APPLICATION NOTE I No. 455

Very Low Noise Generation of High Performing Mastercycler® X50

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Abstract

Excessive noise pollution in a laboratory environment can lead to stress, impaired concentration and hence reduced well-being and productivity. In the comparative tests presented herein, measurements of operating noise were performed for the Mastercycler® X50s and four thermal cyclers from other manufacturers. The values obtained characterize the Mastercycler X50 as a thermal cycler that stands out among all thermal cyclers in the same category by virtue of its very low noise generation and as such a contribution to a healthy, productive lab environment.

Introduction

The development of increasingly sophisticated workflow to cope with growing sample throughput, instrument digitalization, process standardization and stricter accreditation in modern laboratories has led to increased usage of devices or even complete automation of entire processes.
Users' evaluation and buying decision for thermal cyclers in the market is mainly based on speed and temperature performance, functionalities, as well as ease-of-use [1-3]. However, there are obscure hazards buried in the increasingly complex lab environment such as increased operational noise and waste heat generated by the instruments [4]. Thus, less prominent device features such as noise level are gaining significance in influencing purchasing decisions when evaluating cyclers within the same market range.

This Application Note compares the noise level generation of five thermal cyclers under different common operational conditions.

Materials and Methods

The sound power level was determined in A-weighted decibel [dB(A)] for five thermal cyclers listed in Table 1 in accordance with DIN EN ISO 3744.
The measurements were taken at the following three operational states:

1) Idle state: Thermal cycler switched on, temperature control of block and lid turned off, with no application running on device.
2) Continuous temperature control of the block at 4 °C.
3) Standard 3-step PCR protocol:

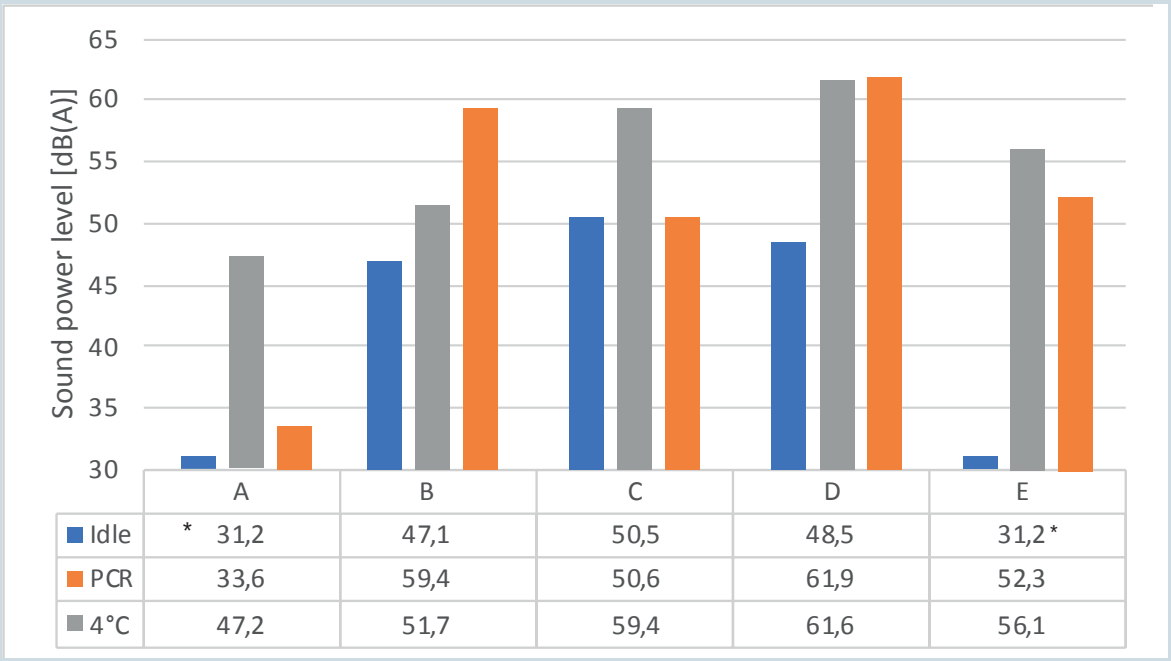
Eppendorf Header Settings	Lid	105 °C.
	TSP/ESP	ON
	Lid auto-off	ON
	Temperature mode	Standard
3-step programs	Denaturation	95 °C/15 s
	Annealing	60 °C/15 s
	Elongation	72 °C/30 s

Device	Manufacturer	Model
A	Eppendorf	Mastercycler X50s
B	Bio-Rad®	C1000 Touch 96-well
C	Bioer™	GeneExplorer 96G
D	Applied Biosystems®	ProFlex 96-well
E	Applied Biosystems®	VeritiPro 96-well

Table 1: List of thermal cyclers under examination

Results and Discussion

Five competing cyclers tested were shown to generate different sound power levels when operating under different conditions. The three operational states (idle, PCR and 4°C) were chosen to represent the standard use of a thermal cycler.



	A	B	C	D	E
Idle	* 31,2	47,1	50,5	48,5	31,2*
PCR	33,6	59,4	50,6	61,9	52,3
4°C	47,2	51,7	59,4	61,6	56,1

Figure 1: Sound power levels of the thermal cyclers during three operational states.
*value representing background noise as sound level too low to be differentiated from surrounding noise

The intensity of the operational noise under different conditions for each thermal cycler varied within the range of ca. 9-25 dB(A), with the biggest span being cyclers that have very low noise when idle to being loudest when cooling at 4°C, such as shown by thermal cyclers A and E (Figure 1).

When in idle state, two thermal cyclers were found to have very low noise generation, with sound power level below 40 dB(A). In particular, the average noise level of thermal cycler A and E under idle state is too low for relevant differentiation of the operating noise to the surrounding sound level (ca. 32 dB(A)). Thus, only the background noise can be considered as the upper limit for these two measurements. On the other hand, thermal cycler C was found to have the highest intensity of noise when in idle state, reaching past 50 dB(A). In the level of human sound perception, this noise level is equivalent to a sound of rainfall [5].

3-step PCR was taken as the standard operational use of a thermal cycler, with the three cycling temperatures defined above as commonly used parameters. Measurement at this state showed two of the five cyclers (B and D) generated sound power reaching ca. 60 dB(A), which is equivalent to human perceived noise level during normal conversation [5]. Similarly, cyclers C and D also reached this noise level during continuous temperature control of the block at 4°C, with cycler E only slightly lower.
All in all, four competing cyclers produced above 50 dB(A) during at least two operating conditions, while the cycler A was determined to have very low noise generation during all three states.

In human sound perception, an increase of sound power level by 10 dB(A) means a doubling of the loudness [6, 7]. As an example, using the conversion factor ($z=2^{\Delta L/10}$ L/10) calculation of sound power level, a user would perceive the detected sound power level difference of 28.3 dB(A) between thermal cycler A and D as a seven-fold higher loudness on cycler D in comparison to the Mastercycler X50s during a 3-step PCR run (Figure 2). Similarly, the four other thermal cyclers showed two- to six-fold higher loudness perceptions in comparison to Mastercycler X50s when running a PCR.

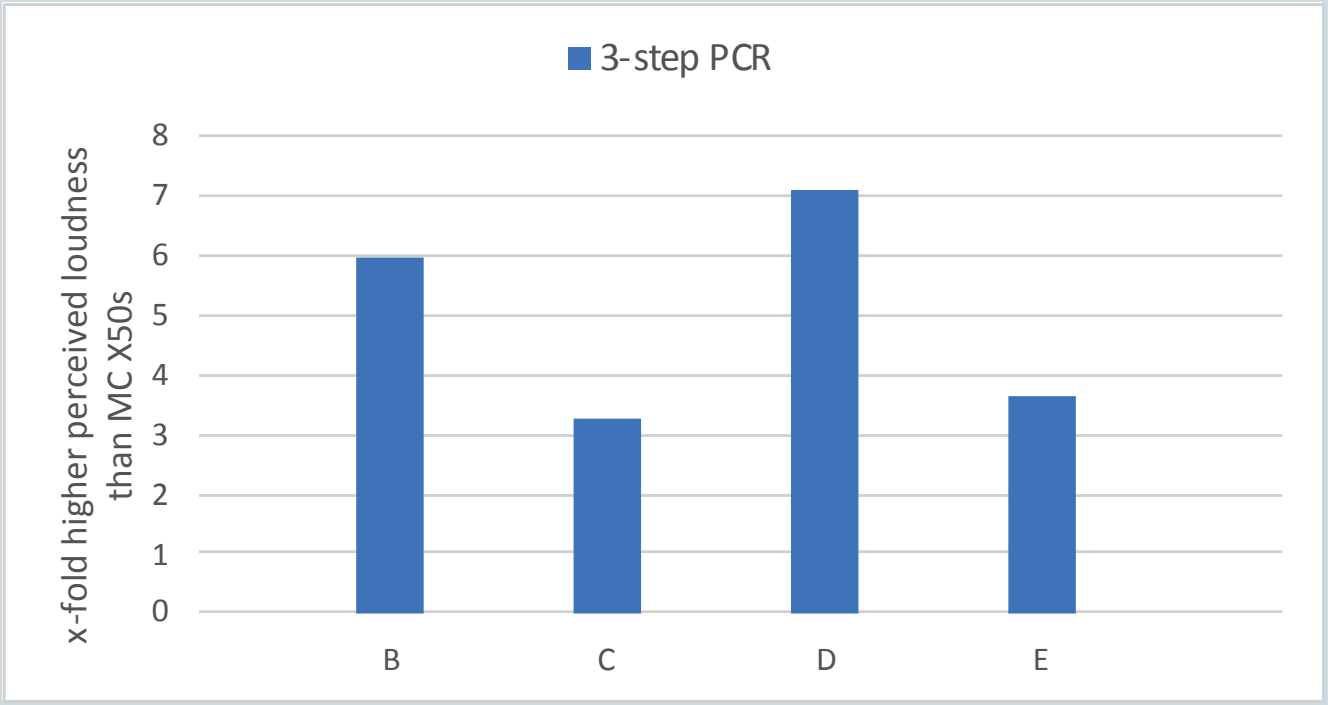


Figure 2: Loudness perceptions in comparison to the Mastercycler (MC) X50s calculated based on detected differences in sound power level according to conversion factor $z=2^{\Delta L/10}$ (see Fig. 1).

It must be noted that the above data reflect the noise level from a single thermal cycler. According to the recommendation of ISO 11690-1 the noise emission and/or noise exposure should not exceed the following maximum values [8]:

- In industrial workplaces: < 80 dB(A),
- For routine office work: < 55 dB(A),
- For meeting rooms or tasks involving concentration: < 45 dB(A).

In a lab where there is usually more than one cycler at different operational states, the cumulative noise generation would not be insignificant. For example, if the sound power generated by a single cycler has reached the recommended limit such as thermal cycler B (PCR), C (4°C), D (PCR, 4°C) and E (4°C), it means that the user is constantly being in a busy office when next to the cycler. As such, the presence of more devices in the same space would present a source of noise pollution worthy of concern.

Conclusion

During the development of the Mastercycler X50, the issue of noise generation under different operating states was taken seriously in view of increasing number of devices in a laboratory to meet higher output demand. The operational noise data presented here characterize the Mastercycler X50 as a thermal cycler with very low operational noise on top of its previously described excellent temperature performance, advanced functionalities and ease-of-use.

References

[1] Gerke N & Phang A. Comparative run time evaluations of PCR thermal cyclers. Eppendorf SE, Application Note 274.
[2] Phang A and Schommartz T. Ultimate PCR optimization with Mastercycler X50 2D-gradient. Eppendorf SE, Application Note 387.
[3] Phang A and Schommartz T. Highly reproducible low volume PCR with Mastercycler® X50 and epMotion. Eppendorf SE, Application Note 388.
[4] World Health Organization (2004). Additional laboratory hazards – Noise. In: Laboratory biosafety manual. 3rd Ed. Geneva: WHO Library Cataloguing-in-Publication Data: 111.
[5] Christina Wolf. Effect measurement of (goods) transport noise. CPM report 2011:2.
[6] Moore BCJ (2007). Cochlear hearing loss: physiological, psychological and technical issues. 2nd Ed. John Wiley & Sons Ltd.
[7] Stevens SS (1957). On the psychophysical law. Psychological Review 64 (3): 153–181.
[8] ISO 11690-1:2020. Acoustics - Recommended practice for the design of low-noise workplaces containing machinery - Part 1: Noise control strategies.

Ordering information

Description	Order no. International	Order no. North America
Mastercycler® X50s (96-well silver block, with touchscreen interface)	6311 000.010	6311000010
Mastercycler® X50a (96-well alu block, with touchscreen interface)	6313 000.018	6313000018
Mastercycler® X50h (384-well alu block, with touchscreen interface)	6316 000.019	6316000019
Mastercycler® X50l (96-well silver block, eco module)	6301 000.012	6301000012
Mastercycler® X50l (96-well alu block, eco module)	6303 000.010	6303000010
Mastercycler® X50t (384-well alu block, eco module)	6306 000.010	6306000010

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