



# THE IMPACT OF THRESHOLD, CRITERION LEVEL AND EXCHANGE RATE ON NOISE EXPOSURE DATA RESULTS

APPLICATION NOTE QUEST-001 (A4)

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## Introduction

Noise dosimeter measurement settings can have a significant impact on hearing safety compliance. For safety professionals, it is important to understand how measurement settings affect the final calculations used to assess worker safety at a facility. This application note focuses on the influence threshold, exchange rate, and criterion (criteria) level settings have on the  $L_{avg}$ <sup>1</sup>.

The threshold, exchange rate, and criterion level settings vary across government regulation, industrial hygiene association guidelines, and internal corporation hearing conservation programs. Government regulations may tend to focus on keeping workers protected against permissible exposure limits (PEL). Many company policies and industrial hygienists have gone a step further than government regulations, especially in the United States. These companies and industrial hygienists have lowered the threshold, criterion level, and exchange rate settings to better protect workers and to minimize the company's risk of a worker safety incident.

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## Threshold, Exchange Rate, and Criterion Level

Lowering the setting values further protects workers against noise-induced hearing loss in a few ways. First, a lower criterion level means more workers will need to wear hearing protection. The criterion level is the 8-hour average sound level employers must keep the employee's exposure below. If the exposure cannot be reduced below the criterion level through methods such as reducing noise at the source, employees must wear hearing protection to reduce their exposure below the criterion level. Lowering the criterion level may also result in hearing conservation programs becoming applicable at lower decibel values.

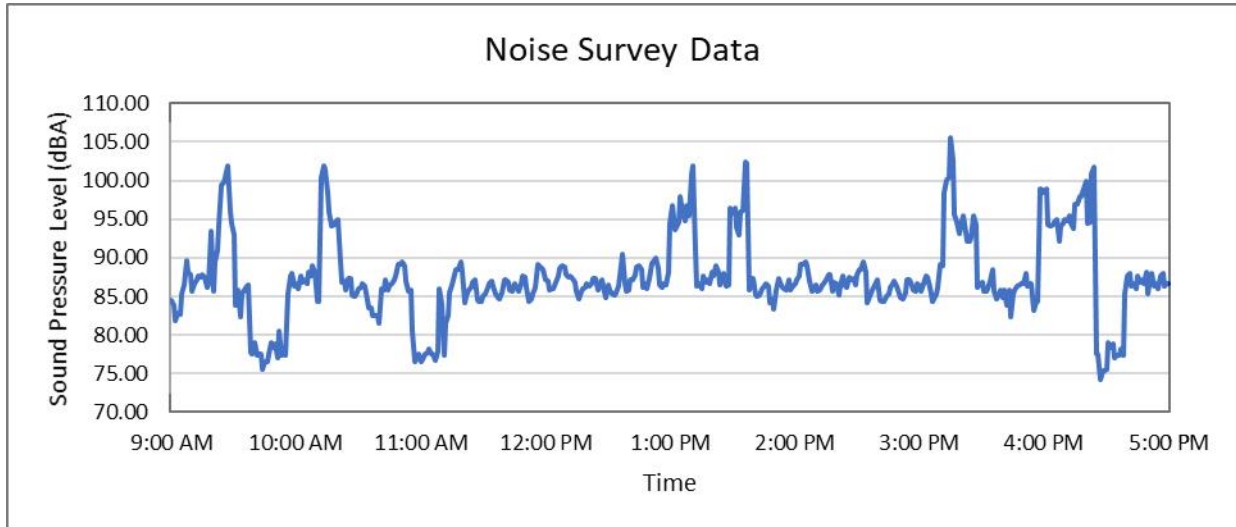
The second way lowering the setting values is more protective for workers is that lowering the threshold and exchange rate mathematically causes an increase in the  $L_{avg}$  value. The threshold value defines the cutoff point for which all values below it are assumed to have no energy, i.e. they are considered 0 dB. For example, lowering the threshold from 90 dBA to 80 dBA will now include all data points between 80 dBA and 90 dBA in the  $L_{avg}$  calculation that were not previously included. This results in a higher  $L_{avg}$  if any of the noise sampled is in the 80 dBA to 90 dBA range. Lowering the exchange rate will also increase  $L_{avg}$ . The exchange rate is a value, typically 3 dB or 5 dB, that is sometimes referred to as the doubling rate. In  $L_{avg}$  calculations, for each increase in the measured sound pressure level by the exchange rate, the energy the sound pressure level is assigned doubles. For example, when an exchange rate of 5 dB is used, in the  $L_{avg}$  calculations a sound pressure level sample of 95 dBA will be assigned twice the energy of a 90 dBA sound pressure level sample. When the exchange rate is lowered, more energy is assigned to the measured sound pressure levels in the  $L_{avg}$  calculations.

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<sup>1</sup>Wherever the term  $L_{avg}$  is used in this application note, it is assumed to be measured over a period of 8 hours and is therefore equivalent to the 8-hour TWA.  $L_{avg}$  is the same as  $L_{eq}$  when an exchange rate of 3 dB is used and there is no threshold applied.

If more energy is included in the calculations,  $L_{avg}$  will be higher. The higher the  $L_{avg}$  value, the more likely it is that an employee will be enrolled in a hearing conservation program. The  $L_{avg}$  value at which an employee must be enrolled in a hearing conservation program varies depending on the country or company-specific standard that is followed. An increase in  $L_{avg}$  will also increase the likelihood that a worker will exceed the criterion level and be required to wear hearing protection in order to bring their exposure below the criterion level.

To illustrate the effect setting values have on safety decisions, the raw noise study data shown below (Figure 1) was processed against six different sets of noise dosimeter settings (Table 1) to calculate the  $L_{avg}$  and dose %.



**Figure 1: Noise Survey Data (SPL vs. Time)**

**Table 1: Noise Survey Calculation Results**

	<b>OSHA PEL (OSHA 29 CFR 1910.95)</b>	<b>Custom Setup 1</b>	<b>Custom Setup 2</b>	<b>Custom Setup 3</b>	<b>EU (Directive 2003/10/EC)</b>	<b>ACGIH</b>
Threshold	90 dBA	85 dBA	90 dBA	85 dBA	None	80 dBA
Criterion Level	90 dBA	90 dB	90 dBA	85 dBA	87 dBA	85 dBA
Exchange Rate	5 dB	5 dB	3 dB	5 dB	3 dB	3 dB
<b><math>L_{avg}</math></b>	<b>84.7 dBA</b>	<b>89.2 dBA</b>	<b>90.2 dBA</b>	<b>89.2 dBA</b>	<b>91.4 dBA</b>	<b>91.4 dBA</b>
Dose	48.0 %	88.9 %	104.4 %	177.8 %	276.6 %	436.8 %

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## Results Discussion

In the first settings scenario in Table 1, the data was measured against the OSHA PEL (OSHA 29 CFR 1910.95), which had the highest settings value combination for threshold, criteria level, and exchange rate. When the noise exposure study was measured against these settings, the resulting  $L_{avg}$  was the lowest of all six scenarios at 84.7 dBA. This  $L_{avg}$  was below the 90 dBA criterion level. In the United States where OSHA PEL is the federal regulation, the company would not be required to provide hearing protection to the worker because the  $L_{avg}$  was below 85 dBA<sup>2</sup>, and the worker would not be required to wear hearing protection because the  $L_{avg}$  was below 90 dBA<sup>2</sup>.

The OSHA PEL and Custom Setup 1 settings are the same with the exception that Custom Setup 1 reduces the threshold from 90 dBA to 85 dBA. When the threshold was lowered from 90 dBA to 85 dBA, it caused an increase to the  $L_{avg}$ . This was because the calculations now included noise sampled between 85 dBA and 90 dBA. Much of the noise measured in this noise survey was between 85 dBA and 90 dBA. Lowering the threshold had a significant impact on the calculated results. The settings applied in Custom Setup 1 resulted in a  $L_{avg}$  of 89.2 dBA. The  $L_{avg}$  was slightly below the criterion level of 90 dBA. The increase in  $L_{avg}$  to 89.2 dBA results in an increased likelihood the employer would be required to enroll the worker in a hearing conservation program. This decision depends on which standard the company follows, whether that be a country-specific regulation or a more protective local government or company standard.

In Custom Setup 3, the criterion level was lowered from 90 dBA to 85 dBA versus Custom Setup 1. The  $L_{avg}$  remained the same, but lowering the criterion level by exactly the exchange rate (5 dB) caused the dose value to double compared to Custom Setup 1. The resulting noise was 78% over the allowable daily exposure limit. The  $L_{avg}$  was above the criterion level; therefore, hearing protection will need to be worn to bring the worker's noise exposure below the criterion level.

Custom Setup 2 had the same threshold and criterion level as OSHA PEL, but had a lower exchange rate. When the exchange rate was lowered, the measured sound pressure levels were assigned more energy in the  $L_{avg}$  calculations. This resulted in a higher  $L_{avg}$ . Lowering the exchange rate from 5 dB to 3 dB resulted in the  $L_{avg}$  increasing from 84.7 dBA to 90.2 dBA. The  $L_{avg}$  was slightly above the criterion level. Therefore, hearing protection will need to be worn to bring the worker's noise exposure below the criterion level.

Out of all six settings scenarios applied in Table 1, the EU (Directive 2003/10/EC) and ACGIH settings resulted in the highest calculated noise exposures. In both scenarios, the exchange rate was set to 3 dB. Note with the EU Directive there was no threshold used. This meant all the sound pressure sampled was included in the  $L_{avg}$  calculation. The EU and ACGIH settings resulted in exposures that were 2.8 and 4.4 times the daily noise exposure limit, respectively. In both scenarios, the employer would need to take action to bring the worker's noise exposure below the criterion level. According to EU Directive 2003/10/EC, hearing protection devices are required to be worn at 85 dBA and employers must make hearing protection devices available at 80 dBA.

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<sup>2</sup> OSHA 29 CFR 1910.95

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## Noise Dosimeters: Value of Virtual Dosimeters

In order to best evaluate a worker's noise exposure at different settings, a noise dosimeter with two or more virtual dosimeters is recommended for conducting a noise exposure study. A virtual dosimeter is a firmware feature within a noise dosimeter which allows the user to program a custom measurement settings profile. Each virtual dosimeter's settings profile gives unique data value results. For example, an industrial hygienist could program a dosimeter with three virtual dosimeters to measure against Custom Setup 1, 2, and 3 from Table 1. The noise dosimeter would provide a total of three sets of results, i.e. one set of results for each setup. TSI® Incorporated (TSI) has two noise dosimeter models, the Quest™ Edge 4+ and the Edge 5. The Edge 4+ has two virtual dosimeters and has a Bluetooth® model available for monitoring noise at a distance through an app. The intrinsically safe Edge 5 has three virtual dosimeters. A device with two or more virtual dosimeters gives the industrial hygienist and safety professional the ability to measure noise exposure against both a government regulation and a recommended industrial hygiene practice such as ACGIH or other safety or internal company measurement settings. This ensures compliance to applicable regulations, but also allows for decision making in the best interest of minimizing noise-induced hearing loss to workers.

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## Conclusion

To reduce noise-induced hearing loss, it is critical safety professionals implement hearing conservation policies to best protect workers over the span of their career. The noise exposure study analyzed in this application note highlights how lowering the noise dosimeter setting values will increase the  $L_{avg}$ . As  $L_{avg}$  increases, the likelihood an employee will be enrolled in a hearing conservation program also increases. Noise dosimeters like the TSI® Quest™ Edge 4+ and 5 with capabilities to calculate noise exposure against multiple settings profiles help safety professionals maintain government compliance, but more importantly, ensure the safety of workers.



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**USA** Tel: +1 800 680 1220  
**UK** Tel: +44 149 4 459200  
**France** Tel: +33 1 41 19 21 99  
**Germany** Tel: +49 241 523030

**India** Tel: +91 80 67877200  
**China** Tel: +86 10 8219 7688  
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