Cybenetics Cooling Solutions Test Protocol

Revision 1.5

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Revision History

Version	Release Date	Notes
1.0	December 2020	First draft
1.1	May 2021	Grammatical edits
1.2	June 2021	Minor fixes
1.3	December 2023	Major revision
1.4	January 2025	Major revision
1.5	August 2026	Climate chamber section added, including the reasoning for holding ambient temperature constant instead of applying a delta correction. Repeatability (at least two sessions, averaged), the AIO pump condition, average-CPU-frequency reporting and the noise measurement uncertainty are now stated explicitly.

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Prologue

Evaluating the performance of cooling solutions on real hardware might be the easiest and most widely used method, but it has many shortcomings. For example, you cannot set a desired load and keep it steady. Moreover, you are bound to hardware changes, and once the need arises to move to a new platform, you need to erase your entire database and start fresh since the results from the new hardware won't be compatible with the previous ones. All the issues mentioned above and some other smaller ones led us to build a test system for evaluating cooling solutions, which we call Jalapeno.

After several years of using Jalapeno, we realized that the performance differences we noticed weren't reflected in real-world usage. Hence, we had to change our methodology again and use real hardware for our tests.

Test Equipment

We use high-end Intel and AMD systems for all of our cooling solution evaluates, with increased heat loads that push most cooling solutions to the limit. The major issue when using real and not simulated load is that with every hardware change you have to completely erase the performance database, but despite this major downside we strongly believe that using real hardware for cooling evaluations is a one way road.

Intel Test System Specs	
Mainboard	ASRock Z890 Taichi [BIOS: 2.09.AS01 – Nov 4, 2024]
CPU	Intel Core Ultra 9 285K (Intel Default Mode)
GPU	-
NVMe	XPG GAMMIX S50 Lite 1TB
RAM	Gskill Ripjaws S5 DDR5 (2 x 16GB) 6000MHz
Power Supply	Seasonic Vertex 1200W (Cybenetics Platinum)
Case	DimasTech Bench
Ambient Temperature	25°C ±0.5°C
Humidity	30% ±4%RH
Load Application	Prime (Small FFTs) running for 20 minutes per test 10 minute cooler period between each test

ATE Software	Chassis Thermal Performance v 6.45 – Cybenetics LTD

AMD Test System Specs	
Mainboard	Asus TUF GAMING X670E-PLUS
CPU	AMD Ryzen 9 7900x (PBO Enabled)
GPU	-
NVMe	XPG GAMMIX S50 Lite 1TB
RAM	XPG Lancer DDR5 (2 x 16GB) 6000MHz
Power Supply	Seasonic Vertex 1200W (Cybenetics Platinum)
Case	Cooler Master Test Bench
Ambient Temperature	25°C ±0.5°C
Humidity	30% ±4%RH
Load Application	Prime (Small FFTs) running for 20 minutes per test 10 minute cooler period between each test
ATE Software	Chassis Thermal Performance v 6.45 – Cybenetics LTD

We also use the following equipment besides the system shown above.

- Corsair Commander Pro (Fan controller) [1]
- Pico TC-08 (Thermocouple data logger) [2]
- Giant Force Climate Chamber (GTH-800-20-CP-AR)
- Cybenetics Powenetics v2 PMD (Power Measurements Device) [3]

Climate Chamber Technical Specifications:

- Manufacturer: Giant Force
- Model Number: GTH-800-20-CP-AR
- Temp Range: -20°C ~ +100°C
- Humidity Range: 20% ~ 98% RH
- Temp/humidity Constancy: ±0.2°C; ±2.5%RH
- Temp/humidity Uniformity at center: ±0.5°C; ±4%RH
- Indication Resolution:
- Internal Dimensions (WHD): 100 x 100 x 80 cm
- External Dimensions (WHD): 145 x 190 x 135 cm
- Net Weight (approx): 450 kgs
- Heat-up Time (No load, no linear): (from 20°C to +100°C) 30min
- Pull-down Time (No load, no linear): (from 20°C to -20°C) 50min
- Cooling System: Airtight compressor + evaporator fins + air-cooling condenser
- Power Source: 3Φ AC 380V ±5%, 50Hz±1% 10KW
- Based on Standards: ISO 5801-2007, AMCA 210-0, ASHRAE 51-2007, IEC 61591-2005, GB/T 1236-200

We use a hemi-anechoic chamber with an extremely low noise floor for all measurements at around 6 dBA to measure noise output. The DUT is installed in the chamber, and the schemes provide a detailed overview of the mic and DUT's positions inside the chamber.

The measuring microphone is positioned so that it forms a 30° to 45° degree angle with the horizontal axis, and its vertical distance from the object of measurement is one meter.

Climate Chamber

All thermal performance tests are conducted inside a Giant Force GTH-800-20-CP-AR climate chamber, which holds the ambient temperature steady for the whole of every test. This matters more than it may appear. The common alternative is to report the difference between the CPU temperature and the room temperature, the so-called delta, and to treat that difference as independent of the room. In our experience it is not. Once we began testing inside a controlled chamber it became clear that delta-corrected results taken at different room temperatures do not agree with each other. Holding the ambient fixed removes the correction altogether, so every cooler in our database is measured under the same conditions rather than mathematically adjusted to them.
Climate chamber specifications:
Temperature range: -20 °C to +100 °C
Humidity range: 20 % to 98 % RH
Temperature and humidity constancy: ±0.2 °C, ±2.5 % RH
Temperature and humidity uniformity at the centre: ±0.5 °C, ±4 % RH
Internal dimensions (W x H x D): 100 x 100 x 80 cm
Based on standards: ISO 5801:2007, AMCA 210, ASHRAE 51-2007, IEC 61591:2005, GB/T 1236

The chamber is set to 25 °C and 30 % relative humidity for all cooler tests. Noise measurements are taken separately, in the hemi-anechoic chamber, at 25 °C ±2 °C and 40 % to 50 % relative humidity.

Noise Measurement Procedure In Detail

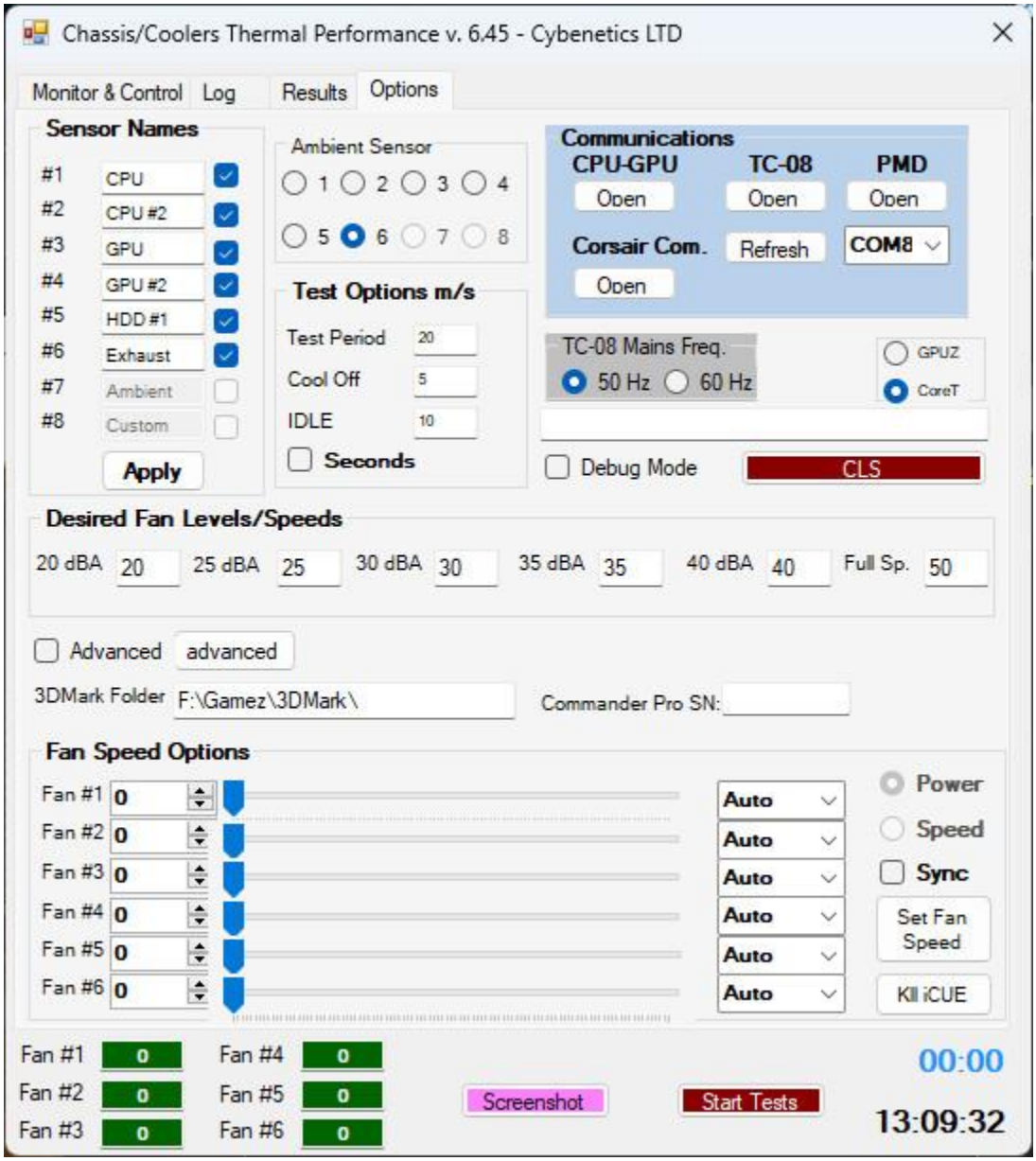
We turn on the sound meter Bruel & Kjaer G-4 Type 2270 [4] 15 to 30 minutes before starting the measurements to allow it to reach operational temperature.

Before we start the measurements, we calibrate the sound meter using the Bruel & Kjaer Sound Calibrator Type 4231 [5].

We install the cooling solution in the chamber vertically to the microphone, in a fixed position (see Photo 1), to have the same conditions in each measurement. In all tests, the cooler's fan(s) pushes air perpendicular to the microphone direction.

Photo 1

We utilize a Corsair Commander Pro [1] to control the cooling fan(s) using custom software developed by our team. In addition, the Commander Pro is driven by a passively operating system that doesn't affect the chamber's noise floor.



Our software allows for precise fan speed adjustments in both RPM (fan speed control) and percentage of operation (PWM control).

We measure the noise the fan(s) produces at 40% - 100% of their maximum speed in 10% increments. Next, we change the fan speed by reversing the measurements' logic to achieve 20, 25, 30, 35 dBA, and 40 dBA noise output. We log the corresponding speeds.
The expanded uncertainty of our noise measurements is ±1.23 dB (k = 2, approximately 95 % confidence), evaluated in our controlled uncertainty records and applied across all Cybenetics noise testing. Thermal measurements are not covered by that figure; they are reported as measured, under the chamber conditions stated above.

Thermal Performance Evaluation: Procedure

To conduct the thermal performance tests, we use the software described above and the measurements we took during the noise tests. This is why we need to run noise testing first.

Specifically, we use the fan speed measurements from the 20, 25, 30, 35, and 40 dBA noise output levels and the maximum fan speed. If the cooler has more than one fan, we take the readings from all fans.

We install the Device Under Test (DUT) inside the climate chamber, setting the ambient temperature at 25°C (77°F) and the humidity at 30%. Then, we connect the Pico TC-08 thermocouple data logger [2] to two thermal probes: one measuring ambient temperature and another one measuring the cooler's exhaust temperature.

To ensure that the cooler's base is seated correctly on the test system, we ensure that the mounting system is fully secured. We also ensure it makes proper contact by inspecting it after the tests are finished to see if the thermal paste covers the entire surface evenly.

We use the same thermal paste in all our tests for comparable results. Our choice is Arctic Cooling MX-4.

Photo 2

The DUT's fans are connected to the Corsair Commander Pro to have complete control over them. Both the Corsair Commander Pro and the Pico TC-08 are controlled and monitored by our software, and the same applies to Powenetics V2, which provides vital information, including CPU speed, temperatures, and accurate power consumption, measuring the PSU's corresponding connector outputs.

All tests run automatically through our software without the intervention of a test engineer, except for the initial settings required at the very beginning of the procedure. Each noise level's testing procedure lasts 20 minutes with a 10-minute cool-down period.

Every cooling solution is tested in at least two complete sessions, and the figures we publish are the average of those sessions. A single session is never published on its own.
In all-in-one liquid coolers the pump runs at full speed throughout every test. Only the fans are varied, so the pump never becomes an uncontrolled variable between one noise level and the next.

Thermal Performance Evaluation: Details

Some cooling solutions don't reach a noise level of 40 dBA at a one-meter distance; in some cases, we have measured coolers that don't even reach 35 dBA. This is why comparing these coolers with all the rest at the same noise output level is essential. It makes sense when a noisy cooler equipped with strong fans achieves better temperatures than a low-noise cooler, but what happens when we normalize noise output and force both of them to operate with the same noise output levels? Things get interesting here, and you can compare apples to apples.

Thermal Performance Evaluation: Duration & Results

The average duration of all thermal performance tests is approximately three hours, depending on how many output noise levels the DUT can achieve. For example, noisy coolers can run all noise output scenarios, from 20 dBA up to 40 dBA, and we also have to add the full fan speed test.

Once all tests are finished, we enter the results into our database for further analysis. All results are gathered automatically and can be exported in various formats.

Thermal Performance: Data analysis

We compare the coolers at maximum fan speed and full load, and we also make comparisons at lower fan speeds and lower noise output. It goes without saying that a noisy cooler with strong fans will have an advantage over coolers using weaker fans, but users might have a problem with the increased noise of the stronger fans. This is why noise-normalized testing is essential. Moreover, during these tests, we can also determine which cooling solutions are the most noise-effective, allowing for higher fan speeds at the same levels.

For example, two coolers equipped with similar airflow performance.

For example, if cooler "A" has a 1000 RPM average fan speed at 30 dBA and cooler "B" has a fan of similar characteristics operating at an average speed of 1400 RPM at the same noise level, cooler "B" has a clear advantage since its fans push more air and possibly provide higher static pressure. Fan performance is also crucial, especially their static pressure performance, which is critical for coolers with dense fins.

We also record the processor's average operating frequency over each test. Modern processors do not hold a fixed clock: frequency moves continuously with load and with die temperature, so a better cooler is rewarded with a higher sustained frequency as well as a lower temperature. Reading temperature alone would credit two coolers equally when one of them in fact allowed the processor to run faster throughout the test. Powenetics v2 measures the CPU power draw continuously at up to 250 samples per second, so the frequency is always interpreted alongside the power that produced it.

Epilogue

Evaluating the performance of cooling solutions is far from straightforward since many factors come into play, from the thermal paste that you will use to the installation of the cooling system on the CPU, the selected fan speed profile, and the mounting of the fans. Every detail counts, and in real CPUs, you cannot precisely dial the thermal load you want to apply to the cooler. But we measure the CPU's power consumption through Powenetics v2 with a polling rate that reaches 250 measurements per second.

Moreover, it is crucial to consider the cooler's output noise because it is natural that a noisy cooler can perform better than a dead silent one. However, more and more users seek quiet cooling solutions, with some proceeding to fan changes to achieve this. So, including the output noise in the testing results is vital, and tests should not just be run at full fan speed.

References

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