



IT Equipment noise emission standards: overview of new development in the next edition of ISO/ECMA standards

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ABSTRACT

Over the last few years, the IT equipment industry added a few new product categories and the complexity of product noise emission signature also grew with the advances in information processing. Those changes led to new developments to be introduced in the 10th edition of ECMA-74 (target December, 2008) and will also directly impact ISO 7779 and ANSI S12.10 Annex C. This paper outlines some of those new developments, including 1) new operating modes for computing devices in Annex C15 and C18 to better represent the noise emission level variation with microprocessor, memory and graphic usage; 2) handheld devices, such as mobile internet devices and media players; and 3) refinement in the prominent tone determination methodology of Annex D that impacts many categories of IT equipment, such as hard disk drives, computer fans and blowers. The paper provides the background information behind each new development and gives technical details on the changes in order to prepare industry to adopt the new tests.

1 INTRODUCTION

There are three main IT product noise emission test codes: ISO 7779 [1], ANSI S12.10 [2], and ECMA 74 [3]. They are developed and updated by three acoustic committees ISO TC43 SC1 WG23, ANSI S12 Working Group 3 and Ecma Technical Committee 26 respectively. These standards prescribe various aspects of IT product sound power level and emission sound pressure level measurements including operating and installation conditions, measurement duration, reporting of test data, etc. It covers many information processing equipment including a) printing equipment such as printers, copiers, typewriters (Annexes C2-4, C6, C13, C16) ; b) computing equipment such as portable, tabletop and deskside personal computers and workstations (C15); racks and cabinets for general purpose, storage and telecommunication servers (Annex C18); c) drive devices such as hard disk drives (HDD, Annex C9), optical disk drives such as CD and DVD drives (Annex C20); d) IT small appliances, such as projectors.

These standards prescribe system idle mode and peripheral operating modes such as HDD, and ODD operating modes. These modes have been used by computer manufacturers worldwide and have enabled a consistent acoustic testing and reporting process for the last two decades. The resulting noise emission specifications enabled end-users, such as government purchasing agencies and consumers, to make informative decisions when evaluating the noise emissions from various IT products.

The standards do not prescribe any operating conditions that reflect noise levels that end users encounter when running applications that have workload/power above the idle mode that affects product noise emissions. This paper discusses the problems and impacts of not having standardized operating modes for computing devices to reflect workload/usage, outlines actions that IT product acoustic committees have taken and gives an update on the proposed new operating conditions for laptop, personal computers, workstations and servers.

In the last few years, there are increasing numbers of new handheld equipment types, such as mobile computing, media players and internet devices. These devices are operated much closer to users and have unique installation and operating conditions that are not covered by any of the existing product categories. A new product category for handheld equipment is being developed by the standards committee and this paper briefly introduces key aspects of the draft wording.

The procedures for identification of prominent discrete tones that are in Annex D of the standards will have several modifications. The major changes are with respect to low level tones in which some tones are excluded from further analysis because of their low levels: tones which are less than 10 dB above the one per cent threshold of hearing (P1); they are by definition not prominent. For other low level tones, background sounds which are below P1 are considered to be at the level of P1 in order to prevent the unfair classification as prominent of some tones.

2 NEW OPERATING MODES OF COMPUTING EQUIPMENT

2.1 Background

Over the last decade, computing equipment such as laptop, personal computers, workstation, and servers have dramatically advanced performance. In the meantime, the increase in component power and the cooling needed has increased the noise emission level. Advanced control technologies are now commonly used to adjust the fan speed(s) to meet the required cooling requirements and reduce the end user noise exposure and fan power consumption. The noise emission levels can vary with end use workload/power, configuration and meteorological conditions, etc.

The existing idle mode (as prescribed in the 9th edition of EMCA-74) is defined as the system has completed all initialization software and is ready to execute commands. In addition all subsystems such as HDD, ODD, and monitor are idle with no end use applications activated or running, and all cooling elements are at steady-state conditions. This mode was established more than a decade ago when most computing equipment had fan speeds that were independent of work load/power and thus had noise emission levels that also did not depend on workload/power. With the increased utilization of more intelligent fan speed control, thermal and power management, computing equipment noise emission level varies greatly above idle conditions due to many factors, for example: 1) End-use system configurations. A maximally configured system consumes more power, and tends to drive up fan speed(s), therefore noise emission levels and fan power consumptions; 2) System usage and component power loading conditions. A system used for internet browsing, email, instant messaging (IM), etc. may consume less power than one used for computational fluid dynamic (CFD) simulation. High level usage leads to an increased electronic cooling need, which in turn leads to variations in the noise emission levels; 3) Environmental conditions

such as system ambient temperature and altitude. There are large environmental condition difference between a small business server used in a non-air conditioned warehouse vs. one used in an optimally partitioned and liquid cooled data center, or a system in a high altitude condition that fans need to run faster to make up air density effect on the cooling efficiency as compared to a system used in cities close to sea level.

Figure 1 shows the fan speed in % of maximum PWM (pulse-width modulation) vs. component power at four system inlet temperature conditions. The sloped portion of the lines indicates that the fan speeds are automatically adjusted higher with the component power consumption. Such an adjustment is directly related to the component thermal sensor and power consumption, and is done by fan speed control logic [4]. The flat portion of the lines is when sensor reading is below a threshold, and fan is stabilized at a minimum speed pre-configured to protect components that do not have a thermal sensor. Details of how the fan speed control logic works and its impact to the system level noise emission can be found in earlier papers [4, 6, 7].

The fan speed directly contributes to the system noise emission level, and its impact is shown in Figure 2. When the system inlet temperature is high, the cooling system consumes more energy to remove heat generated from electronic components. Taking a very high ambient, 33 °C condition as an example, to remove about 100 watts heat from a component requires fan speed to be ~54% higher than if component power is about 50 watts. This fan speed change results in an increase of sound power level of about 10 dBA (1.0 Bel), or loosely about 2 times louder depending on the signature of the noise. Similarly, if the ambient temperature is around 20 °C, removing the 20 to 100 watts power from the component does not require much of a fan speed change, so there is not much of an increase in the noise level. This leads to a simple conclusion that both environmental conditions and system usage/load play critical roles in computing product noise emission levels.

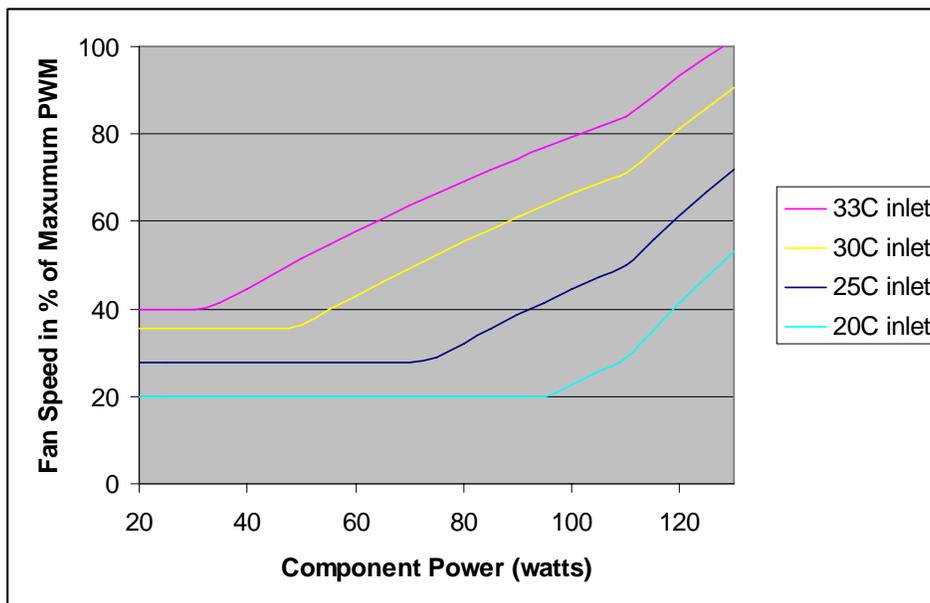


Figure 1 Fan speed vs. component power at four system ambient temperature conditions

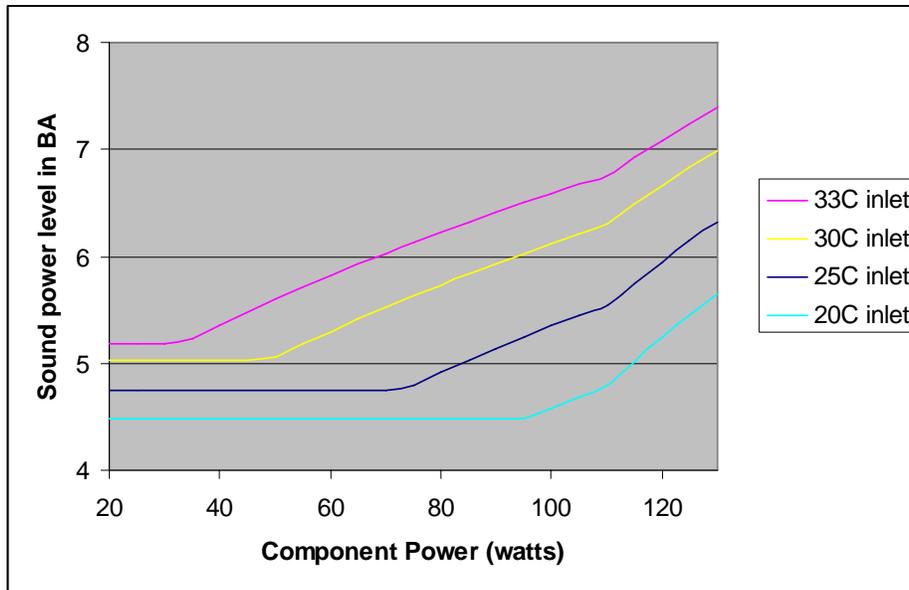


Figure 2 Sound power vs. component power at four system ambient temperature conditions

2.2 Various attempt of defining new operating conditions

Given the large range of operating conditions, efforts were made by various agencies to define new operating modes to better reflect end use noise emission exposures and power/energy consumptions. Two examples are discussed: one is the German eco-label Blue Angel RAL-UZ 78 that covers eco-criteria for personal computers and laptops, and the second is the United States EPA Energy Star that covers power/energy consumption requirements for computing devices.

RAL-UL 78 [5] requires the reporting of noise emissions for four conditions as shown in Table 1 below. The conditions (1), (3) and (4) in Table 1 are consistent with idle and operating conditions prescribed in the acoustic test standards [1, 2, 3]. RAL-UL 78 introduced a new operating condition (2) in an effort to address the higher noise emission level when an end user exercises a key computing component, the CPU. Unfortunately RAL set the level to 90% utilization, which introduced two issues: a) the utilization was not a well-defined parameter in the computer industry, which left a large uncertainty on how the mode is tested and questions on consistency and comparability of values; b) 90% utilization is hardly typical of end use, but more of a high artificial point. If 90% utilization is mistaken for 90% load or performance, it may represent an operating condition that a majority of end users do not encounter, thus seriously compromising the benefit of disclosing its emission level to end users or of using it to pass/fail a product.

Table 1 RAL-UL 78 : Basic Criteria for Award of the Environmental Label Computers
(Workstation Computers and Portable Computers)

UZ 78 Edition June 2006
(1) The hard disk drive is activated. Noise emission levels shall be determined in accordance EN ISO 7779:2001, No. C.9.3.2.
(2) The device operates at high load (processor cooling is activated at a CPU utilization of at least 90% ¹⁵ . Testing is done for 120 seconds following an operating time of 15 minutes at an ambient temperature of 23 ± 1 °C)
(3) The device operates in idle mode. Noise emission levels shall be determined in accordance with EN ISO 7779:2001, No. C.15.3.2.
(4) An optical drive in typical configuration is activated. Optical drives are to be tested in accordance with EN ISO 7779/A1:2003, No. C.19.3.2.

Another well-known effort is Energy Star initiative undertaken by United States EPA [8]. Energy Star Version 5.0 Draft-1 Program requirements for computer servers (see Table 1)

Table 2 U. S. Energy Star Version 5.0 Draft-1, Program Requirements for computer Servers

Operational Modes
L. Off Mode: The power consumption level in the lowest power mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions. For purposes of this specification, Off Mode correlates to ACPI System Level S4 or S5 states, where applicable.
M. Sleep Mode: A low power state that the computer is capable of entering automatically after a period of inactivity or by manual selection. A computer with sleep capability can quickly "wake" in response to network connections or user interface devices. For the purposes of this specification, Sleep mode correlates to ACPI System Level S3 (suspend to RAM) state, where applicable.
N. Idle State: For purposes of testing and qualifying computers under this specification, this is the state in which the operating system and other software have completed loading, the machine is not asleep, and activity is limited to those basic applications that the system starts by default.
O. Active State: The state in which the computer is carrying out useful work in response to a) prior or concurrent user input or b) prior or current instruction over the network. This state includes active processing, seeking data from storage, memory, or cache, not precluding idle state time while awaiting further user input and before entering low power modes. For the purposes of testing and qualifying computers under this specification, this is the state in which the EEPA workload is running, thereby automating the state as described above.
Note: This Version 5.0 specification extends assessment of active efficiency from the solely the idle state to a holistic view that includes energy consumed while the computer is delivering functionality to the user. The definition above has been added accordingly and EPA encourages comments and suggestions on this proposal.

2.3 IT acoustic committees development of new operating modes

The lack of standardized operating modes and the rush to fill the gap have resulted in both government agencies and private sectors defining and running a wide range of active acoustic testing. Such an effort is noble, but introduces inconsistency in both practices and results, adding to a manufacturer's product development cost, and having questionable benefit for the end users.

The central processing unit is a critical part of personal computers, workstation, servers and other rackable systems. It consists of many subsystems including baseboard (aka motherboard) with one or multiple microprocessors, multiple memory modules and/or add-in or graphic cards. Those three subsystems dictate the selection of fans and blowers that are commonly used as part of computing equipment cooling, and define the noise level of most computing equipment.

IT acoustic committees, in particular ANSI S12 WG3 and Ecma TC26 recognized this gap, and started an effort to address this problem in late 2006. During the 2007 annual

meetings held in Reno, Nevada, the committees approved the working item to develop the new operating modes, and also approved its inclusion in future IT product acoustic test codes. A subcommittee proposed three new operating modes for laptop, personal computers and workstations.

The draft wording to add a new operating mode to Annex C for products whose emissions are dependent on workload was presented in a NoiseCon 2008 paper [4] and was also reviewed during the 2008 annual meeting of the acoustic committees. The proposed mode is shown below:

- g) Equipment with a central processing unit shall be tested under the typical workload to best represent the noise levels of majority of end use. The central processing unit may include multiple microprocessors, multiple memory modules and multiple add-in cards (for example, graphics card), here on referred to as subsystems of the central processing unit. Operating of each subsystem shall follow
 - g1) Central processing units with multiple microprocessors: Typical workload of all microprocessors shall be half of the maximum load using microprocessor centric performance testing applications. If multiple microprocessors are included in a central processing unit, the typical workload shall be evenly distributed across all microprocessors, if possible.
 - g2) Central processing units with a memory subsystem: Memory subsystem may include multiple memory modules or devices, whether installed on a motherboard, or via riser cards. Typical workload for memory subsystem operating mode shall be half of the attainable platform performance bandwidth of the memory subsystem, with bandwidth equally distributed over all memory modules, if possible
 - g3) Central processing units with discrete graphic cards: typical workload of graphics cards shall be TBD of the maximum performance as specified by the manufacturers of the card. If multiple cards from different vendors are part of the central processor unit, each card shall be exercised and reported separately
 - g4) Operating mode of other subsystems of a central processor unit: name, workload and configuration of the subsystem shall be included in the report if a measurement is performed.

There are many software applications that may be used for the microprocessor operating mode acoustic testing. If load-scalable performance testing applications, such as SpecPower (<http://www.spec.org/>), MaxPower or ThermNow are used, the acoustic measurement shall be performed at the 50% of the maximum load setting. If load non-scalable applications, such as Linpack (<http://www.netlib.org/linpack/>) and Prime95 are used, the manufacturer may modulate the load between maximum and idle to meet the typical workload condition. Modulation shall be adjusted such that the steady-state noise emission condition is measured. The testing applications mentioned in this paragraph are informative guidelines. Other testing applications are allowed as long as the workload requirements are satisfied.

The memory subsystem may be stressed to an “attainable platform performance bandwidth” which At times is referred to as the “maximum sustainable platform bandwidth”. For a given system and memory configuration, the attainable performance bandwidth may be obtained by running a memory performance testing application at the maximum setting. If such an application is load-scalable, the acoustic testing should be run at the 50% of the maximum setting.

It is important to note that the noise emission level at the 100% of the maximum setting is likely much higher than both idle mode and typical operating mode at any given meteorological condition. However, these are considered corner cases that do not represent normal end use. The measurement and reporting of noise level at the typical workload enables customers to compare products at a condition common to their acoustical experience.

It is also important to note that not all computer systems have noise impacted by all three subsystems. For example, some computer systems have low performance graphic feature, and graphic operating mode noise is substantially below other operating modes. In this case, testing and reporting graphic operating mode is not required.

3 HANDHELD EQUIPMENT

New handheld equipment types, such as mobile internet devices, handheld computing and/or media playback equipment, have been introduced in the last few years. Some of these have a hard disk drive and small fans or blowers for electronic cooling, therefore emitting acoustical noise. These devices are often supported by hand and used at a much closer distance to the user than many existing product categories such as computers and workstations. To enable consistent testing and reporting of the noise emission level of the equipment, a new product category for handheld equipment is being developed. This category aims to cover handheld equipment for computing, office productivity software, internet browsing, digital media playback, and similar functions. The equipment may run a general purpose operating system or be optimized solely for one or more of the functions listed above. The equipment may be held in one or both hands during normal end use, and does not have a keyboard large enough for touch-typing. Ultra-mobile PCs (UMPC), handheld MP3 players, and handheld digital video players are part of this category, but not handheld CD or DVD players. Draft wording for the standards includes the installation conditions for both sound pressure level measurement and sound power level measurement, as well definitions of idle and operating modes.

4 ANNEX D PROMINENT DISCRETE TONE

The major changes in Annex D of these standards for identifying whether a tone is prominent are with respect to low level tones and low level background noise. In order to reduce unnecessary computations, tone levels that are less than 10 dB above the one percent threshold of audibility (P1) (only 1% can hear a tone at that level) then further analysis is not necessary and the tone is considered as “not prominent”. This 10 dB criterion is conservative since the range from threshold to prominence is 10 – 14 dB depending on frequency. The specific wording under consideration is:

“If $L_t < (P1 + 10)$ dB, then by definition the tone is not prominent and no further analysis is required. A statement such as "no prominent discrete tones" may be included in the report.”

For low level tones not meeting the above exclusion, background noise that is below P1 can be replaced by the equivalent P1 level for noise. The issues in evaluating low level tones in low background noise situations were raised and solutions recommended in papers by Kimizuka and Rafaelof.

The procedure for performing the audibility test is clarified and may be performed before or after objective analysis. Microphone positions for determining the presence of prominent discrete tones for sub-assemblies, which do not require the testing for emission sound pressure level, are specified. Clarifications on recommended filter bandwidth are also presented to ensure sufficient definition of tonal levels. Future revisions will consider methods for frequency varying tones

5 SUMMARY

The three key new development of the IT product noise emission measurement standards are in draft stage for ECMA 74 10th edition, ANSI S12.10 part-1, and ISO 7779. Manufacturers and other users of the standards are encouraged to provide inputs. Inputs can be provided to Kaleen Man, chair of ANSI S12 WG3 and to Egons Dunens, chair of Ecma TC26.

6 ACKNOWLEDGEMENTS

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