Cybenetics Cooling Solutions Test Protocol

Revision 2.2

Author: *Aristeidis Bitziopoulos*

Nicosia, Cyprus

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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.
1.6	September 2026	Test systems described as power-hungry rather than high-end. Climate chamber specifications presented as a table. Removed a stray page break that left most of a page blank.
1.7	September 2026	Climate chamber specifications completed from the manufacturer's data sheet; the duplicate screenshot of the same data removed.
1.8	September 2026	Removed an incomplete sentence left over from editing; the example it began is given in full in the paragraph that follows.
2.0	October 2026	THETA cooling performance standard added. Each noise level runs for at least 10 minutes and is extended only until stable, with an objective stability rule and a 20-minute limit. Cool-down lasts at least 5 minutes and includes an idle-stability check. Published run values use the last 4 minutes. One mount is used per platform. Controller operation updated, Intel BIOS detail removed, and new microphone and timing diagrams added. The entire method was reviewed for consistency and clarity; outdated software imagery was removed. References re-checked and updated.
2.1	October 2026	Paragraph and heading spacing made consistent throughout. No change to the text or to the method.
2.2	October 2026	THETA divided into two classes, air coolers and AIO liquid coolers, each with its own requirements on each platform; Diamond set about 2.5% above the best cooler of each class; the badge names the class, e.g. THETA Gold · Air · AMD AM5; all existing THETA levels re-assessed from their measurements.

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Prologue

We initially built a test system called Jalapeno to evaluate cooling solutions with a simulated thermal load. Testing on real hardware does not let us set an arbitrary thermal load and hold it exactly, and results also depend on the hardware platform. Jalapeno was intended to address these limitations.

After several years of using Jalapeno, we found that the performance differences it showed were not reflected in real-world use. We therefore returned to real hardware for our cooler evaluations; Jalapeno is no longer used for this method.

Test Equipment

We use power-hungry Intel and AMD systems for all our cooling solution evaluations, with heat loads that push most coolers to their limits. The results belong to the platform on which they were measured, so results from different platforms are not directly interchangeable. We retain the earlier results with their platform identification. The THETA section explains how we establish new requirements when a platform changes.

Intel Test System Specs	
Mainboard	ASRock Z890 Taichi
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	Prime95 (Small FFTs) running for 10 minutes per test (or till temperature stabilizes) 5 min cooler period between each test
ATE Software	Chassis/Coolers Thermal Performance v7.27 or later – 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	Prime95 (Small FFTs) running for 10 minutes per test (or till temperature stabilizes) 5 min cooler period between each test
ATE Software	Chassis/Coolers Thermal Performance v7.27 or later – Cybenetics LTD

We also use the following equipment alongside the test systems described above.

- Fan control by the Corsair Commander Pro [1] or by the cooler's own controller, driven directly by our software
- Pico TC-08 (Thermocouple data logger) [2]
- Giant Force Climate Chamber (GTH-800-20-CP-AR)
- Cybenetics Powenetics v2 PMD (Power Measurements Device) [3]

We measure noise output in a hemi-anechoic chamber with a noise floor of about 6 dBA. We install the Device Under Test (DUT) in a fixed position so that the cooler and microphone have the same geometry in every measurement, as shown in Figure 1.

We position the measuring microphone at an angle of 30° to 45° to the horizontal, with a vertical distance of 1 m between the microphone and the object of measurement. The cooler's airflow is perpendicular to the microphone axis.

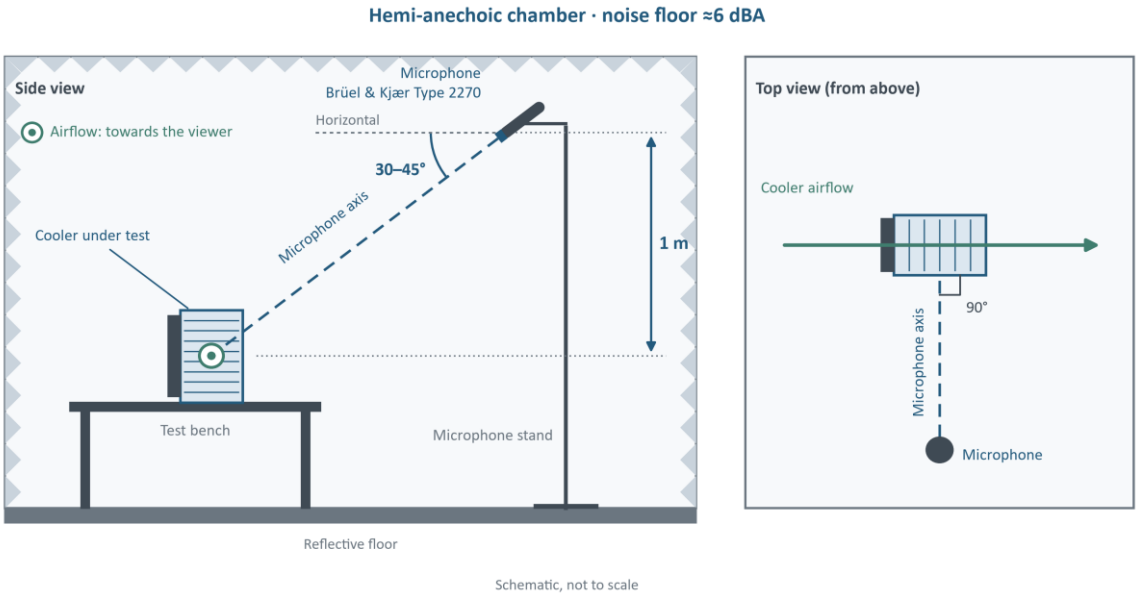

Figure 1: Microphone and cooler geometry in the hemi-anechoic chamber (schematic, not to scale).

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	
Manufacturer	Giant Force
Model number	GTH-800-20-CP-AR
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
External dimensions (W x H x D)	145 x 190 x 135 cm
Net weight (approx.)	450 kg
Heat-up time (no load)	20 °C to +100 °C in 30 min
Pull-down time (no load)	20 °C to -20 °C in 50 min
Cooling system	Airtight compressor, evaporator fins, air-cooled condenser
Power source	3Φ AC 380 V ±5 %, 50 Hz ±1 %, 10 kW
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 fixed position shown in Figure 1. In every noise test, we keep the cooler's airflow perpendicular to the microphone axis.

Our own software sets every fan and pump. We drive standard fans through the Corsair Commander Pro [1]. Where a cooler's fans and pump connect to its own controller, we drive that controller directly through its USB protocol, which we have mapped ourselves. The manufacturer's software does not run during the test. Examples include be quiet! coolers with the IO Center hub, such as Light Loop IO, and Corsair iCUE LINK coolers with the iCUE LINK System Hub, such as iCUE LINK TITAN. The controlling PC is passively cooled and does not affect the chamber's noise floor.

Our software adjusts the fan settings in RPM or PWM percentage, as supported by the controller. We record the actual speed of each fan and keep the pump setting fixed during each evaluation.

The operator selects the cooler test method in Options, and our software applies the stability rule and the cool-down described in the procedure (Figures 2 and 3).

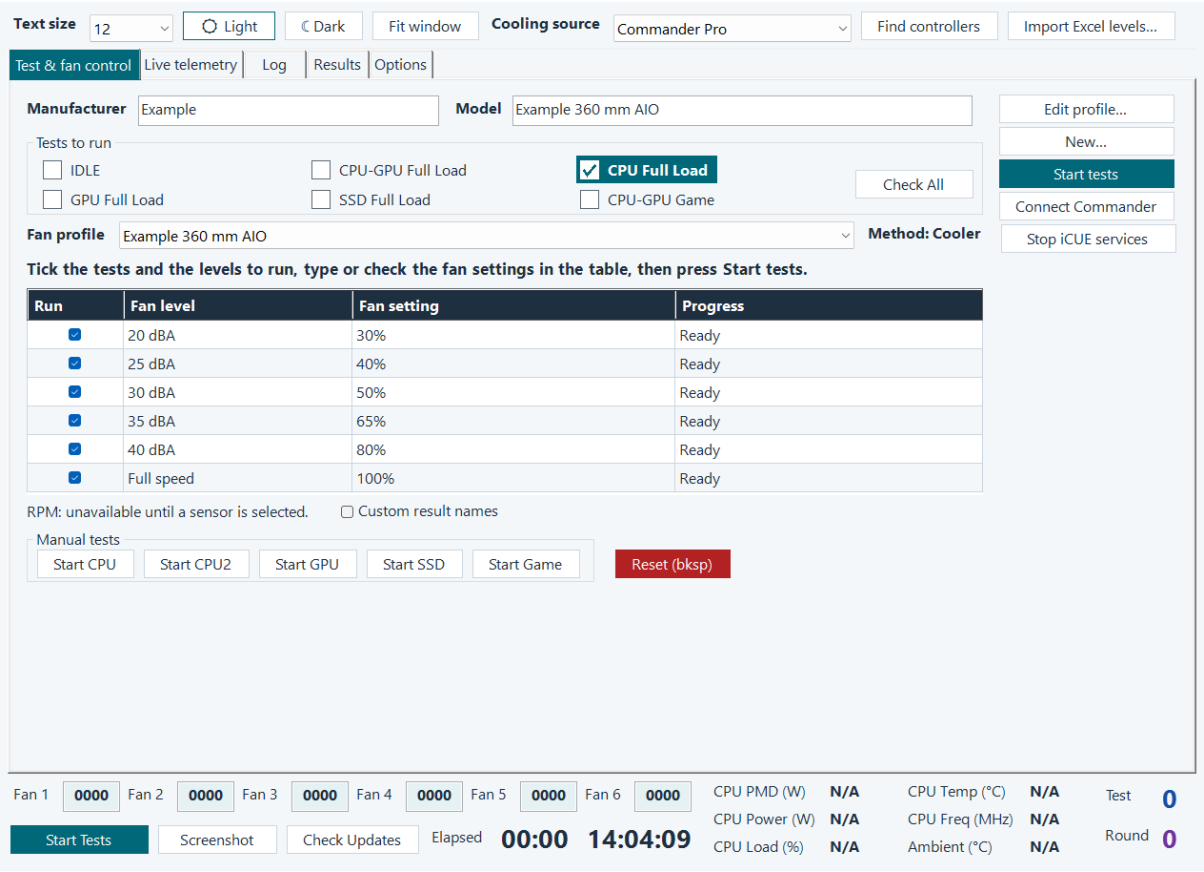

Figure 2: The test software (v7.27): test and fan control, with the noise levels to run.

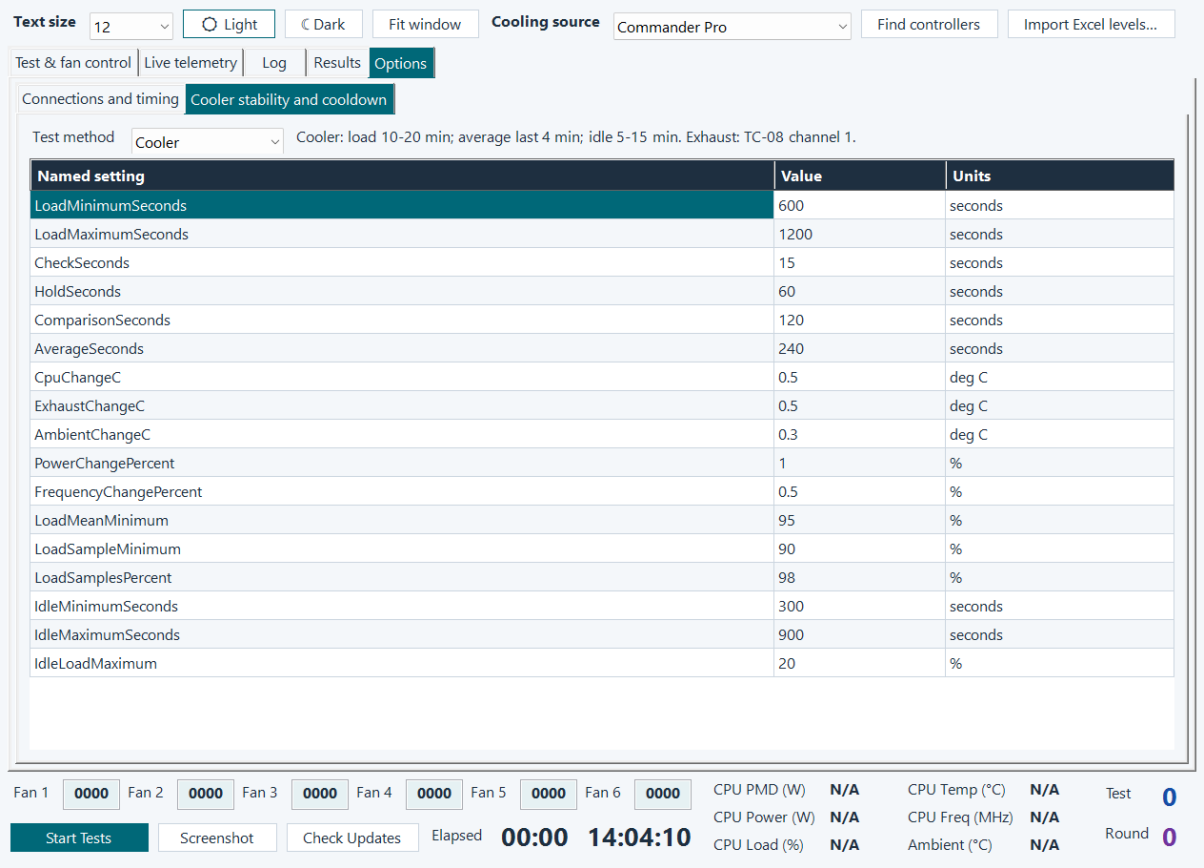

Figure 3: The test software (v7.27): the stability and cool-down settings of the cooler test method.

We first measure fan noise from 40 % to 100 % of maximum fan speed in 10 % increments. We then adjust the fan settings to reach 20, 25, 30, 35 and 40 dBA normalized noise output, where the cooler can attain these levels, and record the corresponding speeds of every fan. These measured settings, together with full fan speed, are used in the thermal tests.

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

We perform noise testing before thermal testing so that we can use the measured fan settings for 20, 25, 30, 35 and 40 dBA normalized noise output and for full fan speed. We run only the noise levels that the cooler can attain. Where the cooler has more than one fan, we record the speed of every fan.

We install the DUT inside the climate chamber and set the ambient temperature to 25 °C (77 °F) and the relative humidity to 30 %. We connect the Pico TC-08 thermocouple data logger [2] to two probes, one measuring ambient temperature and the other measuring the cooler's exhaust temperature.

We test each cooler with one mount per platform, using the mount that its manufacturer specifies as best performing: the default mount, or an offset mount where one is provided. We state the mount in the report and keep it for the repeat sessions. We fully secure the mounting system and check contact after the tests by inspecting whether the thermal paste covers the contact surface evenly.

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

Photo 1

Our software controls the DUT's fans and pump through the Corsair Commander Pro or the cooler's own controller, as described in the noise procedure. It also records the Pico TC-08 ambient and exhaust temperatures and the CPU power measured at the EPS connectors by Powenetics v2. CPU temperature and operating frequency are recorded from the test system; Powenetics v2 measures electrical power, rather than CPU frequency or temperature.

After the initial setup, our software runs the tests automatically. Each noise level runs under sustained full CPU load for at least 10 minutes and is extended only until stable. Every 15 s, we compare the mean of the last 2 minutes with the mean of the previous 2 minutes. We consider the run stable when CPU temperature and exhaust temperature each change by no more than 0.5 °C, measured CPU power at the EPS connectors (Powenetics v2) by no more than 1 %, CPU frequency by no more than 0.5 %, and ambient temperature by no more than 0.3 °C, with all these conditions satisfied continuously for 60 s. The power and frequency

changes are expressed as a percentage of the earlier of the two 2-minute means. We do not stop before 10 minutes. If a run has not become stable by 20 minutes, we stop and flag it, and investigate it before publishing any result.

For each valid run, the published values are the averages of the last 4 minutes before the stop. We apply this same window to the component averages used for Overall Performance.

Between noise levels, we allow at least 5 minutes of cool-down under idle conditions. We extend this period until the idle temperatures are stable: the mean of the last 2 minutes differs from the mean of the previous 2 minutes by no more than 0.5 °C for CPU temperature and exhaust temperature, and by no more than 0.3 °C for ambient temperature. Figure 4 summarizes the sequence.

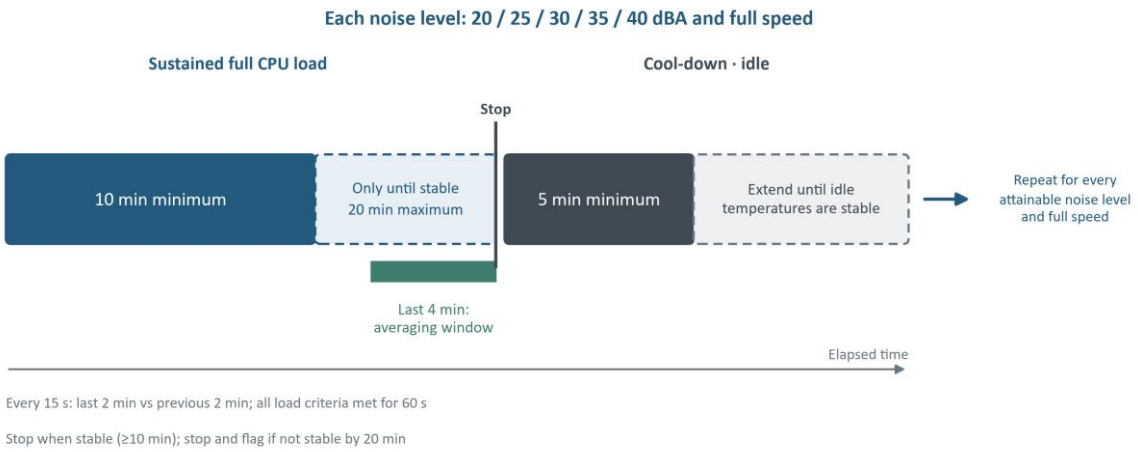

Figure 4: Load, final 4-minute averaging and idle cool-down sequence, repeated for each attainable noise level and full speed. Block widths are schematic; the averaging window ends at the actual stop.

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. When a cooler is tested in two sessions, the published values are the means of the two sessions, and the Overall Performance is calculated from those averaged W, F and T.

In all-in-one liquid coolers, we keep the pump at full speed throughout every test and vary only the fans. The pump's own noise is not part of the normalized fan-noise levels; it is typically too low to affect the result, especially at 30 dBA. Keeping the pump at full speed prevents its setting from becoming another variable between noise levels.

Thermal Performance Evaluation: Details

Some coolers cannot reach 40 dBA at a one-meter distance, and others cannot reach 35 dBA or even 30 dBA. Comparing coolers at the same attainable noise output lets us evaluate their thermal performance under comparable acoustic conditions. Full-speed results remain useful, but a cooler with louder fans may achieve a lower temperature simply by producing more

noise. The THETA section explains how we rate quiet coolers at their own measured 25 dBA point.

Thermal Performance Evaluation: Duration & Results

A complete thermal session takes about two hours, depending on how many noise levels the cooler can reach and how quickly the temperatures stabilize. For six levels, the planning range is 6 × (10–20 minutes under load + 5–15 minutes of cool-down). The 15-minute cool-down figure is a planning allowance, not a limit: we extend cool-down until the idle temperatures are stable. A cooler that reaches every normalized level is tested at 20, 25, 30, 35 and 40 dBA and at full fan speed.

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 coolers under full CPU load both at full fan speed and at the attainable normalized noise levels. Noise-normalized testing shows which coolers sustain the best thermal performance at the same noise output. The fan speed that a cooler can use at a given noise level is one factor in that performance, alongside the fan design, heatsink or radiator, pump and mounting.

For example, at 30 dBA one cooler may run its fans at 1000 RPM and another at 1400 RPM. If the fans have similar characteristics, the higher speed may provide more airflow and static pressure, which can help with dense fins. Fan speed alone, however, does not establish the cooler's overall performance; we compare the measured power, frequency and temperature together.

We record CPU power, operating frequency and temperature throughout each run, and use the averages of the last 4 minutes for its reported values. Modern processors adjust their frequency with load and die temperature, so temperature alone can hide a difference in sustained performance. Powenetics v2 measures CPU power at the EPS connectors continuously at up to 250 samples per second; we interpret the recorded frequency together with that measured power.

We define Overall Performance (OP) as $OP = W \times F / T$. W is the average CPU power in watts measured at the EPS connectors by Powenetics v2, F is the average CPU frequency in MHz, and T is the average CPU temperature in °C. We calculate OP from these component averages over the last 4 minutes, rather than averaging instantaneous OP values.

The product of power and frequency divided by temperature rewards a better cooler on both platforms: AMD runs at its 95 °C temperature limit, so the improvement appears as sustained

power and clocks, while Intel is power-limited, so the improvement appears as a lower temperature.

The THETA Cooling Performance Standard

We named THETA after the Greek letter theta, the symbol engineers use for thermal resistance. This Cybenetics standard rates a cooler's Overall Performance at 30 dBA normalized noise output, using the OP definition in the data analysis section.

We chose 30 dBA because two fans at PHI's 25 dBA reference level each combine to about 28 dBA, while three combine to about 30 dBA. Every cooler we have tested so far has a measured result at this level, or at 25 dBA under the route below for coolers that cannot reach 30 dBA. A performance level is awarded only when that result meets at least the Bronze requirement of the cooler's class.

Air coolers and AIO liquid coolers are rated in two separate classes, each with its own requirements, and each class has one scheme for each test platform: four schemes in all. The badge names the class and the CPU vendor and socket, for example THETA Gold · Air · AMD AM5 or THETA Gold · AIO · Intel LGA1851. The report also names the test CPU: AMD Ryzen 9 7900X or Intel Core Ultra 9 285K, respectively. There is no year on the badge.

A cooler that cannot reach 30 dBA is rated at its own measured 25 dBA point against the 25 dBA requirements. The report states “rated at 25 dBA”. This route requires a measured 25 dBA point; we do not estimate the cooler's performance at 30 dBA. A cooler that cannot run as quietly as 30 dBA receives no performance level.

The 25 dBA requirements express the same performance levels at the lower noise output. We derived them by dividing each 30 dBA threshold by the median OP30/OP25 ratio of the coolers measured at both points when we set these requirements, 1.0140 for AMD (45 coolers) and 1.0212 for Intel (11 coolers), and rounding the result to the nearest 50. These ratios and the listed requirements are fixed for this revision. The ratios set the requirements only; the rating always uses the cooler's own 25 dBA measurement.

An AIO liquid cooler with a large radiator moves considerably more heat at the same noise output than an air cooler, so each cooler is compared with coolers of its own kind. We set the Diamond requirement of each class about 2.5% above the best cooler of that class we had tested when this revision was issued, so that Diamond is a target for the very best coolers. On AMD, the lower levels follow the measured spread of each class.

THETA – Air · AMD AM5 Performance Levels/Requirements – 30 dBA Normalized Noise Output

Performance Level	Requirement
Bronze	≥9,000 & <9,500
Silver	≥9,500 & <10,000
Gold	≥10,000 & <10,250
Platinum	≥10,250 & <10,500
Titanium	≥10,500 & <11,000
Diamond	≥11,000

THETA – Air · AMD AM5 Performance Levels/Requirements – 25 dBA Normalized Noise Output

Performance Level	Requirement
Bronze	≥8,900 & <9,350
Silver	≥9,350 & <9,850
Gold	≥9,850 & <10,100
Platinum	≥10,100 & <10,350
Titanium	≥10,350 & <10,850
Diamond	≥10,850

THETA – AIO · AMD AM5 Performance Levels/Requirements – 30 dBA Normalized Noise Output

Performance Level	Requirement
Bronze	≥10,050 & <10,500
Silver	≥10,500 & <11,000
Gold	≥11,000 & <11,550
Platinum	≥11,550 & <11,900
Titanium	≥11,900 & <12,350
Diamond	≥12,350

THETA – AIO · AMD AM5 Performance Levels/Requirements – 25 dBA Normalized Noise Output

Performance Level	Requirement
Bronze	≥9,900 & <10,350
Silver	≥10,350 & <10,850
Gold	≥10,850 & <11,400
Platinum	≥11,400 & <11,750
Titanium	≥11,750 & <12,200
Diamond	≥12,200

THETA – Air · Intel LGA1851 Performance Levels/Requirements – 30 dBA Normalized Noise Output

Performance Level	Requirement
Bronze	≥12,000 & <12,650
Silver	≥12,650 & <13,350
Gold	≥13,350 & <13,700
Platinum	≥13,700 & <14,050
Titanium	≥14,050 & <14,350
Diamond	≥14,350

THETA – Air · Intel LGA1851 Performance Levels/Requirements – 25 dBA Normalized Noise Output

Performance Level	Requirement
Bronze	≥11,750 & <12,400
Silver	≥12,400 & <13,050
Gold	≥13,050 & <13,400
Platinum	≥13,400 & <13,750
Titanium	≥13,750 & <14,050
Diamond	≥14,050

THETA – AIO · Intel LGA1851 Performance Levels/Requirements – 30 dBA Normalized Noise Output

Performance Level	Requirement
Bronze	≥13,400 & <14,000
Silver	≥14,000 & <14,650
Gold	≥14,650 & <15,400
Platinum	≥15,400 & <15,850
Titanium	≥15,850 & <17,150
Diamond	≥17,150

THETA – AIO · Intel LGA1851 Performance Levels/Requirements – 25 dBA Normalized Noise Output

Performance Level	Requirement
Bronze	≥13,100 & <13,700
Silver	≥13,700 & <14,350
Gold	≥14,350 & <15,100
Platinum	≥15,100 & <15,500
Titanium	≥15,500 & <16,800
Diamond	≥16,800

On Intel, Diamond follows the same rule as on AMD. We carried the lower Intel requirements across from the AMD requirements with the median ratio of Intel to AMD Overall Performance in each class, 1.336 for air coolers and 1.331 for AIO coolers, from the coolers tested on both platforms. We will review the Intel requirements once 25 coolers have Intel results. Any change will be issued in a new revision.

The requirements belong to the test platform. A rating remains valid for the vendor and socket named on its badge. When we replace a platform, we derive new requirements by testing a set of coolers on both the old and new platforms, so that each performance level keeps its standing.

We retain one control cooler for the life of each platform. We re-test it periodically and after any platform change, including the BIOS, CPU sample, mainboard or thermal paste, and track its results on a control chart.

We award THETA levels by simple acceptance: we compare the measured OP directly with the corresponding requirements. Values below the Bronze requirement receive no performance level.

THETA is a Cybenetics performance rating. It is not part of our ISO/IEC 17065 certification schemes and is outside our accreditation.

Coolers Evaluated Before Revision 2.0

We also assigned THETA levels to the coolers we evaluated before Revision 2.0, from their published results at 30 dBA, or at 25 dBA under the rule above. These coolers were not measured again. Their results come from the procedure of Revision 1.8, in which each noise level ran for 20 minutes and was followed by a 10-minute cool-down, so the earlier procedure is not identical to the current procedure. Their evaluation reports say so next to the THETA level.

With Revision 2.2 (October 2026) we divided THETA into the air and AIO classes, each with new requirements. Every cooler already rated was re-rated with the new requirements from its existing measurements; no cooler was measured again.

Epilogue

Evaluating cooling solutions requires attention to the thermal paste, the cooler's contact with the CPU, its specified mount, the fan settings and the mounting of the fans. Every detail affects the result. On a real CPU we cannot dial in an arbitrary thermal load, so we measure CPU power at the EPS connectors with Powenetics v2, at up to 250 measurements per second, and evaluate it together with sustained frequency and temperature.

Noise output is also central to a useful cooler evaluation. A loud cooler can perform better at full speed than a quiet one, but many users want effective cooling at a low noise level. We therefore publish noise-normalized results alongside full-speed results, and use THETA to express the measured performance on the named test platform.

References

[1] https://www.corsair.com/eu/en/p/accessories/cl-9011110-ww/icue-commander-pro-smart-rgb-lighting-and-fan-speed-controller-cl-9011110-ww (last accessed on 3 October 2026)

[2] https://www.picotech.com/data-logger/picolog-tc-08-thermocouple-data-logger (last accessed on 3 October 2026)

[3] https://www.wsn.gr/shop/powenetics-powenetics-v2-power-measurements-device/ (last accessed on 3 October 2026)

[4] https://www.hbkworld.com/en/products/instruments/handheld/hand-held-software/sound-level-meter-apps-2250-2270/pre-packaged-software-2270-bz-7222 (last accessed on 3 October 2026)

[5] https://www.hbkworld.com/en/products/transducers/acoustic/acoustic-calibrators/microphone/4231 (last accessed on 3 October 2026)