operator idle	1.4*	1.3*	16.1
Measured A-weighted sound pressure level in decibels (0 dB=20μPascals)	dBA @ operator5 0% Load	2.3*	2.7*	16.7
Measured A-weighted sound pressure level in decibels (0 dB=20μPascals)	dBA @ operator1 00% Load	21.2	21.9	28.7

* SPL at operator and 1m was within 6dB of background noise. Therefore value is "upper bounds" of sound pressure level

The reported operator locations value were measured as described in ECMA-74 § C.15.2 and specifically in ECMA-74 figure C.4c.

NOTE: The sum of a measured noise emission value and its associated uncertainty represents an upper boundary of the range of values that are likely to occur in measurements (measured value +/- U). The expanded uncertainty for these measurements is estimated at U=3.2 dB.

1M OUT, 1M UP

MEASURED SOUND PRESSURE LEVEL VALUES IN ACCORDANCE WITH ISO 7779:2010

		Puget Systems Serenity PC		
		Fractal Design R5 Case with solid side	Fractal Design R5 Case with window side	Test Bench (no case)
Measured A-weighted sound pressure level in decibels (0 dB=20μPascals)	dBA @ 1m out, 1m up idle	0.9*	0.9*	17.1
Measured A-weighted sound pressure level in decibels (0 dB=20μPascals)	dBA @ 1m out, 1m up 50% load	2.5*	3.0*	17.5
Measured A-weighted sound pressure level in decibels (0 dB=20μPascals)	dBA @ 1m out, 1m up 100% load	21.8	22.5	28.5

* SPL at operator and 1m was within 6dB of background noise. Therefore value is "upper bounds" of sound pressure level

The reported operator locations value were measured as described in ECMA-74 § C.15.2 and specifically in ECMA-74 figure C.4c.

NOTE: The sum of a measured noise emission value and its associated uncertainty represents an upper boundary of the range of values that are likely to occur in measurements (measured value +/- U). The expanded uncertainty for these measurements is estimated at U=3.2 dB.

RESULT SUMMARY: SOUND POWER LEVELS

MEASURED SOUND POWER LEVEL VALUES IN ACCORDANCE WITH ISO 7779:2010

		Puget Systems Serenity PC		
		Fractal Design R5 Case with solid side	Fractal Design R5 Case with window side	Test Bench (no case)
Measured A-weighted sound power level, L_{WA} (0 dB=1ρW), in decibels	dBA @ operator idle	15.7*	15.8*	28.0
Measured A-weighted sound power level, L_{WA} (0 dB=1ρW), in decibels	dBA @ operator5 0% Load	18.3	18.3	29.0

***** Measured sound power was within 6dB of background noise. Therefore value is "upper bounds" of sound power level

The reported sound power values were measured in accordance with ISO 7779:2010 and ISO 3744:2010.

NOTE: The sum of a measured noise emission value and its associated uncertainty represents an upper boundary of the range of values that are likely to occur in measurements (measured value +/- U). The expanded uncertainty for these measurements is estimated at U=3.2 dB.

ACOUSTICAL ENVIRONMENT

Anechoic Chamber Dimensions = 5.4 x 4.8 x 4.2 meters wall to wall
= 3.7 x 3.1 x 3.5 meters wedge tip to tip

Anechoic Chamber Construction:

Structure	Material
walls and ceiling	prefabricated steel panels w/.85 meter fiberglass wedges
floor	25mm (2 x 12.5mm) OSB sandwich w/damping compound

The chamber meets the requirements of anechoic and hemi-anechoic precision grade sound power measurement. Therefore, no environmental k factor is applied (k_2 = 0dB) to measurements in this report, as indicated in Annex A of ISO 3744:2010. The test chamber was qualified per ISO 3745:2012 Annex A[2]. Documentation is available upon request*. The frequency range of qualification is 100Hz to 10,000 Hz.

Background noise levels below 0dBA were documented at the beginning and end of the test session. A-weighted measurements were handled in accordance with the corresponding standards regarding background noise. In all cases background noise criteria were met or exceeded.

[2] *Orfield Laboratories, Inc. has been accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under their National Voluntary Laboratory Accreditation Program (NVLAP) for the ISO 3745 procedure. This report shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the U.S. Government.*

The following environmental conditions were present in the hemi-anechoic chamber during the test.

Environmental Conditions

date	December 17, 2014
temperature	20°C (68°F)
relative humidity	40%
barometric pressure	102.125 kPa (30.12" Hg)

INSTRUMENTATION

Description	Manufacturer	Model#	Serial #
Analyzer	Norsonic	121	31185
Sound Level Calibrator	Brüel & Kjær	4230	1103933
Low Noise 1" Condenser Microphone	Brüel & Kjær	4179	1097574
Low Noise 1" Condenser Microphone	Brüel & Kjær	4179	1865152
Low Noise Microphone Preamplifier	Brüel & Kjær	2660	1097406
Low Noise Microphone Preamplifier	Brüel & Kjær	2660	1885025
Microphone Power Supply	Brüel & Kjær	WB 1057	none

Copies of current calibration logs and certificates are kept on file at the laboratory. All calibrations used are traceable to NIST (the National Institute of Standards and Technology) and were performed at Scantek, Inc. in Columbia, MD.

Before and after the testing, the equipment was calibrated using the reference sound level calibrator, and no irregularities were found.

REMARKS

The test results contained in this report pertain only to the sample submitted for testing and not necessarily to all similar products.

The test sponsor has full control over this information and any release of information will be only to the test sponsor. The specific testing results are deemed to be confidential exclusively for the test sponsor's use. Reproduction of this report, except in full, requires written approval by Orfield Laboratories, Inc.

APPENDIX A: DETAILED DEVICE DESCRIPTIONS

The following detailed descriptive data were provided by the test sponsor.

Test Subjects:

1. **Puget Systems Serenity Desktop PC Option 1**

Description: This test unit is a desktop computer system that can be custom configured by the customer within a preset list of options on the manufacturers website. The focus of this product is quiet computing.
Manufacturers Description: At its core, the Puget Serenity is an incredibly quiet computer. We have poured years of experience into this configuration to achieve the most quiet high performance computer available on the market. There are many resources you can find online (and even our site) that will show you the components necessary to build a quiet computer, but it's simply not possible to build a system with the stability, reliability, performance and silence of a Serenity without the tools that we have here at Puget Systems.
*Note: Identical to Puget Systems Serenity Desktop PC Option 2 listed below, except that this version features a SOLID side panel
Purpose with regards to testing:

A.) Replicate a common enthusiast level desktop PC system indicative of high performance hardware that could/would be used in PC gaming usage scenarios and/or professional capacities such as content creation.
B.) Illustrate the sound-deadening/noise level reduction capabilities of the Fractal Design Define R5 Midtower ATX PC case as compared to the Puget Systems EATX V1 DIY Kit. Specifically regarding noise level reductions of the combined PC component audio levels inside the Fractal Design Define R5 Midtower ATX PC case vs open air (test bench; no sound deadening)
C.) Comparative noise level readings between the Solid Panel and Window Panel variants of the Fractal Design Define R5 Midtower ATX PC case.

Hardware Specifications
Case: Fractal Design Define R5 Solid Side Panel variant (Model Number: FD-CA-DEF-R5-BK)
Processor: Intel Core i7 4790K 4.0GHz Quad Core 8MB 88W
Motherboard: Asus Sabertooth Z97 Mark 2
Graphics Card: Asus GeForce GTX 980 4GB STRIX DirectCU II OC
Memory: Kingston 16GB DDR3-1600 (2x8GB)
Processor Heatsink: Gelid Tranquillo Rev3
Processor Heatsink Fan: Scythe Slipstream 120mm (Model Number: SY1225SL12SL)
Power Supply: Seasonic X-1050 1050W Power Supply
Solid State Drive: Samsung 840 EVO 250GB SATA 6Gb/s 2.5inch SSD
Intake Fan: Scythe Slipstream 120mm (Model Number: SY1225SL12SL)
Exhaust Fan: Fractal Design GP14 Dynamic 140mm Fan (Model Number: FD-FAN-DYN-GP14-WT)
Operating System: Windows 8.1 64-bit OEM

2. Puget Systems Serenity Desktop PC Option 2

Description: This test unit is a desktop computer system that can be custom configured by the customer within a preset list of options on the manufacturers website. The focus of this product is quiet computing.

Manufacturers Description: At its core, the Puget Serenity is an incredibly quiet computer. We have poured years of experience into this configuration to achieve the most quiet high performance computer available on the market. There are many resources you can find online (and even our site) that will show you the components necessary to build a quiet computer, but it's simply not possible to build a system with the stability, reliability, performance and silence of a Serenity without the tools that we have here at Puget Systems.

*Note: Identical to Puget Systems Serenity Desktop PC Option 1 listed above, except that this version features a WINDOW side panel

Purpose with regards to testing:

A.) Replicate a common enthusiast level desktop PC system indicative of high performance hardware that could/would be used in PC gaming usage scenarios and/or professional capacities such as content creation.

B.) Illustrate the sound-deadening/noise level reduction capabilities of the Fractal Design Define R5 Midtower ATX PC case as compared to the Puget Systems EATX V1 DIY Kit. Specifically regarding noise level reductions of the combined PC component audio levels inside the Fractal Design Define R5 Midtower ATX PC case vs open air (test bench; no sound deadening)

C.) Comparative noise level readings between the Solid Panel and Window Panel variants of the Fractal Design Define R5 Midtower ATX PC case.

Hardware Specifications

Case: Fractal Design Define R5 Window Side Panel variant (Model Number: FD-CA-DEF-R5-BK-W)
Processor: Intel Core i7 4790K 4.0GHz Quad Core 8MB 88W
Motherboard: Asus Sabertooth Z97 Mark 2
Graphics Card: Asus GeForce GTX 980 4GB STRIX DirectCU II OC
Memory: Kingston 16GB DDR3-1600 (2x8GB)
Processor Heatsink: Gelid Tranquillo Rev3
Processor Heatsink Fan: Scythe Slipstream 120mm (Model Number: SY1225SL12SL)
Power Supply: Seasonic X-1050 1050W Power Supply
Solid State Drive: Samsung 840 EVO 250GB SATA 6Gb/s 2.5inch SSD
Intake Fan: Scythe Slipstream 120mm (Model Number: SY1225SL12SL)
Exhaust Fan: Fractal Design GP14 Dynamic 140mm Fan (Model Number: FD-FAN-DYN-GP14-WT)
Operating System: Windows 8.1 64-bit OEM

3. Test Bench PC

Description: This test unit is a desktop test-bench computer system. This product is designed for computer enthusiasts that prefer to have rapid and easy access to their computer components. The focus of this product is usage scenarios in which swapping or changing hardware quickly is a priority, such as overclockers, hardware testing personnel and those that commonly run benchmarking programs on various PC hardware.

Manufacturers Description: Test benches are certainly nothing new and are something we have been using at Puget Systems ever since the company was founded. However, we have never found a test bench that completely suits all of our needs. Because of this we finally decided to spend the time and effort to design and build our own unique bench based on the needs of our repair and production departments.

A test bench is an excellent alternative to a traditional chassis if you need to regularly swap out hardware. While primarily designed to be used as a temporary test bench with all the hardware loose, the Puget Systems EATX V1 Test Bench has full mount points for the motherboard, PCI cards, power supply, and up to two 2.5" hard drives. In addition, there is also a half-mount for a 5.25" optical drive. So if you want to make any part of your test setup more permanent, it is very easy to do so.

*Note: This system features an identical hardware configuration to the Puget Systems Serenity Desktop PC Option 1 and Puget Systems Serenity Desktop PC Option 2l isted above, with the exception of housing/case. The purpose of this unit is for comparative purposes of the sound level of the component configuration itself without any forms of sound dampening as applied the Fractal Design Define R5 case.

Purpose with regards to testing:

A.) Replicate a common enthusiast level desktop PC system indicative of high performance hardware that could/would be used in PC gaming usage scenarios and/or professional capacities such as content creation.

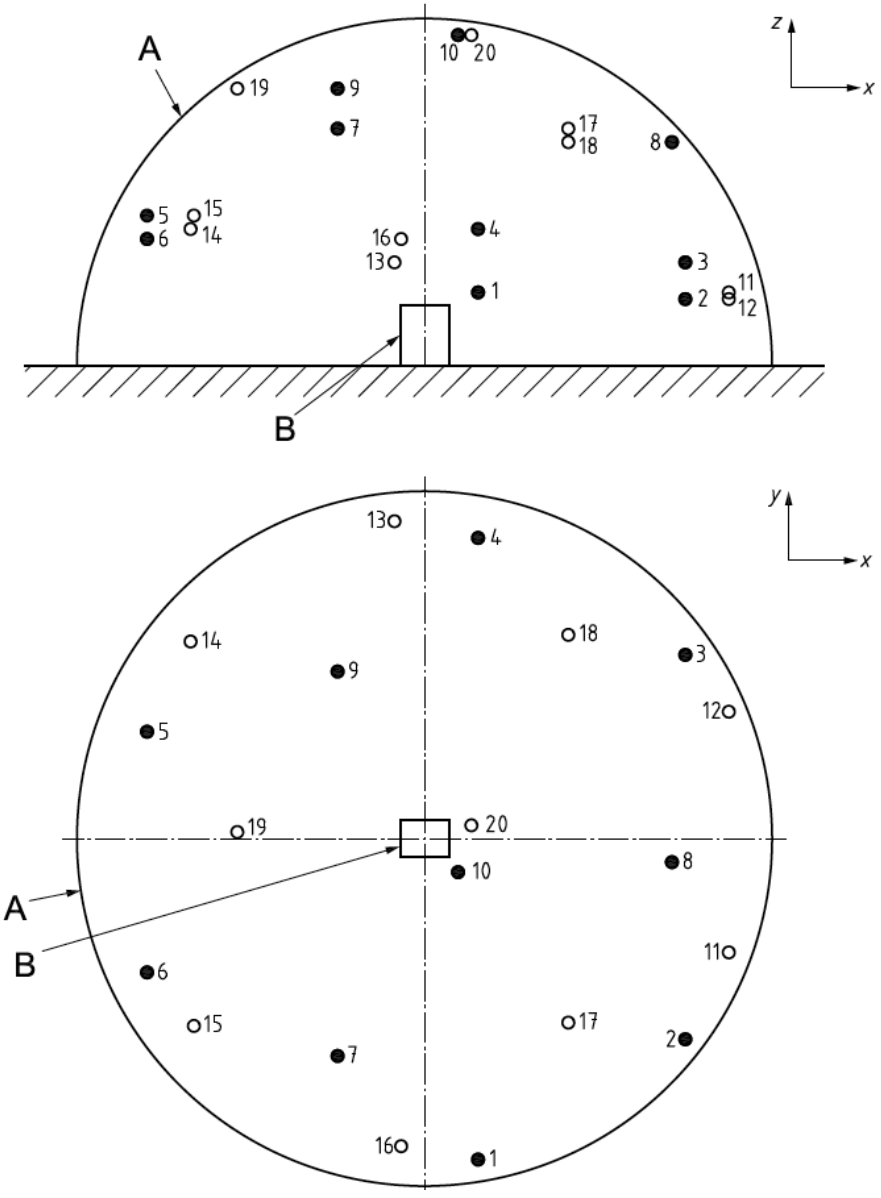
B.) Illustrate the noise level of the combined PC component audio levels without the benefit of sound deadening attributes.

Hardware Specifications

Case: Puget Systems Test Bench EATX V1 DIY Kit
Processor: Intel Core i7 4790K 4.0GHz Quad Core 8MB 88W
Motherboard: Asus Sabertooth Z97 Mark 2
Graphics Card: Asus GeForce GTX 980 4GB STRIX DirectCU II OC
Memory: Kingston 16GB DDR3-1600 (2x8GB)
Processor Heatsink: Gelid Tranquillo Rev3
Processor Heatsink Fan: Scythe Slipstream 120mm (Model Number: SY1225SL12SL)
Power Supply: Seasonic X-1050 1050W Power Supply
Solid State Drive: Samsung 840 EVO 250GB SATA 6Gb/s 2.5inch SSD
Intake Fan: Scythe Slipstream 120mm (Model Number: SY1225SL12SL)
Exhaust Fan: Fractal Design GP14 Dynamic 140mm Fan (Model Number: FD-FAN-DYN-GP14-WT)
Operating System: Windows 8.1 64-bit OEM

APPENDIX B: TEST SETUP DIAGRAMS

Microphone positions for sound power tests (pos. 1-10 used) From ISO 3744:2010 Figure B.1



Microphone positions for sound power tests: From ISO 3744:2010 Table B.1

Table B.1 — Preferred microphone positions for all noise sources

Position number	*x*/*r*	*y*/*r*	*z*/*r*
1	0.16	– 0.96	0.22
2	0.78	– 0.60	0.20
3	0.78	0.55	0.31
4	0.16	0.90	0.41
5	– 0.83	0.32	0.45
6	– 0.83	– 0.40	0.38
7	– 0.26	– 0.65	0.71
8	0.74	– 0.07	0.67
9	– 0.26	0.50	0.83
10	0.10	– 0.10	0.99

Operator microphone location (top view) for sound pressure tests. From ECMA-74 Figure C.4c. Microphone height is 1.2 meters above reflecting plane