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AURAL COMFORT AND SAFETY ASSESSMENT IN A TERTIARY SECTOR ENVIRONMENT

VALUTAZIONE DEL COMFORT ACUSTICO E DELLA SICUREZZA IN UN AMBIENTE DEL SETTORE TERZIARIO

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Riassunto

Nella legislazione italiana il valore limite di esposizione al rumore durante una giornata lavorativa di 8 ore è fissato a 87 dB(A) [art. 189 lettera a) del D.Lgs 9 aprile 2008 n.81] al fine di prevenire danni all'udito. È evidente che in ambienti lavorativi in cui si svolgono attività tipiche del settore terziario tali valori di esposizione al rumore vengano difficilmente raggiunti o superati; quindi, in questi casi, prendendo come riferimento l'allegato XXXIV del TU81/80, contenente gli obblighi da applicare al fine di realizzare gli obiettivi del "titolo VII – Attrezzature munite di videoterminali" del TU81/08 , durante la valutazione del rischio il datore di lavoro è più che altro tenuto a verificare che il rumore emesso dalle attrezzature presenti nel posto di lavoro non perturbi l'attenzione e la comunicazione verbale dei lavoratori. In linea con il concetto di "salute" espresso nel TU81/08, la quale, si ricorda, è definita come "uno stato di completo benessere fisico, mentale e sociale non consistente solo in un'assenza di malattia o di infermità" [TU81/08, art.2 lettera o)], la valutazione del rischio rumore compete al datore di lavoro non solo quando esiste il pericolo di causare un danno permanente agli organi dell'udito ma anche nei casi in cui il rumore agisca, semplicemente, come una fonte di disturbo. In campo internazionale, lo studio del rumore quale fonte di disturbo in ambiente lavorativo è diventato un argomento di diffuso interesse soprattutto negli ultimi decenni e in particolare al giorno d'oggi la letteratura scientifica indaga come diversi fattori fisici e psicologici, quali ad esempio la temperatura, la qualità dell'aria, l'illuminazione, il rumore, la disposizione delle postazioni di lavoro *etc*., influenzino la percezione che gli utenti hanno dell'ambiente che li circonda. Se da una parte la comprensione delle dinamiche che rendono confortevole un ambiente è importante per la società contemporanea (è stato stimato che mediamente si trascorra l'80-90% della propria giornata al chiuso), dall'altra l'argomento acquista un particolare interesse se contestualizzato in un ambiente lavorativo, poiché diversi studi dimostrano che un basso livello di comfort percepito sia spesso associato ad un diminuzione della produttività dei lavoratori. Da questo punto di vista allora è interessante notare che un approccio proattivo alla sicurezza e salute sul lavoro può tradursi in un vantaggio strategico per un'organizzazione, contrariamente all'opinione ancora diffusa che associa la sicurezza ad un costo imposto.

Grazie alla collaborazione tra il Dipartimento di Ingegneria e il Dipartimento di Psicologia dell'Università degli Studi di Padova è stato avviato un progetto di ricerca che si pone proprio l'obiettivo di valutare gli effetti dell'interazione tra condizioni ambientali, benessere percepito e produttività sul lavoro. Il "Laboratorio CORE-CARE", allestito all'interno delle strutture dell'ex Dipartimento di Fisica Tecnica, rappresenta la base operativa di questo progetto. Complessivamente il laboratorio è costituito da due ambienti, ossia una camera di prova e una

sala macchine, nella quale si trovano gli impianti per l'elaborazione e il controllo delle condizioni ambientali della camera di prova stessa. L'intenzione è quella di ricreare un ambiente di lavoro - nello specifico un ufficio - all'interno della camera di prova e di esaminare l'attitudine al lavoro dei soggetti coinvolti in diverse simulazioni al variare delle condizioni ambientali di prova, quali ad esempio temperatura, umidità relativa, rumore ed illuminazione. Il presente lavoro di tesi si inserisce nel contesto di tale progetto di ricerca e si prefigge lo scopo di caratterizzare l'ambiente sonoro all'interno della camera di prova del laboratorio CORE-CARE, individuando la presenza di eventuali zone favorite o sfavorite dal punto di vista acustico per mezzo di un modello software appositamente creato. I risultati conseguiti saranno successivamente impiegati durante la fase di allestimento dell'ufficio. La tesi prevede pertanto una prima fase di revisione bibliografica, discussa nel capitolo 1, grazie alla quale è stato possibile comprendere gli effetti nocivi del rumore sul benessere percepito e sulla produttività, nonché quali siano le principali problematiche acustiche negli ambienti di lavoro simili agli uffici. Nel capitolo 2 vengono presentati i risultati delle misure di caratterizzazione acustica del laboratorio, mentre nel capitolo 3 sono descritte le fasi di costruzione del modello software. Nel capitolo 4, infine, si discute la validità dei risultati ottenuti servendosi di tale modello e si offre una mappatura delle proprietà acustiche della camera climatica del laboratorio CORE-CARE.

Considerando nello specifico le problematiche legate al raggiungimento di un soddisfacente livello di comfort acustico negli uffici, il parlato, cioè il rumore dovuto alla comunicazione verbale tra individui, è riconosciuto come la principale fonte di disturbo sonoro. In particolare, ciò che determina il grado di invadenza del parlato non è tanto il livello di pressione sonora che esso raggiunge, quanto più l'intelligibilità ad esso associata, ossia la percentuale di parole o frasi del discorso che risultano comprensibili. In termini tecnici l'intelligibilità del parlato viene espressa attraverso lo "Speech Transmission Index" (STI), che assume un valore pari a 0 quando l'intelligibilità del parlato è nulla, mentre il valore massimo di 1 quando è perfetta. Come approfondito nel paragrafo 1.1.2, alcuni autori hanno stabilito una correlazione tra la diminuzione della produttività di lavoratori impiegati in mansioni tipicamente svolte in ufficio e il parametro STI, dimostrando che una perfetta comprensione della voce umana altrui può determinare una apprezzabile riduzione delle prestazioni lavorative a seconda del compito eseguito. Le persone comunicano per scambiare informazioni, ma udire e comprendere informazioni indesiderate è controproducente in un ambiente di lavoro, sia per chi tali informazioni le riceve, poiché aumentano le fonti di distrazione e disturbo, sia per chi involontariamente le trasmette, in quanto un ambiente propriamente progettato dal punto di vista acustico deve anche garantire un certo livello di privacy per gli utenti. In ultima analisi, quindi, dalla revisione bibliografica emerge che la corretta progettazione acustica di un ufficio passa attraverso la riduzione dell'intelligibilità del parlato e questo obiettivo si può ottenere agendo principalmente su tre aspetti, vale a dire aumentando l'assorbimento acustico all'interno dell'ambiente, impiegando schermi di separazione tra postazioni di lavoro e servendosi di suoni artificiali di mascheramento.

Le misure di caratterizzazione acustica hanno consentito di descrivere i seguenti parametri:

- tempo di riverbero, con misure effettuate secondo lo standard EN ISO 3382-2: 2008;
- potenza sonora del sistema di ventilazione meccanico, con misure effettuate secondo lo standard EN ISO 3747: 2010;
- speech transmission index, con misure effettuate secondo lo standard IEC 60268:2011.

I risultati, presentati nel paragrafo §2.2, confermano che lo studio di un locale di dimensioni ridotte non necessariamente è più semplice di quello di un ambiente di grandi dimensioni, ma che anzi, il più delle volte, è vero proprio contrario. Minore è il volume dell'ambiente in gioco, maggiore è la probabilità che a basse frequenze l'acustica sia dominata dalla presenza di risonanze modali, le quali influenzano notevolmente la distribuzione spaziale del campo sonoro presente in quel determinato ambiente. Ma in tali condizioni risulta limitato il campo di applicabilità delle equazioni previste dalla teoria classica dell'acustica, e di conseguenza si riduce l'affidabilità della descrizione effettuabile attraverso di essa. Nel caso in esame, il limite inferiore di applicabilità del teoria classica si registra alla frequenza di 400 Hz, con il problema che la principale sorgente sonora all'interno della camera vuota, ossia il sistema di ventilazione meccanico, emette la maggior potenza sonora nelle bande d'ottava con frequenza centrali di 125 e 250 Hz.

La modellizzazione acustica della camera climatica del laboratorio CORE-CARE è stata effettuata utilizzando il software open-source I-Simpa, sviluppato dall'Unità di Ricerca in Acustica Ambientale (UMRAE) dell'Istituto Francese di Scienza e Tecnologia per i Trasporti e lo Sviluppo (IFSTTAR). I-Simpa è distribuito con due codici di calcolo, e cioè il codice SPPS, dal francese "Simulation de la Propagation de Particules Sonores", e il codice TCR, dal francese "Théory Classique de la Révérberation". Indipendentemente dal software che si utilizza, la creazione di un modello acustico è un'operazione che, per diversi motivi, risulta sempre problematica. Per prima cosa bisogna considerare che tutte le variabili che si impongono ad un modello sono ottenute a partire da dati misurati ed utilizzando correlazioni di natura sperimentale. Ma ogni misurazione è interessata da un grado di incertezza ineliminabile e il campo di applicabilità delle relazioni di sperimentali a cui si ricorre non è illimitato. Consideriamo ad esempio la definizione dei coefficienti di assorbimento dei materiali presenti all'interno della camera del laboratorio, affrontata nel paragrafo §3.3. L'assorbimento acustico dei materiali può essere stimato a partire dal tempo di riverbero misurato ma a rigore, vista la presenza di risonanze modali nella stanza, i dati ottenuti per le basse frequenze non dovrebbero essere ritenuti rappresentativi della realtà. In alternativa si può pensare di stabilire i coefficienti di assorbimento dei materiali in base ai dati presenti in letteratura, ma in questo caso il problema consiste nel fatto che difficilmente si avranno dati di letteratura ben applicabili al proprio caso, dal momento che non esiste né l'obbligo per i produttori di dichiarare le proprietà fonoassorbenti dei materiali né l'obbligo di commercializzare prodotti con determinate caratteristiche acustiche.

In secondo luogo, anche nel caso ideale in cui i dati di misura siano del tutto certi e le variabili definite nel modello siano uguali a quelle reali dell'ambiente, non si può ritenere a priori che i risultati ottenuti tramite la simulazione saranno uguali ai dati di misura rilevati, perché non è detto che il software sia capace di replicare il comportamento effettivo dell'ambiente simulato. In altre parole. Come messo in evidenza nel paragrafo §4.2, I-Simpa non modellizza la presenza di risonanze modali all'interno di un ambiente e per tale motivo lo scostamento tra i livelli di pressione sonora ottenuti tramite la simulazione e i livelli di pressione sonora misurati risulta elevato per quelle frequenze in cui il campo sonoro non è diffuso.

I risultati ottenuti mediante una simulazione devono essere interpretati tenendo conto di tutte le limitazioni inevitabilmente insite nel modello. In termini pratici questo si traduce in un analisi dello scostamento tra risultati di simulazione e dati di misura nonché nella definizione di un intervallo di accettabilità dei risultati di simulazione stessi (si veda a tal proposito il paragrafo §4.2.1). Il principio che sta alla base del ragionamento è il seguente: se il risultato di simulazione e il dato di misura ottenuti per un punto noto, vale a dire per un punto in cui effettivamente sono state effettuate le misure, discostano tra loro di una certa percentuale δ alla frequenza in esame, allora si può ipotizzare che lo stesso scostamento δ intervenga per un qualsiasi altro punto esaminato, ottenendo così dei dati di misura plausibili anche per quei punti i cui la misura non è stata, in realtà, effettuata. In altre parole, se il modello è costruito correttamente e si conosce lo scostamento percentuale tra risultati di simulazione e dati di misura per un parametro di interesse, diventa possibile dedurre dai risultati di simulazione quel valore del parametro che, in assenza del modello, sarebbe possibile conoscere solamente compiendo una misura in campo. Applicando la metodologia appena esposta si arriva, in conclusione, ai risultati presentati nel paragrafo §4.3, grazie ai quali è possibile sostenere che la distribuzione del tempo di riverbero e del livello di pressione sonora dovuto al sistema di ventilazione non determinano la presenza di zone favorite o sfavorite dal punto di vista del comfort acustico all'interno della camera climatica del laboratorio CORE-CARE.

Comunque è necessario sottolineare ancora una volta che i risultati deducibili attraverso una simulazione software non sono affatto certi e che necessitano di essere interpretati con consapevolezza. Servirsi di un modello software risulta utile soprattutto in fase di progettazione (si immagini ad esempio di dover valutare gli effetti di un trattamento acustico che si intende realizzare), ma basare la progettazione esclusivamente su di esso, cioè senza accertare la corrispondenza tra risultati attesi e risultati effettivamente raggiunti (verificabili solo svolgendo delle misure direttamente in campo), può condurre a gravi errori di valutazione.

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Introduction

The study of noise as a source of disturbance in the workplace has become a topic of widespread interest in recent decades and several studies show that a low level of aural comfort is often associated with a drop in productivity of workers. Thanks to the collaboration between the Department of Engineering and the Department of Psychology of the University of Padua a research project was launched with the aim of assessing the effects of the interaction between environmental conditions, such as temperature, air quality, lighting or noise, perceived well-being and productivity in a working environment, in particular an office. Tests will be conducted in laboratory CORE-CARE core, consisting of a climatic chamber and an engine room.

This work is a preliminary part of research project and it aims to characterize sound environment inside the test chamber of laboratory CORE-CARE, identifying the presence of any favoured or disadvantaged areas from an acoustic point of view by means of a software model. Achieved results will then be used during office setup phase. Different acoustical parameters were determined through measurements, in particular reverberation time (in accordance with EN ISO 3382-2: 2008), ventilation system sound power level (in accordance with EN ISO 3747: 2010) and speech transmission index (in accordance to IEC 60268:2011) while the model for the laboratory room was built using the open-source software I-Simpa. Combining the information both from measurement data and model results, it is possible to sustain that the distribution of reverberation time and sound pressure level due to the ventilation system do not determine the presence of favoured or disadvantaged areas from the point of view of acoustic comfort inside the climatic chamber of the laboratory CORE-CARE.

Chapter 1

Bibliographic Review

In this chapter the effects of noise on perceived comfort and productivity of workers are discussed through a bibliographic review, referring mainly to office-type environments. Furthermore, the acoustic variables that can be used to describe such environments and possible design solution are presented.

1.1 Noise effects on perceived comfort and worker productivity

It has been estimated that in contemporary society humans spend 80-90% of the day indoors. Thus, to understand how and in what way our life quality is influenced by the surrounding environment is a topic of great importance, even when great health risks do not exist. For workplaces, the issue of perceived comfort is closely related to the evaluation of worker productivity and scientific literature is studying it carefully, with particular reference to tertiary sector environments.

According to Al Horr *et al*. [1] comfort is defined by an absence of unpleasant sensations which provide positive effects on well-being: comfort is subjective in nature and varies from person to person. In particular, taking an office as reference environment for tertiary sector, comfort can be considered as a sum of several components, indeed it depends on both physical parameters (air quality, temperature, noise, light etc.) and functional (ergonomics, resources etc.) or psychological (privacy, aesthetics etc.) aspects. Overall comfort is an outcome of personal health and mood, in addition to functional as well as environmental factors.

Leaman and Bordass [2] defined productivity as the ability of people to enhance their work output through increases in the quantity or quality of the product or service they deliver. Productivity is a ratio of output to input and the definition can vary depending on the context and content of the input and output. In the case of office environments, productivity can be measured using different criteria such as individual, team or organisational performance.

Sound, or rather noise, is certainly one of the most important quantitative factors to be included in evaluation of work environments because it can have negative effects on both comfort and productivity.

1.1.1 Noise and Indoor Environmental Quality

From a general point of view, occupant comfort and well-being in indoor environment depend not only from acoustic variables such as sound pressure level or background noise, but also from many other factors: aural, thermal, visual and indoor air comfort together determine the environment perception, although each physical factor independently contributes to it. For example, if we open an operable window in summer for natural ventilation, thermal comfort and indoor air comfort increased but acoustic comfort decreased with intrusive noise, and, if the window was not transparent, opening the window could change the visual comfort as well. Several studies suggest that interactions between environmental components exist. For example, Pellerin and Candas [3] studied the combined effects of noise and temperature on environmental perception and acceptability on 18 lightly clothed subjects, individually exposed for 2h in a climatic chamber. Main results indicate that acoustic perception decreases when thermal environment is far from thermoneutrality and that thermal unpleasantness is higher when noise level increases. Moreover, they proposed an equivalence between acoustic and thermal sensations: a 1°C deviation from thermoneutral conditions could equal 2,6–2,9 dB(A) increase in noise level. Also Yang and Moon [4] investigated the influence of multisensory interaction on indoor environmental comfort with three physical indoor environmental factors, i.e., acoustic, thermal, and illumination conditions in an environmentally controlled laboratory. The results indicate that acoustic comfort increases at thermoneutrality, thermal comfort increases with a decrease in the noise level at 500 lx, and visual comfort increases with a decrease in the noise level at thermoneutrality. Again, indoor environmental comfort increases with a decrease in the noise level at thermoneutrality in brighter conditions and in steady state thermal and illumination conditions with time-varying sound stimuli, the effect of acoustic factors was the greatest on indoor environmental comfort, followed by room temperature and illuminance. Therefore, interactions among the environmental factors affect occupant overall comfort and combined effects of environmental factors should be carefully considered.

Indoor environmental quality (IEQ) can be defined as a measure of the ability of a closed environment to ensure occupants well-being. IEQ represents a domain that encompasses different sub-domains that affect the human life inside a building, e.g. indoor air quality, lighting, thermal comfort, acoustics, drinking water, ergonomics, electromagnetic radiation, and many related factors. IEQ and occupant comfort are closely related and the overall IEQ acceptance can be used as a quantitative assessment criterion for an indoor environment where an occupant's evaluation is expected. Nevertheless, the complexity of the relationship between occupant comfort and well-being parameters with IEQ are further exacerbated due to relationships that these parameters have with each other as well [5].

Focusing on the influence of aural comfort on IEQ index definition, it is shown that acoustic aspects are as important as the thermal ones for those places where activities that require mental effort are carried out, e.g. a classroom or an office. Questionnaires are an important tool for analysing the thermo-hygrometric, acoustic, and lighting conditions of indoor environments: using questionnaires purposely developed for the evaluation of thermal, acoustic and visual conditions in seven classrooms at the University of Pavia (Italy) [6], Buratti *et al.* [7] worked out a combined comfort index weighting these three aspects on the basis of the occupants judgements and it was found that the mean percentage of given importance was greater for the acoustical one (34,5% thermal, 35,7% acoustical and 30,1% visual). Other research also confirm these results.

Lee *et al.* [8] investigated the relationship between Indoor Environmental Quality (IEQ) and learning performance in air-conditioned university teaching rooms via subjective assessment and objective measurement. Their results show strong associations of the overall IEQ votes with the environmental parameters and while thermal comfort, indoor air quality and visual environment are of comparable importance, aural environment is considered the major determining factor. Wong *et al.* [9] examined the IEQ in offices basing the study one the evaluations made by 293 office workers in Hong Kong and calculated the overall IEQ acceptance from a multivariate logistic regression model. In this case the relative significance of noise level on the overall IEQ acceptance is lower than that of operative temperature and carbon dioxide concentration, but in any case equivalent noise level has important effects on the global evaluation. Again, Lai *et al.* [10] considered overall IEQ in terms of occupant acceptance in residential building. In this study, the overall IEQ of residential apartments in Hong Kong was evaluated by 125 occupants in four aspects, namely thermal comfort, indoor air quality, equivalent noise level and illumination level. Based on the total votes, both thermal and aural environmental qualities were deemed the most important contributors whereas indoor air quality was considered the least.

As we have just seen, the scientific literature recognizes that both thermal comfort and air quality, as well as acoustic and visual comfort, are fundamental parameters when evaluating the indoor environmental quality and that it is necessary to consider these parameters simultaneously and interactively. Consequently, the study of acoustic parameters cannot be neglected at all and it is a basic step for indoor quality evaluation.

1.1.2 Noise and productivity

Al Horr *et al.* [1] distinguished eight physical factors which are directly related to the IEQ of a workplace and which affect occupant satisfaction and productivity - Indoor Air Quality and Ventilation, Thermal Comfort, Lighting and Daylighting, Noise and Acoustics, Office Layout, Biophilia and Views, Look and Feel, Location and Amenities. Studies of acoustic quality and suitability of rooms designed for intensively intellectual and cognitive activities, such as educational and work environments, have been the focus of scientific research and this topic has been studied especially for open plan offices because of their wide use [11]. Noise in an office can have two locations for sources, external or internal. External sounds include traffic, the public, air traffic or machinery, while internal noises include co-worker conversations, machine sounds such as telephones, keyboard typing noise and other office equipment. Results show a correlation between loss of productivity in workers or self-assessed performance and bad acoustic conditions [12, 13, 14, 15]. In particular, acoustic variables can negatively affect worker productivity depending on considered variable and required task.

Speech is widely considered the most distracting sound in open plan offices. It is not the sound level of speech that determines its distracting power but its intelligibility, which can be physically determined by measuring the Speech Transmission Index (STI).

As reminded by Haapakangas *et al.* [16], basic cognitive research has repeatedly demonstrated that background speech impairs cognitive performance and that these effects are larger than those produced by non-speech noise. Unattended background speech has been shown to affects cognitive tasks, such as short-term memory, mental arithmetic, reading comprehension, proofreading, and writing performance. Jahncke *et al.* [17] explain that working memory processes are of crucial importance when working with complex tasks because they process information necessary for the task at hand and they temporarily store and handle the needed information. Thus, investigating cognitive, emotional, and physiological effects of two open plan office noise conditions, respectively high noise level Leq = 51 dB(A) and low noise level Leq = 39 dB(A), during work in a simulated open-plan office, they found that the participants remembered fewer words, rated themselves as more tired, and were less motivated with work in noise compared to low noise. Furthermore they tested the effects of four restoration condition (river movie with sound, only river sound, silence, and office noise) after the working period and they found that participants who saw a nature movie including river sounds during restoration phase rated themselves as having more energy after the restoration period, in comparison with both the participants who listened to noise and river sounds. If properly designed, acoustic environment can improve occupants well-being.

Hongisto [18] developed a model to predict intelligible speech effects on work performance: the best performance occurs when speech is absent (STI = 0), and the strongest performance decrement (more than 6%) occurs when speech is perfectly heard (STI = 1), while the performance starts to decrease when STI exceeds 0,2 and highest performance decrease is reached already when STI exceeds 0,60. Jahncke *et al.* [19] tested Hongisto's model and found that the steepest slope of overall performance occurred when STI was located between 0,23 and 0,34. Also, the performance decrease function was different depending on performed task, i.e. significant decrease for word memory task and math task instead insignificant decrease for information search task and word fluency tasks. In [20], 57 subjects were confronted with a serial memory task in four STI conditions (from 0,25 to 0,65). As expected, performance seemed to decrease when speech intelligibility was improved, but results did not exhibit the

shape of STI-performance curve found in [18]. The effect was strongly dependent on participants and a within-subjects analysis showed that some people proved to be insensitive to intelligible speech while achieving the task.
Although with lower effects, also office noise without speech can produce disruptive effects on memory, especially when it is varying in time and unpredictable and even if people feel able to adapt to it. From literature review reported still in [18], it results that teletype machine noise (70 dB) decreases productivity by 20%.
However, if on one hand the negative effects of noise on worker productivity, above all of intelligible speech noise, are recognized, on the other hand we should not think that absolute silence has positive effects on it. Acun and Yilmazer [21] discovered during interviews that employees were concerned with silence as much as they were concerned with the noise. Employees expressed that the sound of keyboard and mouse means that they were working at that moment, there were other people around, and they were not working alone, or not working overtime.
It is clear that the study of the effects of indoor environmental conditions, in particular of acoustical ones, on people productivity is a topic that requires the contribution of different subjects (psychology, engineering, architecture etc.) and its complexity is great because elements of subjectivity cannot be neglected. About that, Kaarlela-Tuomaala *et al.* [22] recommend to measuring individual noise sensitivity while performing any experiments on productivity. Our hearing recognises information in the sounds that we hear and noise can be defined as an information we don’t need or want. Nevertheless, it is not said that we all need or want the same information.

1.2 Acoustical environment description

The acoustic environment as perceived, experienced or understood by a person or people in context is called soundscape [21]. Creating a satisfactory soundscape lies upon controlling the sound levels and sound sources, as well as considering people expectations and the type of activity that is carried out in the assessed environment. A satisfactory soundscape in working environment can improve comfort perception and occupant productivity with benefits not only for worker health but also for business: for example, taking previously mentioned Hongisto’s model [18] as a reference, it is possible to calculate that decreasing STI from 0,7 to 0,5 worker causes productivity improves of 2% and it means an annual saving of € 60’000 if there are 100 workers with average annual salary costs of € 30’000.
In the present paragraph main quantitative parameters that determine office-type environments soundscape and design solution for good acoustical environments are briefly discuss, still focusing mostly on open plan office.

Anyway, it is necessary to repeat again that noisiness is a subjective perception. Objective measurements are certainly a good starting point, but at the same time they may not be enough. Even if time-averaged sound pressure level over the working day is the same in two different environments, one of them can be considered noisier then the other, as it happens in [22]. This confirms that every environment needs a customized and original evaluation.

1.2.1 Acoustic parameters and target values

The international standard EN ISO 3382-3: 2012[1] specifies methods for the measurement of room acoustic properties in open plan offices with furnishing and it defines single number quantities which can describe acoustic performance of office. The most commonly mentioned causes of poor acoustic conditions in offices are disturbance caused by colleagues' speech and poor speech privacy. The effects seem to mainly depend on speech intelligibility and not on the loudness of speech. Also EN ISO 3382-3 proposes this approach.

- **Spatial decay rate of speech $D_{2,S}$** [dB] is the rate of spatial decay of A-weighted sound pressure level of speech per distance doubling.

- **A-weighted sound pressure level of speech at a distance of 4 m $L_{p,A,S,4m}$** [dB(A)] is the nominal A-weighted sound pressure level of normal speech at a distance of 4,0 m from the sound source.

- **speech transmission index STI** is a physical quantity representing the transmission quality of speech with respect to intelligibility.

- **distraction distance r_D** [m] is the distance from speaker where the speech transmission index falls below 0,50.

- **privacy distance r_P** [m] is the distance from speaker where the speech transmission index falls below 0,20.

- **background noise level $L_{p,A,B}$** [dB(A)] is the A-weighted sound pressure level in octave bands present at the workstation during working hours with people absent.

Haapakangas *et al.* [23] examined r_D, $D_{2,S}$, $L_{p,A,S,4m}$, $L_{p,A,B}$ as possible predictors of perceived noise disturbance. The results show that distracting background speech largely explains the overall perception of noise and in particular increase in distraction distance predicts an increase

[1] EN ISO 3382-3: 2012. Acoustics - Measurement of room acoustic parameters. Part 3: Open plan offices.

in disturbance by noise. Having reference values for these parameters is useful to set up a correct design of the workplace, avoiding problems linked to comfort and productivity reduction. Target values were been discussed in literature and also they are reported in EN ISO 3382-3 (annex A). Optimum work performance is possible when sentence intelligibility is negligible, that is STI < 0,20. More commonly suggested value is STI < 0,50 between the speaker and the listener to avoid loss of productivity and annoyance. As mentioned as mentioned in previous §1.1.2, even STI equal to 0,34 is linked in some cases to a decrease in productivity. Figure 1 is a schematic representation of Hongisto's model to predict decrease in productivity as function of STI. In table 1 there are STI recommended values and related speech intelligibility conditions. Both figures are taken from [18].

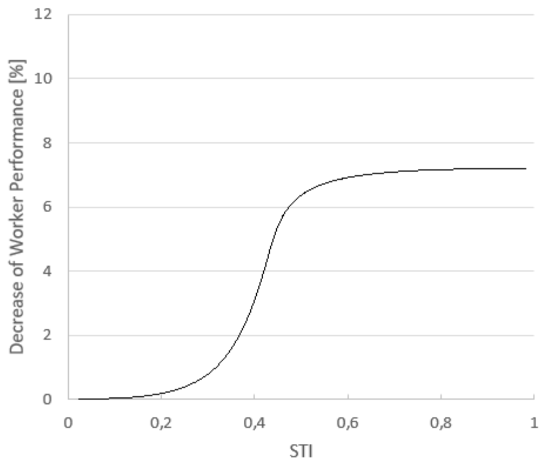


Figure 1 Prediction model, which gives the decrease in performance as function of STI. Highest performance is obtained when no speech is heard (STI=0) and the highest performance decrease is reached when speech is highly intelligible (STI>0,7)

Table 1 Recommendations for the STI between adjacent workstations in an open-plan office

STI	Speech intelligibility	Speech privacy
0,00 ÷ 0,05	Vary bad	Confidential
0,05 ÷ 0,2	Bad	Good
0,2 ÷ 0,4	Poor	Reasonable
0,4 ÷ 0,6	Fair	Poor
0,6 ÷ 0,75	Good	Very poor
0,75 ÷ 0,99	Excellent	No

Hongisto et al. [24] and Virjonen et al. [25] suggest a classification in which "class A" corresponds to the highest acoustic quality while "class D" corresponds to the lowest. It should be noted that the recommended acoustic class depends on the type of work. The highest possible speech privacy, class A, is necessary for individual work but in the case of team work, class C could be sufficient. Basing on Hongisto and Keranen [26], $D_{2,S}$, $L_{p,A,S,4m}$ and r_D can be predicted with errors less than 1,5dB, 3.0dB and 2,5m respectly. In table 2, recommended values for the parameters are reported.

Table 2 Acoustic classification and target values of open plan offices.

Class	Acoustic classification	DL_2 [dB(A)]	$L_{p,S,4m}$ [dB]	r_D [m]
A	Excellent	>11	<48	<5
B	Good	9 to 11	48 to 51	5 to 8
C	Fair	7 to 9	51 to 54	8 to 11
D	Poor	<5	>54	> 11

As regards background noise, it is not perceived as a noise source in open-plan offices as long as it decreases speech intelligibility. Background noise can be a beneficial sound source when it is properly design. Haapakangas *et al*. [16] recommend to use an equivalent masking sound level of 45 dB(A) because such noise level it is not in itself perceived as a distraction, even among the more noise-sensitive individuals. Also Bradley and Gover [27] found that ambient noise levels of about 45 dBA were judged to be most preferred in the presence of speech from an adjacent workstation. They suggested that ambient noise levels should not exceed 48 dBA. Huang *et al*. [28] found a correlation between the satisfaction level of the acoustic environment and the A-weighted sound pressure level. According to this correlation, which is shown in figure 2, when the noise level is below 49,6 dB(A), subjects felt satisfied with the acoustic environment and when the noise level increases above this threshold subjects felt increasingly uncomfortable. Keeping in mind this relationship is useful to understand why such target value for background noise (and sound masking) have been proposed.

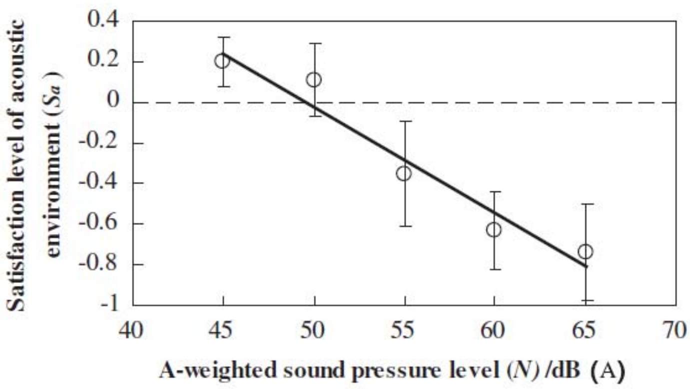


Figure 2 Relationship between satisfaction level of the acoustic environment and A-weighted sound pressure level. The relation is express by Sa= -0,542N +2,6 and it is proposed in [28].

Lastly, it should be remember that several indices have been proposed in order to evaluate aural comfort, for example Equivalent Sound Pressure Level, Noise Rating Curves, Room Criteria Curves etc. Given the nature of the noise generally encountered in offices, it was found [29] that that Equivalent Sound Pressure Level and Zwicker's loudness level are the best among the commonly used noise indices to express a correlation between acoustic environment and auditory sensation feeling of office workers, while NC and NR are not satisfactory.
Besides the sound level, the presence of tonal components seemed to influence the degree of annoyance. As explained in [30] people exposed to noise with tonal components are more annoyed than the others and the effect of the tonal component on annoyance corresponds to a difference in pressure level of approximately 3-6 dB. Tonal components might increase the annoyance levels and thy should be included in the evaluation.

1.2.2 Design strategy

It is important to study how different room acoustic solutions usually applied in open-plan offices can be used to reduce the negative effects of irrelevant speech.
Hongisto *et al.* [31] developed a simple model to predict speech intelligibility between two nearby workstations both in open plan offices and in conventional offices. The principle of the model is shown in figure 3.
Leaving out the mathematical expressions for each component that can be deepened in [31], seven separate sound "paths" or "sources" are considered:

- speech through separation screen $L_{p,1}$;
- speech reflected from ceiling or walls $L_{p,2}$;
- speech diffracted over the screen $L_{p,3}$;
- reverberant speech $L_{p,4}$;
- noise caused by ventilation, office equipment and masking system, $L_{p,5}$, $L_{p,6}$, $L_{p,7}$.

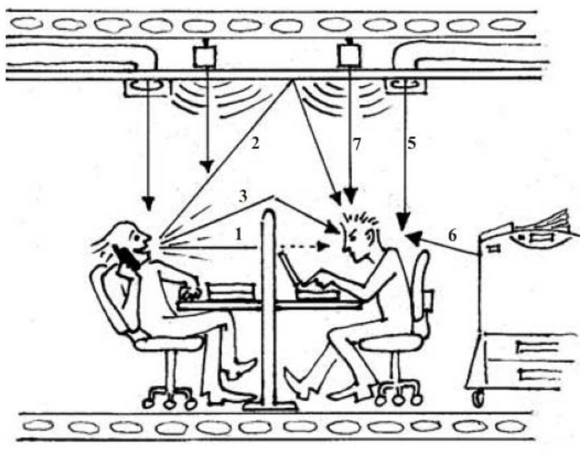


Figure 3 Side view of the 2D-office model including the most important speech propagation paths and masking sound sources. Path 4 (reverberant speech) is not illustrated

Paths 1-4 constitute different propagation paths of speech from nearby workstations and their sum represents the total sound speech level L_S. Paths 5-7 represent the most important background noise sources and their sum gives the total background noise L_N. The difference between L_S and L_N is called speech-to-noise ratio L_{SN} and it can be used to estimate STI. The following figure 4 is taken from reference [18] and it represents STI as function of reverberation time T and signal to noise level L_{SN}. Despite its limitations, this model is still useful to understand how total speech level is composed and how room acoustics can be controlled technically by three main factors:

- room absorption, which prevents reverberation and early reflections;
- screens between desks, which cut the direct sound;
- artificial masking sound, which gives a stable sound environment and masks the speech from nearby workstations.

Scientific literature agrees in considering that speech intelligibility can be reduced in open-plan offices by simultaneous application of high room absorption, high screens between desks and the use of masking sound [32, 33, 34, 35]. Good acoustic conditions cannot be obtained unless these three factors are simultaneously considered.

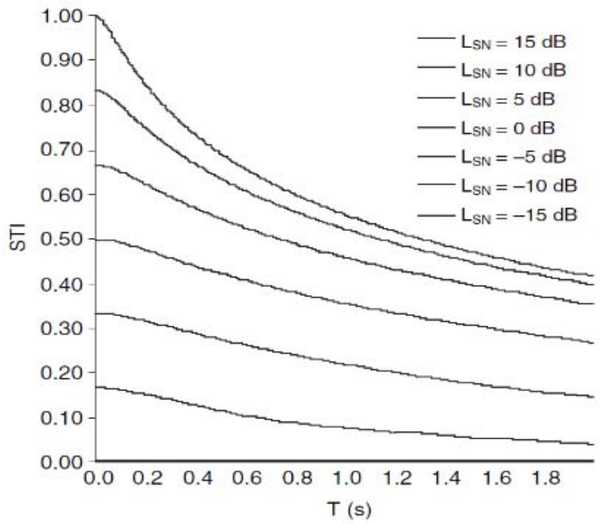


Figure 4 A schematic graph that can be used to estimate the STI basing on model of [31]. STI increases with increasing L_{SN} and decreasing T. This model should not be misunderstood by choosing long reverberation and high masking noise. It is always recommended to choose short reverberation (<0,40 s) as that makes normal conversations easy, inherent rise in voice level due to disturbing echoes is eliminated and noises are effectively attenuated with increasing distance to talker.

In [36], r_D values were influenced by the variation in ambient noise when the office was simulated in the situations without divider panels between work stations. The inclusion of divider panels increases the values of this parameter when the noise is high while the insertion of divider panels reduces it when sound pressure level is low. This can be explained by the fact that, with a high noise level, the speech intelligibility in the office is very low, so the insertion of divider panels improves the speech intelligibility at each work station, i.e. the sound is reflected by the divider panels and it returns to the speaker, intensifying the sound in the work stations behind and diagonally from the speaker. With a reduced noise level, the speech intelligibility in the room is greater. Therefore, the insertion of divider panels served to block direct sound to the work stations in front of the speaker, reducing the r_D.

DL_2 is the decay, in decibels per double the distance, of the spatial distribution curve of sound within a given range of distances. The higher the values of DL_2 parameter are, the better the acoustic conditions are in offices, because noise will be more attenuated. DL_2 parameter varied significantly with the insertion or removal of divider panels. In practice, DL_2 can be much greater than the theoretical limit for open field of -6dB for distance doubling thanks to the use of high screens between work desks and high absorbing materials in both horizontal and vertical directions. According to [24] and [25] there was no correlation between reverberation time (T_{20} or EDT) and DL_2 because reverberation time explains only the local temporal attenuation of sound but not the spatial attenuation. Low values of reverberation time can coincide with low values of DL_2. For this reason it is suggested that reverberation time should no longer be used as a design quantity in open-plan office. Reverberation time should be below 0,45 seconds in acoustic class C, and below 0,35 seconds in acoustic class A, in open-plan offices. Although DL_2 indicates the perceived spatial attenuation very well, it does not describe the absolute SPL of speech. If $L_{p,S,4m}$, is high due to, for example, hard nearby walls and screens, speech may still reach far from the speaker, even though DL_2 is high. Therefore, it is necessary to determine both DL_2 and $L_{p,S,4m}$.

Haapakangas *et al.* [37] compered five different sounds which can be used in open-plan offices to mask distracting speech: filtered pink noise, ventilation noise, instrumental music, vocal music and the sound of spring water. These sounds were superimposed on speech and the masked speech conditions corresponded to an acoustically excellent open-plan office (STI=0,38). The performance results and subjective perceptions of participants showed that the spring water sound was the most optimal speech masker whereas vocal music produced negative effect similar to those of speech. The use of constant masking sounds should be preferred in open plan offices instead of instrumental or vocal music. According to Veitch *et al.* [38], the recommended spectrum for background noise, which considers both acceptable sound quality and effective masking performance, should be close to the speech spectrum, being -5 dB/octave within 63–4000 Hz and the overall masking level should not exceed 46 dBA.

In conclusion, optimally filtered pink noise or recorded sounds from the nature or the environment are the preferred artificial masking sounds. The artificial masking sound is produced by speakers that are easily found on the market. However, masking sound increases equivalent continuous noise level $L_{A,eq,8h}$ in the office only marginally. The level of office noise is usually between 46dB and 58dB. The recommended level of masking sound is usually 45dB at most. Adding such a masking sound over office noise increases the overall level less than 1 dB. Such a difference should not increase the physical load.

Chapter 2

Acoustic Characterization Measurement of Laboratory CORE-CARE

This chapter presents the laboratory CORE-CARE, set up in one of the buildings of the Industrial Engineering department of Padua University. After a brief description of the geometrical characteristics of the site, the main results of the surveys carried out inside the laboratory are presented in order to determine its acoustical properties.

2.1 Room description

Since the summer of 2016, University of Padua has started a research project through a collaboration between Engineering and Psychology Departments with the aim of recognizing the effects of environmental parameters on the productivity of people and their perception of the working environment according to different room parameters. For this purpose, in two room on the 3rd floor of the Technical Physics building, previously intended as a classrooms, the Laboratory CORE-CARE was built. The laboratory is composed by:

- Climate Chamber, which was obtained by installing radiant systems on each surface (ceiling, floor, walls), so as to be able to control heating flows in the room. Inside this chamber air recirculation is given by a mechanical ventilation system. In this room a working environment, i.e. an office, will be set up to test comfort and quality of the perceived environment and occupant productivity as environmental conditions change.
- Engine room, in which all the systems to generate and control the fluid vectors were installed, as well as a machine for air ventilation able to heat or cool and dehumidify the test room, in order to control humidity and ventilation flow rate.

A detailed description of the changes applied to the rooms and laboratory systems is given in [39], while here only the final configuration of the climate chamber is reported because the study of acoustics is only about this part of the laboratory. In figure 5 the exploded view drawing of the test room is showed in order to give a general overview of how the chamber looks. Figure 6 shows different pictures of the climatic room while in table 3 room surfaces properties are listed. Figure 7, 8, 9 show schematized room elements dimensions.

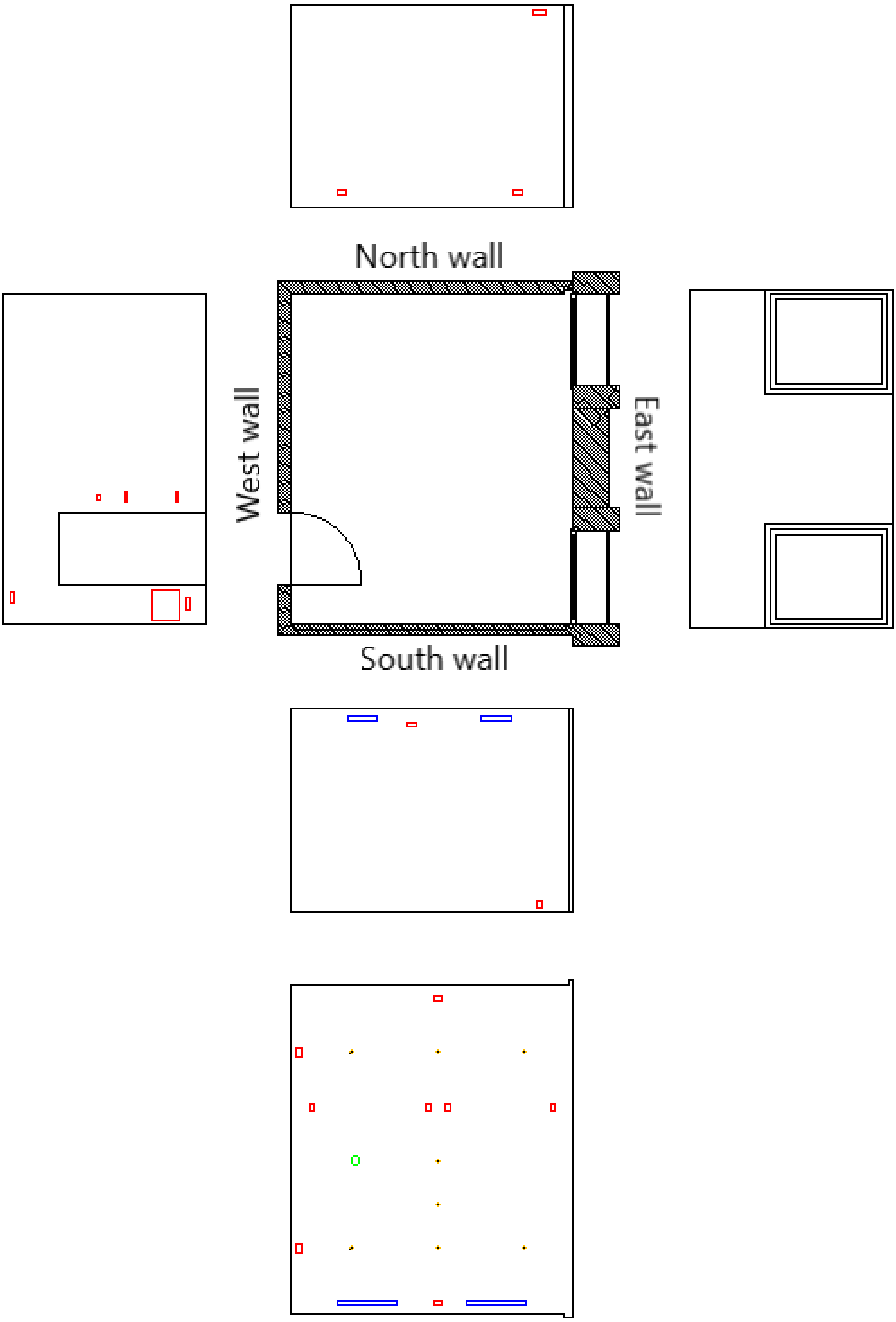


Figure 5 Exploded view drawing of climate chamber. In red: electrical boxes; in blue: supply and extraction ventilation grilles; in yellow: lighting supports; in green: fire protection device.

a) Details of east wall and windows.

b) Details of west wall and door.

c) Details of south wall and returns vents at the bottom.

d) Details of north wall and delivery vents on the ceiling.

Figure 6 Picture of Laboratory CORE-CARE climatic chamber.

Table 3 Room dimensions and properties.

	A_{net} [m^2]	**Material description**
North wall	10,8531	Plasterboard with 50 mm empty gap
South wall	10,8531	Plasterboard with 50 mm empty gap
West wall	10,6919	Plasterboard with 50 mm empty gap
East wall	7,8228	Plasterboard with 50 mm empty gap
Ceiling	17,6606	Plasterboard with 20 mm empty gap
Floor	17,6606	Painted smooth concrete
Door	1,9747	Solid door
Windows	3,3988	Double glazing with air gap
Window frame	1,445	Pvc

Total Surface [m^2]	82,3606	**Volume [m^3]**	49,27307

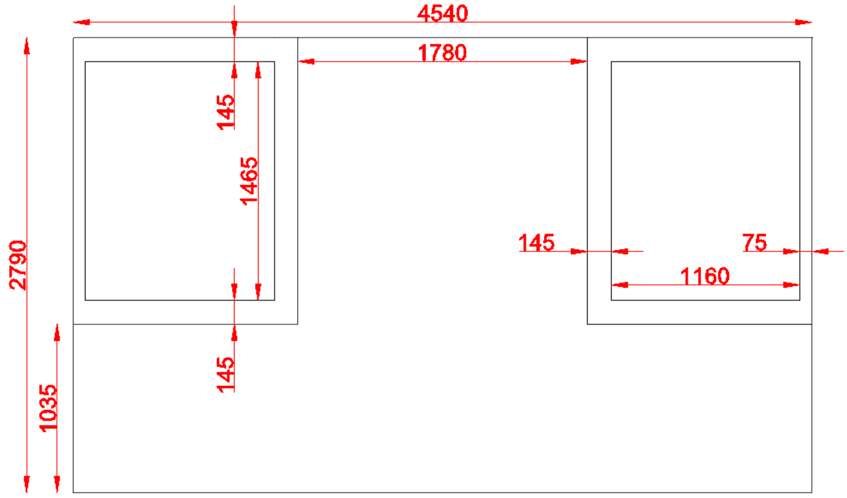


Figure 9 East wall measurements in mm.

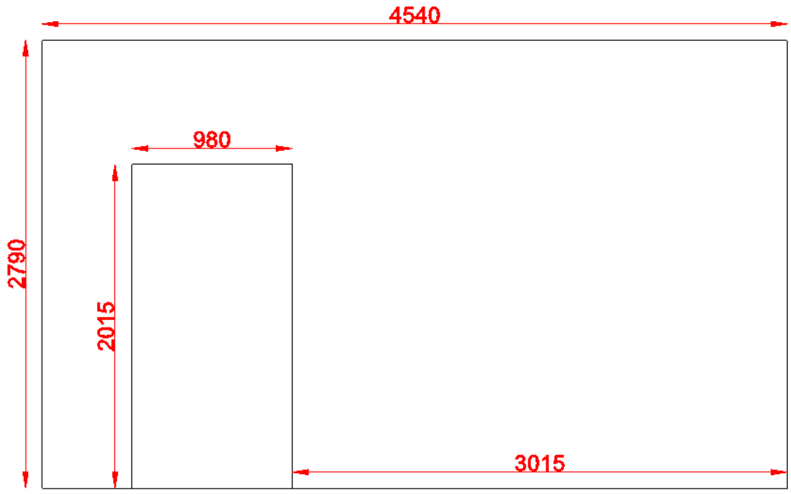


Figure 8 West wall measurements in mm.

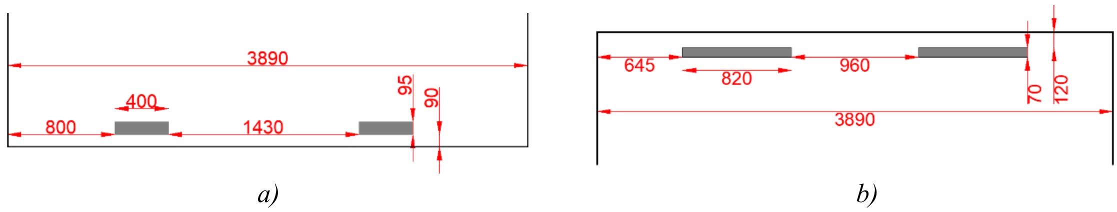


Figure 7 Ventilation grills schematisation and position in mm:
a) Return vents on south wall (at the bottom); b) Delivery vents on ceiling (at the corner with north wall).

From room acoustic point of view, elements such as power outlets or supports for lighting lamps can be overlooked because they have negligible dimensions compared to the wall in which they are placed. In the same way, the presence of ventilation grids in itself does not change the acoustic behavior of the surfaces in which they are installed. However it is necessary to specify their position, as they are active sound sources in the room.

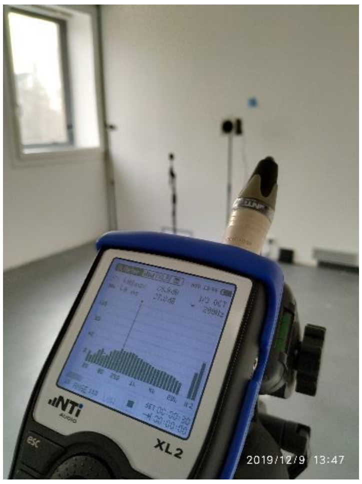
2.2 Room acoustic characterization measurements

The determination of the acoustic properties of the room was carried out by taking in field measurements. Precisely, during the day of 9 December 2019 reverberation time, sound power of ventilation system and STI were measured, according to the modalities described in the following paragraphs. The equipment (shown in figure 10) consists in:

- NTI audio XL_2 analyzer;
- NTI audio Talk Box;
- Microphone NTi Audio M2210, S/N: 1474;
- Reference Sound Source compliant with the ISO 6926 standard;
- Ballons;
- Thermo-hygronometric detector.

The microphone has been adjusted to a height of 1,2 m to simulate the average height of a seated man's ear. The Talk Box was instead fixed at a height of 1,4 m from the floor.

a) Microphone and balloons for RT measurement.



b) NTi XL_2 analyzer.

c) Thermo-hygrometric detector.

d) Close up of Reference Sound Source for sound power level determination.

e) Microphone and Talk Box for STI determination.

Figure 10 Pictures of used equipment.

In table 4 the coordinates of the points used for the positioning of the sound sources and the microphones are given, while in figure 11 these points are shown in plan.

Table 4 Measurement point coordinates in mm. Point S rapresents NTI Talk Box position (height z = 1400 mm) while all other points are microphone position (height z = 1200 mm).

Point	X [mm]	Y [mm]	Point	X [mm]	Y [mm]	Point	X [mm]	Y [mm]
S	1945	500	**V1**	900	900	**A**	1320	1570
R1	1945	1500	**V2**	2990	900	**B**	2600	1450
R2	1945	2500	**V3**	2990	3640	**C**	2860	2840
R3	1945	3500	**V4**	900	3640	**D**	1600	3400

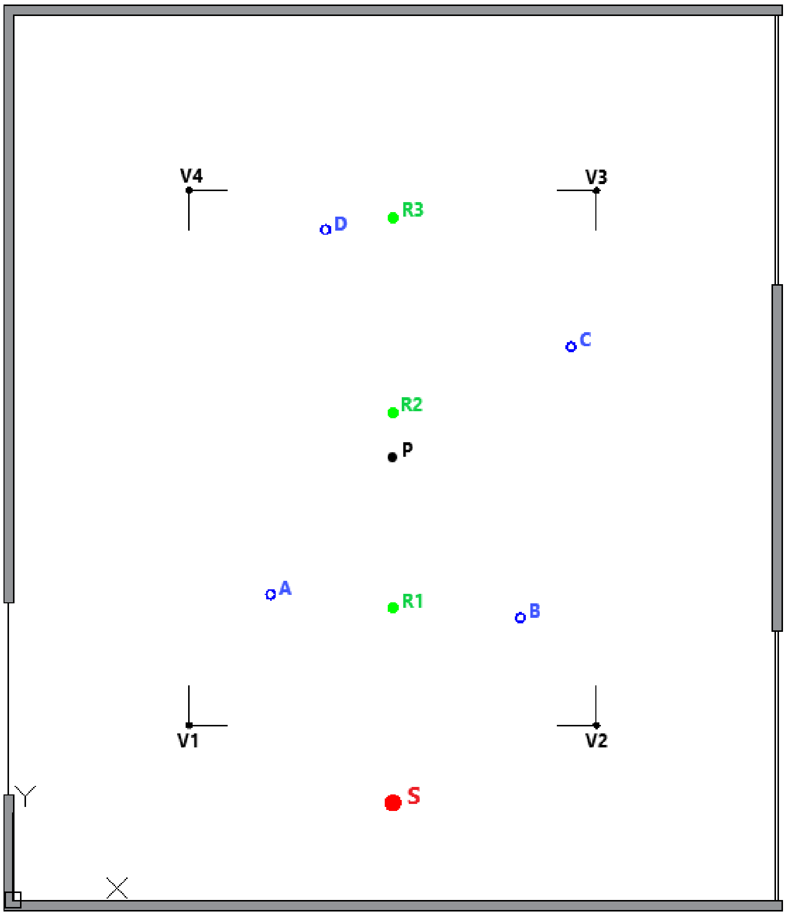


Figure 11 Measurements point map. Point "P" is the room midpoint with coordinates X = 1945mm and Y = 2270 mm.

Points V1 ÷ V4 were chosen leaving a 90 cm gap from the walls of the room both in x and y direction. The line of points containing S and R1 ÷ R3 coincides with the x-axis of the chamber plan. Consequently, these points are also centrally located with respect to the ventilation grilles in the ceiling and south wall. Finally, points A÷ D have been chosen randomly with the only criterion that they are at least 1m from each other.

2.2.1 Determination of Reverberation Time

Reverberation time is defined as the duration required for the space-averaged sound energy density in an enclosure to decrease by 60 dB after the source emission has stopped. Reverberation time is expressed in seconds and it is indicated as T_{60}. The decay curve is considered between -5 dB and -65 dB and first 5 dB are excluded to avoid the influence of early particularly strong reflections. Reverberation time can be evaluated based on a smaller dynamic range than 60 dB. Thus, if reverberation time is derived from the time at which the decay curve first reaches 5 dB and 25 dB below the initial level, it is labelled T_{20}; if decay values of 5 dB to 35 dB below the initial level are used, it is labelled T_{30}.

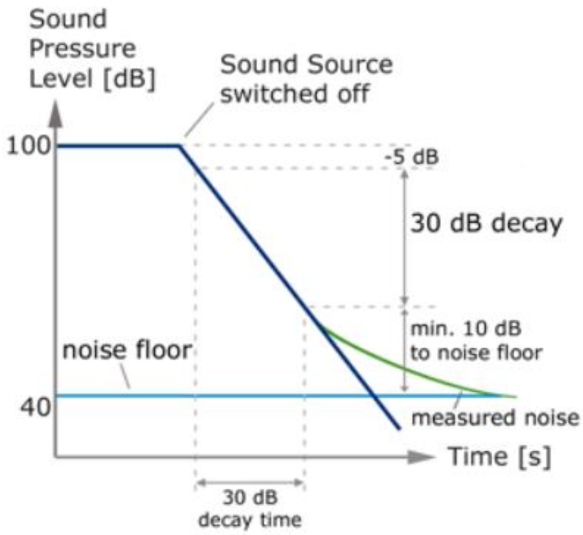


Figure 12 Example of determination of T_{30}. Reverberation time is determined applying a linear fit to the acquired decay curve. In this case $T_{60} = 2 * (time\ to\ decay\ by\ 30\ dB)$.

In this study, reverberation time measurement was performed considering T_{20} and according to the impulse response method, using balloons as impulsive sound sources. The choice is motivated by the fact that balloons are easy to carry around and they have an omnidirectional radiation characteristic. Moreover, the main disadvantage of this type of sound source is that it may not create sufficient energy in large rooms; but for the laboratory room this problem does not arise, given its small size. The reference standard for determination of reverberation time is EN ISO 3382-2: 2008[2]. The use of T_{20} has been preferred over T_{30} to avoid the risk of applying a bad linear fit to the acquired decay curve, which is likely to occur if the sound source does not produce a sufficiently high sound pressure level compared to background noise. Microphone was positioned progressively in 3 positions, i.e. points A, C and D of figure 11. For each microphone position 3 measurements of 50 s were done and, in order to obtain as many source-microphone combinations as possible, the balloons were blown up in randomly

[2] EN ISO 3382-2: 2008. Acoustics – Measurement of acoustic parameters – Reverberation time in ordinary rooms.

chosen corners of the room. Totally 9 surveys were carried out: reverberation time for each microphone position, i.e. RT_A, RT_C and RT_D, is given by the mean of the 3 measurements done for that microphone position; consequently, the mean reverberation time of the room RTa_{vg} is obtained as an average of RT_A, RT_C and RT_D. In many rooms, the number of present people can have a strong influence on the reverberation time and thus reverberation time measurements should be made in a room containing no people. However, a room with up to two persons present may be allowed to represent its unoccupied state. During the surveys there were two people inside the room, thus the contribution to sound absorption due to their presence can be neglected. From figure 13 to figure 15 measurements results are shown graphically while annex A contains details data for each measurement in form of tables.

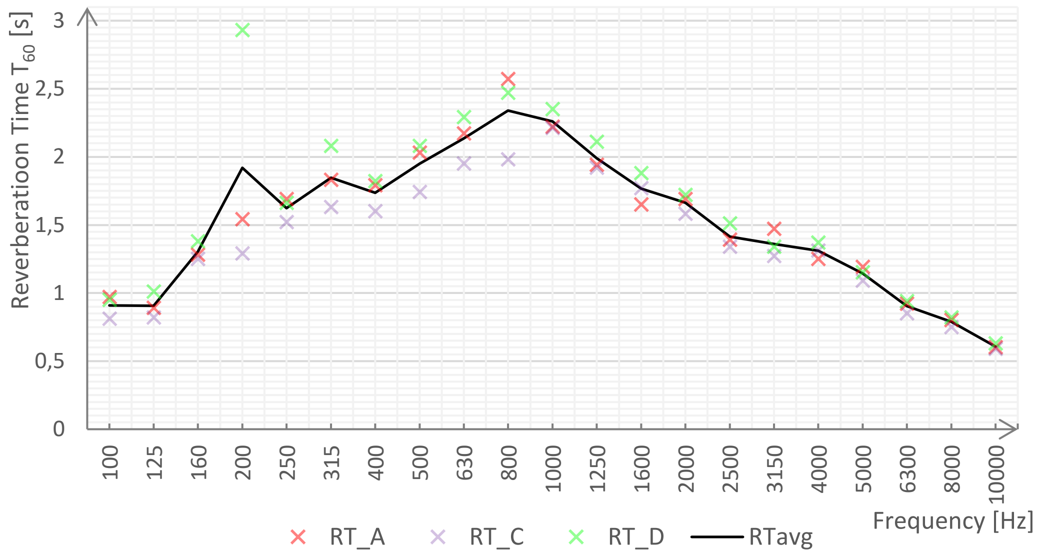


Figure 13 Average Reverberation Time RT_{avg} for laboratory climate room.

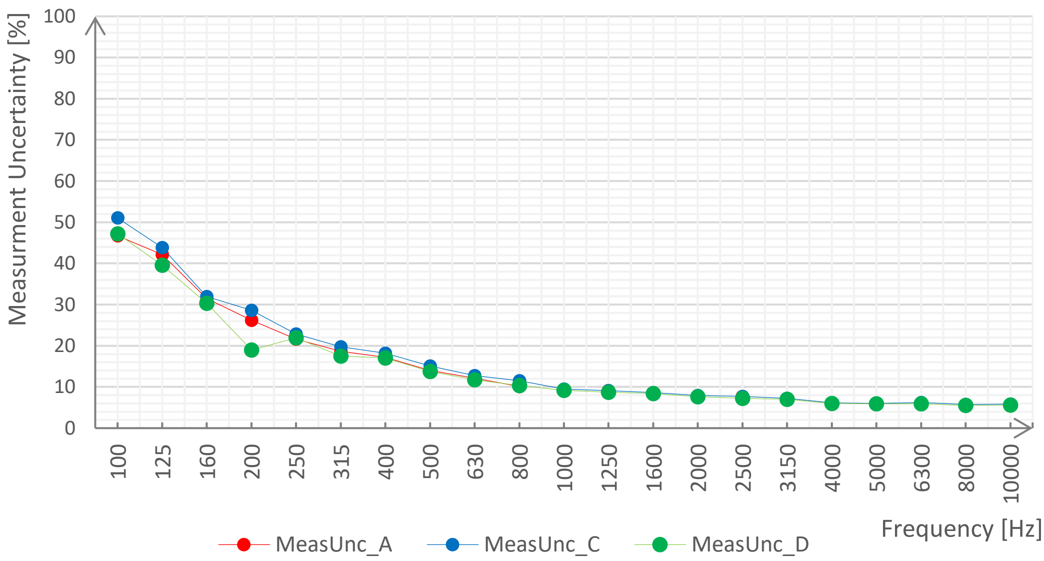


Figure 14 Measurement Uncertainty trend related to RT_A, RT_C and RT_D data.

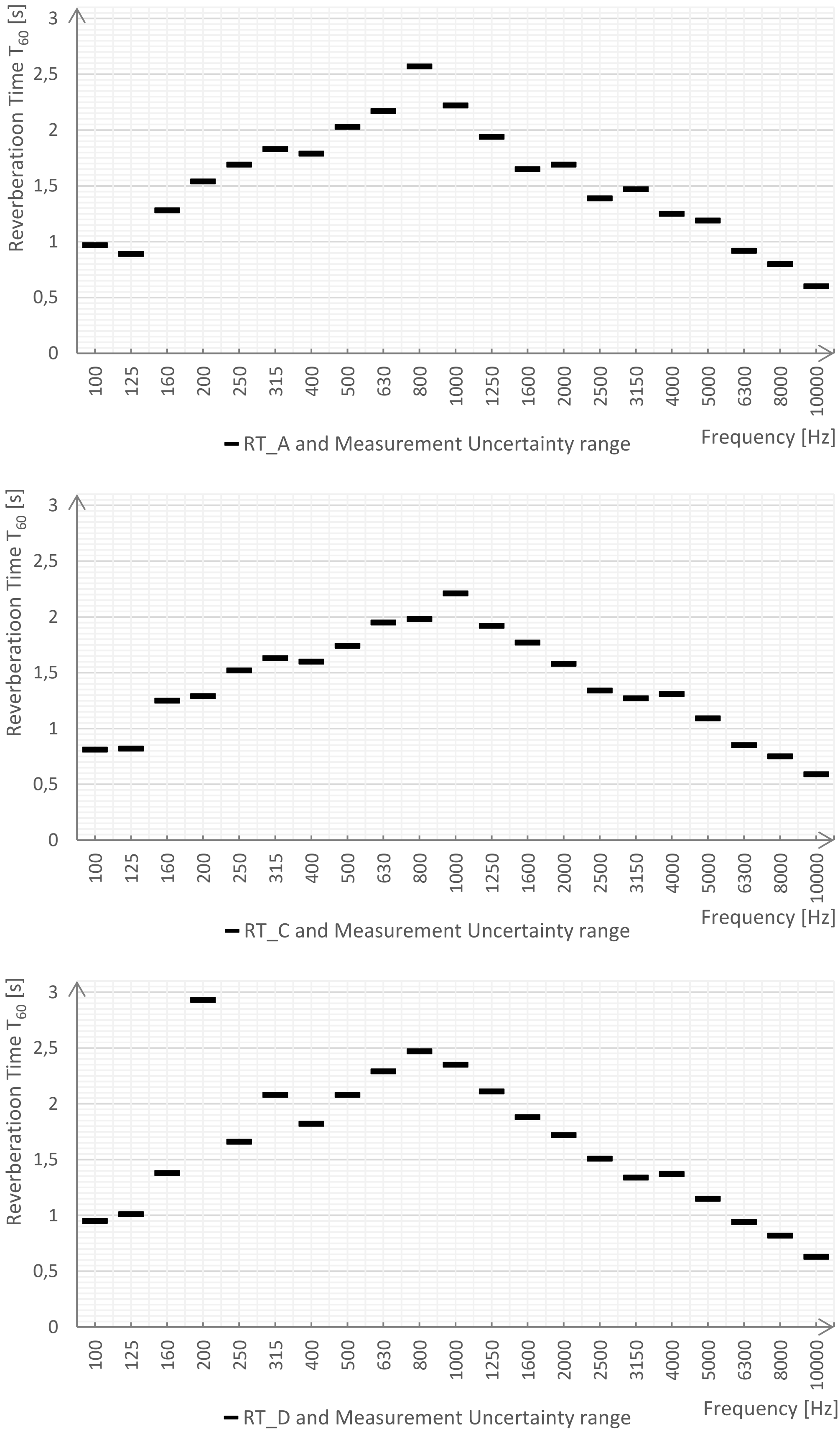


Figure 15 Reverberation time RT_A RT_C and RT_D and data uncertainty band. The wider the band, the greater the uncertainty associated with the measurement.

Schroeder's frequency f_0 is a fundamental parameter for the study of the acoustic behaviour of an environment because it marks the boundary above which acoustic resonance phenomena can be overlooked. Consider a frequency f, if:

- $f < f_0$, then the acoustics is dominated by the presence of standing waves. If the wavelength λ of the sound wave is comparable with the dimensions of the room, then resonance phenomena of the sound waves themselves may occur as a result of reflection from room boundaries. This means that the sound pressure inside the room can vary greatly in space and therefore the acoustic behaviour of the room must be studied by solving the wave propagation equations.
- $f > f_0$,. resonance phenomena can be neglected and room acoustics can be statistically studied because at each point in the room the sound pressure is the sum of the contributions of such a large number of components that they cannot be distinguished. Then the simplifications of classical acoustics theory are worthwhile, that means the sound field can be divided into two regions, the direct sound field, where theoretically the sound pressure decreases by -6 dB as the listener's distance doubles, and the diffuse sound field, where the sound pressure level is uniform in space because reflected sound predominates over the contribution of direct sound.

According to annex A, the limit frequency of the laboratory room is f_0 equal to 436 Hz. Acoustic behaviour below the limit frequency becomes problematic because it is characterized by the presence of room modes. This can explain why the measurements data at low bands are characterized by high uncertainty, as shown in previous figures. For those frequencies the sound field is not diffuse, that means that spatial distribution of the sound pressure level can vary greatly from one area to another and therefore reverberation time may differ significantly along the space too. In particular, graph of figure 14 shows that the measurement uncertainty has a decreasing trend and that the greatest inclination is recorded at the initial section of the curve, precisely for bands $f < f_0$. For frequencies above the limit frequency the measurement uncertainty is greatly reduced and the graphs of the three curves are indistinguishable as they are superimposed. Obviously a certain degree of uncertainty remains inevitably, however this does not happen because the data to be measured is uncertain, but because the uncertainty is inherent in the measurement operation itself.

2.2.2 Determination of ventilation system Sound Power Level

Standard EN ISO 3747:2010[3] was taken as reference to determine the sound power emitted from the mechanical ventilation system. This standard specifies a method for determining the sound power level or sound energy level of a noise source by comparing measured sound pressure levels emitted by a noise source (machinery or equipment) mounted in situ in a reverberant environment, with those from a calibrated reference sound source. As the emitted sound power of the source under test varies depending on the treated air flow, measurements were repeated by setting the system for progressively increasing flow rates.
Table 5 summarizes the ventilation system set up and the detected environmental condition in laboratory climate chamber. As you can see, the environmental conditions remained constant during the surveys.

Table 5 Ventilation system set up and environmental detected conditions during background noise and sound pressure level measurements. While temperature and relative humidity was detected with the thermo-hygrometric detector, atmospheric pressure data was taken from daily weather forecasts.

	Back_noise	**Scene_1**	**Scene_2**	**Scene_3**	**Scene_4**	**Scene_5**
Flow rate	0 m^3/h	80 m^3/h	120 m^3/h	160 m^3/h	200 m^3/h	240 m^3/h
Temperature	23 °C	23 °C	23 °C	23 °C	23 °C	23 °C
Rel. Humidity	32 %	32 %	32 %	32 %	32 %	32 %
Atm. Pressure	100,7 kPa	100,7 kPa	100,7 kPa	100,7 kPa	100,7 kPa	100,7 kPa

First of all, time-averaged background noise sound pressure level and time-averaged sound pressure level related to the ventilation system were detected. For each situation, 3 measurements have been done using an averaging time of 30 s and positioning the microphones in points R1, R2 and R3 of figure 11. Subsequently, reference sound source was positioned in centre of the room (point P of figure 11) with microphone in points V1,V2, V3 and V4. Totally, 4 surveys of 30 s have been made to measure reference sound source time-averaged sound pressure level. Reference sound source average rotation speed was 2871 rpm. This value is slightly lower than reference rotation speed, which is of 2887 rpm at 23°C and 101325 Pa: this difference can be explained because the instrument is very sensitive to environmental condition such as air density. Nevertheless this fact does not involve an appreciable change in the sound power emitted by the reference sound source. Figure 16 ÷ 21 show resulting sound power level for each configuration of ventilation system, considering third octave bands between 100 and 10000 Hz. Complete frequency by frequency data for source under test and reference sound source sound pressure level and calculations are given in annex B. Figure 21 represents overall sound power level as a function of ventilation system nominal flow rate.

[3] EN ISO 3747:2010. Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure - Engineering/survey methods for use in situ in a reverberant environment.

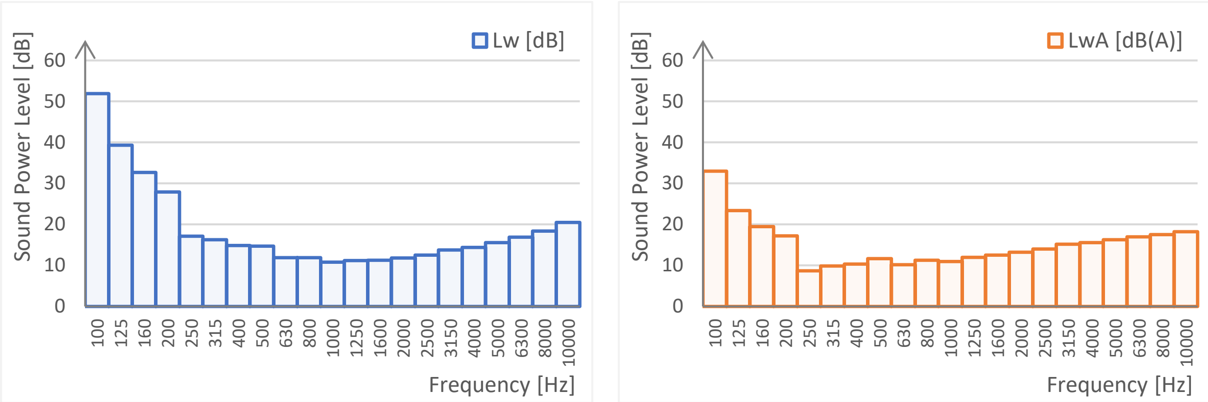


Figure 16 Sound power level spectrum in third octave band for ventilation system **nominal flow rate 80 m³/h**.

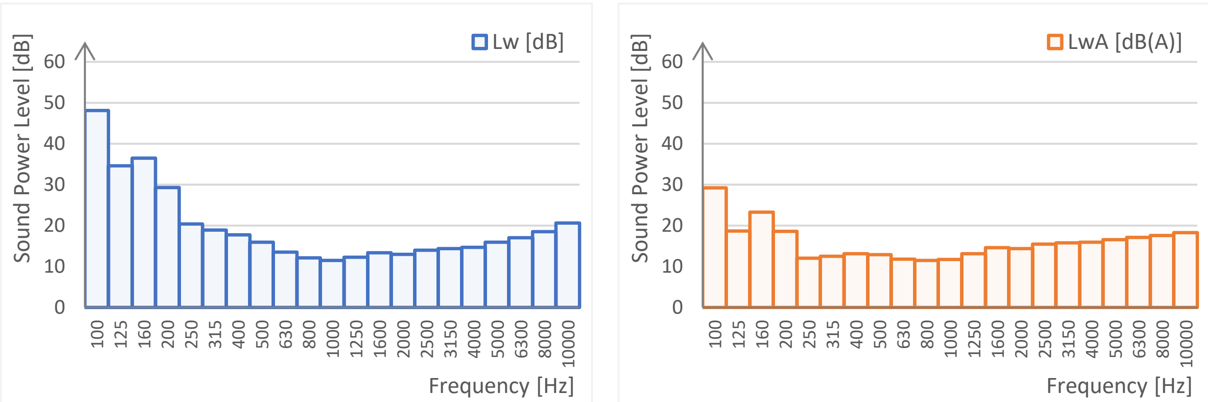


Figure 17 Sound power level spectrum in third octave band for ventilation system **nominal flow rate 120 m³/h**.

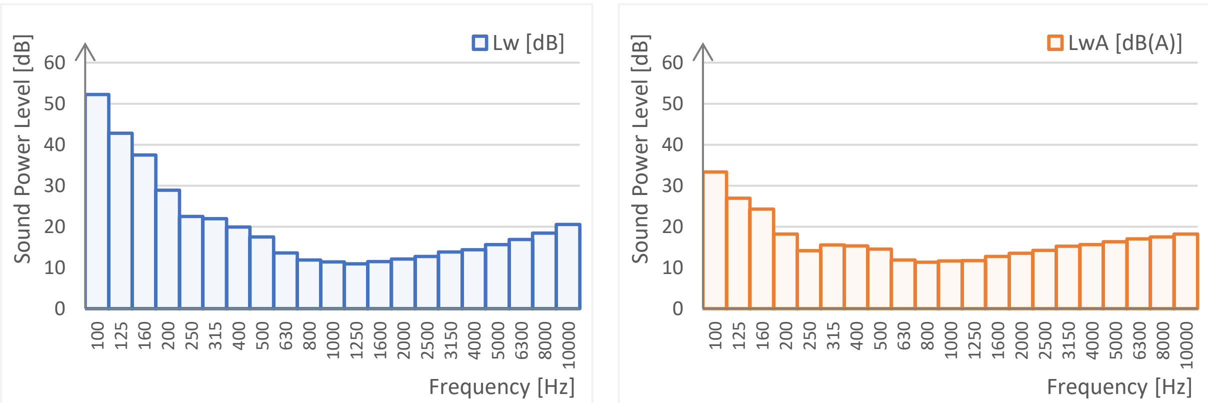


Figure 18 Sound power level spectrum in third octave band for ventilation system **nominal flow rate 160 m³/h**.

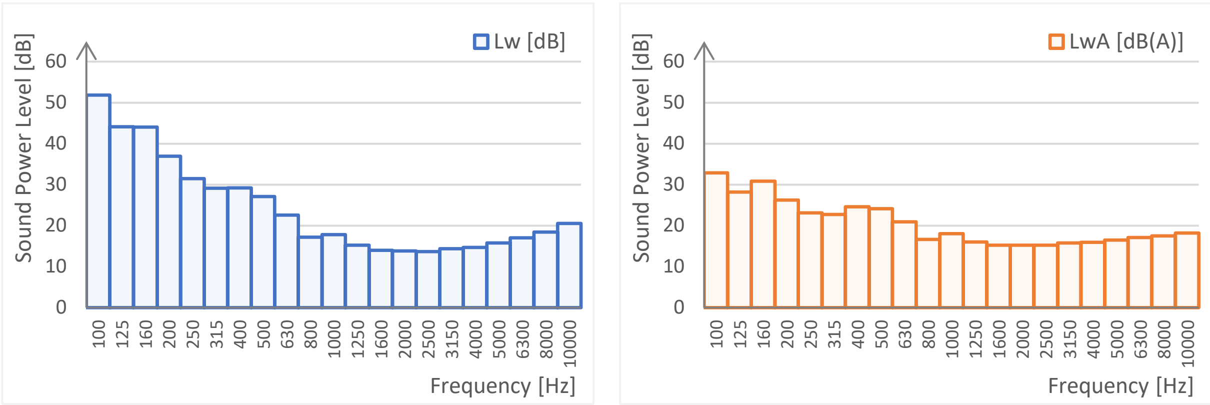


Figure 19 Sound power level spectrum in third octave band for ventilation system ***nominal flow rate 200 m³/h***.

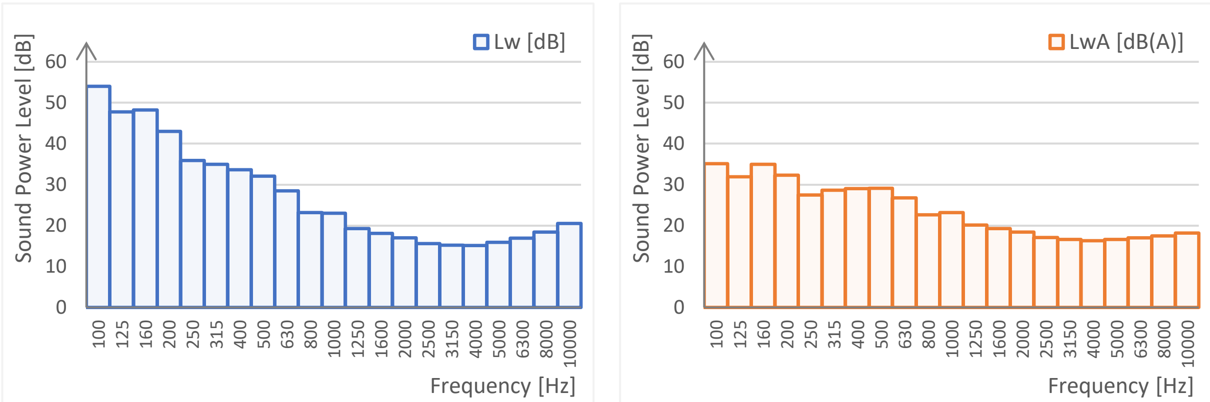


Figure 20 Sound power level spectrum in third octave band for ventilation system ***nominal flow rate 240 m³/h***.

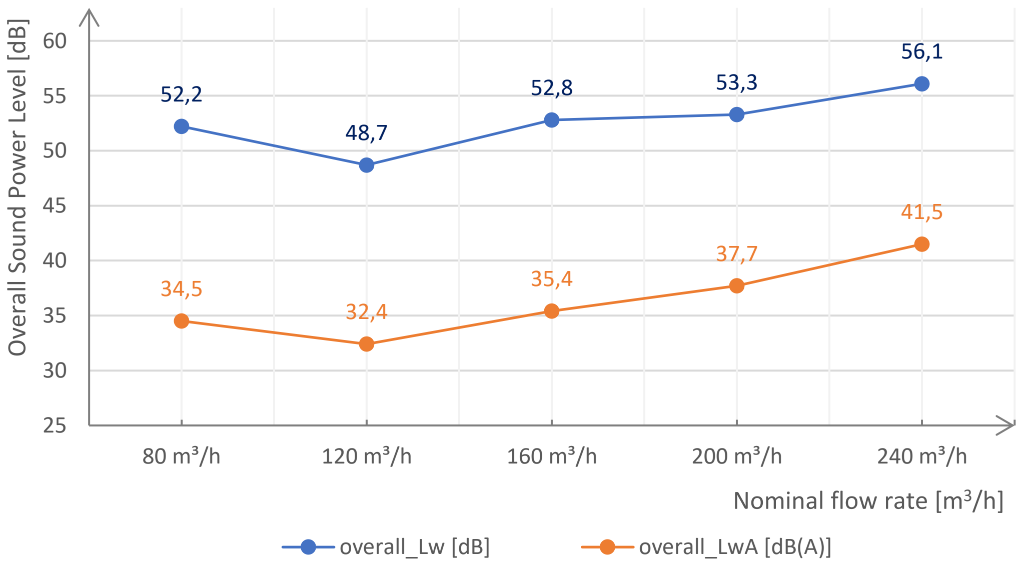


Figure 21 Overall sound power level overall_L_W [dB] and A-weighted overall sound power level overall_L_{WA} [dB(A)] as function of mechanical ventilation system nominal flow rate [m³/h].

As assumed, the sound power emitted by the mechanical ventilation system has the largest components at low frequency and the sound power level increases as the flow rate increases. However, it is necessary to specify that the accuracy of the results obtained is limited. The ISO 3747 procedure involves the calculation of a background noise correction factor, K_{1i}, for each frequency band. This factor depends from the difference between the time-averaged sound pressure level at the i-th microphone position of source under test and of background noise, ΔL_{Pi}. K_{1i} is smaller as higher ΔL_{Pi} with the limit of $K_{1i} = 1,3$ for $\Delta L_{Pi} \leq 6$ dB. But higher K_{1i} is, lower is the accuracy of the results. In other words, if the sound pressure level due to the source under test is not sufficiently higher than background noise sound pressure level, source sound power level cannot be precisely calculated. For the ventilation system, only sound pressure levels related to a treated flow rate of 200 m^3/h and 240 m^3/h are adequate and calculations results in compliance with the standard (see annex B). In the same way, the results for smaller flow rates are purely indicative, since the activation of the ventilation system in those configurations does not determine an appreciable increase of sound pressure level compared to the background noise. Even the sound power associated with the flow rate of 80 m^3/h is greater than that associated with 120 m^3/h: it is clear that this result is due to the data collected during the measurements and not to the actual characteristics of the system. However all results have been reported because they are useful for determining a boundary to the sound power level of the noise source under test.

2.2.3 Determination of Speech Transmission Index

IEC 60268-16: 2011[4] defines objective methods for rating the transmission quality of speech with respect to intelligibility. The principle on which the standard is based is the evaluation of reduction of the modulation index m_i of a test signal, simulating the speech characteristics of a real talker, when sounded in a room or through a communication channel. STI measurement methods are based on measuring the MTFs (Modulation Transfer Functions) in 7 octave bands and for each octave band, one MTF quantifies the degree of preservation of the intensity modulations in this band. The test signal is transmitted by a sound source situated at the talker's position to a microphone at any listener's position, where the modulation index is m_o.

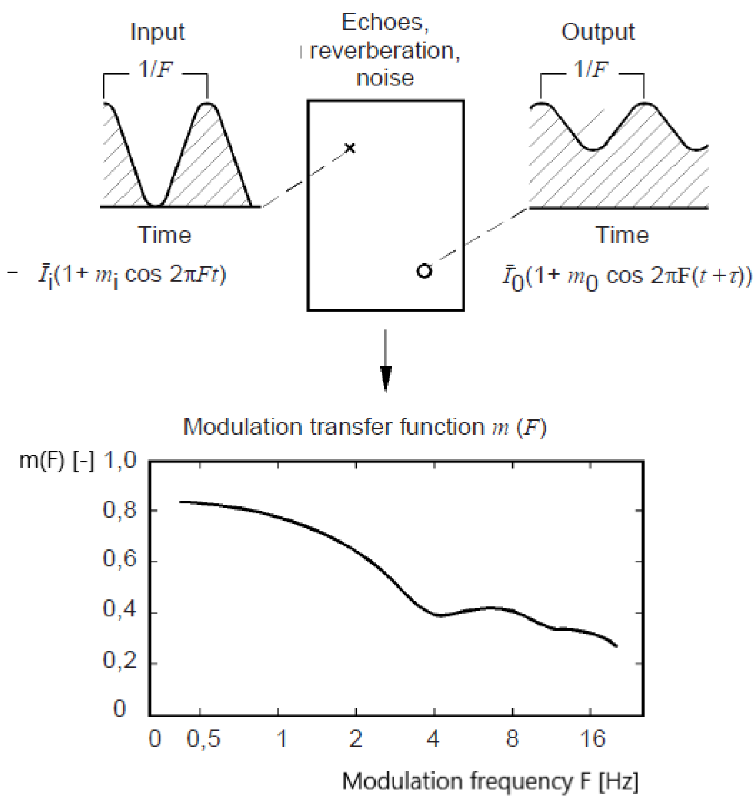


Figure 22 Modulation transfer function for one octave band: input/output comparison. Terms m_i and m_o are the modulation indices of the input and the output signals, respectively. Modulation transfer function m(F) quantify reduction in the modulation index.

For the case study, STI has been determined using STI-PA method which applies, uniquely, to 12 modulation frequencies, two to each of the seven frequency bands. This method is time

[4] IEC 60268-16: 2011. Sound system equipment – Objective rating of speech intelligibility by speech transmission index.

saving compared to the full STI method, since STI method requires assessment of complete MTF for which 98 individual measures are required (14 modulation frequencies applied to the seven frequency bands). Correlation between speech intelligibility and STI is shown in table 6.

Table 6 Relation between STI and speech intelligibility.

STI	**0,00 ÷ 0,30**	**0,30 ÷ 0,45**	**0,45 ÷ 0,60**	**0,60 ÷ 0,75**	**0,75 ÷ 1,00**
Intelligibility	Bad	Poor	Fair	Good	Excellent

STI measurements were performed setting the ventilation system at the same flow rate configurations of previous paragraph. NTI Audio Talk Box was positioned in point S of figure 11 while microphone in points R1, R2 and R3. Thus, for each configuration 3 measurements of 15 s were done. Results are shown in the following figures, while detailed data are given in appendix C.

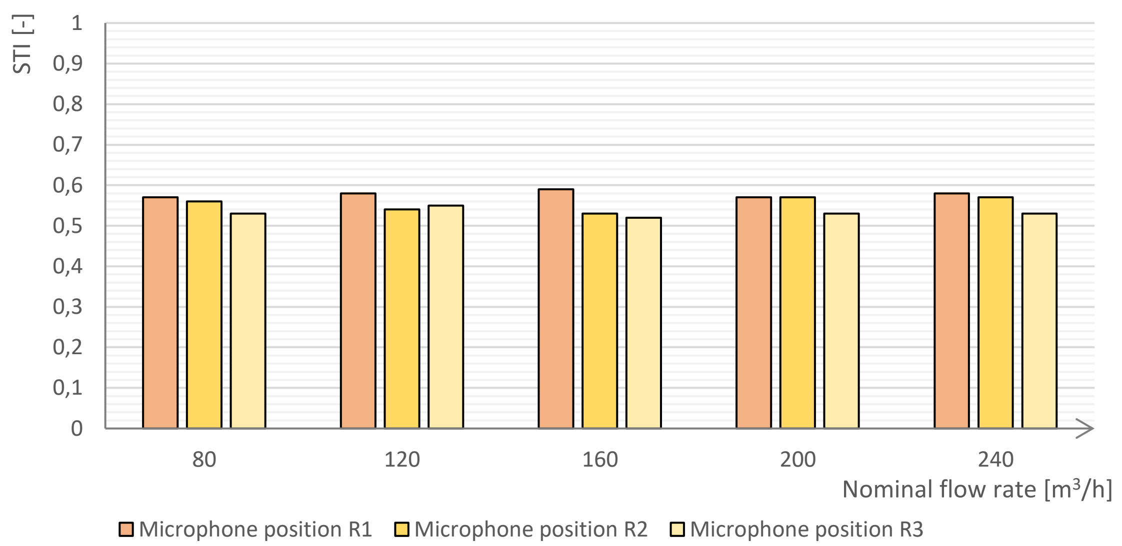


Figure 23 STI at microphone position R1, R2 and R3 as function of ventilation system nominal flow rate.

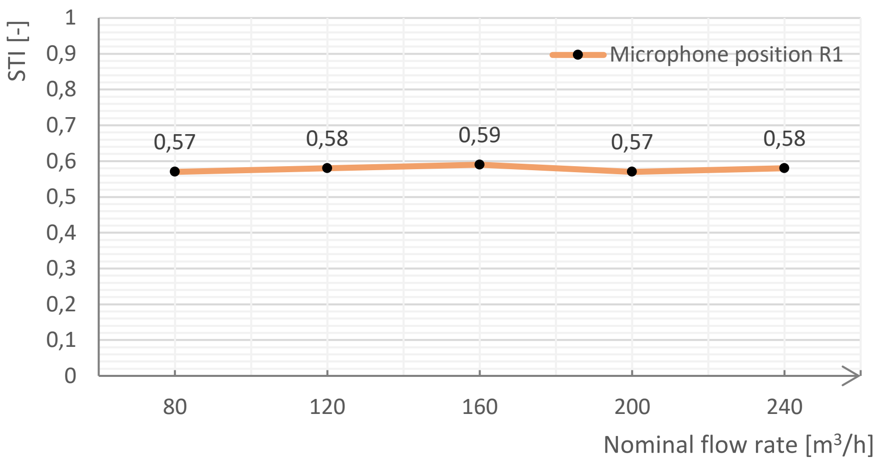


Figure 24 STI trend for point R1as function of nominal flow rate.

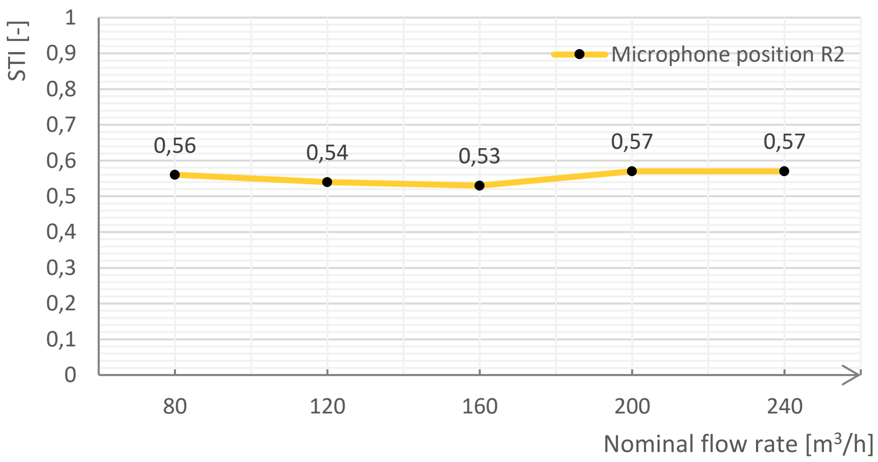


Figure 25 STI trend for point R2 as function of nominal flow rate.

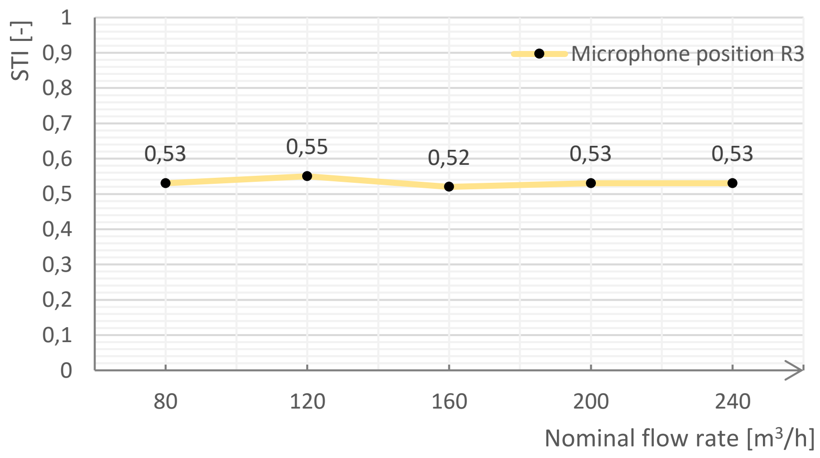


Figure 26 STI trend for point R3 as function of nominal flow rate.

For each microphone position STI values are approximatively constant as the flow rate changes. According to figure 23, STI values show a decreasing trend as the microphone position changes. This result is easily explained since STI is dependent on the distance from the source. Since R1 is the microphone position closest to the source, the highest STI value is associated with it, regardless of the nominal flow rate of the ventilation system. At the same time, the difference between the STI values associated with position R2 and position R3 is smaller, because the STI values for point R3 are more affected by reflection against the opposite wall than the sound source. Figures 24, 25 and 26 shows that STI does not depend on the flow rate of the ventilation system. According to table 6 speech intelligibility can be consider fair. As an indication, speech intelligibility measurements were then made increasing the number of people inside the room in order to obtain a bigger sound absorption. Results shown in figures from 27 to 30 are obtained considering 2 people, 4 people and 6 people standing in the laboratory room. Sound source and microphone were positioned as previous measurement, while ventilation system was off.

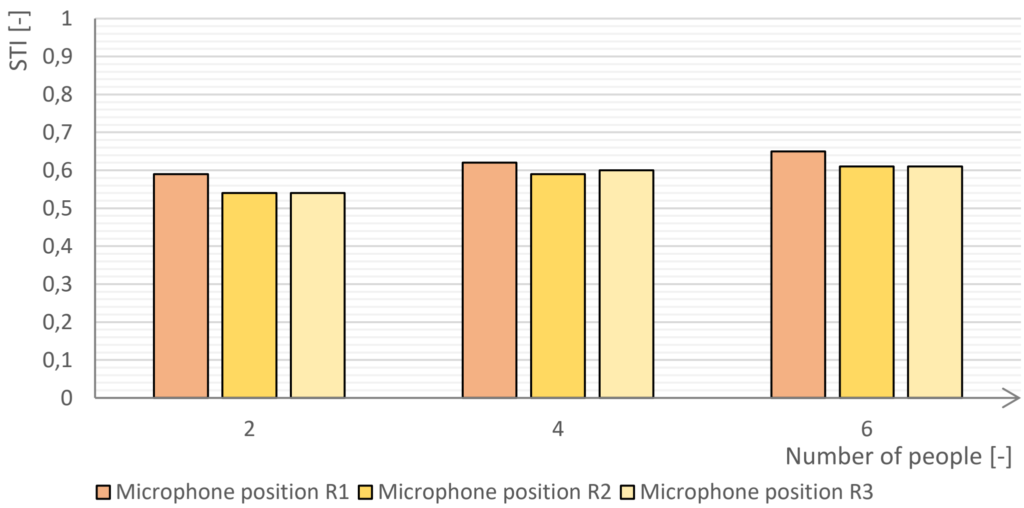


Figure 27 STI at position R1, R2 and R3 as function of number of people.

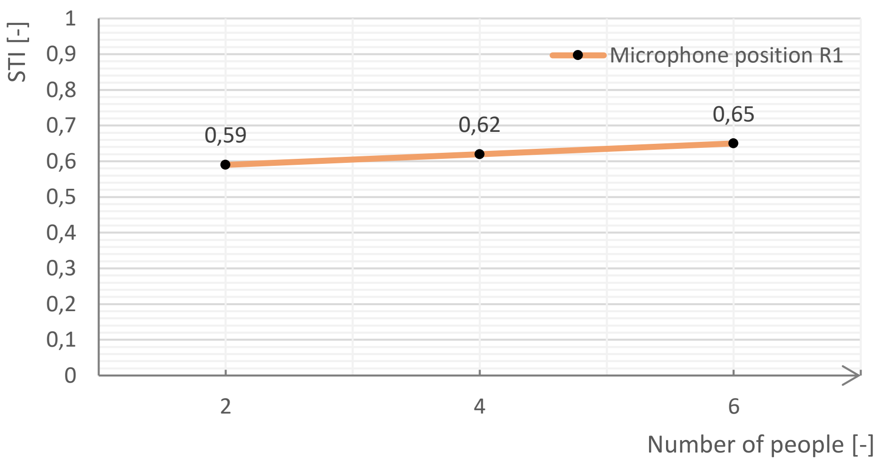


Figure 28 STI trend for point R1as function of number of people.

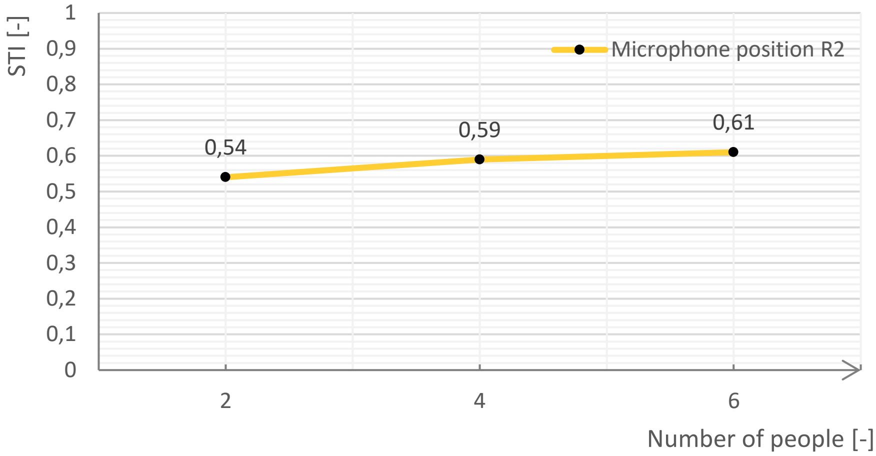


Figure 29 STI trend for point R2 as function of number of people.

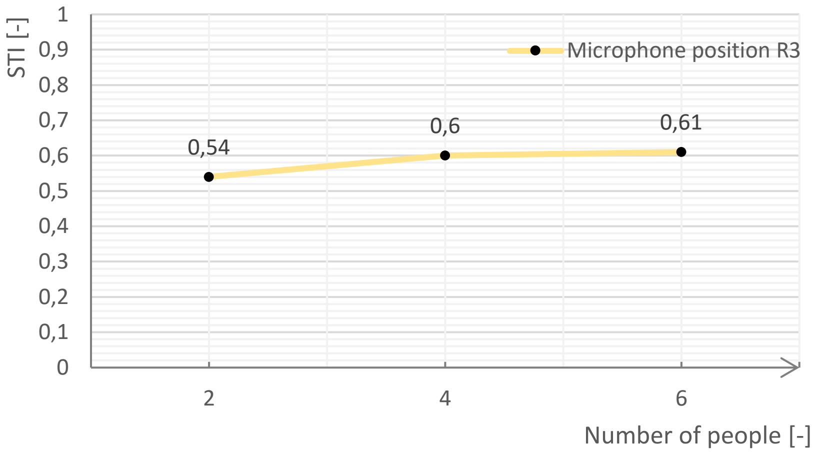


Figure 30 STI trend for point R3as function of number of people.

As expected sound absorption increase is associated with an improvement of STI. In fact, by increasing the overall sound absorption of the room, the phenomena of sound reflection are limited and consequently the contribution of direct speech sound prevails over that of reflected speech sound. In any case, a good level of speech intelligibility depends on the correct balance between direct and reflected speech sound because reflections that reach the ear around 25 and 30 ms after the direct sound are responsible for Haas effect: they are perceived as integrated into the direct sound so they have a positive effect on speech perception. Therefore, the increase in sound absorption was beneficial in terms of STI because only the late reflected sound waves were limited.

Chapter 3

Acoustic Modelling of Laboratory Room

In this chapter the operating principle of the acustic software I-Simpa is presented and it is explained how laboratory room model was built using I-Simpa version 1.2.3.

3.1 I-Simpa software presentation

I-Simpa is an Open Source project dedicated to 3D acoustics modelling. I-Simpa was initiated during research projects, some of them being funded by the French Environment and Energy Management Agency and by the French institute of sciences and technology for transport, development and networks. I-Simpa is distribuited with two codes:

- **TCR**, from French “Théorie Classique de la Réverbération”, is a numerical application of the Classical Theory of Reverberation as proposed by Sabine. It allows to obtain an evaluation of the diffuse sound field in a single room on the basis of Sabine’s relations for the reverberation time and for the sound level of the reverberated field.

- **SPPS**, from French “Simulation de la Propagation de Particules Sonores”, relies upon tracking sound particles, carrying an amount of energy ε and emitted from a sound source, within a 3D-domain. Each particle propagates along a straight line between two time steps Δt (the whole trajectory may be curved), until collision with an object. At each collision, sound particles may be absorbed, reflected, scattered, diffused, transmitted, depending on the nature of the object.

In contrast to classical acoustic theory, where the study of the sound field is based on the propagation of a wave in a continuous material medium, the approach used in the SPPS code is geometric. In a field of complex propagation, the sound field is then decomposed into a multitude of elementary particles, called sound particles or phonons, without mutual interaction and carrying an infinitesimal energy and constant over time. These particles propagate at the speed of sound, either in straight line (homogeneous atmosphere), or with curved trajectories (in the presence of a velocity profile, atmospheric turbulence *etc.*), between two successive shocks with the obstacles and limits of the propagation medium. In a collision with an obstacle or a boundary of the propagation domain, the particles can be absorbed or reflected in a new direction of propagation. Geometric acoustics thus become a special case of particle dynamics, so that a sound field can be likened to a gas of sound particles. Under these conditions, the distribution of the energy of the sound field is assimilated to the distribution of the sound particles. Since the local density of sound energy is proportional to the local density of phonons, the only difficulty lies in determining the distribution of these sound particles over time.

Sound particles concept is relatively similar to the traditional methods of sound beam tracing, implemented in most current closed or open environment noise prediction software. Nevertheless, even if in form these two methods are comparable, the major differences lie in the management of the sound energy carried by sound particles and sound rays. For sound rays method, each sound ray carries an intensity whose amplitude decreases proportionally with the square of the propagation distance, thus simulating the acoustic radiation of a spherical source (geometric dispersion). In the concept of sound particles, each particle carries an elementary energy ε, whose amplitude does not vary according to the propagation distance.

The principle of simulations of SPPS code is therefore based on the tracking of sound particles, carrying an initial energy ε, emitted from one or more sound sources, in a volume chamber V totally or partially closed. Each particle is propagated along rectilinear or curved paths, until it collides with a wall or scattering object. At each collision, the sound particle (or part of its energy) can be absorbed, reflected or transmitted, depending on the absorption and transmission coefficient of the wall or object. In the current version of the SPPS code, two calculation modes are proposed, i.e. random modelling and energetic modelling.

In ***random modelling***, the energy of sound particles is constant. Depending on the values of the atmospheric absorption and the absorption coefficients of the materials, the particles can be made to disappear completely from the propagation domain, or to remain in the domain with the same energy. Physical phenomena are considered in a probabilistic way. For example, when in contact with an absorption coefficient wall α, the particle could for have a probability $(1 - \alpha)$ of being reflected, and a probability α of being absorbed. If absorbed, the particle disappears from the propagation domain. The other physical phenomena (diffusion by a congestion, diffuse reflection) are also treated statistically. As the number of sound particles decreases over time, the calculation time decreases gradually. Moreover, the density of sound energy at a point of the domain is then proportional to the number of sound particles at the same point.

In ***energetic modelling***, the energy of the particle is weighted according to the values of the atmospheric absorption and the absorption coefficients of the materials. The other physical phenomena (diffusion by congestion, diffuse reflection) are also treated randomly. Since in this mode, the number of sound particles is constant, the duration of the numerical simulations is longer than for the first mode. Moreover, the sound energy density at a point of the domain is then proportional to the sum of the energy of the sound particles at this same point. When particle energy falls below an established value, the particle is no more take into account.

Figure 31 is taken from [40] and explain the algorithm on which SPPS is based.

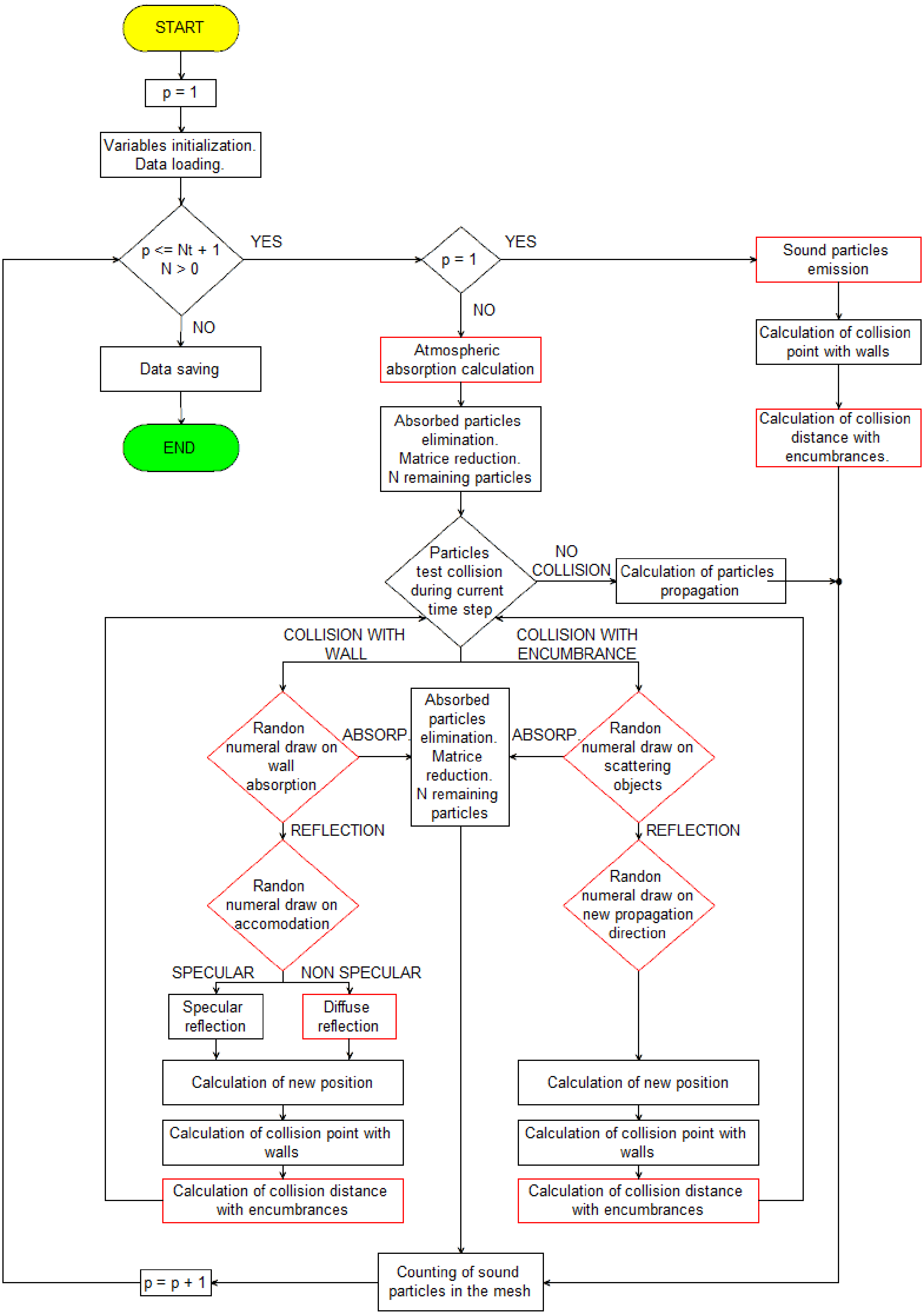


Figure 31 Flow chart of SPPS code. The procedures for random draws are indicated in red.
Nt and p are respectively the maximum number of time steps (fixed by the user) and the index of the time step.
N is the number of particles.

When a sound wave with unit energy collides with a boundary (wall, object, *etc...*), a first part R (i.e. the reflection coefficient) of the energy is reflected while a second part α is absorbed. A portion β of absorbed energy can be dissipated within the boundary material and the remaining part τ is transmitted. In the probabilistic approach, when sound particles collide with boundary, the first step is to determine the amount of them that are absorbed or reflected. This is done by comparing a random number u between 0 and 1, for each particle, with the absorption coefficient α. If $u < \alpha$, the particle is absorbed. If this case, a new random number v between 0 and α is chosen. If $v < \tau$, the particle is transmitted, while in the other case, the particle simply disappears from the propagation medium. Lastly, if $u \geq \alpha$, the particle is reflected according to the reflection law of the boundary. In the energetic approach, the energy of the particle is weighted by the reflection coefficient R. Then, the particle is reflected according to the reflection law of the boundary. Here again, a part β of the energy of the particle can be dissipated within the material, while another part τ can be transmitted. If transmission occurs, a new particle is created with an initial energy τ [41].
As the processing of certain physical phenomena can be performed by random number draws, this simulation procedure can therefore be likened to a Monte Carlo method. The accuracy of prediction is then mainly dependent of the initial number of particles. The physical phenomena simulated by these draws of random numbers will be all the better respected as the number of random draws will be large, that is to say that the initial number N of sound particles will also be very large. Nevertheless, more N will be large, longer will be the duration of the simulations. The choice of N is therefore a compromise between the computation time and the accuracy of the results, but is also a function of the geometry and acoustic characteristics of the propagation domain. For example, the more the propagation domain will be absorbing (at the walls, scattering objects, atmospheric absorption), the more it will be necessary to consider sound particles to have a satisfactory description of the physical phenomena [42].

3.2 Scene import

I-Simpa is very sensitive to the quality of 3D files. It does not accept a "bad" geometry, with faces intersections, overlaps or holes between faces. If 3D model is not correct, the model will be imported but the mesh will be not generated.
The software Autodesk AutoCAD® (version 2018) was used to design the model. For acoustic calculations it is not necessary to create a complex 3D model, so the room model is built simply as an empty box, whose walls are drawn using AutoCAD "surface" element, according to room dimension presented in §2.1 . In other words, the model boundaries represent only the interior faces of the room while the thickness of the elements is neglected. Since only ".stl" and ".3ds" are formats compatible with I-Simpa import option, it was necessary to export the cad ".dwg"

file to one of this two formats. For this purpose two additional software were used because this step cannot be done directly in AutoCAD.
Conversion to ".3ds" was made using SketchUp (version 2019). Using the ".3ds" format allows you to maintain the distinction between layers applied in the ".dwg" file. This means that if you create a layer for each element of the model, these layers are kept separate even after the conversion from ".dwg" to ".3ds" and each element is well defined once imported into I-Simpa. This strategy is useful especially when the model contains many elements but has two main disadvantages: on one hand SketchUp is not an open source software (you can use a free trial version but it is only available for 30 days); on the other hand particular attention must be paid to the use of the "polyline" element while working with ".dwg". Indeed, if the polylines used in the drawing are not deleted, they are interpreted as signs of discontinuity between surfaces For example, if there is a polyline in the edge between floor and wall of the ".dwg" file, the model, once converted into ".3ds", will present a crack between floor and wall as if they were disconnected from each other. But if this happens, I-Simpa do not generate the mesh because the model results not perfectly closed. The solution of this problem then consists in deleting all the polylines possibly used before proceeding to format conversion.
Conversion to ".stl" was made using Autodesk Formit (version 17.4). Unlike the previous case, in this one there is not any problem due to the presence of polyline elements. However, the disadvantage is the fact that ".stl" format loses the distinction between layers defined in the ".dwg" file. After importing the model into I-Simpa it is necessary to redefine each object of the scene one at a time and this operation can take a long time if the objects are numerous.

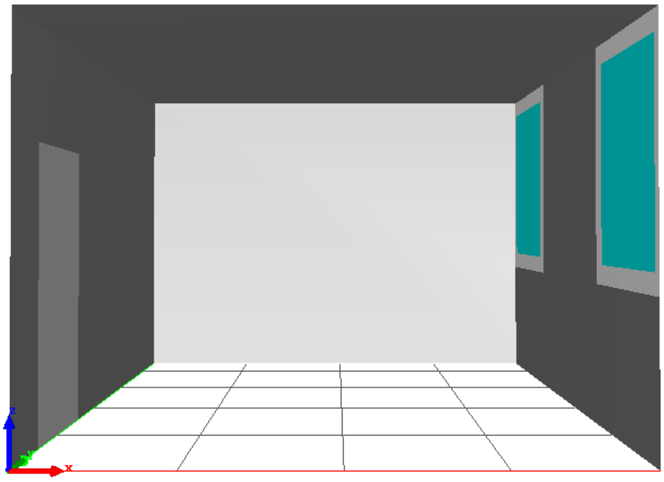


Figure 32 I-Simpa empty laboratory room model. Room dimension are in accordance with table 3.

Overall, since the model of the room is simple, the choice of one import strategy over the other is on the whole irrelevant in terms of the time required for modeling.

3.3 Room materials absorption coefficients

3.3.1 Sound absorption in I-Simpa

Sound absorption at a specified frequency is a property of a material whereby sound energy is converted into heat by propagation in a medium or when sound strikes the boundary between two media. Sound absorption coefficient α expresses the fraction of incident sound energy that is absorbed by a material: for a perfectly reflecting material α assumes a value equal to 0 while for a perfectly absorbent material α is equal to 1. According to the manual I-Simpa bases sound absorption processing on standard ISO 9613-1[5] which defines the equivalent absorption area A of an empty room as:

$$A = \frac{55{,}3V}{cT_R} - 4Vm \quad [m^2] \tag{3.1}$$

where V is room volume in m^3, c is the sound speed in ms^{-1}, T_R the reverberation time in s and the term (4Vm) expresses the equivalent air absorption area in m^2. By definition:

$$A = \sum_{i=1}^{n} A_i = \sum_{i=1}^{n} \alpha_i S_i = \overline{\alpha} S_{TOT} \quad [m^2] \tag{3.2}$$

in which α_i is the absorption coefficient of each material in the room, S_i its surface in m^2 and S_{TOT} total room surface in m^2. Then mean absorption coefficient $\overline{\alpha}$ if given by:

$$\overline{\alpha} = \frac{A}{S_{TOT}} \quad [-] \tag{3.3}$$

Figure 33 shows air equivalent sound absorption area calculated A_{air} for laboratory room applying average measured reverberation time RT_{avg} to previous equations.

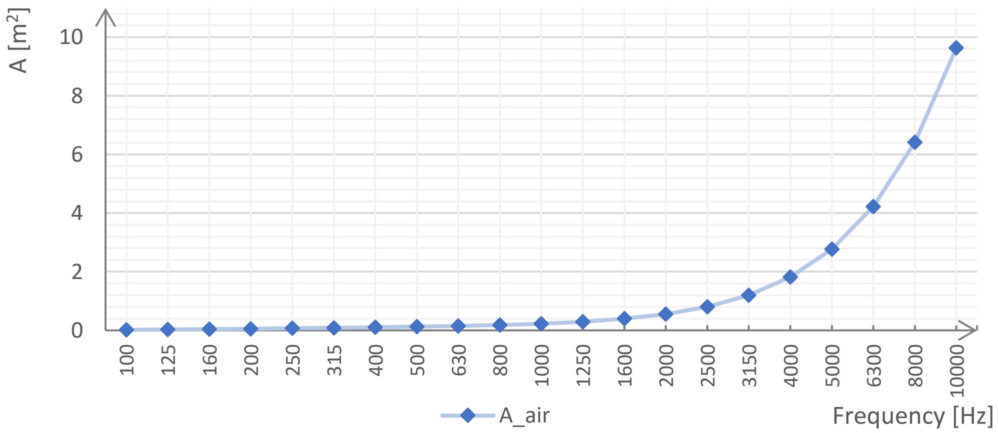


Figure 33 Mean equivalent room absorption area $\bar{A}_{mis}$ and air equivalent absorption area A_{air}.

As one would expect from literature, Air equivalent sound absorption area A_{air} increases with increasing frequency. At high frequencies the sound absorption due to air is not negligible.

[5] ISO 9613-1: 1993. Acoustics – Attenuation of sound during propagation outdoors – Calculation of the absorption of sound by the atmosphere.

3.3.2 Materials sound absorption definition

In order to replicate the acoustic behaviour of a room with a software model, it is necessary to attribute to the model absorption characteristics as close as possible to those actually possessed by the environment. But knowing the true sound absorption of a material is impossible. Nevertheless two ways can be followed, although both present obstacles:

- sound absorption can be estimated from the measurement results, but if on one hand the measurement data is inevitably uncertain due to the measurement operation itself, on the other the correlation between absorption and reverberation time (equation 3.1) is experimental in nature so it allows to obtain only an estimation of the unknown variable. Furthermore, only an estimation of the mean sound absorption coefficient can be obtained in this way;
- sound absorption can be estimated from literature data, which are the result of standardized tests involving material samples But sound-absorbing properties also depend on the laying conditions of the material, so this type of data may not be able to describe the real situation correctly. Moreover, since there is no obligation for manufacturers to declare acoustic properties or to produce materials that have certified characteristics, it may happen that data you need is not existing.

Materials absorption coefficient were defined referring to data library of a commercial acoustics software, Odeon, introducing simplifications with reference to table 3 of §2.1:

- Ceiling and walls are attributed the library material 4042 (plasterboard on frame, 13 mm boards, 100 mm empty cavity). Actually the thickness of the empty cavity of the ceiling is less than that of the walls so the ceiling should absorb more than the walls at low frequencies. For the moment this difference is being neglected. Ceiling and walls sound absorption coefficient is indicated with α_1.
- Floor is attributed the library material 102 (smooth concrete, painted or glazed). Floor sound absorption coefficient is indicated with α_2.
- Door is attributed the library material 10007 (solid wooden door). Door sound absorption coefficient is indicated with α_3.
- Window glass is attributed the library material 10003 (double glazing, 2-3 mm glass, 10 mm gap). Window sound absorption coefficient is indicated with α_4.
- Window frames have not been attributed any material. There is no data on PVC sound absorption in the library and no reliable data has been found in other sources. Since the window frames have a very small surface area (about 1,5 m^2), they contribute to the absorption in a limited way and the error that is introduced is acceptable. Therefore it is assumed that they have the same absorption coefficient α_4.

As mentioned above, the estimation of sound absorption from measurement data allows to reason only in terms of "global" equivalent absorption area and average absorption coefficient, without the possibility to differentiate the sound absorbing properties of the various materials in the environment. Then you can bypass limit modifying literature sound absorption coefficients in such a way as to obtain a global equivalent absorption area $A_{modified}$ equal to $A_{measurement}$. In particular, each coefficient is modified in proportion to the ratio between $A_{measurement}$ and $A_{literature}$ according to:

$$\alpha_i^{mod.} = \frac{A_{meas.}}{A_{lit.}} * \alpha_i^{lit.} \quad [-] \tag{3.4}$$

so that

$$A_{mod.} = \sum_i \alpha_i^{mod.} S_i = \sum_i \frac{A_{meas.}}{A_{lit.}} \alpha_i^{lit.} S_i = A_{meas.} \frac{\sum_i \alpha_i^{lit.} S_i}{A_{lit.}} = A_{meas.} \quad [m^2] \tag{3.5}$$

Absorption data are shown in the following figures (see annex D for data in tabular form). With regard to $A_{measurement}$ it is obtained by applying average reverberation time of the room, i.e. RT_{avg}, to equation (3.1). It is also specified that data shown in the graphs represent the absorption values for how they are processed by I-Simpa, according to the decimal approximations that the software allows. Specifically, I-Simpa allows to define the absorption coefficients of the materials only up to the second decimal and for this reason in the software, defining $\bar{\alpha}_{measurement}$, you will actually get $\bar{\alpha}_{approximate}$ which leads to define an equivalent absorption area $A_{approximate}$ different from $A_{measurement}$.

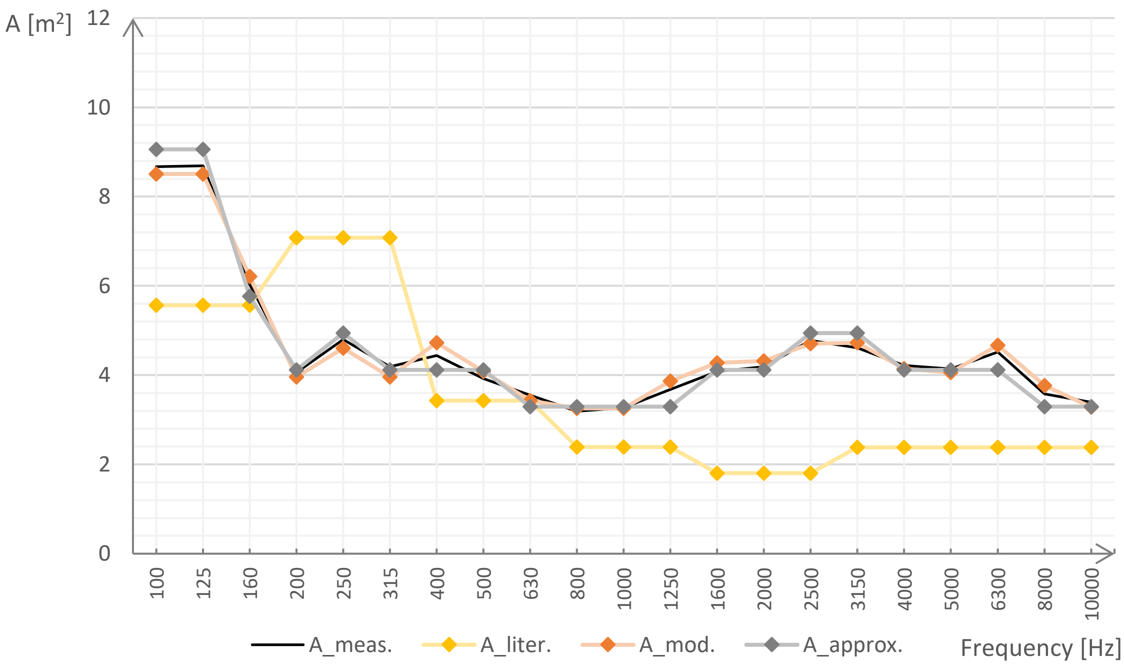


Figure 34 Equivalent sound absorption area.

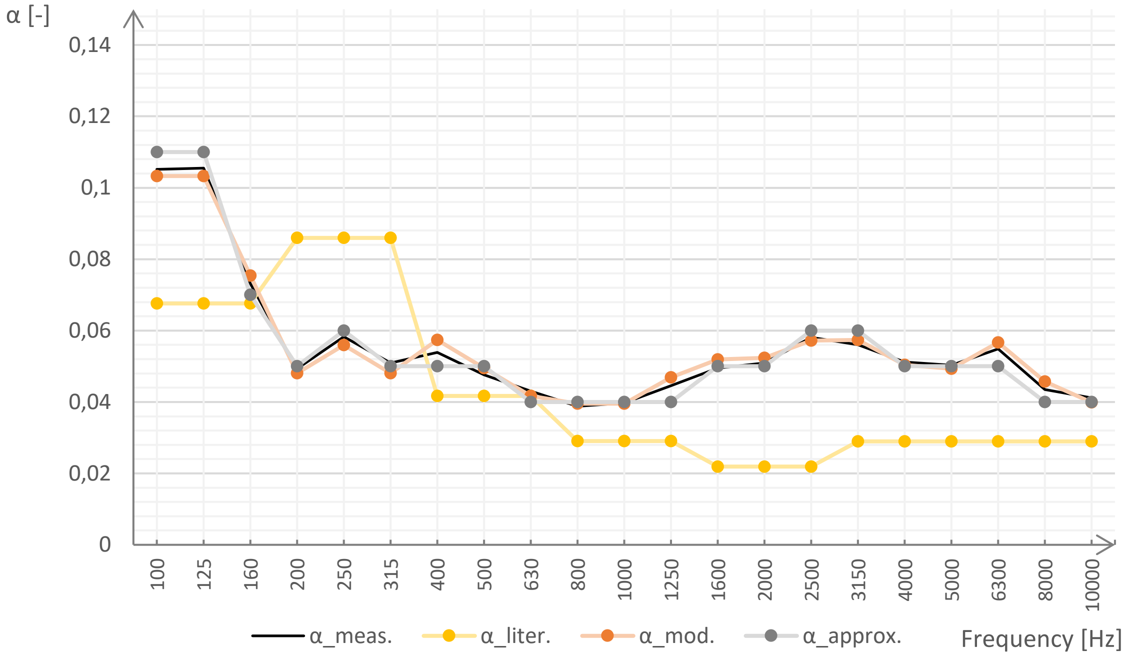


Figure 35 Mean sound absorption coefficient.

As said, it is not possible to perfectly replicate $A_{measurement}$ in I-Simpa due to numerical approximations; however these graphs show that you can enter values very close to it. It is then a question of understanding which of these trends will allow to obtain the most faithful simulation of the other variables monitored during measurements. This issue will be addressed in chapter 4. In the following figures a comparison between literature and modified sound absorption coefficient for materials is shown.

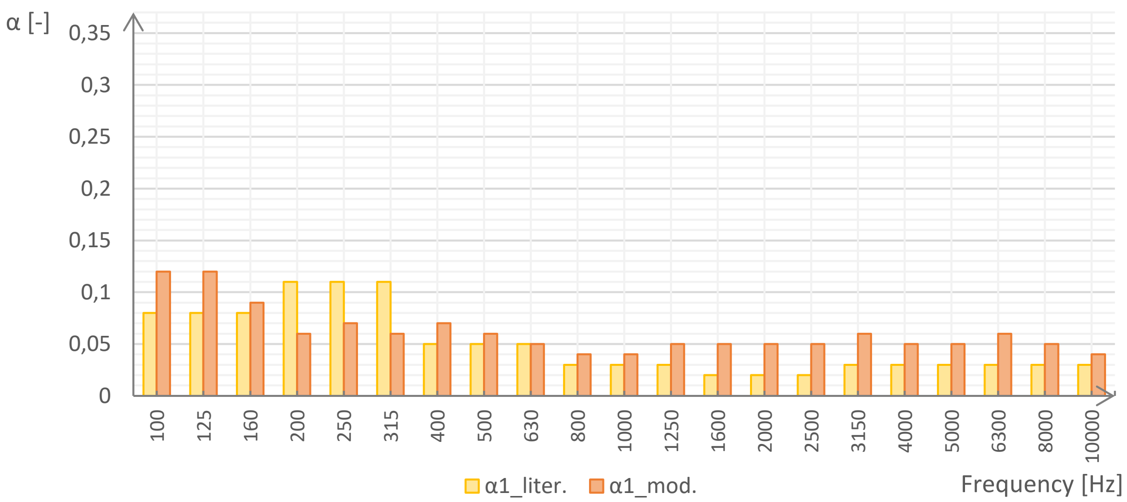


Figure 36 Literature and modified plasterboard sound absorption coefficient.

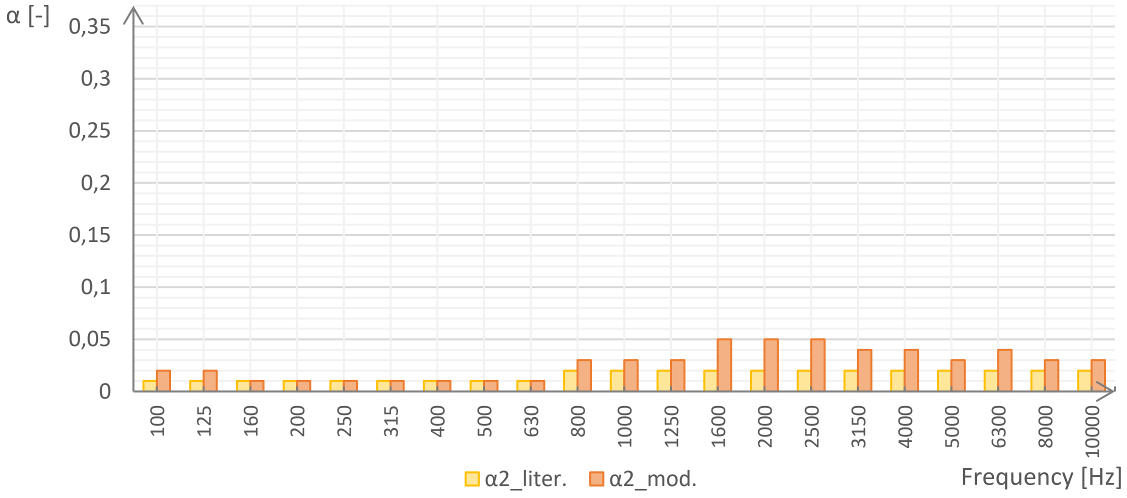


Figure 39 Literature and modified smooth concrete sound absorption coefficient.

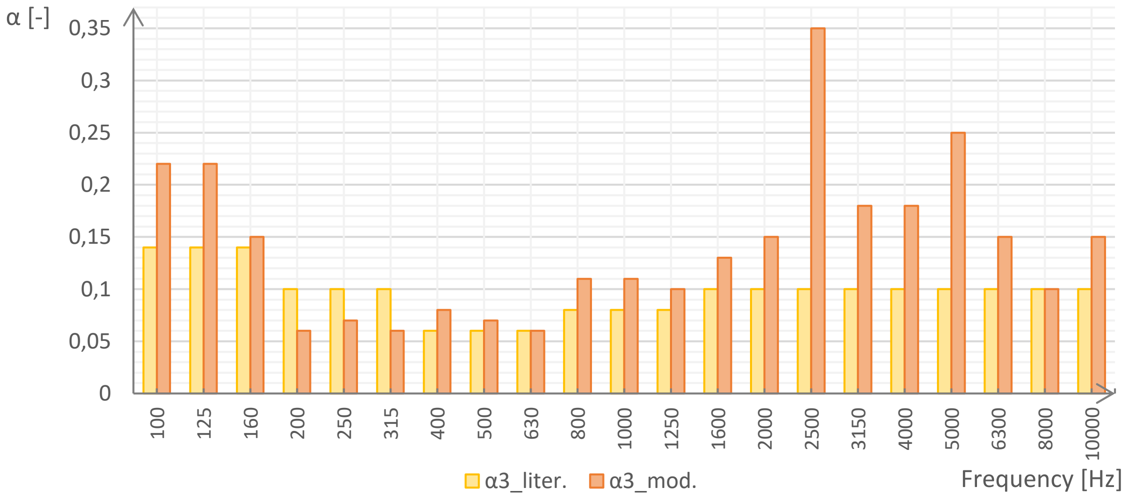


Figure 38 Literature and modified solid door sound absorption coefficient.

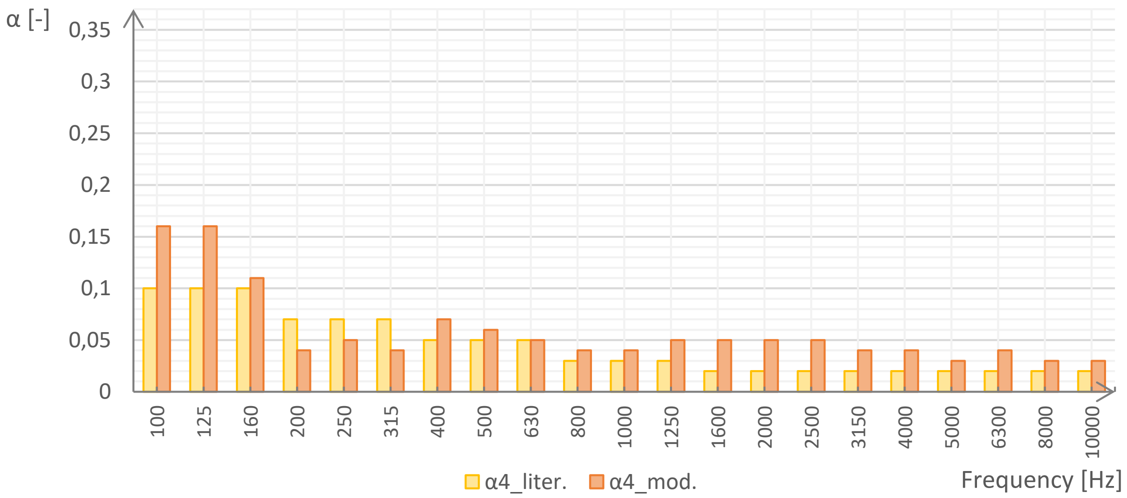


Figure 37 Literature and modified double glaze window sound absorption coefficient.

Tabular data are always presented in annex D.

3.4 Sound source definition

3.4.1 Sound directivity

Considering a point sound source in free space which radiates uniformly in all directions with a sound power W, the sound intensity I averaged over an encompassing spherical surface of radius r is given by:

$$I = \frac{W}{4\pi r^2} \quad \left[\frac{W}{m^2}\right] \tag{3.6}$$

This means that sound intensity is uniform in all space directions, and specifically it is inversely proportional to the square of the radius of the sphere, i.e. of the considered distance.

When the radiation of sound from a source is grater in a specific direction rather than other, the directional properties of a sound source may be quantified by the introduction of a directivity factor which describes the angular dependence of the sound intensity. Directivity factor Q is:

$$Q = \frac{I_\vartheta}{I} \quad [-] \tag{3.7}$$

where I_ϑ is the sound intensity in the preferred direction of emission at a certain distance r and I the sound intensity at the same r that would be measured if the source was omnidirectional.

By placing an omnidirectional source close to a reflecting surface, and assuming a constant sound power output W, the sound intensity is then expressed by:

$$I = \frac{QW}{4\pi r^2} \quad \left[\frac{W}{m^2}\right] \tag{3.8}$$

The sound intensity is uniformly distributed in the restricted region of propagation but it is increased by Q because of the contribution of reflected sound waves as if the sound source had a preferential direction of emission. The determination of the directivity factor must be carried out experimentally on a case-by-case basis but for the most frequent situations values for Q are given in literature, as presented in table 7.

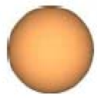
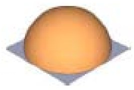
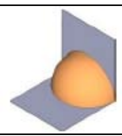
Sound pressure level in a point within the direct sound field of a sound source emitting at standard condition (pressure 101325 Pa, temperature 20°C) is expressed by:

$$L_{p(\text{direct field})} \approx L_W + 10\log\frac{Q}{4\pi r^2} \quad [dB] \tag{3.9}$$

The directivity index, DI, is introduced to express in dB the directional increase in sound intensity due to Q and it is defined by:

$$DI = 10\log Q \quad [dB] \tag{3.10}$$

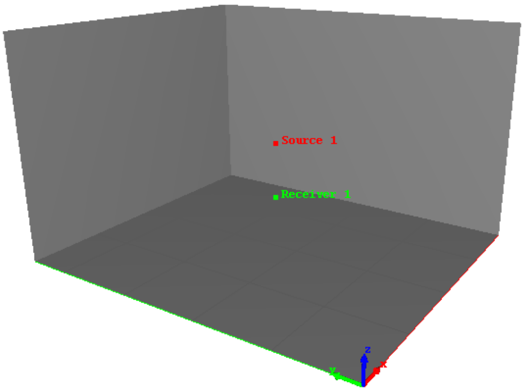
Table 7 Directivity factors Q and Directivity Index DI for a simple source near reflecting surfaces.

Configuration description and representation		**Q [-]**	**DI [dB]**
Free space		1	0
Centred in a large flat surface		2	3
Centred at the edge formed by the junction of two large flat surfaces		4	6
At the corner formed by the junction of three flat surfaces		8	9

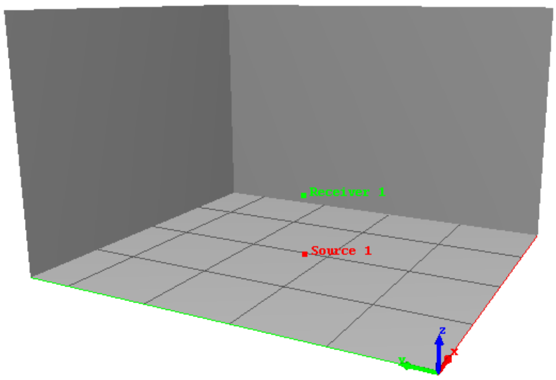
Taking as example a sound source centred in a large flat surface (Q = 2), the sound pressure level at a point within the direct sound field is increased by 3 dB compared to the free space configuration of the source (Q = 1).

3.4.2 Checking directivity in I-Simpa

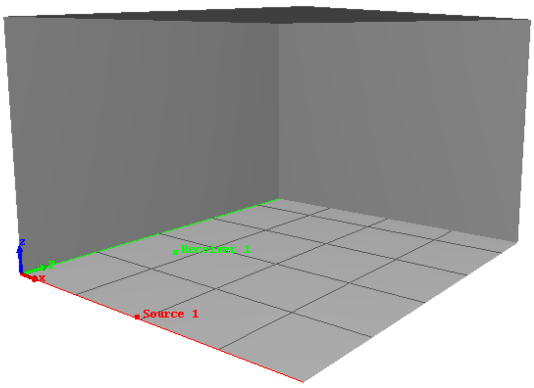
Taking into account the concept of directivity explained in previous §3.3.1, it has been necessary to check how the I-Simpa can modelled such phenomenon. First of all it should be pointed out that in the current version of the software the possibility to specify the directivity of a sound source exists only in an unofficial way (there is the possibility to implement an external line of code but this feature is experimental and it is still not documented in the official manual). In addition, there are no data concerning the directivity attributable to the ventilation system grilles installed in the laboratory room, therefore this road is precluded.
Nevertheless, since ventilation grilles are installed on walls and ceiling, we have to model the case of a sound source near to a reflecting surface, so it is necessary to check how such situation is modeled in I-Simpa considering the way in which sound reflection is elaborated by it.
Consider a sound source with an overall sound power level of 80 dB (pink noise spectrum) and a punctual receiver lying within the direct sound field of the source. Four different configurations are built in an environment which present the same dimension of laboratory room. Sound source is positioned near to one or more room boundaries and an absorption coefficient α equal to 0 is assigned to that walls near the source, with the aim of replicate a perfectly reflecting surface. To the other surfaces an absorption coefficient of 0,5 is assigned.



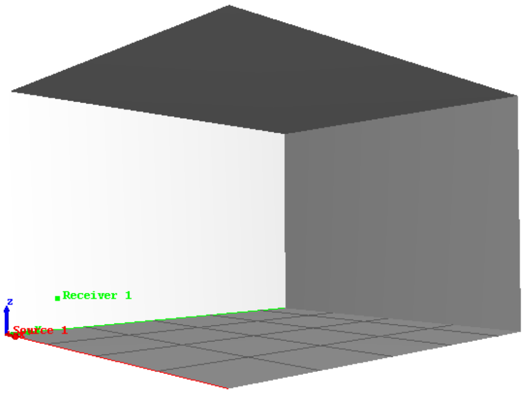
a) Scene Q = 1.
S coordinate: x = 1,945; y = 2,27; z = 1,395.
R coordinate: x = 1,945; y = 2,27; z = 0,695.



b) Scene Q = 2.
S coordinate: x = 1,945; y = 2,27; z = 0,01.
R coordinate: x = 1,945; y = 2,27; z = 0,71.



c) Scene Q = 4.
S coordinate: x = 1,945; y = 0,01; z = 0,01.
R coordinate: x = 1,945; y = 0,505; z = 0,505.



d) Scene Q = 8.
S coordinate: x = 0,01; y = 0,01; z = 0,01.
R coordinate: x = 0,4141; y = 0,4141; z = 0,4141.

Figure 40 I-Simpa scene and position in the tested configuration. The distance between source and receiver is calculated as Euclidean distance according to $r = \sqrt{(x_s - x_r)^2 + (y_s - y_r)^2 + (z_s - z_r)^2}$.

Table 8 Material spectrum for reflecting surface and absorption surface.

Frequency	Absporption α	Diffusion	Transmission	Loss [dB]	Diffusion Law
100 ÷ 10000 Hz	0	0	Uncheck	0	Specular
100 ÷ 10000 Hz	0,5	0	Uncheck	0	Specular

Table 9 Scene acoustic parameters.

	Derived from	Scene_A	Scene_B	Scene_C	Scene_D
Q [-]	Literature (see table 7)	1	2	4	8
D.I. [dB]	Literature (see table 7)	0	3	6	9
A [m²]	$A = \sum \alpha_i S_i$	41,18	32,35	26,92	20,59
$\alpha_{average}$ [-]	$\alpha_{average} = \frac{A}{S_{tot}}$	0,5	0,39	0,33	0,25
Rc [m²]	$R_c = \frac{A}{1-\alpha_{average}}$	82,36	53,28	40	27,45
RT [s]	$RT = 0{,}16 * \frac{V}{A}$	0,1926	0,2452	0,2946	0,3853
***f_0* [Hz]**	$f_0 \cong 2000\sqrt{\frac{RT}{V}}$	125	141	155	177
d_c [m]	$d_c \cong \frac{1}{4}\sqrt{\frac{QR_c}{\pi}}$	1,28	1,46	1,78	2,09
r [m]	$r \gg \lambda\,;\ r \leq d_c$	0,7	0,7	0,7	0,717

For each configuration, 3 simulations have been launched both with SPPS code both with TCR code by setting the parameters summarized in tables 15 and 16.

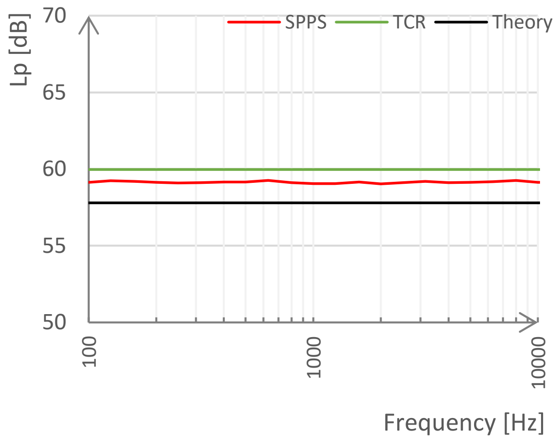
Table 10 Calculation parameters used for directivity simulation with SPPS code.

Active calculation of acoustic transmission	Check
Active calculation of atmospheric absorption	Uncheck
Active calculation of diffusion by fitting objects	Check
Active calculation of direct field only	Uncheck
Calculation method	Random
Export surface receivers for each frequency band	Check
Limit of propagation (10^n)	5
Number of sound particles per source	250000
Number of sound particles per source (display)	0
Radius of receivers [m]	0,31
Simulation legth [s]	2
Surface receiver mode	SPL mapping
Time step [s]	0,01

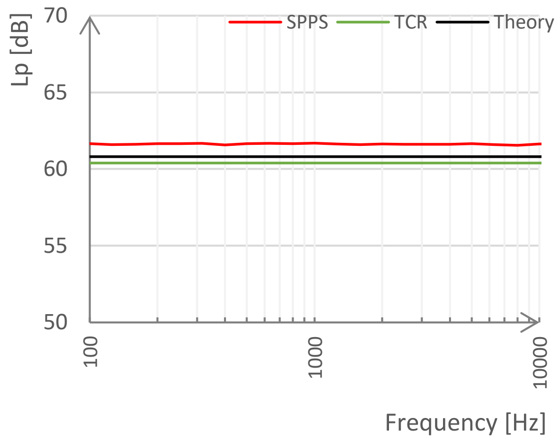
Table 11 Calculation parameters used for directivity simulation with TCR code.

Active calculation of acoustic transmission	Check
Export surface receivers for each frequency band	Uncheck

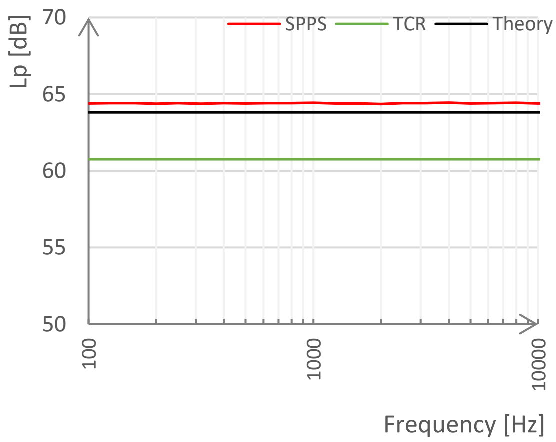
In figure 41 simulated sound pressure level, $Lp_{(SPPS)}$ and $Lp_{(TCR)}$, and therical sound pressure level $Lp_{(Theory)}$ are represented. $Lp_{(Theory)}$ is calculated scene data applying equation (3.9). Figures 42÷44 show a comparison between simulated directivity index, DI_{SPPS} or DI_{TCR}, and expected theoretical one. Simulated directivity index is calculated as difference between simulated sound pressure level of scene B, C or D, i.e. for Q equal to 2, 4 or 8 respectively, and scene A, when Q is equal to 1. Again, complete data are given in annex D.



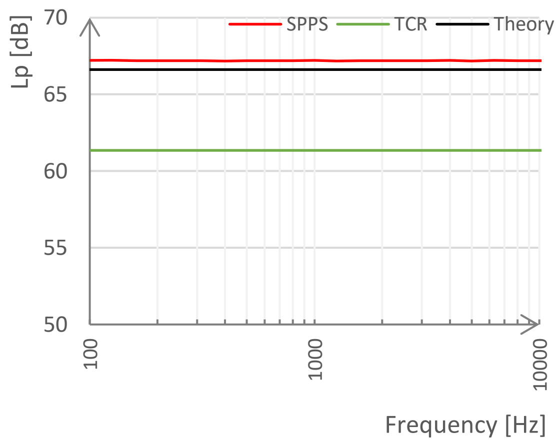
a) *Scene A (Q = 1).*



b) Scene B (Q = 2).



c) Scene C (Q = 4).



d) Scene D (Q = 8).

Figure 41 Sound pressure level for the four simulated scene.

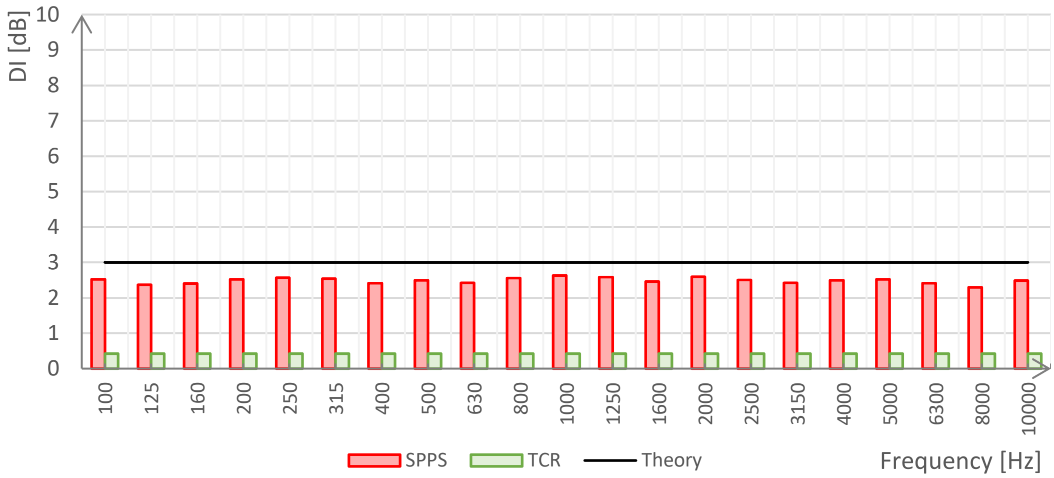


Figure 42 Comparison between DI for scene B, simulated with SPPS and TCR code.

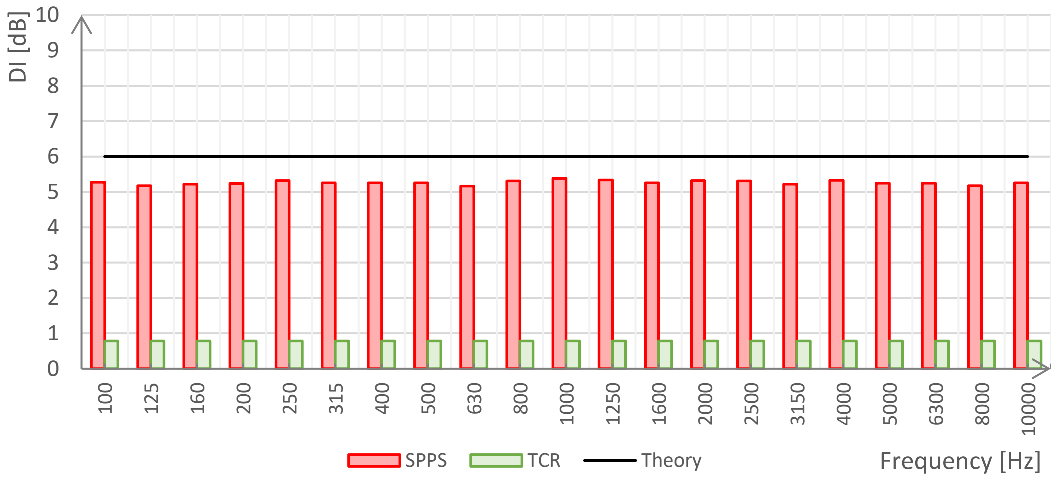


Figure 43 Comparison between DI for scene C, simulated with SPPS and TCR code.

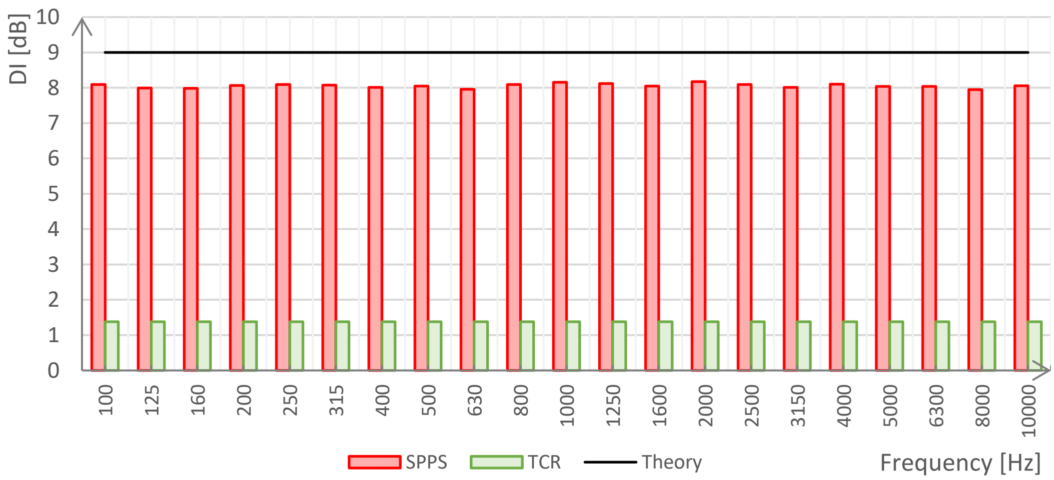


Figure 44 Comparison between DI for scene D, simulated with SPPS and TCR code.

As expected sound pressure level is the same for all frequencies, since sound absorption properties are the same. Small difference small differences are found for $Lp_{(SPPS)}$, but this depends on how the code SPPS works. Figure 41 show that SPPS code simulates results similar to that expected from the theoretical formula more than TCR code does. TCR code is a numerical application of classical theory of reverberation as proposed by Sabine, so, since it is not possible to set a directivity factor Q different from 1 in the software, simulated direct sound pressure level is independent of the positioning of the sound source with respect to reflective surfaces but it only depends on the distance between source and receiver ($L_{p(direct)} \propto r^{-2}$). Differently, in SPPS code, a sound particle colliding with a wall is reflected in a new direction of propagation, with a probability $R = 1 - \alpha$ where α is the absorption coefficient of the wall. But if α is zero, sound particle is surely reflected, therefore a sound source placed near a reflecting wall actually emits sound particles only in one direction, as if the directionality property of the source had changed. Consequently, while the TCR code does not allow to simulate a DI coherent with the theoretical one, SPPS code allows to obtain values close to it.
Note that in figure 41a) the difference between $Lp_{(SPPS)}$ and $Lp_{(Theory)}$ is bigger than the other scenes, and this can be explained thinking about the distance r that has been set between source and receiver. For a distance r equal to 0,7 m the receiver falls within source direct sound field, since the critical distance d_c for scene A is equal to 1,28 m. But transition between diffuse field and direct field takes place gradually and inside direct sound field the contribution of reverberant sound still exists even though it results in a negligible increase in the total sound pressure level. Within the diffuse field this behaviour reverses and the contribution of the direct sound becomes negligible compared to that of the reflected sound, so much so that the sound pressure level is considered to be uniform throughout the space. The critical distance d_c is the distance at which the sound pressure level of the direct sound and the reverberant sound are equal: at d_c there is an increase of +3dB in total sound pressure level compared to the contribution of direct sound field alone. Thus, scene A is partly affected by the contribution of the sound reflected on the walls. In the other scenes the critical distance is greater and this contribution is even more limited.

3.3.3 Modeling ventilation system as sound source in I-Simpa

Ventilation system represents the main sound source inside the empty laboratory room and therefore it is necessary to define it into the model. Simply, since there are 4 ventilation system grids in laboratory room (2 return grids on the bottom of the south wall and 2 delivery grids on the ceiling, see figure 7 in §2.1), it is assumed that each grids has a sound power level equal to:

$$L_{w\_grid} = 10 * \log\left(\frac{10^{0,1L_w}}{4}\right) \quad [dB] \qquad (3.11)$$

where L_W is ventilation system sound power measured in §2.2.2.

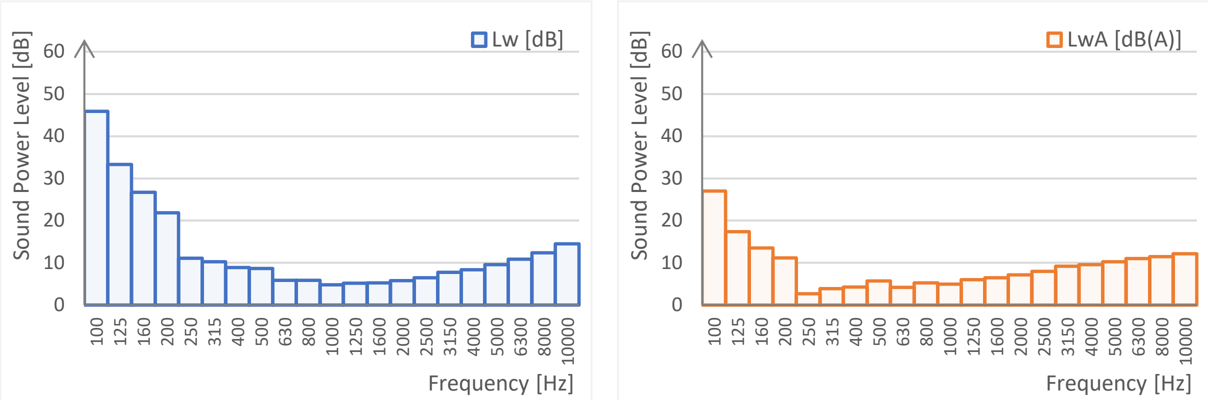


Figure 45 Grids sound power level spectrum in third octave band for ***nominal flow rate 80 m³/h****.*

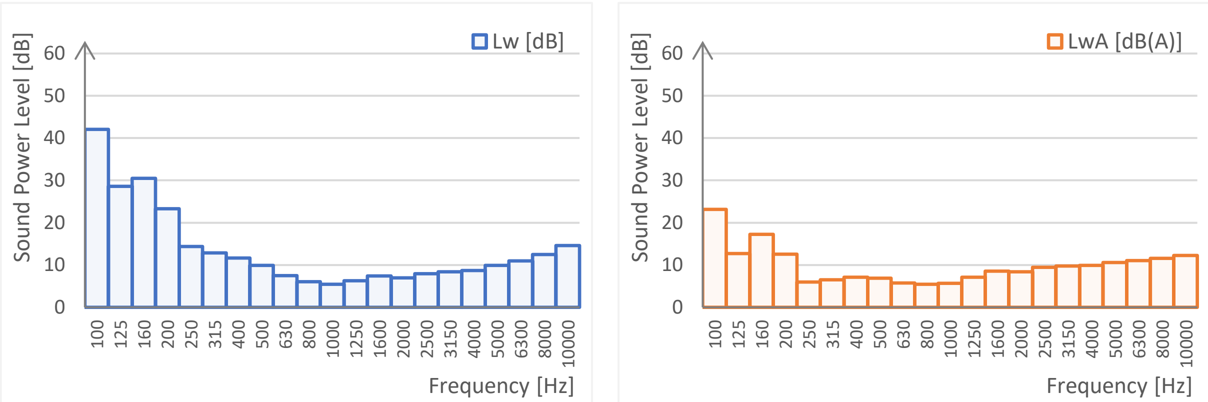


Figure 46 Grids sound power level spectrum in third octave band for ***nominal flow rate 120 m³/h****.*

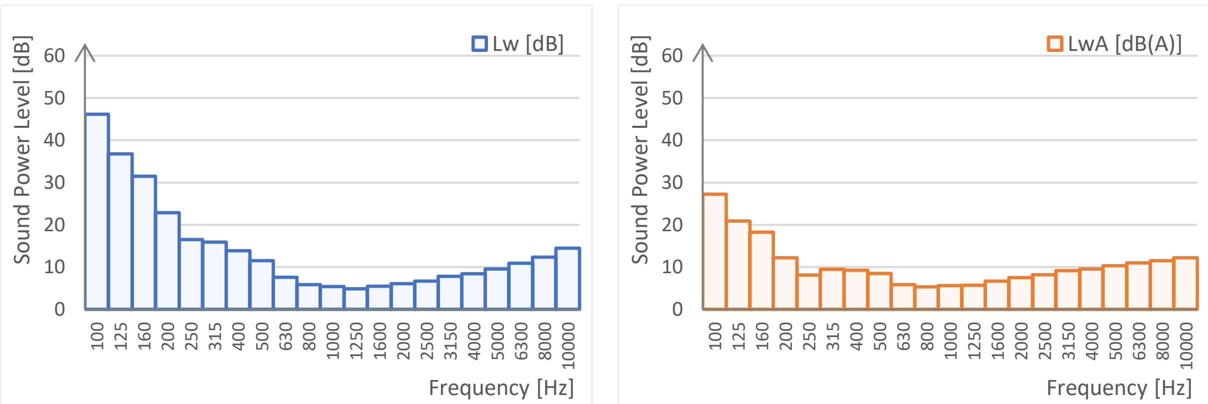


Figure 48 Grids sound power level spectrum in third octave band for ***nominal flow rate 160 m³/h****.*

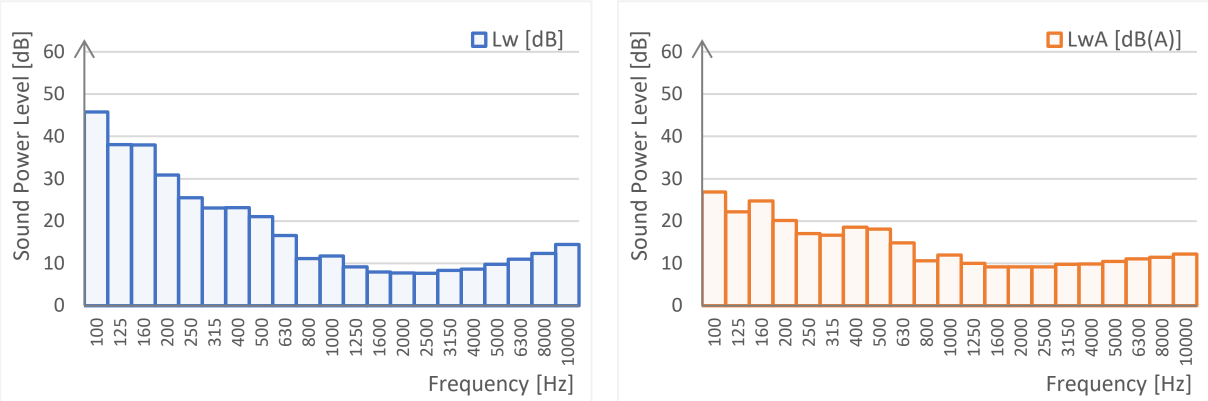


Figure 49 Grids sound power level spectrum in third octave band for ***nominal flow rate 200 m³/h***.

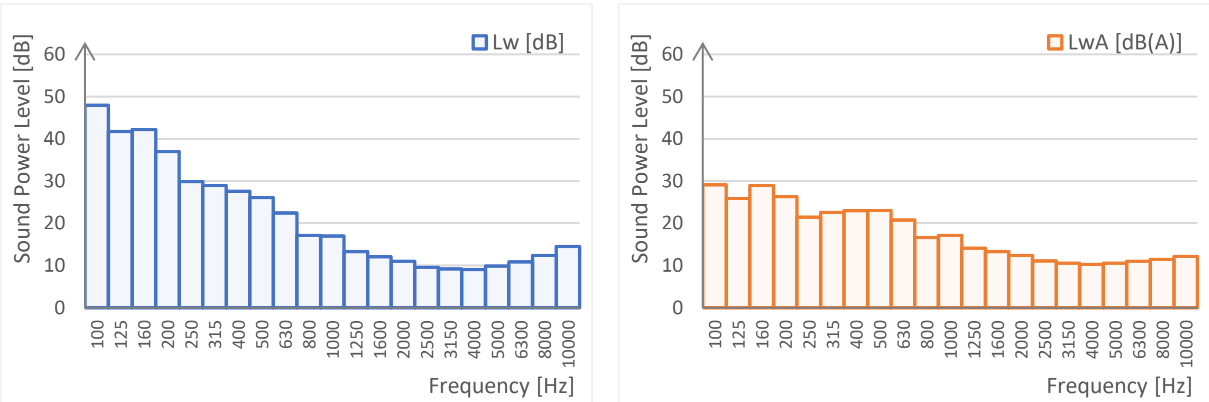


Figure 50 Grids *sound power level spectrum in third octave band for system* ***nominal flow rate 240 m³/h***.

Actually it is likely that returns and delivery grids don't have exactly the same spectrum, but for the moment this is negligible. The directionality of the noise emission of the ventilation grilles is also neglected, since the experimental measurement of the directivity factor has not been carried out and it would not be possible to take it into account in I-Simpa as explained in previous paragraph. Complete data are given in annex D.

Chapter 4

Acoustic Mapping of Laboratory Room

In this chapter we present the results returned by I-Simpa attributing to various models the absorption coefficients defined in chapter 3. By comparison, it is possible to understand which simulation strategy allows to replicate with greater precision the real acoustic behaviour of the room. The final part of the chapter discusses the existence of favoured or disadvantaged areas from the point of view of aural comfort in the climate chamber of laboratory CORE-CARE.

4.1 Simulation process

As implicitly anticipated in chapter 3, acoustic modelling of a real environment involves several critical points that need to be investigated and an uncritical approach to it leads to rough miscalculations. The process steps can be summarised as follows:

- standard experimental tests are carried out in a real-life environment in order to characterise measurable acoustic quantities (for example reverberation time, sound pressure level, STI, *etc.*);
- from collected data the primary variables that determine the measured effect are derived (for example sound absorption, sound power level, distance between source and receiver, directivity factor, *etc.*);
- the same variables defined in the previous point are imposed to the software;
- based on the parameters set, the software calculates the parameters of interest.

But how do the measured and simulated parameters relate to each other? Theoretically they should be equal to each other since the variables that determine them are the same. However, it must be considered that:

- each measurement is inevitably associated with a certain degree of uncertainty, so the data collected may be more or less accurate, but never perfect;
- variables are estimated through experimental methods that are not always applicable or suitable to describe the real case. For example, in the present case, the sound power level of the ventilation system has been calculated on the basis of the method proposed by ISO 3747, but this method has limits when the sound pressure level is not significantly higher than background noise (and this happens for low flow rates) or when the sound field is not diffuse (this happens for frequencies from 100 to 160 Hz);

- it is not always possible to insert the same variables in the software (for example it has been seen that in I-Simpa it is not possible to impose a sound absorption equal to that estimated because of decimal approximations or that it is not yet possible to specify the directivity factor of a sound source);
- the software is not always able to replicate the actual behaviour of the environment.

Thus, considering that the results returned by a software simulation are certainly reliable is a fallacious reasoning, rather it is necessary to check from time to time if model results and measurement data are actually convergent.

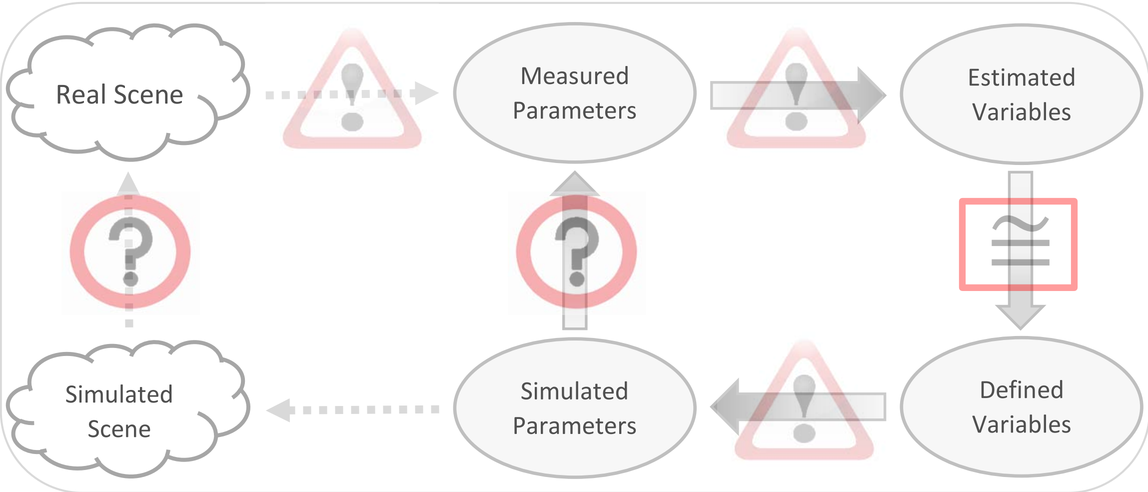


Figure 51 Logic of simulation process.

The figure schematically represents the simulation process just described as well as its critical points. The process closes correctly, i.e. in other words you can assume that the software model can replicate the real environment with a certain precision, when the simulated results and the measurement data are similar to each other, and this in turn assumes that:

- the measurement data are reliable;
- the variables are accurately estimated through methods that describe the real environment;
- the variables are defined appropriately in the software;
- the software correctly replicates the behaviour of studied environment.

It is clear that the simulation process will never close perfectly and, in practical terms, this means that the results of a software simulation must be interpreted in relation to a confidence interval containing plausible values for that result.

4.2 Preferred simulation strategy

In the model correctly constructed and imported according to §3.1, punctual sources and punctual receivers are positioned in such a way as to replicate measurement conditions of §2.1, with the aim of verify how differ measurement and simulated results by applying sound absorption coefficients defined in §3.3.2. In section "environment" of I-Simpa the same weather conditions are set, i.e. temperature 23°C, pressure 100700Pa and relative humidity 32%. Only reverberation time, reference sound source sound pressure level and ventilation system sound pressure level are compared, since STI cannot be calculated in I-Simpa (this possibility should be introduced in future versions of the software).

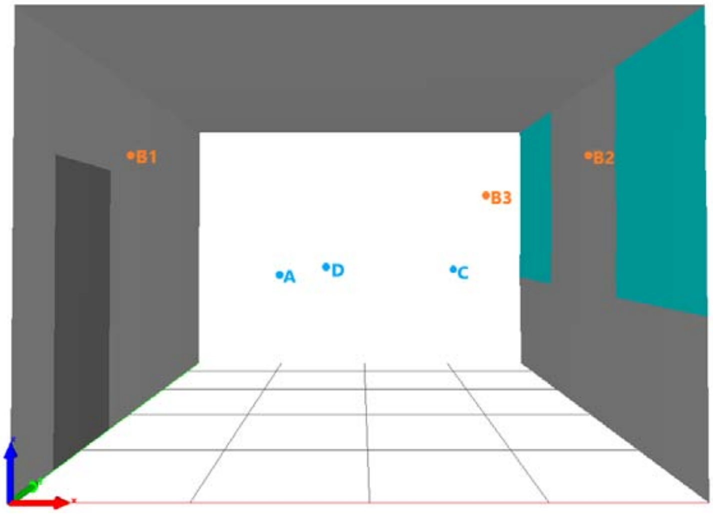


Figure 52 Reverberation Time simulation.

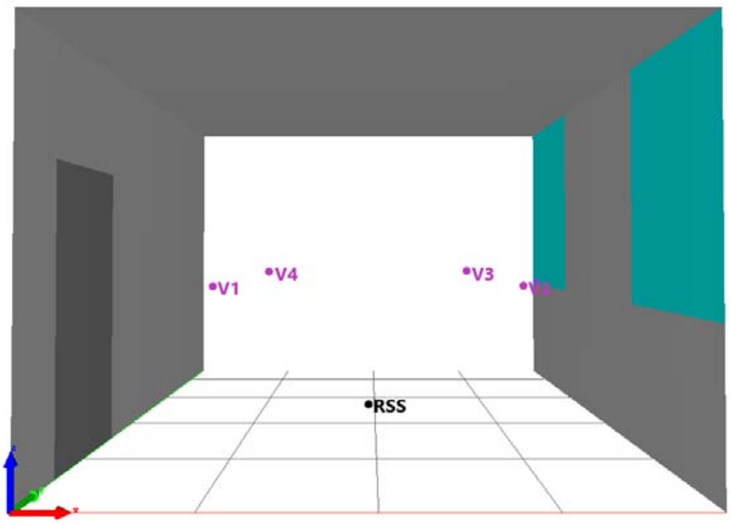


Figure 53 Reference Sound Source sound pressure level simulation.

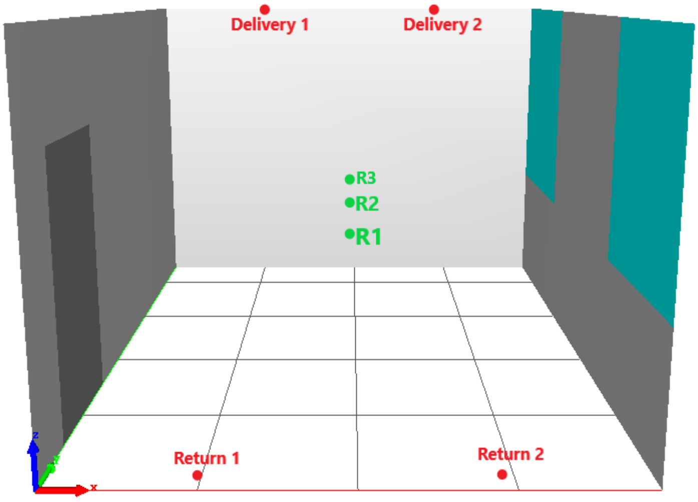


Figure 54 Ventilation System sound pressure level simulation.

In figure 52, points B1, B2 and B3 represent the position of balloons used to perform reverberation time measurement. A pink noise spectrum with overall sound power level of 100dB is attributed to these sources: since sound absorption is an intrinsic property of the material, it is independent on the type of sound source, it is not strictly necessary to replicate the acoustic spectrum of a balloon burst. Reference sound source spectrum is defined in appendix B (table B.6), and as regards the ventilation system, operating condition with a nominal flow rate of 240 m^3/h is simulated (sound power spectrum in table D.6 of appendix D). Simulations are performed using both SPPS code and TCR code according to calculation parameters shown in the following table.

Table 12 Calculation parameters used for simulation with SPPS code.

	RT	$Lp_{(RSS)}$	$Lp_{(VS)}$
Active calculation of acoustic transmission	Check	Check	Check
Active calculation of atmospheric absorption	Check	Check	Check
Active calculation of diffusion by fitting objects	Check	Check	Check
Active calculation of direct field only	Uncheck	Uncheck	Uncheck
Calculation method	Random	Random	Random
Export surface receivers for each frequency band	Check	Check	Check
Limit of propagation (10^n)	5	5	5
Number of sound particles per source	200000	500000	150000
Number of sound particles per source (display)	0	0	0
Radius of receivers [m]	0,31	0,31	0,31
Simulation legth [s]	2	2	2
Surface receiver mode	SPL mapping	SPL mapping	SPL mapping
Time step [s]	0,005	0,005	0,005

Table 13 Calculation parameters used for simulation with TCR code.

	RT	**$Lp_{(RSS)}$**	**$Lp_{(VS)}$**
Active calculation of acoustic transmission	Check	Check	Check
Export surface receivers for each frequency	Check	Check	Check

Note that calculation option for code SPPS are chosen to balance calculation time and accuracy for the simulation results. Each simulation is carried out in about 5 minutes, while setting energetic mode each simulation takes more than 1 hour. It is obvious that this choice would not be advantageous. The difference between simulated and measured parameter is expressed as:

$$\delta_X = \frac{X_{I-Simpa} - X_{measurment}}{X_{measurement}} \quad [\%] \qquad (4.1)$$

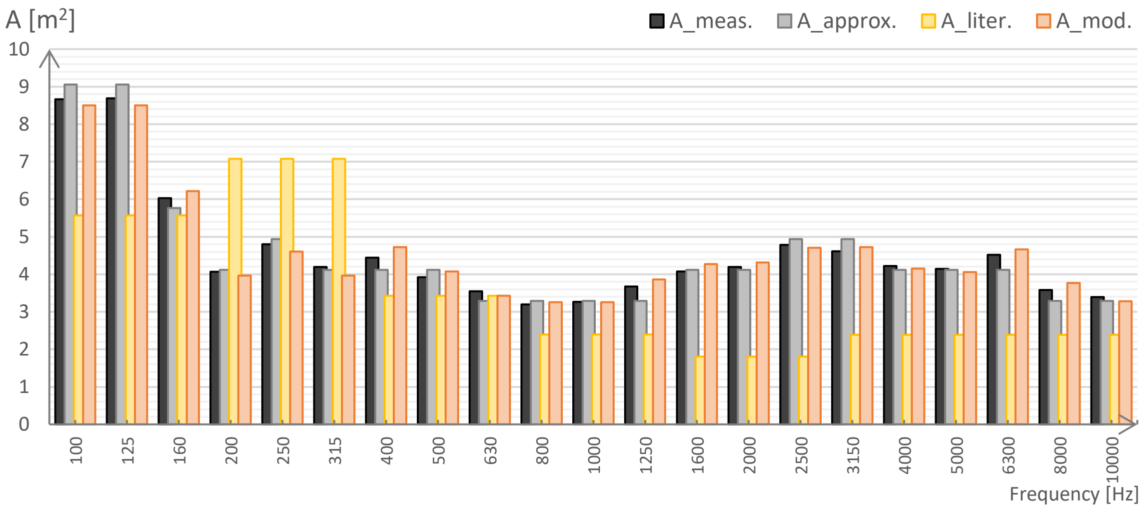


Figure 55 Estimated and imposed equivalent sound absorption area.

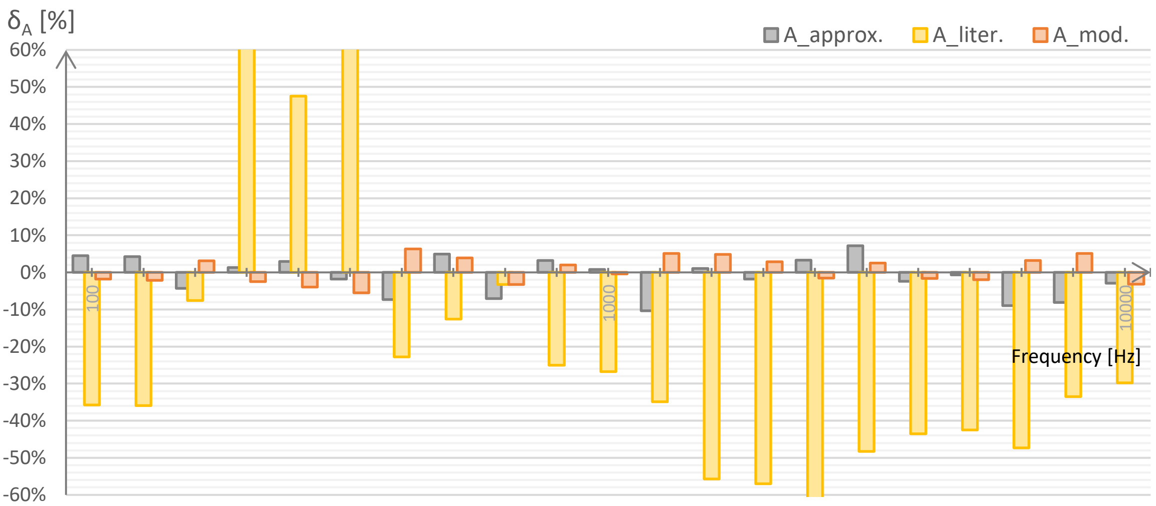
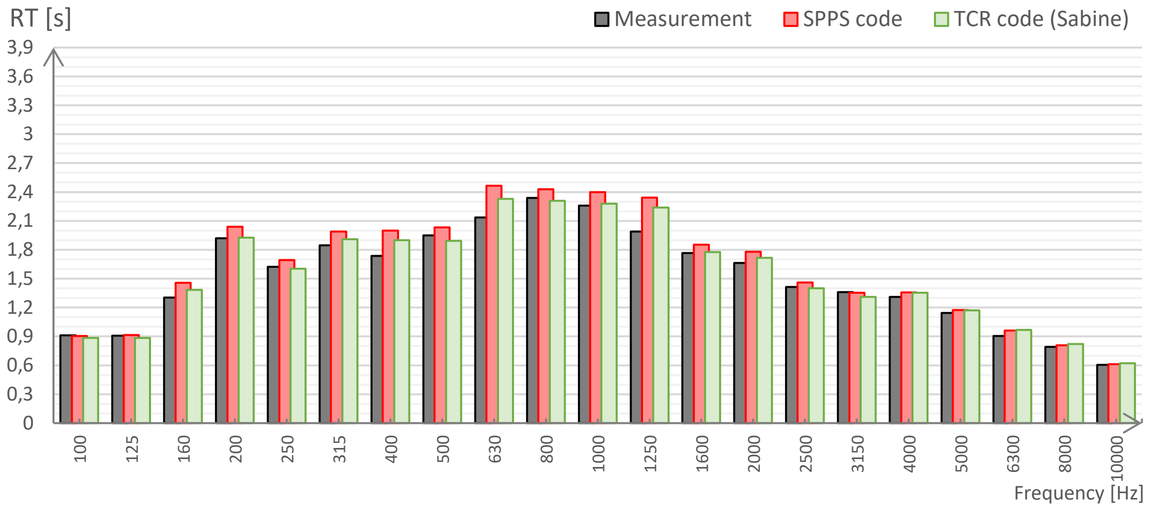
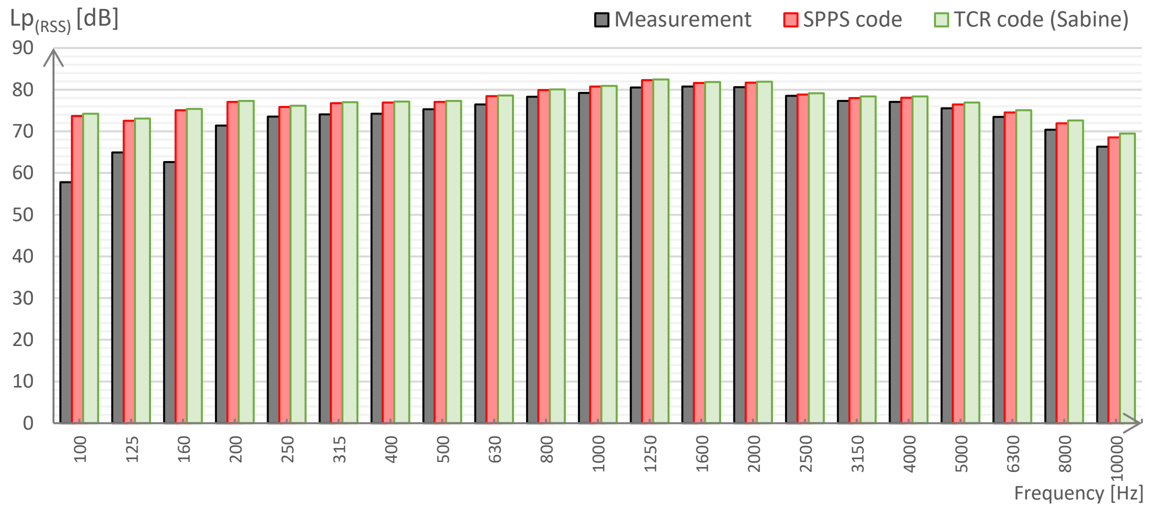


Figure 56 Comparison of percentage difference of imposed equivalent sound absorption area.

Sound absorption “$A_{approximate}$”





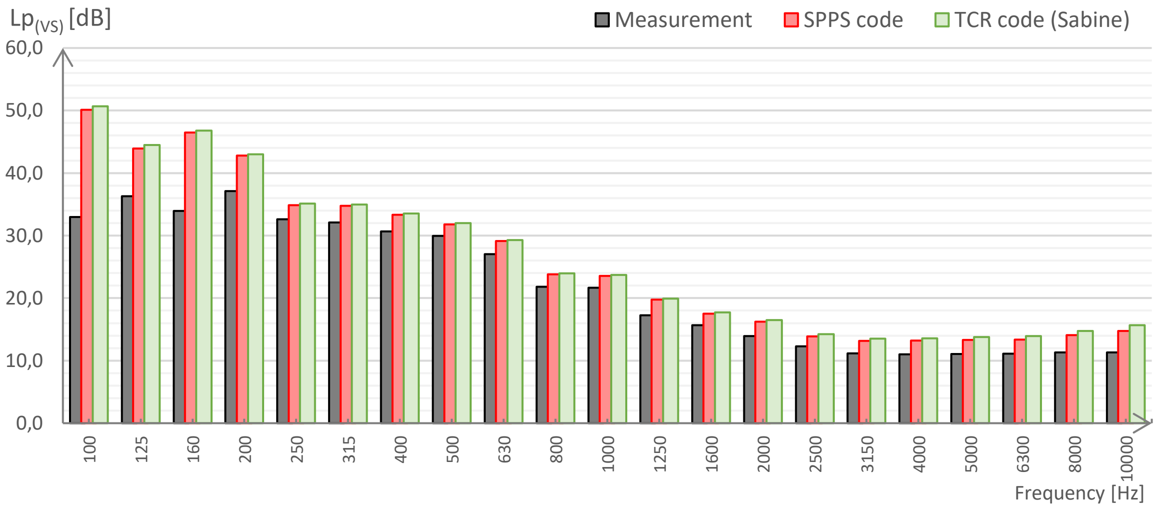


Figure 57 Simulation results obtained applying sound absorption $A_{approximate}$.

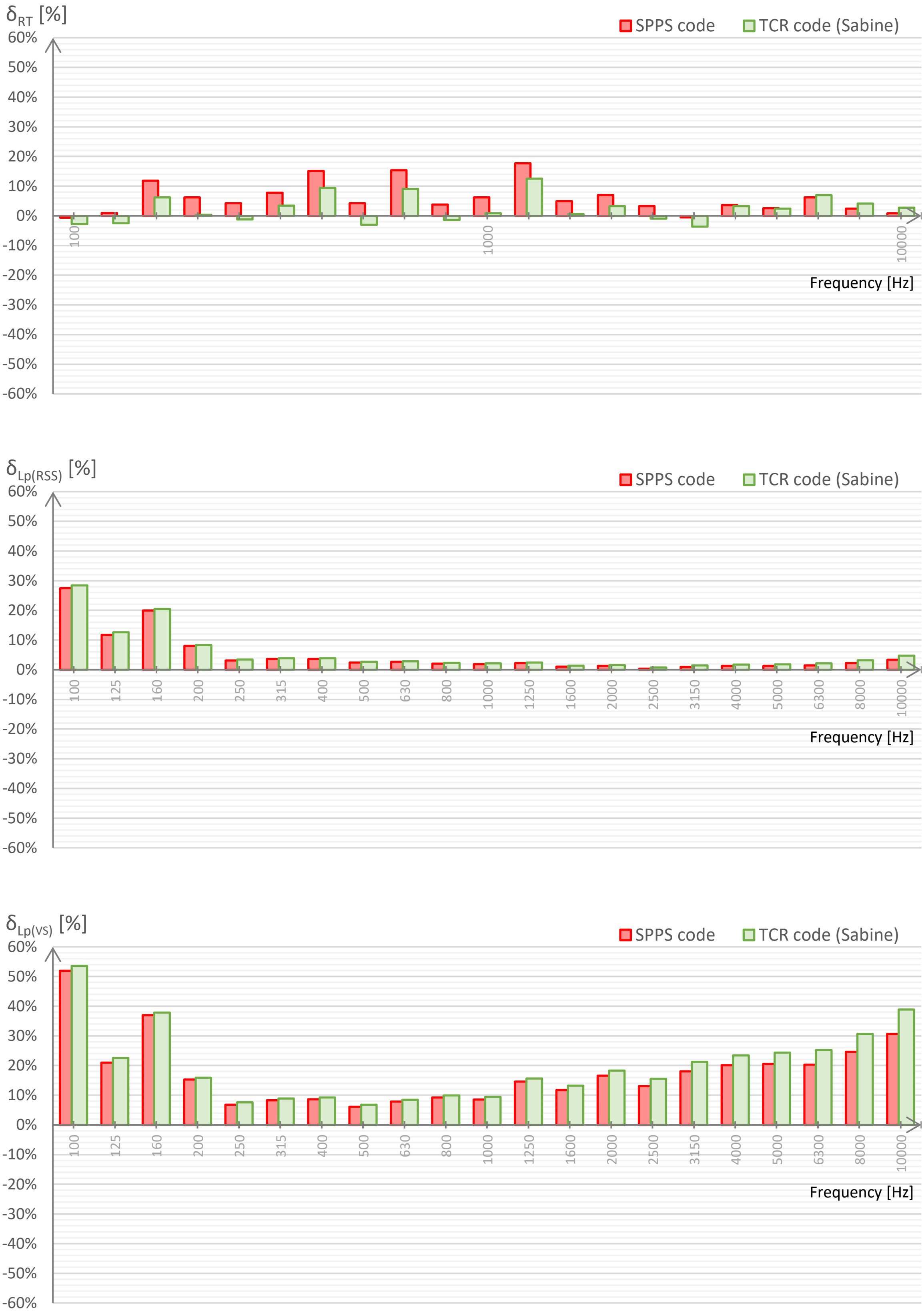
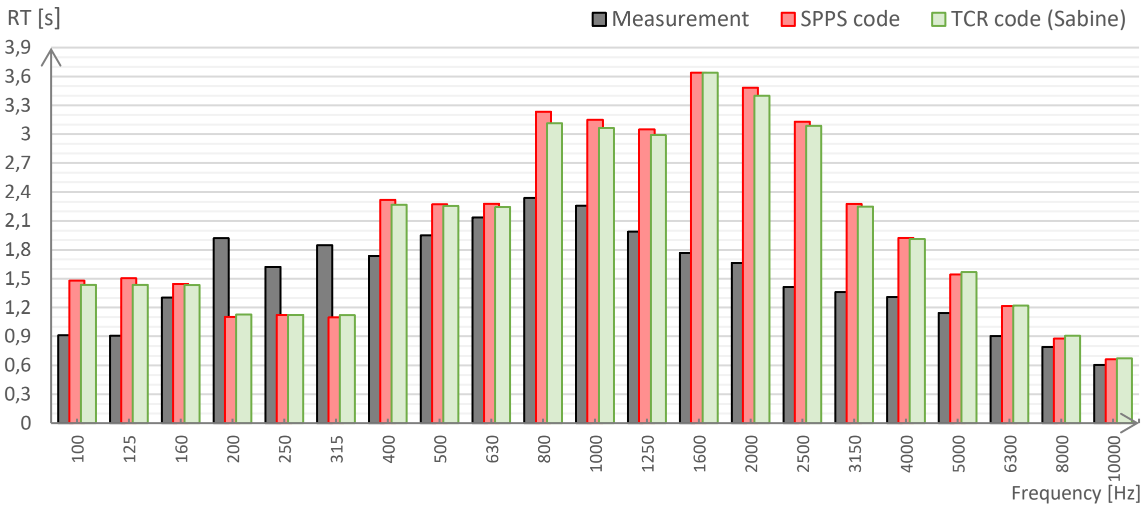
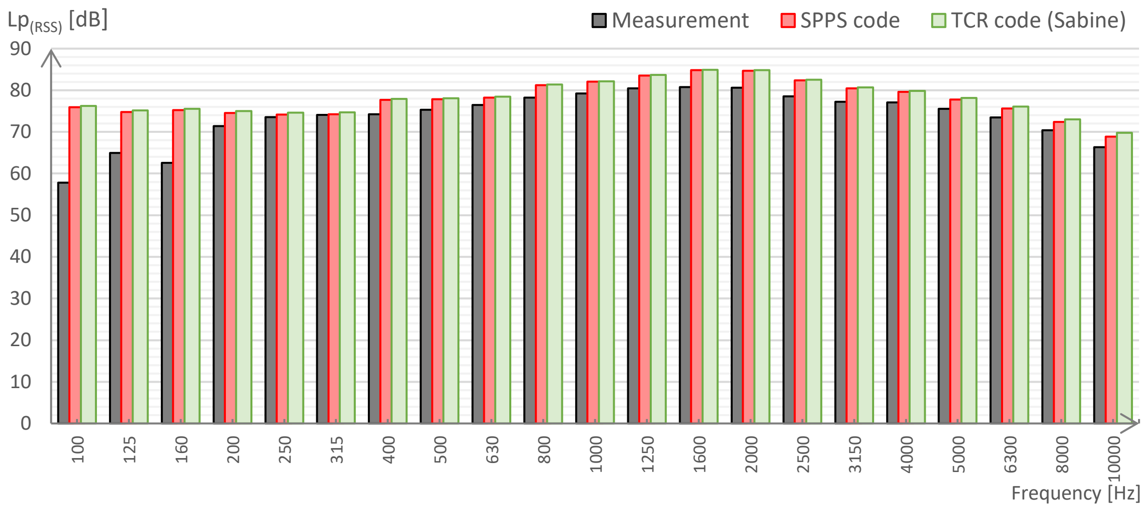


Figure 58 Comparison of percentage difference between simulation result and measurement data for SPPS and TCR code

Sound absorption "$A_{literature}$"





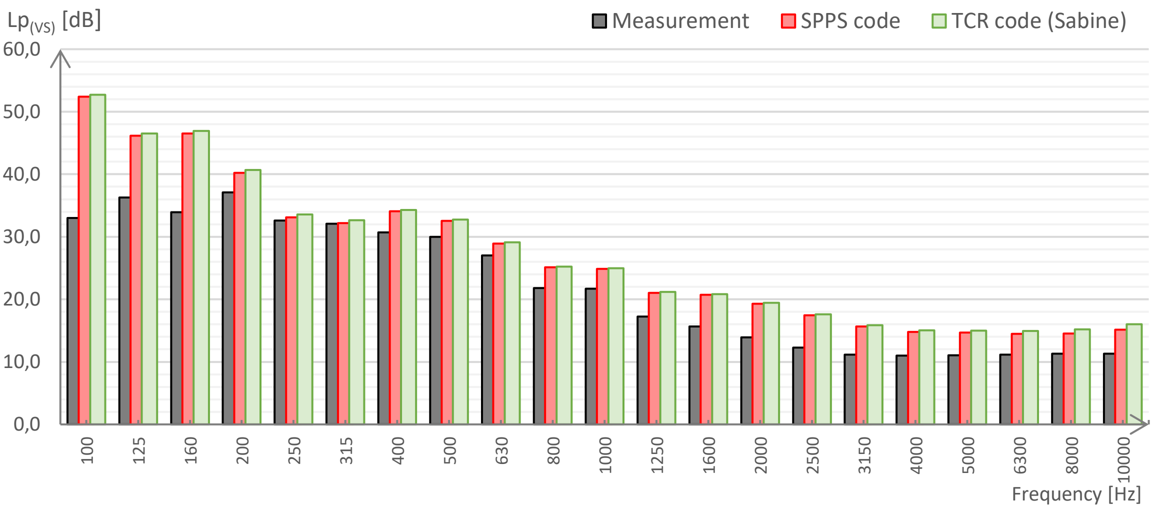


Figure 59 Simulation results obtained applying sound absorption $A_{literature}$.

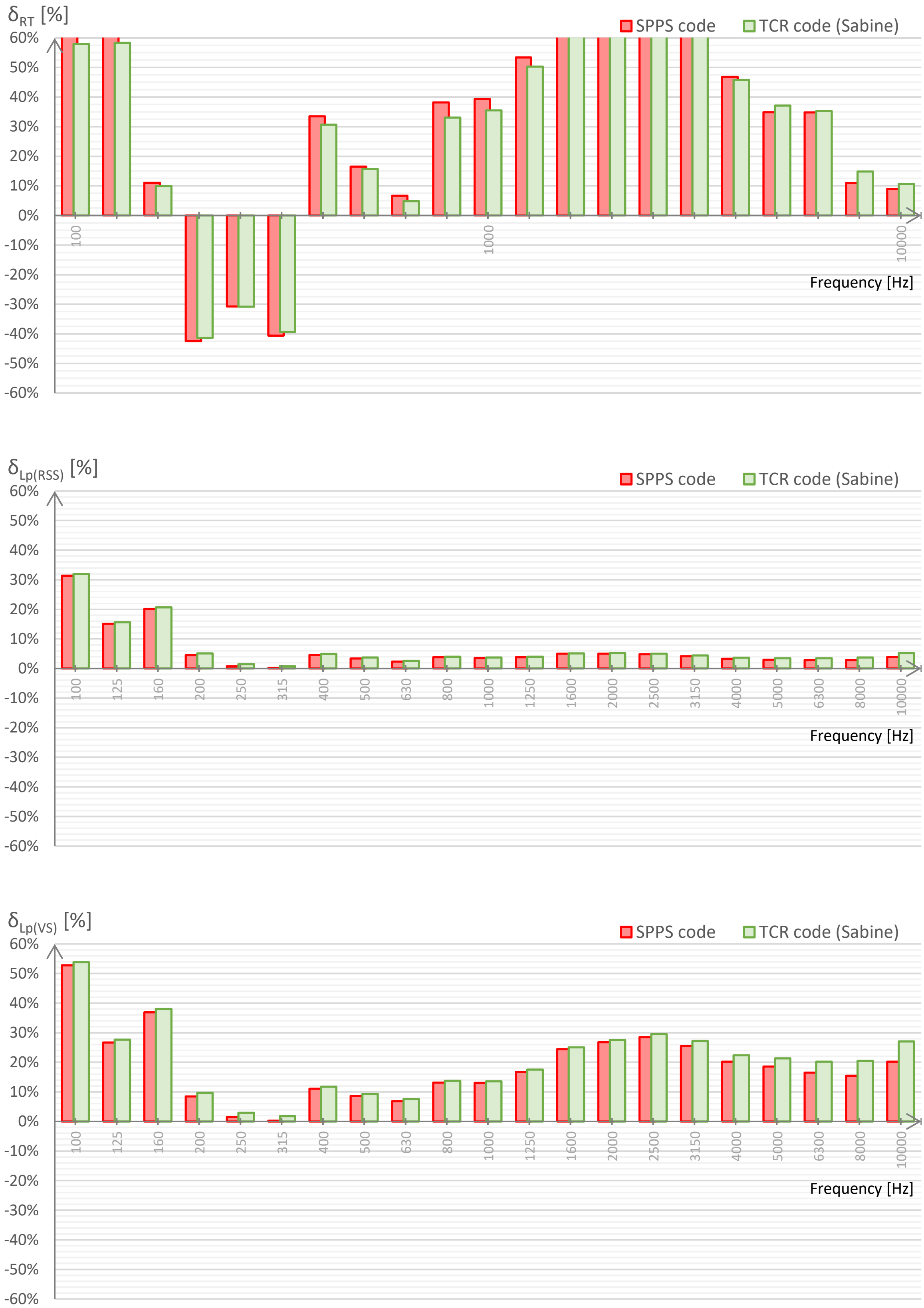
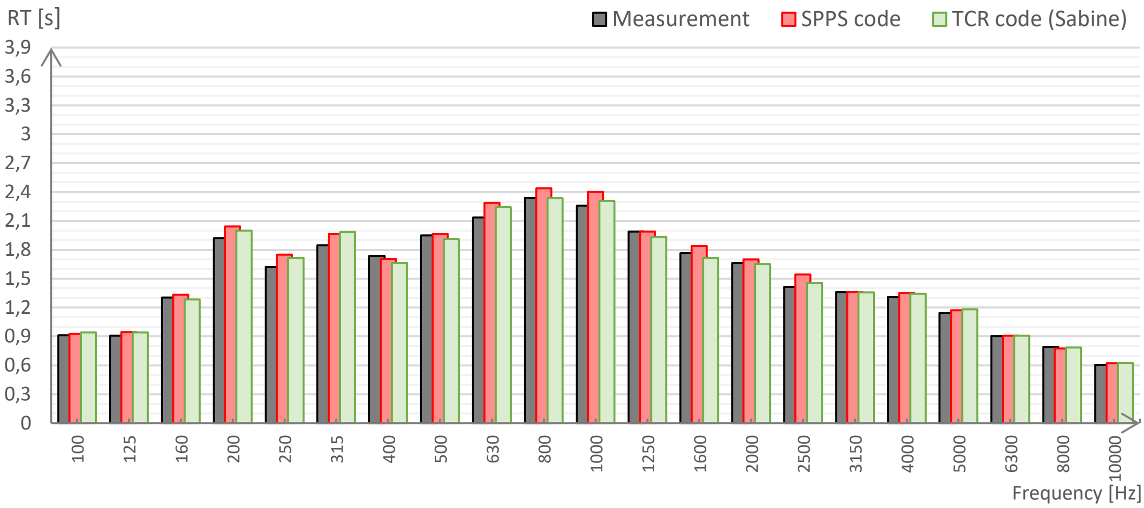
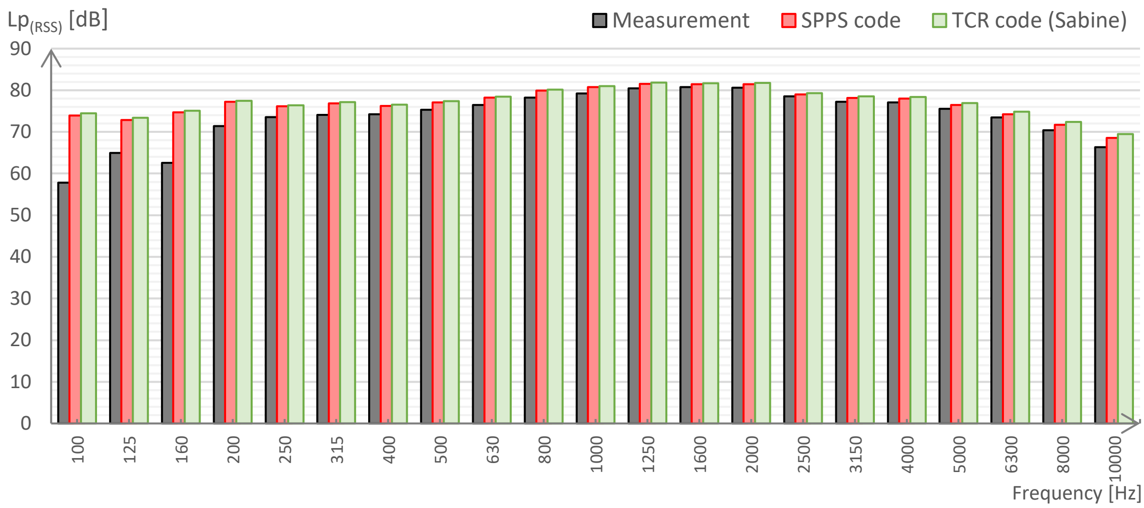


Figure 60 Comparison of percentage difference between simulation result and measurement data for SPPS and TCR code.

Sound absorption "$A_{modified}$"





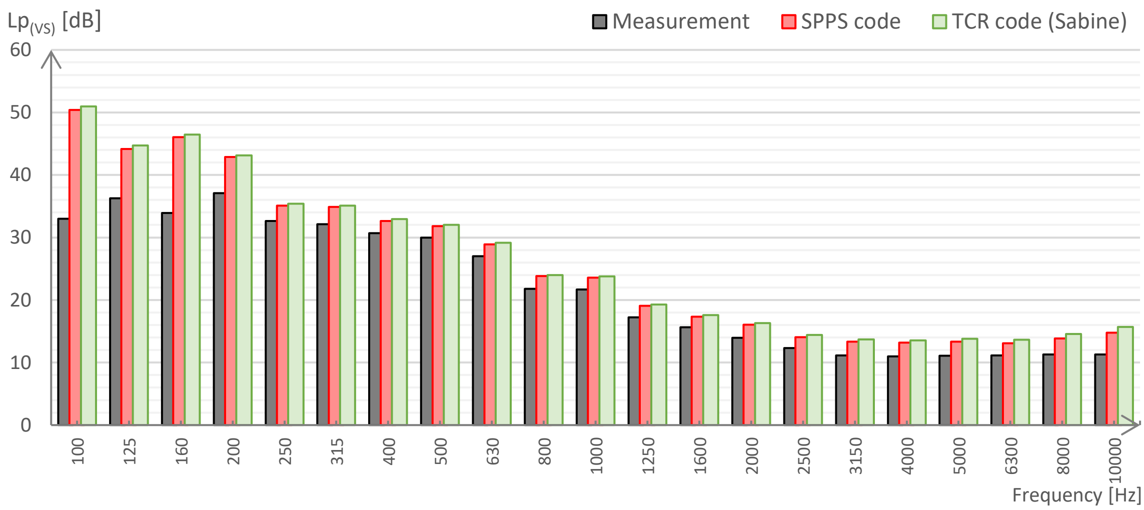
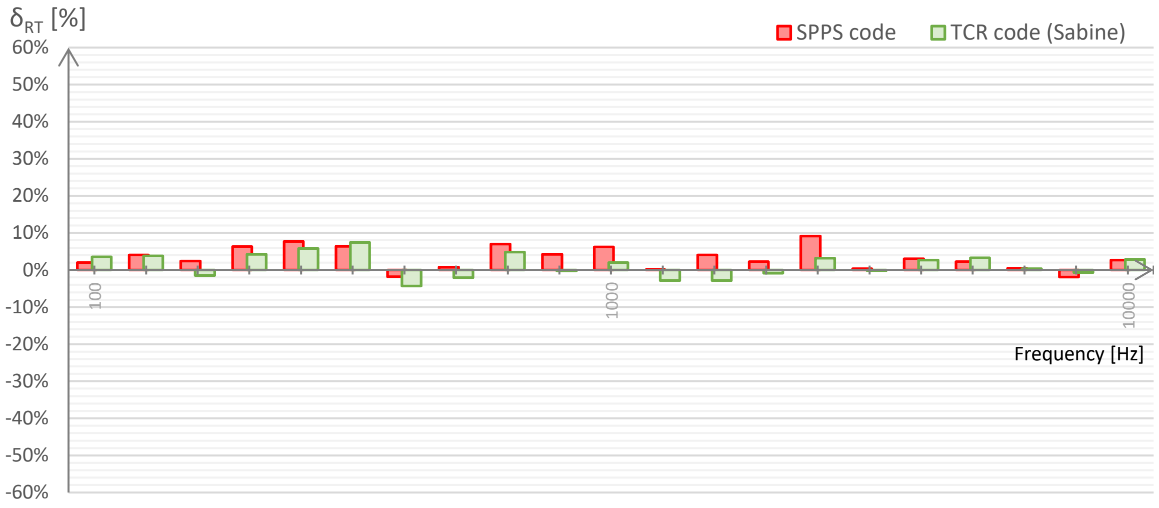
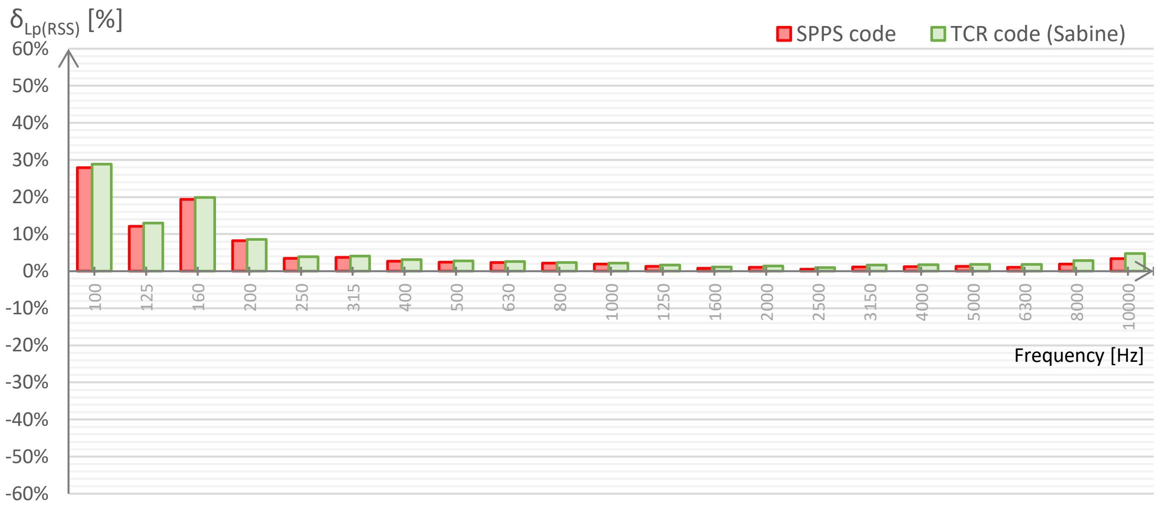


Figure 61 Simulation results obtained applying sound absorption $A_{modified}$.





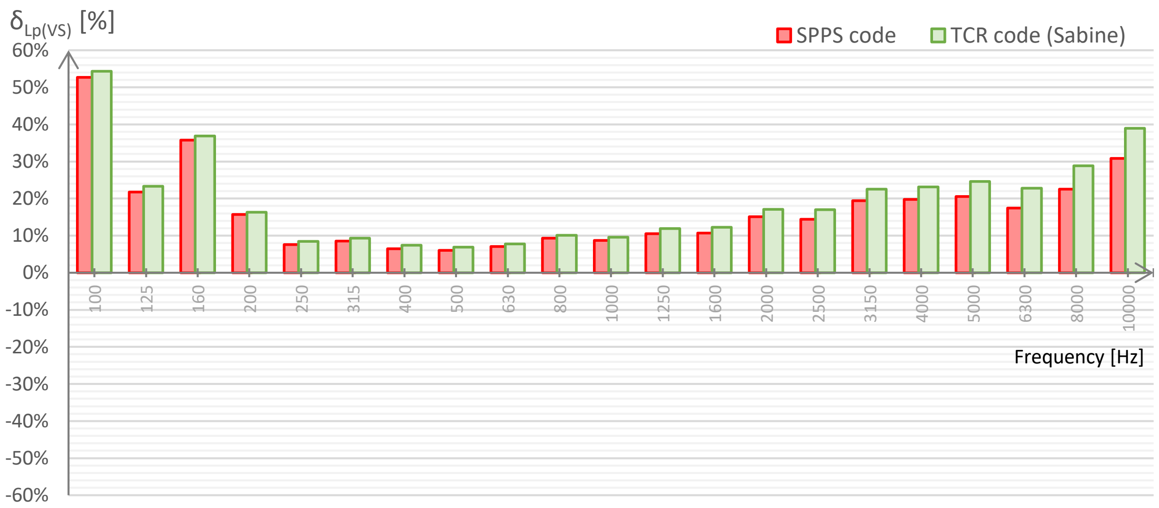


Figure 62 Comparison of percentage difference between simulation result and measurement data for SPPS and TCR code.

In accordance with what explained in §4.1, the reliability of a software simulation does not depend only on the possibility of correctly setting the scene from the point of view of the "variables", e.g. absorption coefficients of materials, position of sources and receivers, environmental conditions, geometry of the environment, *etc.*; but it is obvious that, being equal the other conditions, the more precisely these variables are defined, the more similar will be the simulated and measurement results. Comparing the above graphs, you can see that when the percentage difference between the equivalent sound absorption area imposed to in I-Simpa and the estimated equivalent sound absorption area, i.e. "$A_{measurement}$", is large, then the deviation between simulated and measured reverberation time is also high. Referring for example to the simulation carried out by defining sound absorption as "$A_{literature}$", an underestimation of absorption of 57% corresponds to an overestimation of 110% of the reverberation time calculated with the SPPS code and 105% with the TCR code (absorption and reverberation time are inversely proportional: the lower the absorption, the longer the reverberation time; therefore, if absorption is underestimated, reverberation time is overestimated and vice-versa). The underestimation of the sound absorption area also leads to an overestimation of the sound pressure level (the lower the absorption, the greater the contribution of the diffuse field on the total sound field), although in a less evident way, since the sound pressure level also depends on other variables and therefore the weight of absorption on the final result is lower. Imposing "$A_{literature}$" to I-Simpa does not allow to obtain satisfactory simulation results. Otherwise, "$A_{approximate}$" and "$A_{modified}$" are closer to "$A_{measurement}$" and δ_{RT} for both absorption scenarios is reduced; however "$A_{modified}$" allows to get closer to "$A_{measurement}$" and it turns out to be the preferred choice since it is associated with $-10\% \leq \delta_{RT} \leq 10\%$.
Reasoning in terms of possibility to simulate with I-Simpa the real acoustical environment, we can see that the SPPS calculation code and the TCR code lead to similar results, mainly due to the fact that both codes are not able to describe in an acceptable way the sound pressure level that develops at the lowest frequencies. Considering for example $\delta_{Lp(RSS)}$ calculated for "$A_{modified}$" (figure 62), it can be seen that for frequencies of 100, 125 and 160 Hz $\delta_{Lp(RSS)} > 10\%$, while for frequencies above 200 Hz, $\delta_{Lp(RSS)} < 10\%$ (even $\delta_{Lp(RSS)} < 5\%$ from 250 Hz and up). As explained in §2.2.1, below Schroeder's frequency (remember that f_0 is equal to 436 Hz for the laboratory room) the sound field is characterized by the presence of room modes and, as shown in table B.2 of annex B, the sound field is not diffused at frequencies 100-125-160 Hz. But then for such frequencies to consider the total sound field as the composition of direct sound field and diffuse sound field leads to an evaluation error; and this is exactly what happens in simulations with SPPS code and TCR code. The same applies also to the simulation of sound pressure level due to the ventilation system, with the clarification that the percentage difference between simulated and measured data is greater because, still reasoning according to the logic of figure 51, we must consider a further element of uncertainty in the model, i.e. ventilation system sound power level: it is mainly developed at frequencies below 1000 Hz, while for

higher frequencies ventilation system activation does not lead to a significant increase in the sound pressure level compared to background noise and consequently the ISO 3747 method overestimates the sound power of the tested source (see the definition of the background noise correction factor K_{1i} in §B.5 of annex B).

It can then be verified whether by calculating only the contribution of direct sound, I-Simpa allows to simulate more correctly the sound pressure level at frequencies 100, 125 and 160 Hz. The results are presented in the following graphs and are obtained by applying the equivalent sound absorption area "$A_{modified}$". Calculation options for SPPS and TCR are the same as in table 12, with the obvious exception of "Active calculation of direct field only" which is enable.

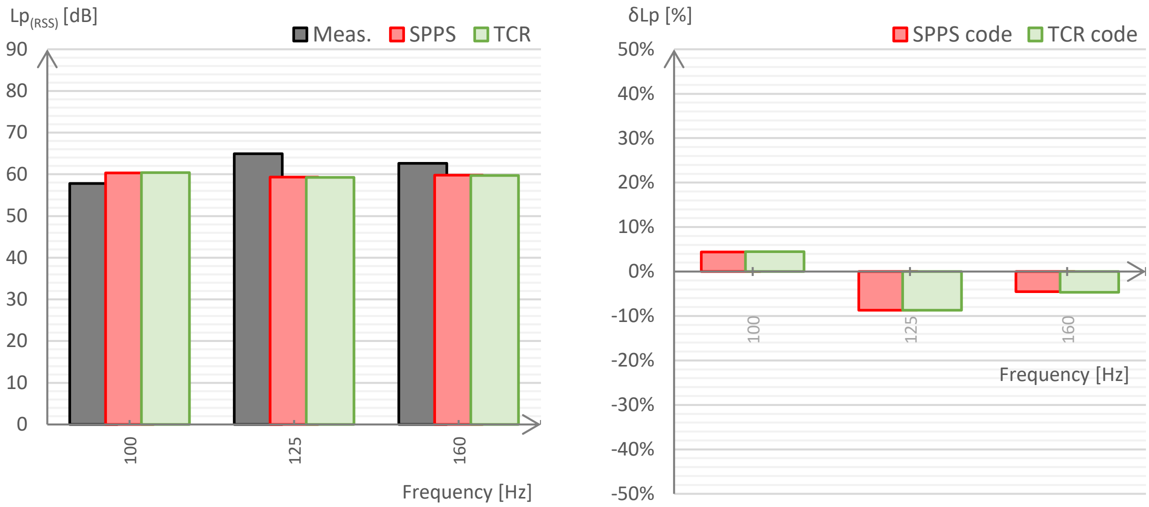


Figure 63 RSS sound pressure level (only direct field) calculated applying $A_{modified}$ and percentage difference between simulation results and measurement data.

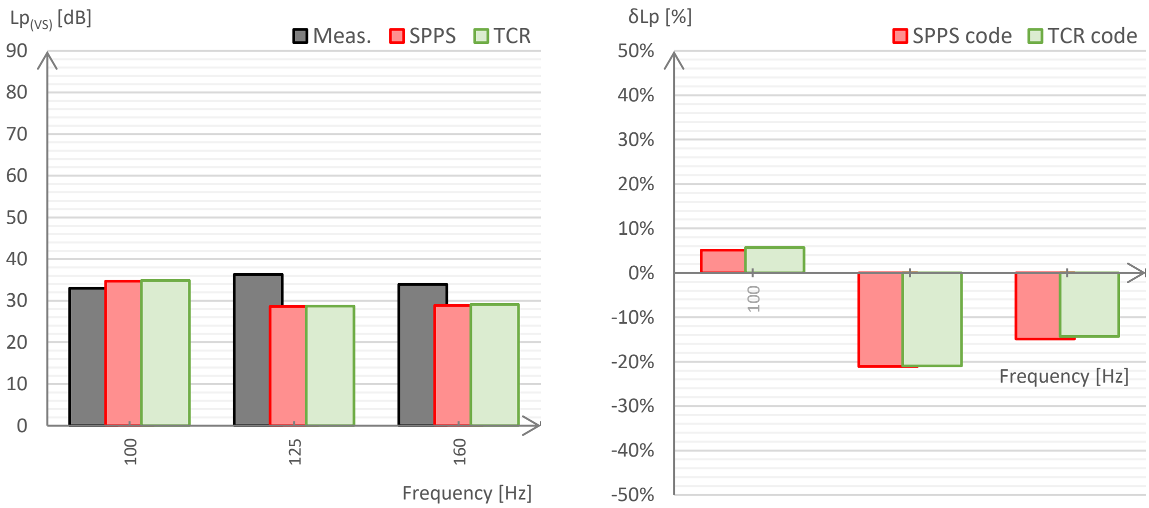


Figure 64 Ventilation system sound pressure level (only direct field) calculated for nominal flow rate 240 m^3/h applying $A_{modified}$ and percentage difference between simulation results and measurement data.

While previously the simulated RSS sound pressure level was greatly overestimated compared to the measurement sound pressure level, neglecting the contribution of the diffuse field results in an underestimation of the sound pressure level for the frequencies 160 and 200 Hz. Since the difference between the measurement data is approximately 3 dB, it is fair to say that this deviation is due to the impossibility to simulate the directivity factor of the sound source with the software (we are in the case of a sound source close to a reflecting surface, therefore directivity factor Q is equal to 2 and directivity index DI is equal to 3, see table 7). By deactivating the calculation of the diffuse sound field, even SPPS code does not allow to correctly simulate Q. The same happens for the sound pressure level due to the ventilation system. Neglecting the contribution of the diffuse sound field makes it possible to simulate the sound pressure level for the frequencies of 100, 125 and 160 Hz in a more realistic way. Therefore, summarising the above, the preferred simulation results were obtained by applying the equivalent sound absorption area "$A_{modified}$", calculating only the contribution of direct sound in the simulation of the sound pressure level for the frequencies 100-160 Hz and the global sound field (direct sound plus reflected sound) for frequencies from 200 Hz and up.

However, it is important to point out once again that just as measurement data cannot be considered absolutely certain, it is all the more wrong to believe that the simulation model perfectly replicates the real environment. In other words, the simulation results are indications that, although useful, must be interpreted in the light of a range of validity and not as incontrovertible facts.

4.2.1 Criteria for simulation results acceptability

As we have seen, simulation results deviate from measurement data in a more or less marked way depending on the frequency considered. Hence, it is necessary to establish a reliability criterion for the simulation, before proceeding with the analysis of the results. The simplest way is to assume as a precaution that the deviation between simulation and measurement is constant at each frequency and equal to the detected maximum δ (plus a safety margin). Alternatively you can think of repeating the simulation several times and studying the average deviation associated with each frequency. In this study both roads are covered. For the SPPS code various simulations are performed and the simulation and measurement results for each single measurement point are compared: this means that equation (4.1) is applied, for example, comparing simulated RT_A and measured RT_A, so for each frequency a certain δ and a confidence interval are obtained. The criterion of constant deviation is applied to the TCR code, because it is not possible to create a statistic for the TCR code since the results are the same at each simulation. The results are presented in Appendix E (from table E.26 to table E.29).

Rearranging equation (4.1), knowing simulation result and its deviation, the corresponding measurement data when applying SPPS acceptability criterion is calculated as:

$$X_{meas.} = \frac{X_{SPPS}}{1 + \delta_{X(SPPS)}} \tag{4.2}$$

Otherwise, the corresponding measurement data when applying TCR acceptability criterion falls within a range whose extremes are calculated as:

$$\mathrm{X}_{meas.} = \mathrm{X}_{TCR} + \delta_{X(TCR)} \tag{4.3}$$

However, both approaches have a limit, i.e. they can only be considered valid if the difference δ calculated from a certain measurement data is similar to that obtained using another measurement point. In other words, if the measured parameter takes on very different values depending on the chosen measurement points, then also the related δ are different from each other and consequently it is not possible to estimate a probable measurement value for an unknown point because there is not a generally valid δ. This means that satisfactory results are only obtained when the sound field is diffuse since I-Simpa is not able to replicate the presence of room modes within the laboratory room.

4.3 Acoustic mapping of laboratory CORE-CARE

Basing on the principles seen in previous paragraphs, an acoustic mapping of the climatic chamber of laboratory CORE-CARE is carried out. The aim is to identify whether there are favoured or disadvantaged areas inside the room from the point of view of acoustic comfort, in view of the office layout and productivity tests that will be carried out in the near future. To carry out the mapping, a grid of receivers arranged as in figure 65 was used. The parameters monitored are the reverberation time and the sound pressure level due to the ventilation system with a nominal flow rate of 240 m^3/h (this is the most unfavourable case because it is associated with the maximum sound power value of the source; for lower flow rates, lower sound pressure levels would be obtained but with the same distribution). Simulations are performed with the same options defined in tables 12 and 13.

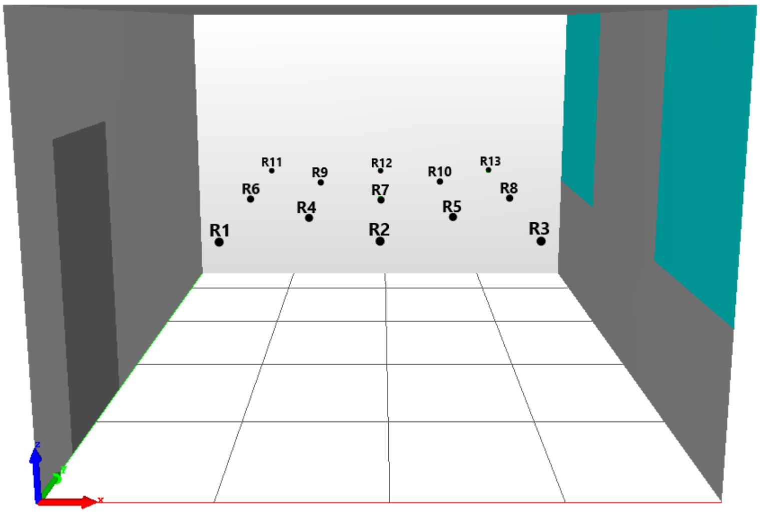


Figure 65 Positioning the receivers for mapping the lab chamber. The coordinates of the points are summarized in table E.30 of annex E.

The results of the simulations for each of these 13 points are contained in annex E (from table table E.31 to table E.70) together with the corresponding measurement data deduced by applying equations (4.2) for SPPS code and equation (4.3) for TCR code. To understand the different point of view of proposed acceptability criteria, consider for example table E.44, containing the results of ventilation system sound pressure level for point R1 for all frequency and plot them in following figures.

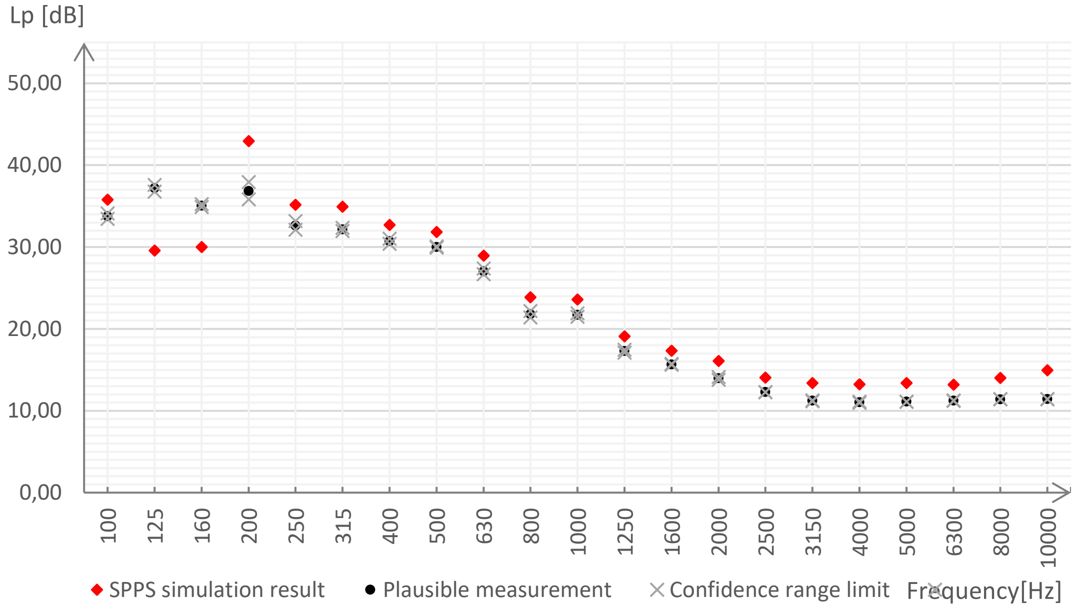


Figure 66 Ventilation system sound pressure level for point R1 calculated with SPPS code.

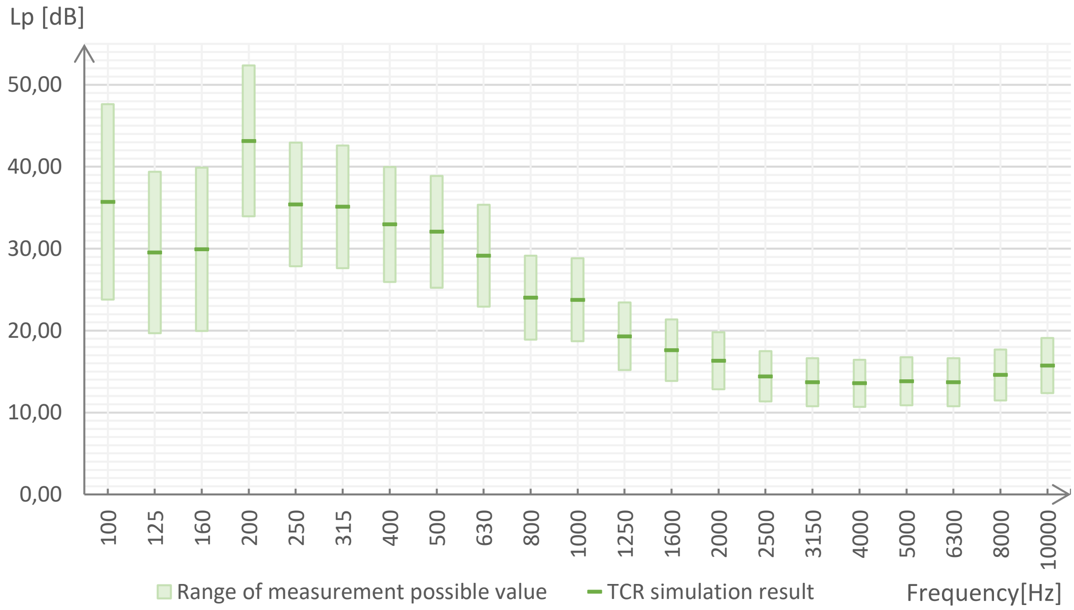


Figure 67 Ventilation system sound pressure level for point R1 calculated with TCR code

The meaning of the graph in figure 66 is: once obtained a simulation result and the corresponding measurement data for point R1, it can be assumed with 95% confidence that the “estimated” measurement data is equal to the "real" measurement, i.e. the data that would be obtained by actually carrying out a measurement in R1. Referring for example to 500 Hz:

- the sound pressure level obtained from SPPS simulation is equal to 31,8 dB;
- the simulation data deviates on average from the measurement of $\delta_{avg.}$ equal 6,12% (with 95% of confidence that δ_{avg} lies between 5,87% and 6,37%, see table E.28);
- then applying equation (4.2), the plausible measurement data is 30 dB. If you actually do a measurement in R1, you are 95% confident of finding a sound pressure level between 29,9 and 30,1 dB (table E.41).

On the other hand, figure 67 means: once TCR simulation result for point R1 has been obtained, it must be assumed that the actual measurement data may deviate from it by an established percentage. Again, for the frequency of 500 Hz:

- the sound pressure level obtained from SPPS simulation is equal to 31,1dB;
- a range of acceptability for simulation result δ_{TCR} equal to $\pm$20% has been decided (see table E.29 in annex E);
- then applying equation (4.3), a measurement actually done in R1 is expected to give a sound pressure level between 25,2 and 38,9 dB (table E.41).

It is clear that this second approach is precautionary and it can lead to results that are difficult to interpret, especially if the imposed acceptability range is high. For example in figure 67 δ_{TCR} is equal to 35% for frequency f < 200 Hz so it should be considered that the corresponding measurement can be in a range with extremes 20 and 50 dB. But such information for obvious reasons is useless. Moreover, as mentioned above, both methods are based on the assumption that the established acceptability percentage, and in turn the difference between simulation and measurement result, is valid regardless of where the simulation takes place. But this is true only if the sound field is diffuse: in the non-diffuse field the measurement data is not necessarily representative of the environment, (different data could be obtained by making measurements in more points due to the presence of room modes) so even the deviation between measurement data and simulated result is not generalizable. Additionally, I-Simpa does not replicate the presence of room modes, so the results must be interpreted in a particularly critical way.

By extending this reasoning to all other points, we obtain a mapping of the acoustic properties of the laboratory room. The following figures show the maps for reverberation time at 1000 Hz and for ventilation system overall sound pressure level, calculated using both SPPS code and TCR code.

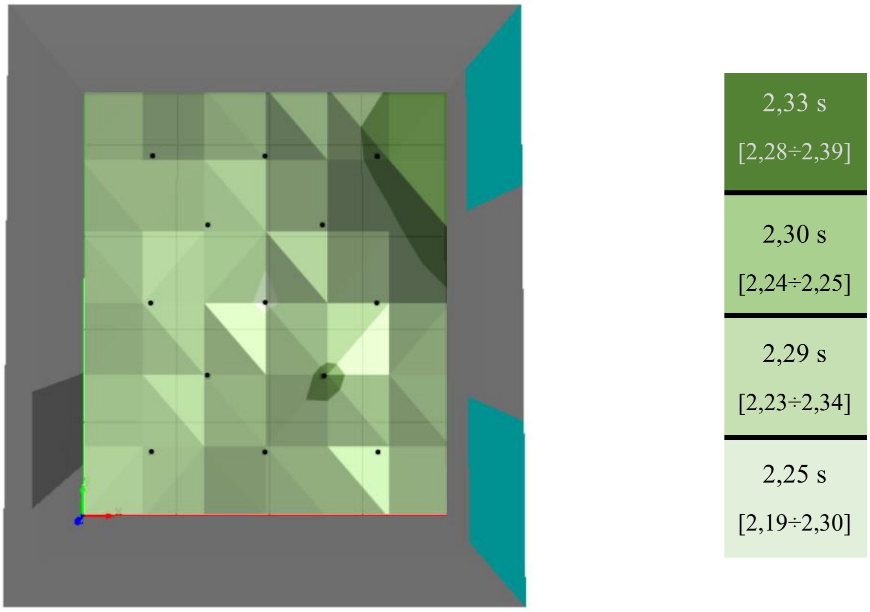


Figure 68 Reverberation Time map for 1000 Hz based on SPPS code result.

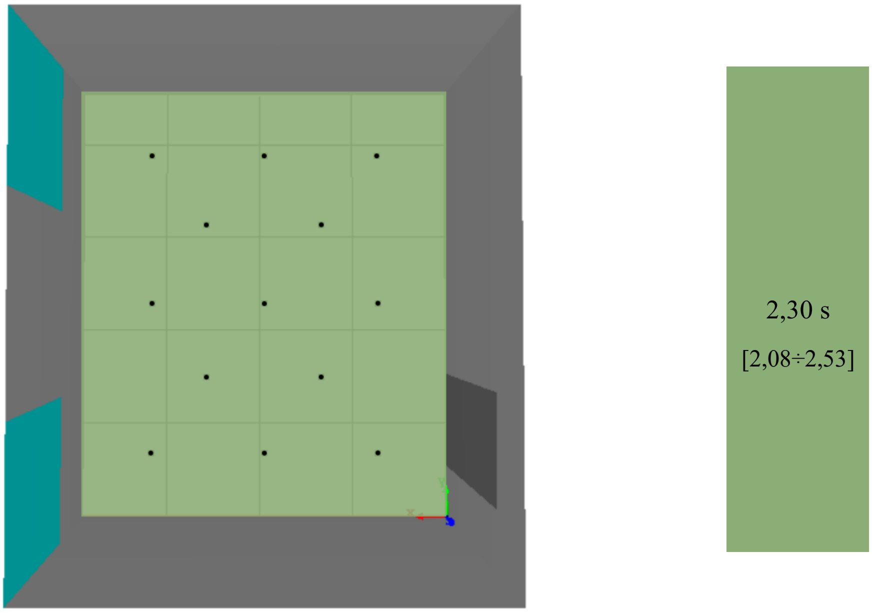


Figure 69 Reverberation Time map for 1000 Hz based on TCR code result

At a height above ground of 1,3 m the reverberation time distribution at 1000 Hz is almost uniform across the entire laboratory surface and reverberation time expected to be measured is about 2,3 s. Usually for offices it is recommended that the reverberation time is between 0,5 s and 1,1 s, so under test conditions the reverberation time may seem too high. However, it should be considered that in common situations, the presence of people or furniture (desks, chairs, *etc.*) significantly increases the sound absorption for f >500 Hz; thus reverberation time will be much lower than that detected inside the empty room (and most likely within the recommended range without the need of special arrangements).

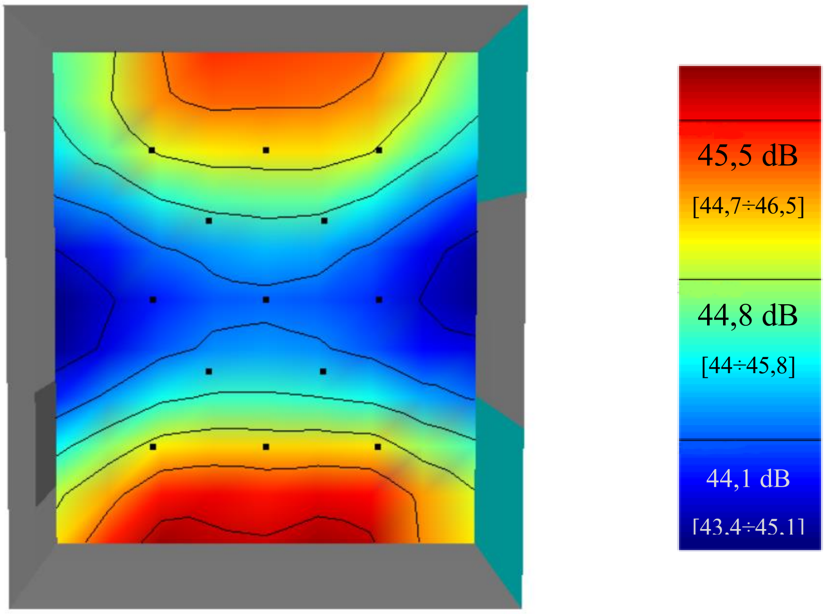


Figure 70 Ventilation system overall sound pressure level based on SPPS code results. For f < 200 Hz only direct field is considered.

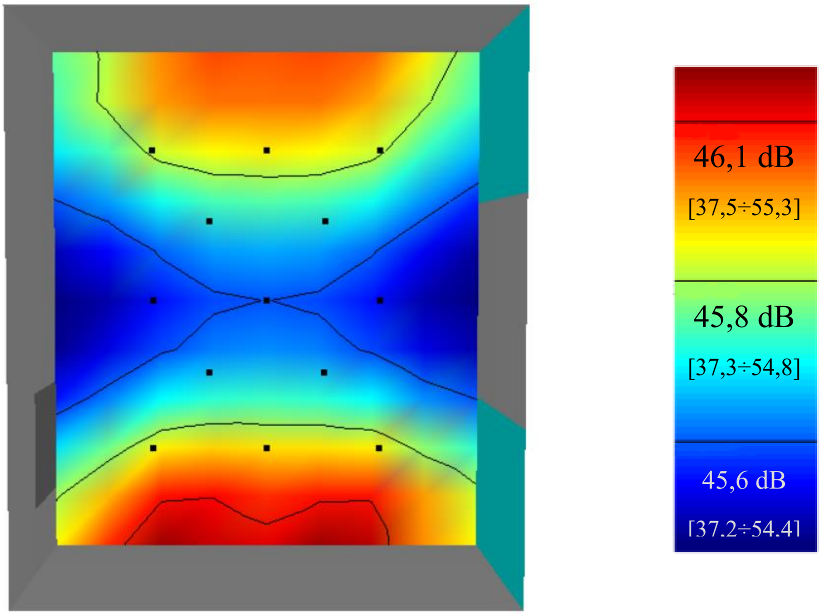


Figure 71 Ventilation system overall sound pressure level based on TCR code results. For f < 200 Hz only direct field is considered.

The sound pressure level due to the ventilation system is also uniform in the laboratory surface and settles around 45 dB when the nominal flow rate of the system is 240 m3/h. Differences in sound pressure in the order of 1dB do not lead to differences in hearing sensation. Given the uniformity of sound pressure level distribution, it can be assumed that there are no acoustically favoured or disadvantaged areas within the laboratory room towards of workstations layout inside the laboratory room.

Conclusions

The reverberation time measured inside the climatic chamber of laboratory CORE-CARE takes on a maximum value of about 2,3 s at frequencies between 800÷1250 Hz. Since the measurements were made in an empty room, it is expected that in ordinary conditions, i.e. in presence of people and furniture, the reverberation time is expected to be shorter. Schroeder frequency f_0 is equal to 436 Hz, which means that, strictly speaking, classical acoustic theory can be used to describe the sound field developed within the laboratory room only for frequencies $f > f_0$, while for $f < f_0$ a modal approach should be used to a better evaluation of the acoustic properties of the environment.

The sound power level of the mechanical ventilation system increases as the treated flow rate increases from overall sound pressure level of 52,2 dB for nominal flow rate of 80 m^3/h to overall sound pressure level of 56,1 dB for nominal flow rate of 240 m^3/h . Sound power spectrum shows that the maximum sound power is transmitted for frequency $f \leq 500$ Hz. For nominal flow rates below 160 m^3/h ventilation system sound power level is overestimated: for these flow rates the sound pressure level developed inside the room is not sufficiently higher than the background noise so ISO 3747: 2010 method is not accurate.

Inside the room, speech transmission index is independent of the flow rate treated by the ventilation system and it assumes a value of about 0,55 when the room is empty. Speech intelligibility is therefore fair, but can be improved by increasing the sound absorption inside the room (it has been seen that with 6 people inside the room STI is about 0,65, which corresponds to good intelligibility).

A combined analysis of measurement data and simulation results shows that sound energy distribution within laboratory CORE-CARE does not vary in such a way as to determine the presence of disadvantaged areas from the point of view of acoustic comfort. However, the main limitation of the study lies in the inability to analyse and simulate correctly the presence of room modes, and it is good to keep in mind that neither the measurement data nor the model created are able to describe exactly the real acoustic behaviour of the environment for those frequencies where the sound field is not diffuse (this happens for $f < 200$ Hz with the problem that ventilation system sound power level is relevant at those bands).

The interpretation of the results resulting from a simulation must be carried out carefully, regardless of the software used. The quality of the results depends on several factors (3D model, the choice of materials, the calculation parameters *etc.*) each of which inevitably entails a certain margin of uncertainty. In the near future the model can be improved (for example, taking into account the diffusion coefficient for a better description of reflection phenomenon) or expanded (including the presence of people and furniture) or used to monitor the variation in sound pressure level inside the room when other sound sources are also present in the room (what happens, for example, if you install an artificial masking system?).

In design practice the use of software for acoustic modelling is obviously very widespread but, as far as demonstrated, an uncritical approach to these tools can lead to errors of evaluation with non-negligible implications also in terms of safety. In the case dealt with in this study, for example, neglecting the analysis of the deviation between measurement data and simulation results would lead to underestimate or overestimate the reverberation time rather than the sound pressure level due to the ventilation system and in turn to map the areas of acoustic comfort/discomfort incorrectly. But a software model could be used to design an emergency evacuation voice alarm system (EVAC) or to evaluate the noise reduction achievable with a sound insulation treatment of a particularly noisy machine. The higher the probability of an event occurring or the greater the damage associated with it are, the greater the risk is; and it is clear that in general applied acoustic, as a subject of study, also contributes to the containment of risk within acceptable levels, since it can intervene at different stages of the risk analysis and management (risk identification and assessment, but also design of prevention and protection measures *etc*.).

Therefore, proper acoustic design can be based on the use of modelling software tools as long as the correspondence, or rather the deviation, between simulation results and actual environment is verified by means of measurements made in the course of work in order to validate (or correct if necessary) the built model.

Annex A

Reverberation Time Measurement

Instrument used to perform the survey are:

4 NTI audio XL_2 analyzer, SNo. A2A-03534-D1, FW2.22;

5 NTi Audio M2210 microphone, S/N: 1474, mic. sensitivity 20,7 mV/Pa;

6 Balloons as impulsive noise source.

Table A. 1 Microphone and XL_2 analyser configuration while performing reverberation time measurement.

	XL_2 analyser set up
Profile	Full mode
Resolution	1/3 octave
Timer set	0:00:50
Range	A - 150 dB

Figure A.1 shows in a qualitative way localization and measurement points of the sound source inside the laboratory room:

- X1÷X3 represent the balloons position;
- A÷D represent the microphone position.

For each microphone position, 3 measurements were done and the balloons were blown up in randomly chosen corners of the room to obtain as many source-microphone combinations as possible.

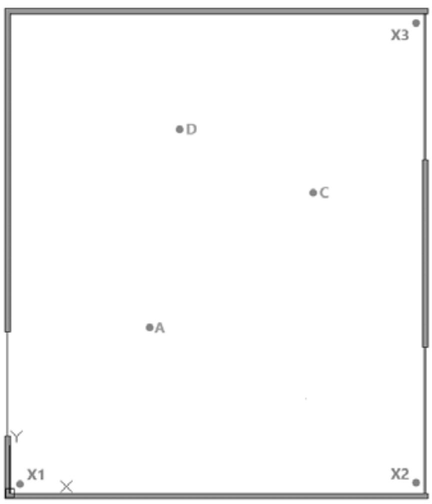


Figure A.1 Qualitative map of reverberation time measurement points.

For each microphone position reverberation time is obtained as arithmetic mean of the 3 measurements done for that point. In turn, the overall reverberation time of the chamber is obtained as an arithmetic mean of the values calculated for points A ÷ D.

NTI audio XL_2 analyser calculate reverberation time using a linear least-squares regression of the actual measured decay curve. The instrument automatically calculates two auxiliary results, correlation and uncertainty. Correlation indicates how well the calculated linear fit matches to the actual decay curve. A high correlation value indicates a linear, non-distorted decay curve. The correlation factor is expressed as a percentage; 100% represents perfectly linear sound pressure level decay after the sound source has ceased. The natural deviation from this linearity results in lower correlation values. Actual correlation factors are typically between 80 and 100%. Uncertainty is introduced because pink noise (typically used in measurements) is not a consistent signal, rather a random signal. It depends on the reverberation time (longer times produce lower uncertainty) and the bandwidth of the individual frequency band (broader bandwidth produces lower uncertainty). Also, lower bands show a higher uncertainty factor.

Schroeder's frequency f_0 is estimated according to:

$$f_0 \cong 2000 * \sqrt{\frac{\mathrm{RT_{avg}}}{\mathrm{V}}} \quad [\mathrm{Hz}] \qquad \text{(A.1)}$$

where RT_{avg} is the average reverberation time [s] for each bands and V is room volume [m^3]. As a precautionary measure, the limit frequency is assumed to be the highest f_o. According to table A.5 the limit frequency f_0 is obtained for $RT_{avg(@\ 800\ Hz)}$ and it is equal to 436 Hz. Thus:

- $f < 436$ Hz sound field cannot be considered diffuse;
- $f > 436$ Hz sound field can be considered diffuse.

Table A.2 Reverberation time in microphone position A.

Frequency [Hz]	RT_{A_1}		RT_{A_2}		RT_{A_3}		RT_A [s]	MeasUnc [%]
	T20 [s]	CorItn [%]	T20 [s]	CorItn [%]	T20 [s]	CorItn[%]		
50 Hz	0,9	94,93	0,58	99,29	0,98	96,21	0,82	71,92
63 Hz	-	-	-	-	0,99	95,52	0,99	-
80 Hz	0,52	99,88	0,84	98,57	0,97	98,56	0,78	57,17
100 Hz	0,84	99,46	0,84	99,37	1,22	98,28	0,97	46,71
125 Hz	0,98	99,81	0,82	99,38	0,87	99,28	0,89	42,16
160 Hz	1,34	99,62	1,35	99,49	1,15	99,88	1,28	31,49
200 Hz	1,46	99,51	1,55	99,46	1,61	99,88	1,54	26,19
250 Hz	1,72	96,73	1,63	95,33	1,73	99,31	1,69	21,65
315 Hz	1,75	99,22	1,96	98,67	1,77	99,61	1,83	18,65
400 Hz	1,97	99,85	1,55	99,62	1,85	98,94	1,79	17,19
500 Hz	2,08	99,23	1,9	99,62	2,1	99,69	2,03	13,99
630 Hz	2,28	99,15	2,11	99,75	2,12	99,86	2,17	12,1
800 Hz	3,52	97,09	2,27	99,75	1,93	99,92	2,57	10,14
1000 Hz	2,36	99,42	2,3	98,87	2	99,6	2,22	9,45
1250 Hz	1,88	99,88	2,02	99,8	1,92	99,78	1,94	9,04
1600 Hz	1,78	99,83	1,72	99,84	1,46	90,9	1,65	8,95
2000 Hz	-	-	1,73	99,8	1,65	99,93	1,69	-
2500 Hz	1,43	99,79	1,39	99,83	1,35	99,84	1,39	7,56
3150 Hz	-	-	1,35	99,82	1,59	99,74	1,47	-
4000 Hz	-	-	-	-	1,25	99,89	1,25	-
5000 Hz	1,15	99,91	1,28	99,88	1,12	99,91	1,19	5,78
6300 Hz	-	-	0,87	99,25	0,97	99,9	0,92	-
8000 Hz	-	-	-	-	0,8	99,8	0,8	-
10000 Hz	-	-	0,63	99,74	0,58	99,89	0,6	-

Table A.3 Reverberation time in microphone position C.

Frequency [Hz]	RT_{C_1}		RT_{C_2}		RT_{C_3}		RT_C [s]	MeasUnc [%]
	T20 [s]	CorItn [%]	T20 [s]	CorItn [%]	T20 [s]	CorItn[%]		
50 Hz	-	-	-	-	-	-	-	-
63 Hz	0,23	99,51	0,51	98,49	0,28	96,08	0,34	96,84
80 Hz	0,47	99,74	0,46	99,89	0,44	99,91	0,46	74,68
100 Hz	0,84	99,78	0,87	99,35	0,73	99,08	0,81	51,04
125 Hz	0,83	99,77	0,76	99,75	0,88	98,95	0,82	43,88
160 Hz	1,23	99,86	1,06	99,41	1,45	99,94	1,25	31,92
200 Hz	1,42	99,34	1,18	99,52	1,28	99,59	1,29	28,6
250 Hz	1,44	99,39	1,5	99,43	1,63	99,61	1,52	22,82
315 Hz	1,49	99,73	1,78	99,09	1,62	98,93	1,63	19,74
400 Hz	1,45	96,84	1,76	99,84	1,59	98,82	1,6	18,18
500 Hz	1,72	99,72	1,52	99,73	1,97	99,46	1,74	15,1
630 Hz	1,94	99,81	1,96	99,85	1,93	99,7	1,95	12,77
800 Hz	1,98	99,81	2,03	99,78	1,95	99,88	1,98	11,55
1000 Hz	2,35	99,83	2,16	99,76	2,11	99,9	2,21	9,48
1250 Hz	1,97	99,85	1,86	99,86	1,92	99,89	1,92	9,09
1600 Hz	1,97	99,1	1,38	99,52	1,96	99,48	1,77	8,65
2000 Hz	1,64	99,9	1,48	99,85	1,61	99,93	1,58	7,93
2500 Hz	1,42	99,86	1,33	99,97	1,28	99,83	1,34	7,69
3150 Hz	1,34	99,52	1,17	99,78	1,31	99,3	1,27	7,2
4000 Hz	1,33	99,91	1,31	99,91	1,3	99,94	1,31	6,15
5000 Hz	1,11	99,91	1,06	99,78	1,11	99,96	1,09	6,03
6300 Hz	0,94	99,97	0,72	99,68	0,89	99,81	0,85	6,24
8000 Hz	0,75	99,83	0,74	99,95	0,76	99,9	0,75	5,75
10000 Hz	0,57	99,88	0,6	99,87	0,59	99,87	0,59	5,81

Table A.4 Reverberation time in microphone position D.

Frequency [Hz]	RT_{D_1}		RT_{D_2}		RT_{D_3}		RT_D [s]	MeasUnc [%]
	T20 [s]	CorItn [%]	T20 [s]	CorItn [%]	T20 [s]	CorItn [%]		
50 Hz	0,89	93,8	0,89	96,33	0,75	92,85	0,84	70,92
63 Hz	0,83	96,92	0,91	93,71	0,53	98,81	0,76	64,61
80 Hz	0,95	98,59	1,19	95,33	0,49	99,83	0,88	53,83
100 Hz	0,87	98,05	0,95	99,42	1,03	96,82	0,95	47,22
125 Hz	1,15	99,51	0,94	99,39	0,95	99,83	1,01	39,58
160 Hz	1,41	99,08	1,15	99,71	1,58	98,41	1,38	30,35
200 Hz	1,58	99,91	5,58	94,01	1,63	99,63	2,93	19,01
250 Hz	1,71	99,54	1,58	97,49	1,69	98,03	1,66	21,89
315 Hz	2,46	99,87	1,94	98,35	1,85	99,68	2,08	17,46
400 Hz	1,83	99,57	1,95	99,04	1,69	99,27	1,82	17,04
500 Hz	2,5	99,74	1,81	99,15	1,94	99,6	2,08	13,8
630 Hz	2,53	99,91	2,05	99,88	2,28	99,53	2,29	11,78
800 Hz	2,4	99,62	2,83	99,34	2,18	99,83	2,47	10,35
1000 Hz	2,22	99,94	2,28	99,4	2,54	99,83	2,35	9,2
1250 Hz	2,23	99,88	2,18	99,19	1,91	99,59	2,11	8,68
1600 Hz	2,08	99,67	1,91	99,72	1,65	99,37	1,88	8,39
2000 Hz	1,78	99,89	1,76	99,6	1,61	99,82	1,72	7,6
2500 Hz	1,5	99,82	1,53	99,49	1,51	99,9	1,51	7,24
3150 Hz	1,37	99,85	1,31	99,4	1,35	99,66	1,34	7,01
4000 Hz	1,44	99,84	1,36	99,9	1,32	99,93	1,37	6,01
5000 Hz	1,21	99,84	1,08	99,86	1,14	99,67	1,15	5,89
6300 Hz	0,96	97,44	0,95	99,9	0,91	99,75	0,94	5,93
8000 Hz	0,94	99,9	0,76	99,87	0,77	99,87	0,82	5,49
10000 Hz	0,68	99,83	0,65	99,88	0,58	99,87	0,63	5,59

Table A.5 Average Reverberation Time RT_{avg} and Schroeder's frequency f_0.

Band [Hz]	RT_A [s]	RT_C [s]	RT_D [s]	RT_{avg} [s]	f_0 [Hz]
50	0,82	-	0,84	0,83	260 Hz
63	0,99	0,34	0,76	0,70	238 Hz
80	0,78	0,46	0,88	0,71	239 Hz
100	0,97	0,81	0,95	0,91	272 Hz
125	0,89	0,82	1,01	0,91	271 Hz
160	1,28	1,25	1,38	1,30	325 Hz
200	1,54	1,29	2,93	1,92	395 Hz
250	1,69	1,52	1,66	1,62	363 Hz
315	1,83	1,63	2,08	1,85	387 Hz
400	1,79	1,6	1,82	1,74	375 Hz
500	2,03	1,74	2,08	1,95	398 Hz
630	2,17	1,95	2,29	2,14	416 Hz
800	2,57	1,98	2,47	2,34	436 Hz
1000	2,22	2,21	2,35	2,26	428 Hz
1250	1,94	1,92	2,11	1,99	402 Hz
1600	1,65	1,77	1,88	1,77	379 Hz
2000	1,69	1,58	1,72	1,66	367 Hz
2500	1,39	1,34	1,51	1,41	339 Hz
3150	1,47	1,27	1,34	1,36	332 Hz
4000	1,25	1,31	1,37	1,31	326 Hz
5000	1,19	1,09	1,15	1,14	305 Hz
63000	0,92	0,85	0,94	0,90	271 Hz
8000	0,8	0,75	0,82	0,79	253 Hz
10000	0,6	0,59	0,63	0,61	222 Hz

Annex B

Ventilation System Sound Power Level

EN ISO 3747: 2010 is the reference standard used to evaluate ventilation system sound power level. It specifies a method for determining the sound power level or sound energy level of a noise source by comparing measured sound pressure levels emitted by a noise source mounted in situ in a reverberant environment with those from a calibrated reference sound source. This annex contains details of results of the measurements and calculations made following the procedure proposed by the standard.

B.1 Instrumentation and measurement set up

Instrument used to perform the survey are:

- Reference Sound Source compliant with the ISO 6926 standard, normalised to 23 °C and 101325 Pa with a reference rotation speed of 2887 rpm;
- NTI audio XL_2 analyzer, SNo. A2A-03534-D1, FW2.22;
- NTi Audio M2210 microphone, S/N: 1474, mic. sensitivity 20,7 mV/Pa.

Table B.1 Microphone and XL_2 analyzer configuration while performing source under test amd reference source sound pressure level measurement.

	ST sound pressure level measurement	**RSS sound pressure level measurement**
Profile	Full mode	Full mode
Append mode	OFF	OFF
Timer mode	Single	Single
Timer set	0:00:30	0:00:30
k1	0,0 dB	0,0 dB
k2	0,0 dB	0,0 dB
K-set date	k- Values not measured	k- Values not measured
Range	10-110 dB	B-1

Figure B.1 shows in a qualitative way localization and measurement points of the sound source inside the laboratory room:

- X1÷X4 represent the source under test, i.e. the ventilation system vents;
- P is the point used to position the reference sound source;

- V1÷V4 are the measurement point of sound pressure level for reference sound source;
- R1÷R3 are the measurement point of the sound pressure level of the test source.

As only one location for the reference sound source was sufficient, it was positioned as close as possible to the acoustic centre of the noise source under test: point P coincides with the centre of the room and the ventilation system vents are arranged approximately symmetrically with respect to the y-axis of the room.

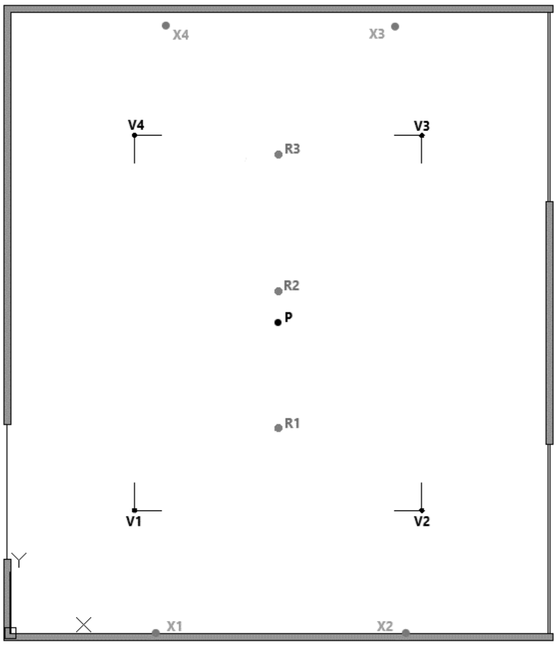


Figure B. 1 Qualitative map of source positioning and measurement point.

The method of ISO 3747: 2010 standard requires that the test environment is sufficiently reverberant to cause the directivity of the source under test to have an insignificant influence on the measured sound pressure level. The excess of sound pressure level ΔL_f, at a given distance d is the difference between the sound pressure level of a sound source in a given room and the sound pressure level that would be expected at the same distance in a free sound field expressed in decibels. The more reverberant the test environment is, the larger ΔL_f, is, the less critical is the selection of the location for the reference sound source because in the reverberant field the sound pressure level is theoretically uniform in every point of the space. ΔL_f, is given by:

$$\Delta L_f = L_{p(RSS)} - L_{w(RSS)} + 11 + 20\log\frac{r}{r_0} \quad [dB] \tag{B.1}$$

where:

- $L_{w(RSS)}$ is the sound power level of the reference sound source calibrated in a position similar to that used for the measurement, in dB;

- $L_{p(RSS)}$ is the sound pressure level measured at a distance r, in m, from the reference sound source, in dB;
- r is the distance from the microphone to the reference sound source, in m;
- r_0 is the reference distance, 1 m.

Table B.2 Excess of sound pressure level ΔL_f for a distance between microphone positions (point V1÷V4) and reference sound source r = 2 m.

Frequency [Hz]	$\Delta L_{f,M1}$ [dB]	$\Delta L_{f,M2}$ [dB]	$\Delta L_{f,M3}$ [dB]	$\Delta L_{f,M4}$ [dB]
50 Hz	12,6	7,9	11,2	7,8
63 Hz	0,9	0,5	-0,1	0,6
80 Hz	3,0	3,8	2,6	1,9
100 Hz	-3,2	-1,5	-3,6	-2,2
125 Hz	5,9	5,9	5,0	6,0
160 Hz	3,0	3,1	2,3	3,4
200 Hz	11,1	11,2	11,1	11,5
250 Hz	13,8	13,9	14,3	13,2
315 Hz	14,9	14,1	14,2	13,8
400 Hz	14,1	14,8	13,7	14,2
500 Hz	15,1	15,1	15,3	14,7
630 Hz	16,0	15,6	16,2	15,3
800 Hz	16,0	16,2	16,2	16,1
1000 Hz	16,0	16,3	16,3	16,2
1250 Hz	15,9	15,8	16,0	15,7
1600 Hz	15,9	15,5	16,1	15,4
2000 Hz	15,5	15,3	15,4	15,4
2500 Hz	15,2	15,1	15,3	15,2
3150 Hz	14,4	14,2	14,5	14,6
4000 Hz	14,3	14,2	14,4	14,4
5000 Hz	13,7	13,4	13,8	13,8
6300 Hz	12,7	12,4	12,8	12,7
8000 Hz	11,3	11,1	11,6	11,4
10000 Hz	9,2	9,1	9,5	9,3
Overall	13,7	13,6	13,8	13,6
Overall (A)	14,8	14,6	14,9	14,7

ΔL_f has a magnitude of at least 7 dB in regions where the requirement for a reverberant sound field is fulfilled. For low frequencies (100-125-160 Hz) the condition is not respected and this brings to a loss of precision of the method because a diffuse sound field doesn't develop at those frequencies. This result is in agreement with the Schroder's frequency f_0 considerations proposed in Appendix A.

B.2 Environmental condition and RSS calibration

RSS calibration is given for standard conditions, i.e. normalised to 23°C, 101325 Pa and with a rotation speed of 2887 RPM. As normally test environmental conditions are different to the standard one, corrective factors must be introduced.

C_2 is the radiation impedance correction factor and it is defined as:

$$C_2 = -10\log\frac{p}{p_0} + 15\log\left(\frac{273{,}15 + t}{t_{ref}}\right) \quad [dB] \qquad (B.2)$$

where

7 p is the static pressure at the time and place of the test, in Pa;

8 p_0 is the reference static pressure, 101325 Pa;

9 t is the air temperature at the time and place of the test, in °C ;

10 t_{ref} is the reference air temperature, 296 K.

ΔL_f is is a correction factor that takes into account the difference between the reference rotation speed (v_{ref} = 2887 rpm) and the actual average rotation speed of the RSS ($v_{average}$ = 2871 rpm) and it is defined by:

$$\Delta L_f = \frac{1}{2}\left(\frac{v_{average}}{60} - \frac{v_{ref}}{60}\right) \quad [dB] \qquad (B.3)$$

ΔL_p is a pressure corrective factor given by:

$$\Delta L_p = 10\log\left(\frac{p}{p_0}\right) \quad [dB] \qquad (B.4)$$

ΔL_T is is a pressure corrective factor defined by:

$$\Delta L_T = 5\log\left(\frac{t_{ref}}{T}\right) \quad [dB] \qquad (B.5)$$

where T is the air temperature at the time and place of the test, in K.
The total correction factor ΔL is defined as:

$$\Delta L = \Delta L_f + \Delta L_p + \Delta L_T \quad [dB] \qquad (B.6)$$

Table B.3 Environmental condition while performing RSS sound pressure level measurement.

Date 09/12/2019	Measure 1	Measure 2	Measure 3	Measure 4
Time	14:55:00	14:56:00	14:57:00	14:59:00
Atmospheric pressure [Pa]	100700	100700	100700	100700
Temperature [°C]	23	23	23	23
Relative humidity [%]	32	32	32	32

Table B.4 Thermodynamic properties of air during survey.

Average RSS rotation speed	2871 RPM
Average air temperature t	23 °C
Average air temperature T	296,15 K
Average static air pressure P	100700 Pa
Average relative humidity UR	32 %
Specific constant for dry air R*	287,05 J/(kg K)
Air density ρ	1,185 kg/m³
Speed of sound c	344,8 m/s
Acoustic impedance of air z	408,4 (Pa s)/m
Radiation impedance correction C_2	0,030 dB

Table B.5 Correction terms at reference/calibration conditions (101325 Pa, 23 °C, 2887 RPM)

C_2 [dB]	ΔL_f [dB]	ΔL_p [dB]	ΔL_T [dB]	$\Delta L_f+\Delta L_T$ [dB]	ΔL [dB]
0,030172	-0,133333	-0,026871	0,000000	-0,026871	-0,160205

Table B.6 Reference sound source sound power level.

Frequency [Hz]	RSS sound power @: 23°C; 101325 Pa; 2887 RPM		RSS sound power @: 23°C; 100700 Pa	
	$L_{W(RSS)ref,atm}$ [dB]	Uncertanty (2σ) [dB]	$L_{W(RSS)ref,atm}+C_2$ [dB]	$L_{W(RSS)}+\Delta L$ [dB] @ 2871 RPM
50 Hz	77,9	3,0	77,9	77,7
63 Hz	77,5	2,0	77,5	77,3
80 Hz	77,0	1,0	77,0	76,8
100 Hz	77,7	0,9	77,7	77,5
125 Hz	76,6	0,8	76,6	76,4
160 Hz	77,0	0,8	77,0	76,8
200 Hz	77,5	0,6	77,5	77,3
250 Hz	77,1	0,6	77,1	76,9
315 Hz	77,2	0,6	77,2	77,0
400 Hz	77,4	0,6	77,4	77,2
500 Hz	77,6	0,5	77,6	77,4
630 Hz	78,0	0,5	78,0	77,8
800 Hz	79,5	0,5	79,5	79,3
1000 Hz	80,4	0,5	80,4	80,2
1250 Hz	82,0	0,5	82,0	81,8
1600 Hz	82,4	0,5	82,4	82,2
2000 Hz	82,6	0,5	82,6	82,4
2500 Hz	80,7	0,5	80,7	80,5
3150 Hz	80,2	0,5	80,2	80,0
4000 Hz	80,1	0,5	80,1	79,9
5000 Hz	79,2	0,5	79,2	79,0
6300 Hz	78,2	0,6	78,2	78,0
8000 Hz	76,4	0,7	76,4	76,2
10000 Hz	74,4	0,8	74,4	74,2
12500 Hz	72,6	1,0	72,6	72,4
16000 Hz	70,6	1,2	70,6	70,4
20000 Hz	68,5	1,2	68,5	68,3
Overall	92,5	0,4	92,4	92,3
Overall (A)	91,9	0,4	91,9	91,9

B.4 Background noise sound pressure level

Background noise is defined as noise from all sources other than the noise source under test. For each microphone position the time-averaged sound pressure level $L_{p(B)\_n}$ is detected by the instrument and it is given by:

$$L_{p(B)\_n} = 10\log\left(\frac{\frac{1}{T}\int_{t1}^{t2} p^2(t)dt}{p_0^2}\right) \quad [dB] \tag{B.7}$$

where T is the measurement time interval (30 s in this case), p the measured sound pressure and p_0 the reference sound pressure value of 20 μPa.

The mean corrected time-averaged background noise sound pressure level in each frequency band is then calculated from:

$$L_{p(B)} = 10\log\left(\frac{1}{3}\sum_{n=1}^{3} 10^{0,1L_{p(B)\_n}}\right) \quad [dB] \tag{B.8}$$

A-weighting time-averaged sound pressure level $L_{pA(B)\_n}$ is given by:

$$L_{pA(B)} = L_{p(B)} + A_{factor} \quad [dB(A)] \tag{B.9}$$

Overall time average sound pressure level is obtained as composition of frequency bands between 100÷10000 Hz according to:

$$Overall\_L_{p(B)} = 10\log\left(\sum_{f} 10^{0,1L_{p(B)}}\right) \quad [dB] \tag{B.10}$$

Table B.7 Background noise sound pressure level.

Frequency [Hz]	$L_{p(B)\_1}$ (mic. in R1)	$L_{p(B)\_2}$ (mic. in R2)	$L_{p(B)\_3}$ (mic. in R3)	$L_{p(B)}$ [dB]	A-weighting [dB]	$L_{pA(B)}$ [dB(A)]
50 Hz	31,5	27,2	33,4	31,4	-30,2	1,2
63 Hz	22,4	23,8	24,8	23,8	-26,2	-2,4
80 Hz	22,9	25,3	19,1	23,1	-22,5	0,6
100 Hz	28,2	30,0	28,6	29,0	-19,1	9,9
125 Hz	23,1	21,7	21,4	22,1	-16,1	6,0
160 Hz	17,6	19,8	17,4	18,4	-13,4	5,0
200 Hz	16,1	14,8	16,3	15,8	-10,9	4,9
250 Hz	11,3	10,4	12,1	11,3	-8,6	2,7
315 Hz	11,0	11,1	13,6	12,1	-6,6	5,5
400 Hz	8,9	9,2	10,8	9,7	-4,8	4,9
500 Hz	8,2	9,2	11,2	9,7	-3,2	6,5
630 Hz	7,1	8,6	12,1	9,8	-1,9	7,9
800 Hz	6,8	8,4	14,4	11,2	-0,8	10,4
1000 Hz	7,1	8,0	12,8	10,1	0,0	10,1
1250 Hz	7,5	7,7	12,1	9,7	0,6	10,3
1600 Hz	7,9	8,2	12,3	10,0	1,0	11,0
2000 Hz	8,5	8,6	11,9	10,0	1,2	11,2
2500 Hz	9,1	9,2	11,9	10,3	1,3	11,6
3150 Hz	9,6	9,8	12,7	10,9	1,2	12,1
4000 Hz	10,2	10,3	12,4	11,1	1,0	12,1
5000 Hz	10,8	10,8	12,3	11,4	0,5	11,9
6300 Hz	11,0	11,1	12,1	11,4	-0,1	11,3
8000 Hz	11,2	11,3	12,0	11,5	-1,1	10,4
10000 Hz	11,3	11,3	11,7	11,4	-2,5	8,9
12500 Hz	11,3	11,2	11,4	11,3	-4,3	7
16000 Hz	11,2	11,2	11,3	11,2	-6,6	4,6
20000 Hz	11,7	11,7	11,7	11,7	-9,3	2,4
Overall	-	-	-	31,0	-	22,8

B.5 Reference Sound Source sound pressure level

$L'_{pi(RSS)}$ is the time-averaged sound pressure level of the reference sound source, measured at the i-th microphone position, corrected for speed, temperature and static pressure in decibels.

$K_{1i(RSS)}$ is the background noise correction at the i-th microphone position for the measurement of the reference sound source given by:

$$K_{1i(RSS)} = -10\log\left(1 - 10^{-0,1\Delta L_{pi(RSS)}}\right) \quad [dB] \qquad (B.11)$$

where

$$\Delta L_{pi(RSS)} = L'_{pi(RSS)} - L_{p(B)_n} \quad [dB] \qquad (B.12)$$

If, at any microphone position, $\Delta L_{pi(RSS)} > 15$ dB, K_{1i} is assumed equal to zero at that position. For $6 \leq \Delta L_{pi(RSS)} \leq 15$ dB, corrections shall be calculated according to equation (B.10). If, at any microphone position, $\Delta L_{pi(RSS)} < 6$ dB, the accuracy of the result is reduced beacause it means that RSS and background noise sound pressure level are similiral. The maximum correction to be applied to these measurements is 1,3 dB.

The time-averaged sound pressure level for the reference sound source in each frequency band corrected by the background noise factor $L_{pi(RSS)}$ is given by:

$$L_{pi(RSS)} = L'_{pi(RSS)} - K_{1i(RSS)} \quad [dB] \qquad (B.13)$$

The mean time-averaged sound pressure level for the reference sound source in each frequency band corrected by the background noise factor $L_{p(RSS)}$ is obtained from:

$$L_{p(RSS)} = 10\log\left(\frac{1}{4}\sum_{n=1}^{4} 10^{0,1L_{pi(RSS)}}\right) \quad [dB] \qquad (B.14)$$

Overall time average sound pressure level is obtained as composition of frequency bands between 100÷10000 Hz according to:

$$Overall\_L_{p(RSS)} = 10\log\left(\sum_{f} 10^{0,1L_{p(RSS)}}\right) \quad [dB] \qquad (B.15)$$

Table B.8 Background noise correction factors for reference sound source sound pressure level. As reference sound source sound pressure level is significantly higher than background noise sound pressure level, i.e. ΔLpi(RSS) > 15 dB for all microphone position and each frequency band, no correction is applied (K1i is always equal to 0).

Frequency [Hz]	$L'_{pi(RSS)}$				ΔL_{pi}				K_{1i}			
	M1'	M2'	M3'	M4'	M1'	M2'	M3'	M4'	M1'	M2'	M3'	M4'
50 Hz	73,3	68,6	71,9	68,5	41,8	41,4	38,5	68,5	0,0	0,0	0,0	0,0
63 Hz	61,2	60,8	60,2	60,9	38,8	37,0	35,4	60,9	0,0	0,0	0,0	0,0
80 Hz	62,8	63,6	62,4	61,7	39,9	38,3	43,3	61,7	0,0	0,0	0,0	0,0
100 Hz	57,3	59,0	56,9	58,3	29,1	29,0	28,3	58,3	0,0	0,0	0,0	0,0
125 Hz	65,3	65,3	64,4	65,4	42,2	43,6	43,0	65,4	0,0	0,0	0,0	0,0
160 Hz	62,8	62,9	62,1	63,2	45,2	43,1	44,7	63,2	0,0	0,0	0,0	0,0
200 Hz	71,4	71,5	71,4	71,8	55,3	56,7	55,1	71,8	0,0	0,0	0,0	0,0
250 Hz	73,7	73,8	74,2	73,1	62,4	63,4	62,1	73,1	0,0	0,0	0,0	0,0
315 Hz	74,9	74,1	74,2	73,8	63,9	63,0	60,6	73,8	0,0	0,0	0,0	0,0
400 Hz	74,3	75,0	73,9	74,4	65,4	65,8	63,1	74,4	0,0	0,0	0,0	0,0
500 Hz	75,5	75,5	75,7	75,1	67,3	66,3	64,5	75,1	0,0	0,0	0,0	0,0
630 Hz	76,8	76,4	77,0	76,1	69,7	67,8	64,9	76,1	0,0	0,0	0,0	0,0
800 Hz	78,3	78,5	78,5	78,4	71,5	70,1	64,1	78,4	0,0	0,0	0,0	0,0
1000 Hz	79,2	79,5	79,5	79,4	72,1	71,5	66,7	79,4	0,0	0,0	0,0	0,0
1250 Hz	80,7	80,6	80,8	80,5	73,2	72,9	68,7	80,5	0,0	0,0	0,0	0,0
1600 Hz	81,1	80,7	81,3	80,6	73,2	72,5	69,0	80,6	0,0	0,0	0,0	0,0
2000 Hz	80,9	80,7	80,8	80,8	72,4	72,1	68,9	80,8	0,0	0,0	0,0	0,0
2500 Hz	78,7	78,6	78,8	78,7	69,6	69,4	66,9	78,7	0,0	0,0	0,0	0,0
3150 Hz	77,4	77,2	77,5	77,6	67,8	67,4	64,8	77,6	0,0	0,0	0,0	0,0
4000 Hz	77,2	77,1	77,3	77,3	67,0	66,8	64,9	77,3	0,0	0,0	0,0	0,0
5000 Hz	75,7	75,4	75,8	75,8	64,9	64,6	63,5	75,8	0,0	0,0	0,0	0,0
6300 Hz	73,7	73,4	73,8	73,7	62,7	62,3	61,7	73,7	0,0	0,0	0,0	0,0
8000 Hz	70,5	70,3	70,8	70,6	59,3	59,0	58,8	70,6	0,0	0,0	0,0	0,0
1000 Hz	66,4	66,3	66,7	66,5	55,1	55,0	55,0	66,5	0,0	0,0	0,0	0,0
12500 Hz	60,7	60,4	61,0	60,6	49,4	49,2	49,6	60,6	0,0	0,0	0,0	0,0
16000 Hz	56,3	56,3	56,8	56,2	45,1	45,1	45,5	56,2	0,0	0,0	0,0	0,0
20000 Hz	51,1	51,0	51,6	51,0	39,4	39,3	39,9	51,0	0,0	0,0	0,0	0,0

Table B.9 Reference sound source sound pressure level corrected by K_{1i}.

Frequency [Hz]	**$L_{pi(RSS)}$ (corrected by K_{1i})**				**$L_{p(RSS)}$ [dB]**	**$L_{pA(RSS)}$ [dB(A)]**
	M1	**M2**	**M3**	**M4**		
50 Hz	73,1	68,4	71,7	68,3	70,9	40,7
63 Hz	61,0	60,6	60,0	60,7	60,6	34,4
80 Hz	62,6	63,4	62,2	61,5	62,5	40,0
100 Hz	57,1	58,8	56,7	58,1	57,8	38,7
125 Hz	65,1	65,1	64,2	65,2	65,0	48,9
160 Hz	62,6	62,7	61,9	63,0	62,6	49,2
200 Hz	71,2	71,3	71,2	71,6	71,4	60,5
250 Hz	73,5	73,6	74,0	72,9	73,6	65,0
315 Hz	74,7	73,9	74,0	73,6	74,1	67,5
400 Hz	74,1	74,8	73,7	74,2	74,3	69,5
500 Hz	75,3	75,3	75,5	74,9	75,3	72,1
630 Hz	76,6	76,2	76,8	75,9	76,4	74,5
800 Hz	78,1	78,3	78,3	78,2	78,3	77,5
1000 Hz	79,0	79,3	79,3	79,2	79,2	79,2
1250 Hz	80,5	80,4	80,6	80,3	80,5	81,1
1600 Hz	80,9	80,5	81,1	80,4	80,8	81,8
2000 Hz	80,7	80,5	80,6	80,6	80,6	81,8
2500 Hz	78,5	78,4	78,6	78,5	78,5	79,8
3150 Hz	77,2	77,0	77,3	77,4	77,3	78,5
4000 Hz	77,0	76,9	77,1	77,1	77,1	78,1
5000 Hz	75,5	75,2	75,6	75,6	75,5	76,0
6300 Hz	73,5	73,2	73,6	73,5	73,5	73,4
8000 Hz	70,3	70,1	70,6	70,4	70,4	69,3
1000 Hz	66,2	66,1	66,5	66,3	66,3	63,8
12500 Hz	60,5	60,2	60,8	60,4	60,5	56,2
16000 Hz	56,1	56,1	56,6	56,0	56,2	49,6
20000 Hz	50,9	50,8	51,4	50,8	51,0	41,7
Overall	-	-	-	-	89,6	89,7

B.5 Test Source sound pressure level

$L'_{pi(ST)}$ is the time-averaged sound pressure level of the reference sound source, measured at the i-th microphone position, corrected for speed, temperature and static pressure in decibels.

$K_{1i(ST)}$ is the background noise correction at the i-th microphone position for the measurement of the reference sound source given by:

$$K_{1i(ST)} = -10\log\left(1 - 10^{-0,1\Delta L_{pi(ST)}}\right) \quad [dB] \qquad (B.16)$$

where

$$\Delta L_{pi(ST)} = L'_{pi(ST)} - L_{p(B)_n} \quad [dB] \qquad (B.17)$$

If, at any microphone position, $\Delta L_{pi(ST)} > 15$ dB, K_{1i} is assumed equal to zero at that position. For $6 \leq \Delta L_{pi(ST)} \leq 15$ dB, corrections shall be calculated according to equation (B.16). If, at any microphone position, $\Delta L_{pi(ST)} < 6$ dB, the accuracy of results is reduced and the maximum correction to be applied to these measurements is 1,3 dB.

The time-averaged sound pressure level for the reference sound source in each frequency band corrected by the background noise factor $L_{pi(RSS)}$ is given by:

$$L_{pi(RSS)} = L'_{pi(RSS)} - K_{1i(RSS)} \quad [dB] \qquad (B.18)$$

The mean time-averaged sound pressure level for the reference sound source in each frequency band corrected by the background noise factor $L_{p(RSS)}$ is obtained from:

$$L_{p(RSS)} = 10\log\left(\frac{1}{4}\sum_{n=1}^{4} 10^{0,1L_{pi(RSS)}}\right) \quad [dB] \qquad (B.19)$$

Overall time average sound pressure level is obtained as composition of frequency bands between 100÷10000 Hz according to:

$$Overall\_L_{p(RSS)} = 10\log\left(\sum_{f} 10^{0,1L_{p(RSS)}}\right) \quad [dB] \qquad (B.20)$$

Table B.10 Source sound pressure level (measured and corrected) for **ventilation system flow rate 80 m³/h**. *As test source pressure level is similar to background noise sound pressure level, i.e. ΔLpi(RSS) < 6 dB for all microphone position and each frequency band, maximum correction is applied (K1i is always equal to 1,3).*

Frequency [Hz]	$L'_{p(ST)}$			ΔL_{pi}			K_{1i}			$L_{p(ST)}$			$L_{p(ST)}$ [dB]	$L_{pA(ST)}$ [dB(A)]
	M1’	M2’	M3’	M1’	M2’	M3’	M1’	M2’	M3’	M1	M2	M3		
50 Hz	28,6	24,4	30,7	-2,9	-2,8	-2,7	1,3	1,3	1,3	29,9	25,7	32,0	29,9	-0,3
63 Hz	23,7	22,4	23,6	1,3	-1,4	-1,2	1,3	1,3	1,3	25,0	23,7	24,9	24,6	-1,6
80 Hz	22,6	26,4	19,2	-0,3	1,1	0,1	1,3	1,3	1,3	23,9	27,7	20,5	25,0	2,5
100 Hz	29,0	30,6	32,4	0,8	0,6	3,8	1,3	1,3	1,3	30,3	31,9	33,7	32,2	13,1
125 Hz	20,7	31,0	22,7	-2,4	9,3	1,3	1,3	0,5	1,3	22,0	31,5	24,0	27,9	11,8
160 Hz	17,3	18,1	16,1	-0,3	-1,7	-1,3	1,3	1,3	1,3	18,6	19,4	17,4	18,5	5,1
200 Hz	19,7	18,3	23,0	3,6	3,5	6,7	1,3	1,3	1,0	21,0	19,6	24,0	22,0	11,1
250 Hz	13,3	11,9	12,1	2,0	1,5	0,0	1,3	1,3	1,3	14,6	13,2	13,4	13,8	5,2
315 Hz	12,3	12,5	11,5	1,3	1,4	-2,1	1,3	1,3	1,3	13,6	13,8	12,8	13,4	6,8
400 Hz	11,7	10,7	9,5	2,8	1,5	-1,3	1,3	1,3	1,3	13,0	12,0	10,8	12,0	7,2
500 Hz	13,4	10,2	8,9	5,2	1,0	-2,3	1,3	1,3	1,3	14,7	11,5	10,2	12,6	9,4
630 Hz	10,2	9,1	8,2	3,1	0,5	-3,9	1,3	1,3	1,3	11,5	10,4	9,5	10,5	8,6
800 Hz	10,9	9,1	8,3	4,1	0,7	-6,1	1,3	1,3	1,3	12,2	10,4	9,6	10,9	10,1
1000 Hz	9,3	8,7	7,4	2,2	0,7	-5,4	1,3	1,3	1,3	10,6	10,0	8,7	9,8	9,8
1250 Hz	9,0	9,1	7,6	1,5	1,4	-4,5	1,3	1,3	1,3	10,3	10,4	8,9	9,9	10,5
1600 Hz	8,9	8,7	8,0	1,0	0,5	-4,3	1,3	1,3	1,3	10,2	10,0	9,3	9,9	10,9
2000 Hz	8,7	8,9	8,6	0,2	0,3	-3,3	1,3	1,3	1,3	10,0	10,2	9,9	10,0	11,2
2500 Hz	9,1	9,4	9,1	0,0	0,2	-2,8	1,3	1,3	1,3	10,4	10,7	10,4	10,5	11,8
3150 Hz	9,8	9,9	9,7	0,2	0,1	-3,0	1,3	1,3	1,3	11,1	11,2	11,0	11,1	12,3
4000 Hz	10,3	10,4	10,3	0,1	0,1	-2,1	1,3	1,3	1,3	11,6	11,7	11,6	11,6	12,6
5000 Hz	10,8	10,9	10,8	0,0	0,1	-1,5	1,3	1,3	1,3	12,1	12,2	12,1	12,1	12,6
6300 Hz	11,1	11,1	11,0	0,1	0,0	-1,1	1,3	1,3	1,3	12,4	12,4	12,3	12,4	12,3
8000 Hz	11,2	11,3	11,3	0,0	0,0	-0,7	1,3	1,3	1,3	12,5	12,6	12,6	12,6	11,5
1000 Hz	11,3	11,3	11,3	0,0	0,0	-0,4	1,3	1,3	1,3	12,6	12,6	12,6	12,6	10,1
12500 Hz	11,2	11,2	11,2	-0,1	0,0	-0,2	1,3	1,3	1,3	12,5	12,5	12,5	12,5	8,2
16000 Hz	11,2	11,2	11,2	0,0	0,0	-0,1	1,3	1,3	1,3	12,5	12,5	12,5	12,5	5,9
20000 Hz	11,7	11,7	11,7	0,0	0,0	0,0	1,3	1,3	1,3	13,0	13,0	13,0	13,0	3,7
Overall	-	-	-	-	-	-	-	-	-	-	-	-	34,4	23,9

Table B.11 Source sound pressure level (measured and corrected) for ***ventilation system flow rate 120 m³/h****. As test source pressure level is similar to background noise sound pressure level, i.e. ΔLpi(RSS) < 6 dB for almost all microphone position and each frequency band, maximum correction is applied (K1i is equal to 1,3).*

Frequency	$L'_{p(ST)}$			ΔL_{pi}			K_{1i}			$L_{p(ST)}$			$L_{p(ST)}$	$L_{pA(ST)}$
[Hz]	M1'	M2'	M3'	M1'	M2'	M3'	M1'	M2'	M3'	M1	M2	M3	[dB]	[dB(A)]
50 Hz	31,1	30,3	38,4	-0,4	3,1	5,0	1,3	1,3	1,3	32,4	31,6	39,7	36,2	6
63 Hz	22,4	25,0	24,4	0,0	1,2	-0,4	1,3	1,3	1,3	23,7	26,3	25,7	25,4	-0,8
80 Hz	23,1	26,1	20,8	0,2	0,8	1,7	1,3	1,3	1,3	24,4	27,4	22,1	25,2	2,7
100 Hz	25,3	25,3	29,4	-2,9	-4,7	0,8	1,3	1,3	1,3	26,6	26,6	30,7	28,4	9,3
125 Hz	20,1	22,6	22,5	-3,0	0,9	1,1	1,3	1,3	1,3	21,4	23,9	23,8	23,2	7,1
160 Hz	18,6	23,0	20,4	1,0	3,2	3,0	1,3	1,3	1,3	19,9	24,3	21,7	22,3	8,9
200 Hz	22,1	20,4	23,8	6,0	5,6	7,5	1,3	1,3	0,9	23,4	21,7	24,7	23,4	12,5
250 Hz	15,3	15,0	16,8	4,0	4,6	4,7	1,3	1,3	1,3	16,6	16,3	18,1	17,1	8,5
315 Hz	12,6	15,7	15,1	1,6	4,6	1,5	1,3	1,3	1,3	13,9	17,0	16,4	16,0	9,4
400 Hz	12,1	14,1	14,1	3,2	4,9	3,3	1,3	1,3	1,3	13,4	15,4	15,4	14,8	10,0
500 Hz	11,2	12,2	13,7	3,0	3,0	2,5	1,3	1,3	1,3	12,5	13,5	15,0	13,8	10,6
630 Hz	8,6	11,0	12,0	1,5	2,4	-0,1	1,3	1,3	1,3	9,9	12,3	13,3	12,1	10,2
800 Hz	8,4	10,6	10,0	1,6	2,2	-4,4	1,3	1,3	1,3	9,7	11,9	11,3	11,1	10,3
1000 Hz	7,8	9,0	10,3	0,7	1,0	-2,5	1,3	1,3	1,3	9,1	10,3	11,6	10,5	10,5
1250 Hz	7,7	8,8	11,7	0,2	1,1	-0,4	1,3	1,3	1,3	9,0	10,1	13,0	11,0	11,6
1600 Hz	8,1	8,6	13,3	0,2	0,4	1,0	1,3	1,3	1,3	9,4	9,9	14,6	12,0	13,0
2000 Hz	8,6	8,8	11,7	0,1	0,2	-0,2	1,3	1,3	1,3	9,9	10,1	13,0	11,2	12,4
2500 Hz	9,2	9,4	12,7	0,1	0,2	0,8	1,3	1,3	1,3	10,5	10,7	14,0	12,0	13,3
3150 Hz	9,8	9,8	11,3	0,2	0,0	-1,4	1,3	1,3	1,3	11,1	11,1	12,6	11,7	12,9
4000 Hz	10,3	10,3	11,2	0,1	0,0	-1,2	1,3	1,3	1,3	11,6	11,6	12,5	11,9	12,9
5000 Hz	10,8	10,9	11,5	0,0	0,1	-0,8	1,3	1,3	1,3	12,1	12,2	12,8	12,4	12,9
6300 Hz	11,0	11,1	11,5	0,0	0,0	-0,6	1,3	1,3	1,3	12,3	12,4	12,8	12,5	12,4
8000 Hz	11,3	11,3	11,6	0,1	0,0	-0,4	1,3	1,3	1,3	12,6	12,6	12,9	12,7	11,6
1000 Hz	11,3	11,3	11,5	0,0	0,0	-0,2	1,3	1,3	1,3	12,6	12,6	12,8	12,7	10,2
12500 Hz	11,2	11,2	11,3	-0,1	0,0	-0,1	1,3	1,3	1,3	12,5	12,5	12,6	12,5	8,2
16000 Hz	11,2	11,2	11,2	0,0	0,0	-0,1	1,3	1,3	1,3	12,5	12,5	12,5	12,5	5,9
20000 Hz	11,7	11,7	11,7	0,0	0,0	0,0	1,3	1,3	1,3	13,0	13,0	13,0	13,0	3,7
Overall	-	-	-	-	-	-	-	-	-	-	-	-	32,1	24,5

Table B.12 Source sound pressure level (measured and corrected) for ***ventilation system flow rate 160 m³/h****. As test source pressure level is similar to background noise sound pressure level, i.e. ΔLpi(RSS) < 6 dB for almost all microphone position and each frequency band, maximum correction is applied (K1i is equal to 1,3).*

Frequency	**$L'_{p(ST)}$**			**ΔL_{pi}**			**K_{1i}**			**$L_{p(ST)}$**			**$L_{p(ST)}$**	**$L_{pA(ST)}$**
[Hz]	**M1'**	**M2'**	**M3'**	**M1'**	**M2'**	**M3'**	**M1'**	**M2'**	**M3'**	**M1**	**M2**	**M3**	**[dB]**	**[dB(A)]**
50 Hz	30,2	30,5	38,4	-1,3	3,3	5,0	1,3	1,3	1,3	31,5	31,8	39,7	36,1	5,9
63 Hz	26,9	27,4	26,4	4,5	3,6	1,6	1,3	1,3	1,3	28,2	28,7	27,7	28,2	2,0
80 Hz	25,5	28,5	22,6	2,6	3,2	3,5	1,3	1,3	1,3	26,8	29,8	23,9	27,5	5,0
100 Hz	30,4	29,3	33,0	2,2	-0,7	4,4	1,3	1,3	1,3	31,7	30,6	34,3	32,5	13,4
125 Hz	27,8	31,4	32,2	4,7	9,7	10,8	1,3	0,5	0,4	29,1	31,9	32,6	31,4	15,3
160 Hz	21,2	23,5	20,6	3,6	3,7	3,2	1,3	1,3	1,3	22,5	24,8	21,9	23,3	9,9
200 Hz	20,6	20,0	24,0	4,5	5,2	7,7	1,3	1,3	0,8	21,9	21,3	24,8	23,0	12,1
250 Hz	18,9	17,4	18,0	7,6	7,0	5,9	0,8	1,0	1,3	19,7	18,4	19,3	19,2	10,6
315 Hz	17,9	16,4	18,7	6,9	5,3	5,1	1,0	1,3	1,3	18,9	17,7	20,0	19,0	12,4
400 Hz	16,5	15,8	15,4	7,6	6,6	4,6	0,8	1,1	1,3	17,3	16,9	16,7	17,0	12,2
500 Hz	15,0	14,2	13,4	6,8	5,0	2,2	1,0	1,3	1,3	16,0	15,5	14,7	15,4	12,2
630 Hz	11,0	10,8	11,0	3,9	2,2	-1,1	1,3	1,3	1,3	12,3	12,1	12,3	12,2	10,3
800 Hz	9,3	9,7	9,7	2,5	1,3	-4,7	1,3	1,3	1,3	10,6	11,0	11,0	10,9	10,1
1000 Hz	9,4	9,1	8,7	2,3	1,1	-4,1	1,3	1,3	1,3	10,7	10,4	10,0	10,4	10,4
1250 Hz	8,4	8,2	8,2	0,9	0,5	-3,9	1,3	1,3	1,3	9,7	9,5	9,5	9,6	10,2
1600 Hz	9,2	8,7	8,6	1,3	0,5	-3,7	1,3	1,3	1,3	10,5	10,0	9,9	10,1	11,1
2000 Hz	9,0	9,1	9,0	0,5	0,5	-2,9	1,3	1,3	1,3	10,3	10,4	10,3	10,3	11,5
2500 Hz	9,3	9,5	9,3	0,2	0,3	-2,6	1,3	1,3	1,3	10,6	10,8	10,6	10,7	12,0
3150 Hz	9,7	10,0	9,8	0,1	0,2	-2,9	1,3	1,3	1,3	11,0	11,3	11,1	11,1	12,3
4000 Hz	10,2	10,4	10,3	0,0	0,1	-2,1	1,3	1,3	1,3	11,5	11,7	11,6	11,6	12,6
5000 Hz	10,8	10,9	10,8	0,0	0,1	-1,5	1,3	1,3	1,3	12,1	12,2	12,1	12,1	12,6
6300 Hz	11,0	11,1	11,1	0,0	0,0	-1,0	1,3	1,3	1,3	12,3	12,4	12,4	12,4	12,3
8000 Hz	11,2	11,3	11,3	0,0	0,0	-0,7	1,3	1,3	1,3	12,5	12,6	12,6	12,6	11,5
1000 Hz	11,3	11,4	11,3	0,0	0,1	-0,4	1,3	1,3	1,3	12,6	12,7	12,6	12,6	10,1
12500 Hz	11,2	11,2	11,2	-0,1	0,0	-0,2	1,3	1,3	1,3	12,5	12,5	12,5	12,5	8,2
16000 Hz	11,2	11,2	11,2	0,0	0,0	-0,1	1,3	1,3	1,3	12,5	12,5	12,5	12,5	5,9
20000 Hz	11,7	11,7	11,7	0,0	0,0	0,0	1,3	1,3	1,3	13,0	13,0	13,0	13,0	3,7
Overall	-	-	-	-	-	-	-	-	-	-	-	-	36	25,1

Table B.13 Source sound pressure level (measured and corrected) for ***ventilation system flow rate 200 m^3/h****. The ventilation system produces noise mainly in the frequency bands between 100 ÷ 1000 Hz. For these frequency bands test source sound pressure level is appreciably higher than background noise sound pressure level, so background noise correction factor $K_{1i} \leq 1,3$.*

Frequency	$L'_{p(ST)}$			ΔL_{pi}			K_{1i}			$L_{p(ST)}$			$L_{p(ST)}$	$L_{pA(ST)}$
[Hz]	M1'	M2'	M3'	M1	M2	M3	M1'	M2'	M3'	M1	M2	M3	[dB]	[dB(A)]
50 Hz	31,0	31,2	39,6	-0,5	4,0	6,2	1,3	1,3	1,2	32,3	32,5	40,8	37,1	6,9
63 Hz	28,3	28,6	26,5	5,9	4,8	1,7	1,3	1,3	1,3	29,6	29,9	27,8	29,2	3
80 Hz	29,3	32,0	23,3	6,4	6,7	4,2	1,1	1,0	1,3	30,4	33,0	24,6	30,6	8
100 Hz	31,4	30,1	30,8	3,2	0,1	2,2	1,3	1,3	1,3	32,7	31,4	32,1	32,1	13,0
125 Hz	34,0	31,6	30,4	10,9	9,9	9,0	0,4	0,5	0,6	34,4	32,1	31,0	32,7	16,6
160 Hz	29,2	29,4	29,8	11,6	9,6	12,4	0,3	0,5	0,3	29,5	29,9	30,1	29,8	16,4
200 Hz	30,6	29,0	32,5	14,5	14,2	16,2	0,2	0,2	0,0	30,8	29,2	32,5	31,0	20,1
250 Hz	26,6	28,6	29,1	15,3	18,2	17,0	0,0	0,0	0,0	26,6	28,6	29,1	28,2	19,6
315 Hz	25,9	26,5	25,9	14,9	15,4	12,3	0,1	0,0	0,3	26,0	26,5	26,2	26,2	19,6
400 Hz	26,8	26,0	25,8	17,9	16,8	15,0	0,0	0,0	0,1	26,8	26,0	25,9	26,3	21,5
500 Hz	24,7	25,7	24,4	16,5	16,5	13,2	0,0	0,0	0,2	24,7	25,7	24,6	25,0	21,8
630 Hz	20,5	21,6	20,4	13,4	13,0	8,3	0,2	0,2	0,7	20,7	21,8	21,1	21,2	19,3
800 Hz	15,2	15,6	15,0	8,4	7,2	0,6	0,7	0,9	1,3	15,9	16,5	16,3	16,2	15,4
1000 Hz	15,7	16,2	15,7	8,6	8,2	2,9	0,6	0,7	1,3	16,3	16,9	17,0	16,8	16,8
1250 Hz	12,2	13,0	12,6	4,7	5,3	0,5	1,3	1,3	1,3	13,5	14,3	13,9	13,9	14,5
1600 Hz	11,2	11,4	11,3	3,3	3,2	-1,0	1,3	1,3	1,3	12,5	12,7	12,6	12,6	13,6
2000 Hz	10,7	10,8	10,6	2,2	2,2	-1,3	1,3	1,3	1,3	12,0	12,1	11,9	12,0	13,2
2500 Hz	10,4	10,3	10,4	1,3	1,1	-1,5	1,3	1,3	1,3	11,7	11,6	11,7	11,7	13,0
3150 Hz	10,4	10,4	10,3	0,8	0,6	-2,4	1,3	1,3	1,3	11,7	11,7	11,6	11,7	12,9
4000 Hz	10,6	10,6	10,6	0,4	0,3	-1,8	1,3	1,3	1,3	11,9	11,9	11,9	11,9	12,9
5000 Hz	10,9	11,0	11,0	0,1	0,2	-1,3	1,3	1,3	1,3	12,2	12,3	12,3	12,3	12,8
6300 Hz	11,2	11,1	11,2	0,2	0,0	-0,9	1,3	1,3	1,3	12,5	12,4	12,5	12,5	12,4
8000 Hz	11,3	11,3	11,3	0,1	0,0	-0,7	1,3	1,3	1,3	12,6	12,6	12,6	12,6	11,5
1000 Hz	11,3	11,3	11,3	0,0	0,0	-0,4	1,3	1,3	1,3	12,6	12,6	12,6	12,6	10,1
12500 Hz	11,2	11,2	11,2	-0,1	0,0	-0,2	1,3	1,3	1,3	12,5	12,5	12,5	12,5	8,2
16000 Hz	11,2	11,2	11,2	0,0	0,0	-0,1	1,3	1,3	1,3	12,5	12,5	12,5	12,5	5,9
20000 Hz	11,7	11,7	11,7	0,0	0,0	0,0	1,3	1,3	1,3	13,0	13,0	13,0	13,0	3,7
Overall	-	-	-	-	-	-	-	-	-	-	-	-	39	30,2

Table B.14 Source sound pressure level (measured and corrected) for ***ventilation system flow rate 240 m³/h****. The ventilation system produces noise mainly in the frequency bands between 100 ÷ 1000 Hz. For these frequency bands test source sound pressure level is appreciably higher than background noise sound pressure level, so background noise correction factor K1i ≤ 1,3.*

Frequency	$L'_{p(ST)}$			ΔL_{pi}			K_{1i}			$L_{p(ST)}$			$L_{p(ST)}$	$L_{pA(ST)}$
[Hz]	M1'	M2'	M3'	M1'	M2'	M3'	M1'	M2'	M3'	M1	M2	M3	[dB]	[dB(A)]
50 Hz	40,5	35,7	45,5	9,0	8,5	12,1	0,6	0,7	0,3	41,1	36,4	45,8	42,6	12,4
63 Hz	30,6	30,5	27,3	8,2	6,7	2,5	0,7	1,0	1,3	31,3	31,5	28,6	30,7	4,5
80 Hz	30,2	33,6	25,7	7,3	8,3	6,6	0,9	0,7	1,1	31,1	34,3	26,8	31,7	9,2
100 Hz	32,4	32,9	33,6	4,2	2,9	5,0	1,3	1,3	1,3	33,7	34,2	34,9	34,3	15,2
125 Hz	37,4	35,0	36,1	14,3	13,3	14,7	0,2	0,2	0,1	37,6	35,2	36,2	36,4	20,3
160 Hz	34,1	33,7	34,0	16,5	13,9	16,6	0,0	0,2	0,0	34,1	33,9	34,0	34,0	20,6
200 Hz	36,6	35,3	38,7	20,5	20,5	22,4	0,0	0,0	0,0	36,6	35,3	38,7	37,1	26,2
250 Hz	31,8	32,4	33,5	20,5	22,0	21,4	0,0	0,0	0,0	31,8	32,4	33,5	32,6	24,0
315 Hz	31,8	32,4	32,1	20,8	21,3	18,5	0,0	0,0	0,0	31,8	32,4	32,1	32,1	25,5
400 Hz	30,1	31,0	30,9	21,2	21,8	20,1	0,0	0,0	0,0	30,1	31,0	30,9	30,7	25,9
500 Hz	30,1	29,9	29,9	21,9	20,7	18,7	0,0	0,0	0,0	30,1	29,9	29,9	30,0	26,8
630 Hz	26,5	27,6	26,9	19,4	19,0	14,8	0,0	0,0	0,1	26,5	27,6	27,0	27,1	25,2
800 Hz	21,4	21,4	22,5	14,6	13,0	8,1	0,2	0,2	0,7	21,6	21,6	23,2	22,2	21,4
1000 Hz	21,3	21,8	21,9	14,2	13,8	9,1	0,2	0,2	0,6	21,5	22,0	22,5	22,0	22,0
1250 Hz	17,0	17,5	17,2	9,5	9,8	5,1	0,5	0,5	1,3	17,5	18,0	18,5	18,0	18,6
1600 Hz	15,6	15,7	15,7	7,7	7,5	3,4	0,8	0,9	1,3	16,4	16,6	17,0	16,7	17,7
2000 Hz	13,8	14,2	13,8	5,3	5,6	1,9	1,3	1,3	1,3	15,1	15,5	15,1	15,2	16,4
2500 Hz	12,3	12,3	12,3	3,2	3,1	0,4	1,3	1,3	1,3	13,6	13,6	13,6	13,6	14,9
3150 Hz	11,2	11,2	11,1	1,6	1,4	-1,6	1,3	1,3	1,3	12,5	12,5	12,4	12,5	13,7
4000 Hz	11,1	11,0	10,9	0,9	0,7	-1,5	1,3	1,3	1,3	12,4	12,3	12,2	12,3	13,3
5000 Hz	11,1	11,0	11,1	0,3	0,2	-1,2	1,3	1,3	1,3	12,4	12,3	12,4	12,4	12,9
6300 Hz	11,2	11,1	11,1	0,2	0,0	-1,0	1,3	1,3	1,3	12,5	12,4	12,4	12,4	12,3
8000 Hz	11,3	11,3	11,3	0,1	0,0	-0,7	1,3	1,3	1,3	12,6	12,6	12,6	12,6	11,5
1000 Hz	11,3	11,3	11,3	0,0	0,0	-0,4	1,3	1,3	1,3	12,6	12,6	12,6	12,6	10,1
12500 Hz	11,2	11,2	11,2	-0,1	0,0	-0,2	1,3	1,3	1,3	12,5	12,5	12,5	12,5	8,2
16000 Hz	11,2	11,2	11,2	0,0	0,0	-0,1	1,3	1,3	1,3	12,5	12,5	12,5	12,5	5,9
20000 Hz	11,7	11,7	11,7	0,0	0,0	0,0	1,3	1,3	1,3	13,0	13,0	13,0	13,0	3,7
Overall	-	-	-	-	-	-	-	-	-	-	-	-	43,3	34,9

B.6 Sound Power Level

The sound power level of the noise source under test in each octave band, $L_{w(ST)}$, for the meteorological conditions at the time and place of the test is given by:

$$L_{w(ST)} = L_{w(RSS)} - L_{p(RSS)} + L_{p(ST)} \quad [dB] \qquad (B.21)$$

where

- $L_{w(RSS)}$ is the sound power level of the reference sound source calibrated for the test conditions, i.e. temperature 23°C, atmospheric pressure100700 Pa and rotation speed 2871 rpm.
- $L_{p(RSS)}$ is the mean time-averaged sound pressure level for the reference sound source in each frequency band corrected by the background noise factor K_{1i}.
- $L_{p(ST)}$ is the mean time-averaged sound pressure level for the test source in each frequency band corrected by the background noise factor K_{1i}.

$L_{w(ST)\_ref}$ is the test source sound power level normalized to standard atmospheric condition, i.e. air temperature 23°C and atmospheric pressure 101325 Pa and it is given by:

$$L_{w(ST)\_ref} = L_{w(RSS)} + C_2 \quad [dB] \qquad (B.22)$$

in which C_2 is the radiation impedance correction factor calculated in accordance with (B.1).

Table B.15 Sound power level at test and at reference condition for ***ventilation system flow rate 80 m³/h***.

Frequency [Hz]	[dB]					[dB(A)]				
	$L_{w(RSS)}$	$L_{p(RSS)}$	$L_{p(ST)}$	$L_{w(ST)}$	L_{w_ref}	$L_{wA(RSS)}$	$L_{pA(RSS)}$	$L_{pA(ST)}$	$L_{wA(ST)}$	L_{wA_ref}
50 Hz	77,7	70,9	29,9	36,7	36,7	47,7	40,7	-0,3	6,7	6,7
63 Hz	77,3	60,6	24,6	41,3	41,3	51,3	34,4	-1,6	15,3	15,3
80 Hz	76,8	62,5	25,0	39,3	39,3	54,5	40,0	2,5	17	17
100 Hz	77,5	57,8	32,2	51,9	51,9	58,6	38,7	13,1	33	33
125 Hz	76,4	65,0	27,9	39,3	39,3	60,5	48,9	11,8	23,4	23,4
160 Hz	76,8	62,6	18,5	32,7	32,7	63,6	49,2	5,1	19,5	19,5
200 Hz	77,3	71,4	22,0	27,9	27,9	66,6	60,5	11,1	17,2	17,2
250 Hz	76,9	73,6	13,8	17,1	17,1	68,5	65,0	5,2	8,7	8,7
315 Hz	77,0	74,1	13,4	16,3	16,3	70,6	67,5	6,8	9,9	9,9
400 Hz	77,2	74,3	12,0	14,9	14,9	72,6	69,5	7,2	10,3	10,3
500 Hz	77,4	75,3	12,6	14,7	14,7	74,4	72,1	9,4	11,7	11,7
630 Hz	77,8	76,4	10,5	11,9	11,9	76,1	74,5	8,6	10,2	10,2
800 Hz	79,3	78,3	10,9	11,9	11,9	78,7	77,5	10,1	11,3	11,3
1000 Hz	80,2	79,2	9,8	10,8	10,8	80,4	79,2	9,8	11	11
1250 Hz	81,8	80,5	9,9	11,2	11,2	82,6	81,1	10,5	12	12
1600 Hz	82,2	80,8	9,9	11,3	11,3	83,4	81,8	10,9	12,5	12,5
2000 Hz	82,4	80,6	10,0	11,8	11,8	83,8	81,8	11,2	13,2	13,2
2500 Hz	80,5	78,5	10,5	12,5	12,5	82	79,8	11,8	14	14
3150 Hz	80,0	77,3	11,1	13,8	13,8	81,4	78,5	12,3	15,2	15,2
4000 Hz	79,9	77,1	11,6	14,4	14,4	81,1	78,1	12,6	15,6	15,6
5000 Hz	79,0	75,5	12,1	15,6	15,6	79,7	76,0	12,6	16,3	16,3
6300 Hz	78,0	73,5	12,4	16,9	16,9	78,1	73,4	12,3	17	17
8000 Hz	76,2	70,4	12,6	18,4	18,4	75,3	69,3	11,5	17,5	17,5
10000 Hz	74,2	66,3	12,6	20,5	20,5	71,9	63,8	10,1	18,2	18,2
12500 Hz	72,4	60,5	12,5	24,4	24,4	68,3	56,2	8,2	20,3	20,3
16000 Hz	70,4	56,2	12,5	26,7	26,7	64	49,6	5,9	20,3	20,3
20000 Hz	68,3	51,0	13,0	30,3	30,3	59,2	41,7	3,7	21,2	21,2
Overall	92,4	89,6	34,4	52,2	52,2	91,9	89,7	23,9	34,5	34,5

Table B.16 Sound power level at test and at reference condition for ***ventilation system flow rate 120 m^3/h***.

Frequency [Hz]	[dB]					[dB(A)]				
	$L_{w(RSS)}$	$L_{p(RSS)}$	$L_{p(ST)}$	$L_{w(ST)}$	L_{w_ref}	$L_{wA(RSS)}$	$L_{pA(RSS)}$	$L_{pA(ST)}$	$L_{wA(ST)}$	L_{wA_ref}
50 Hz	77,7	70,9	36,2	43	43	47,7	40,7	6	13	13
63 Hz	77,3	60,6	25,4	42,1	42,1	51,3	34,4	-0,8	16,1	16,1
80 Hz	76,8	62,5	25,2	39,5	39,5	54,5	40,0	2,7	17,2	17,2
100 Hz	77,5	57,8	28,4	48,1	48,1	58,6	38,7	9,3	29,2	29,2
125 Hz	76,4	65,0	23,2	34,6	34,6	60,5	48,9	7,1	18,7	18,7
160 Hz	76,8	62,6	22,3	36,5	36,5	63,6	49,2	8,9	23,3	23,3
200 Hz	77,3	71,4	23,4	29,3	29,3	66,6	60,5	12,5	18,6	18,6
250 Hz	76,9	73,6	17,1	20,4	20,4	68,5	65,0	8,5	12	12
315 Hz	77,0	74,1	16,0	18,9	18,9	70,6	67,5	9,4	12,5	12,5
400 Hz	77,2	74,3	14,8	17,7	17,7	72,6	69,5	10,0	13,1	13,1
500 Hz	77,4	75,3	13,8	15,9	15,9	74,4	72,1	10,6	12,9	12,9
630 Hz	77,8	76,4	12,1	13,5	13,5	76,1	74,5	10,2	11,8	11,8
800 Hz	79,3	78,3	11,1	12,1	12,1	78,7	77,5	10,3	11,5	11,5
1000 Hz	80,2	79,2	10,5	11,5	11,5	80,4	79,2	10,5	11,7	11,7
1250 Hz	81,8	80,5	11,0	12,3	12,3	82,6	81,1	11,6	13,1	13,1
1600 Hz	82,2	80,8	12,0	13,4	13,4	83,4	81,8	13,0	14,6	14,6
2000 Hz	82,4	80,6	11,2	13	13	83,8	81,8	12,4	14,4	14,4
2500 Hz	80,5	78,5	12,0	14	14	82	79,8	13,3	15,5	15,5
3150 Hz	80,0	77,3	11,7	14,4	14,4	81,4	78,5	12,9	15,8	15,8
4000 Hz	79,9	77,1	11,9	14,7	14,7	81,1	78,1	12,9	15,9	15,9
5000 Hz	79,0	75,5	12,4	15,9	15,9	79,7	76,0	12,9	16,6	16,6
6300 Hz	78,0	73,5	12,5	17	17	78,1	73,4	12,4	17,1	17,1
8000 Hz	76,2	70,4	12,7	18,5	18,5	75,3	69,3	11,6	17,6	17,6
10000 Hz	74,2	66,3	12,7	20,6	20,6	71,9	63,8	10,2	18,3	18,3
12500 Hz	72,4	60,5	12,5	24,4	24,4	68,3	56,2	8,2	20,3	20,3
16000 Hz	70,4	56,2	12,5	26,7	26,7	64	49,6	5,9	20,3	20,3
20000 Hz	68,3	51,0	13,0	30,3	30,3	59,2	41,7	3,7	21,2	21,2
Overall	92,4	89,6	32,1	48,7	48,7	91,9	89,7	24,5	32,4	32,4

Table B.17 Sound power level at test and at reference condition for ***ventilation system flow rate 160 m³/h***.

Frequency [Hz]	[dB]					[dB(A)]				
	$L_{w(RSS)}$	$L_{p(RSS)}$	$L_{p(ST)}$	$L_{w(ST)}$	L_{w_ref}	$L_{wA(RSS)}$	$L_{pA(RSS)}$	$L_{pA(ST)}$	$L_{wA(ST)}$	L_{wA_ref}
50 Hz	77,7	70,9	36,1	42,9	42,9	47,7	40,7	5,9	12,9	12,9
63 Hz	77,3	60,6	28,2	44,9	44,9	51,3	34,4	2,0	18,9	18,9
80 Hz	76,8	62,5	27,5	41,8	41,8	54,5	40,0	5,0	19,5	19,5
100 Hz	77,5	57,8	32,5	52,2	52,2	58,6	38,7	13,4	33,3	33,3
125 Hz	76,4	65,0	31,4	42,8	42,8	60,5	48,9	15,3	26,9	26,9
160 Hz	76,8	62,6	23,3	37,5	37,5	63,6	49,2	9,9	24,3	24,3
200 Hz	77,3	71,4	23,0	28,9	28,9	66,6	60,5	12,1	18,2	18,2
250 Hz	76,9	73,6	19,2	22,5	22,5	68,5	65,0	10,6	14,1	14,1
315 Hz	77,0	74,1	19,0	21,9	21,9	70,6	67,5	12,4	15,5	15,5
400 Hz	77,2	74,3	17,0	19,9	19,9	72,6	69,5	12,2	15,3	15,3
500 Hz	77,4	75,3	15,4	17,5	17,5	74,4	72,1	12,2	14,5	14,5
630 Hz	77,8	76,4	12,2	13,6	13,6	76,1	74,5	10,3	11,9	11,9
800 Hz	79,3	78,3	10,9	11,9	11,9	78,7	77,5	10,1	11,3	11,3
1000 Hz	80,2	79,2	10,4	11,4	11,4	80,4	79,2	10,4	11,6	11,6
1250 Hz	81,8	80,5	9,6	10,9	10,9	82,6	81,1	10,2	11,7	11,7
1600 Hz	82,2	80,8	10,1	11,5	11,5	83,4	81,8	11,1	12,7	12,7
2000 Hz	82,4	80,6	10,3	12,1	12,1	83,8	81,8	11,5	13,5	13,5
2500 Hz	80,5	78,5	10,7	12,7	12,7	82	79,8	12,0	14,2	14,2
3150 Hz	80,0	77,3	11,1	13,8	13,8	81,4	78,5	12,3	15,2	15,2
4000 Hz	79,9	77,1	11,6	14,4	14,4	81,1	78,1	12,6	15,6	15,6
5000 Hz	79,0	75,5	12,1	15,6	15,6	79,7	76,0	12,6	16,3	16,3
6300 Hz	78,0	73,5	12,4	16,9	16,9	78,1	73,4	12,3	17	17
8000 Hz	76,2	70,4	12,6	18,4	18,4	75,3	69,3	11,5	17,5	17,5
10000 Hz	74,2	66,3	12,6	20,5	20,5	71,9	63,8	10,1	18,2	18,2
12500 Hz	72,4	60,5	12,5	24,4	24,4	68,3	56,2	8,2	20,3	20,3
16000 Hz	70,4	56,2	12,5	26,7	26,7	64	49,6	5,9	20,3	20,3
20000 Hz	68,3	51,0	13,0	30,3	30,3	59,2	41,7	3,7	21,2	21,2
Overall	92,4	89,6	36	52,8	52,8	91,9	89,7	25,1	35,4	35,4

Table B.18 Sound power level at test and at reference condition for ***ventilation system flow rate 200 m³/h***.

Frequency [Hz]	[dB]					[dB(A)]				
	$L_{w(RSS)}$	$L_{p(RSS)}$	$L_{p(ST)}$	$L_{w(ST)}$	L_{w_ref}	$L_{wA(RSS)}$	$L_{pA(RSS)}$	$L_{pA(ST)}$	$L_{wA(ST)}$	L_{wA_ref}
50 Hz	77,7	70,9	37,1	43,9	43,9	47,7	40,7	6,9	13,9	13,9
63 Hz	77,3	60,6	29,2	45,9	45,9	51,3	34,4	3	19,9	19,9
80 Hz	76,8	62,5	30,6	44,9	44,9	54,5	40,0	8	22,5	22,5
100 Hz	77,5	57,8	32,1	51,8	51,8	58,6	38,7	13,0	32,9	32,9
125 Hz	76,4	65,0	32,7	44,1	44,1	60,5	48,9	16,6	28,2	28,2
160 Hz	76,8	62,6	29,8	44	44	63,6	49,2	16,4	30,8	30,8
200 Hz	77,3	71,4	31,0	36,9	36,9	66,6	60,5	20,1	26,2	26,2
250 Hz	76,9	73,6	28,2	31,5	31,5	68,5	65,0	19,6	23,1	23,1
315 Hz	77,0	74,1	26,2	29,1	29,1	70,6	67,5	19,6	22,7	22,7
400 Hz	77,2	74,3	26,3	29,2	29,2	72,6	69,5	21,5	24,6	24,6
500 Hz	77,4	75,3	25,0	27,1	27,1	74,4	72,1	21,8	24,1	24,1
630 Hz	77,8	76,4	21,2	22,6	22,6	76,1	74,5	19,3	20,9	20,9
800 Hz	79,3	78,3	16,2	17,2	17,2	78,7	77,5	15,4	16,6	16,6
1000 Hz	80,2	79,2	16,8	17,8	17,8	80,4	79,2	16,8	18	18
1250 Hz	81,8	80,5	13,9	15,2	15,2	82,6	81,1	14,5	16	16
1600 Hz	82,2	80,8	12,6	14	14	83,4	81,8	13,6	15,2	15,2
2000 Hz	82,4	80,6	12,0	13,8	13,8	83,8	81,8	13,2	15,2	15,2
2500 Hz	80,5	78,5	11,7	13,7	13,7	82	79,8	13,0	15,2	15,2
3150 Hz	80,0	77,3	11,7	14,4	14,4	81,4	78,5	12,9	15,8	15,8
4000 Hz	79,9	77,1	11,9	14,7	14,7	81,1	78,1	12,9	15,9	15,9
5000 Hz	79,0	75,5	12,3	15,8	15,8	79,7	76,0	12,8	16,5	16,5
6300 Hz	78,0	73,5	12,5	17	17	78,1	73,4	12,4	17,1	17,1
8000 Hz	76,2	70,4	12,6	18,4	18,4	75,3	69,3	11,5	17,5	17,5
10000 Hz	74,2	66,3	12,6	20,5	20,5	71,9	63,8	10,1	18,2	18,2
12500 Hz	72,4	60,5	12,5	24,4	24,4	68,3	56,2	8,2	20,3	20,3
16000 Hz	70,4	56,2	12,5	26,7	26,7	64	49,6	5,9	20,3	20,3
20000 Hz	68,3	51,0	13,0	30,3	30,3	59,2	41,7	3,7	21,2	21,2
Overall	92,4	89,6	39	53,3	53,3	91,9	89,7	30,2	37,7	37,7

Table B. 19 Sound power level at test and at reference condition for **ventilation system flow rate 240 m^3/h**.

Frequency [Hz]	[dB]					[dB(A)]				
	$L_{w(RSS)}$	$L_{p(RSS)}$	$L_{p(ST)}$	$L_{w(ST)}$	L_{w_ref}	$L_{wA(RSS)}$	$L_{pA(RSS)}$	$L_{pA(ST)}$	$L_{wA(ST)}$	L_{wA_ref}
50 Hz	77,7	70,9	42,6	49,4	49,4	47,7	40,7	12,4	19,4	19,4
63 Hz	77,3	60,6	30,7	47,4	47,4	51,3	34,4	4,5	21,4	21,4
80 Hz	76,8	62,5	31,7	46	46	54,5	40,0	9,2	23,7	23,7
100 Hz	77,5	57,8	34,3	54	54	58,6	38,7	15,2	35,1	35,1
125 Hz	76,4	65,0	36,4	47,8	47,8	60,5	48,9	20,3	31,9	31,9
160 Hz	76,8	62,6	34,0	48,2	48,2	63,6	49,2	20,6	35	35
200 Hz	77,3	71,4	37,1	43	43	66,6	60,5	26,2	32,3	32,3
250 Hz	76,9	73,6	32,6	35,9	35,9	68,5	65,0	24,0	27,5	27,5
315 Hz	77,0	74,1	32,1	35	35	70,6	67,5	25,5	28,6	28,6
400 Hz	77,2	74,3	30,7	33,6	33,6	72,6	69,5	25,9	29	29
500 Hz	77,4	75,3	30,0	32,1	32,1	74,4	72,1	26,8	29,1	29,1
630 Hz	77,8	76,4	27,1	28,5	28,5	76,1	74,5	25,2	26,8	26,8
800 Hz	79,3	78,3	22,2	23,2	23,2	78,7	77,5	21,4	22,6	22,6
1000 Hz	80,2	79,2	22,0	23	23	80,4	79,2	22,0	23,2	23,2
1250 Hz	81,8	80,5	18,0	19,3	19,3	82,6	81,1	18,6	20,1	20,1
1600 Hz	82,2	80,8	16,7	18,1	18,1	83,4	81,8	17,7	19,3	19,3
2000 Hz	82,4	80,6	15,2	17	17	83,8	81,8	16,4	18,4	18,4
2500 Hz	80,5	78,5	13,6	15,6	15,6	82	79,8	14,9	17,1	17,1
3150 Hz	80,0	77,3	12,5	15,2	15,2	81,4	78,5	13,7	16,6	16,6
4000 Hz	79,9	77,1	12,3	15,1	15,1	81,1	78,1	13,3	16,3	16,3
5000 Hz	79,0	75,5	12,4	15,9	15,9	79,7	76,0	12,9	16,6	16,6
6300 Hz	78,0	73,5	12,4	16,9	16,9	78,1	73,4	12,3	17	17
8000 Hz	76,2	70,4	12,6	18,4	18,4	75,3	69,3	11,5	17,5	17,5
10000 Hz	74,2	66,3	12,6	20,5	20,5	71,9	63,8	10,1	18,2	18,2
12500 Hz	72,4	60,5	12,5	24,4	24,4	68,3	56,2	8,2	20,3	20,3
16000 Hz	70,4	56,2	12,5	26,7	26,7	64	49,6	5,9	20,3	20,3
20000 Hz	68,3	51,0	13,0	30,3	30,3	59,2	41,7	3,7	21,2	21,2
Overall	92,4	89,6	43,3	56,1	56,1	91,9	89,7	34,9	41,5	41,5

Table B.20 Summary of ventilation system sound power level and A-weighted sound power level according to testes nominal flow rates.

	80 m³/h		120 m³/h		160 m³/h		200 m³/h		240 m³/h	
Band [Hz]	**L_W [dB]**	**L_{WA} [dB(A)]**	**L_W [dB]**	**L_{WA} [dB(A)]**	**L_W [dB]**	**L_{WA} [dB(A)]**	**L_W [dB]**	**L_{WA} [dB(A)]**	**L_W [dB]**	**L_{WA} [dB(A)]**
50	36,7	6,7	43	13	42,9	12,9	43,9	13,9	49,4	19,4
63	41,3	15,3	42,1	16,1	44,9	18,9	45,9	19,9	47,4	21,4
80	39,3	17	39,5	17,2	41,8	19,5	44,9	22,5	46	23,7
100	51,9	33	48,1	29,2	52,2	33,3	51,8	32,9	54	35,1
125	39,3	23,4	34,6	18,7	42,8	26,9	44,1	28,2	47,8	31,9
160	32,7	19,5	36,5	23,3	37,5	24,3	44	30,8	48,2	35
200	27,9	17,2	29,3	18,6	28,9	18,2	36,9	26,2	43	32,3
250	17,1	8,7	20,4	12	22,5	14,1	31,5	23,1	35,9	27,5
315	16,3	9,9	18,9	12,5	21,9	15,5	29,1	22,7	35	28,6
400	14,9	10,3	17,7	13,1	19,9	15,3	29,2	24,6	33,6	29
500	14,7	11,7	15,9	12,9	17,5	14,5	27,1	24,1	32,1	29,1
630	11,9	10,2	13,5	11,8	13,6	11,9	22,6	20,9	28,5	26,8
800	11,9	11,3	12,1	11,5	11,9	11,3	17,2	16,6	23,2	22,6
1000	10,8	11	11,5	11,7	11,4	11,6	17,8	18	23	23,2
1250	11,2	12	12,3	13,1	10,9	11,7	15,2	16	19,3	20,1
1600	11,3	12,5	13,4	14,6	11,5	12,7	14	15,2	18,1	19,3
2000	11,8	13,2	13	14,4	12,1	13,5	13,8	15,2	17	18,4
2500	12,5	14	14	15,5	12,7	14,2	13,7	15,2	15,6	17,1
3150	13,8	15,2	14,4	15,8	13,8	15,2	14,4	15,8	15,2	16,6
4000	14,4	15,6	14,7	15,9	14,4	15,6	14,7	15,9	15,1	16,3
5000	15,6	16,3	15,9	16,6	15,6	16,3	15,8	16,5	15,9	16,6
6300	16,9	17	17	17,1	16,9	17	17	17,1	16,9	17
8000	18,4	17,5	18,5	17,6	18,4	17,5	18,4	17,5	18,4	17,5
10000	20,5	18,2	20,6	18,3	20,5	18,2	20,5	18,2	20,5	18,2
Overall	52,2	34,5	48,7	32,4	52,8	35,4	53,3	37,7	56,1	41,5

Annex C

Speech Transmission Index Measurement

Instrument used to perform the survey are:

- NTI audio XL_2 analyzer;
- NTI audio Talk Box;
- Microphone NTi Audio M2210, S/N: 1474.

STI is calculated by loading the measurement data into the STI Reporting Tool provided with NTI audio XL_2 analyzer The ambient noise has to be sufficiently static during the measurement. A signal-noise ratio of 15 dB or higher is recommended to achieve best speech intelligibility. Impulsive ambient noise during the measurement causes severe measurement errors. Equivalent sound pressure level L_{eq} from table C.3 to table C.10 includes both Talk Box test signal and the background noise. Figure C.2 shows in a qualitative way localization and measurement points of the sound source inside the laboratory room:

- R1÷R3 represent microphone positions;
- S is Talk Box position;
- P1÷P6 are the position of standing people.

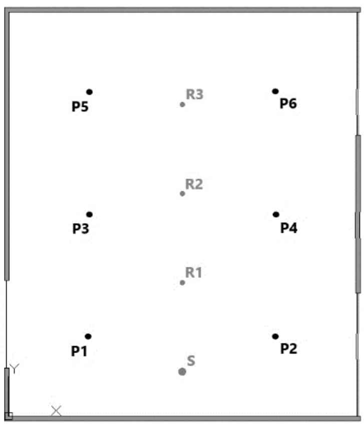


Figure C.1 Qualitative map of STI measurement points.

Table C. 1 XL_2 analyser configuration while performing STI measurement.

	XL_2 analyser set up
Profile	Full mode
Append mode	OFF
Timer set	0:00:15

Table C.2 STI report for microphone position R1, R2 and R3 with **ventilation system flow rate 80 m³/h**.

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Leq [dB]	STI [-]
R1_L_{eq} [dB]	69,3	74,5	65,3	58,5	51,2	43,1	32,9	69,1	0,575
R2_L_{eq} [dB]	68,2	70,2	65,4	58,8	50,2	41,4	29,8	67	0,556
R3_L_{eq} [dB]	67,9	68,6	67,5	58,5	49,8	41,1	29,1	67,4	0,53

Table C.3 STI report for microphone position R1, R2 and R3 with **ventilation system flow rate 120 m³/h**.

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Leq [dB]	STI [-]
R1_L_{eq} [dB]	68,9	74,4	65,7	59,6	51,8	43,2	33,2	69,2	0,584
R2_L_{eq} [dB]	68,4	70,5	65,3	58,9	50,4	41,3	29,7	67,1	0,545
R3_L_{eq} [dB]	68,0	68,3	67,6	58,9	49,9	41,4	29,0	67,4	0,548

Table C.4 STI report for microphone position R1, R2 and R3 with **ventilation system flow rate 160 m³/h**.

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Leq [dB]	STI [-]
R1_L_{eq} [dB]	69,2	74,2	65,9	59,3	51,8	43,2	33,3	69,2	0,593
R2_L_{eq} [dB]	67,8	70,4	65,1	58,5	49,8	41,4	29,7	66,8	0,529
R3_L_{eq} [dB]	68,0	68,4	66,8	58,2	49,5	41,3	28,5	66,9	0,520

Table C.5 STI report for microphone position R1, R2 and R3 with **ventilation system flow rate 200 m³/h**.

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Leq [dB]	STI [-]
R1_L_{eq} [dB]	69,2	74,3	65,7	59,1	51,3	42,9	32,8	69,0	0,571
R2_L_{eq} [dB]	68,3	70,1	65,2	59,0	49,8	41,7	29,8	66,8	0,566
R3_L_{eq} [dB]	68,0	68,5	67,3	58,5	50,4	41,2	28,8	67,3	0,532

Table C.6 STI report for microphone position R1, R2 and R3 with **ventilation system flow rate 240 m³/h**.

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Leq [dB]	STI [-]
R1_L_{eq} [dB]	69,2	74,1	65,5	59,2	51,9	43,5	33,3	68,9	0,576
R2_L_{eq} [dB]	68,5	70,4	65,3	59,0	50,4	41,4	29,8	67,1	0,571
R3_L_{eq} [dB]	68,0	68,4	67,1	58,3	49,5	41,6	28,9	67,2	0,527

Table C.7 STI report for microphone position R1, R2 and R3 with ***ventilation system switched off and two people standing*** *on point P5 and P6 of figure C.2.*

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Leq [dB]	STI [-]
R1_L_{eq} [dB]	69,5	73,8	65,2	59,2	51,6	43,3	33,1	68,7	0,588
R2_L_{eq} [dB]	68,3	70,6	65,2	58,9	50,1	41,8	29,8	67,1	0,538
R3_L_{eq} [dB]	68,0	68,3	67,4	58,7	49,5	41,4	28,7	67,3	0,543

Table C.8 STI report for microphone position R1, R2 and R3 with ***ventilation system switched off and four people standing*** *on point P5, P6, P1 and P2 of figure C.2.*

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Leq [dB]	STI [-]
R1_L_{eq} [dB]	69,6	73,8	65,6	58,6	51,3	43,1	33,0	68,6	0,623
R2_L_{eq} [dB]	68,5	70,8	64,8	57,4	49,0	40,8	29,5	66,7	0,595
R3_L_{eq} [dB]	67,8	68,5	66,2	58,0	49,6	39,9	28,4	66,6	0,603

Table C.9 STI report for microphone position R1, R2 and R3 with ***ventilation system switched off and six people standing*** *on point P1÷P6 of figure C.2.*

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Leq [dB]	STI [-]
R1_L_{eq} [dB]	68,8	73,7	65,5	57,8	50,4	42,5	32,9	68,3	0,652
R2_L_{eq} [dB]	68,9	70,9	64,2	57,2	48,9	40,0	29,6	66,4	0,605
R3_L_{eq} [dB]	67,8	69,2	65,8	57,5	48,2	39,8	28,2	66,5	0,611

Table C.10 Summary of STI values depending on system treated flow rate and number of people inside the room.

	STI_R1	STI_R2	STI_R3
80 m^3/h	0,57	0,56	0,53
120 m^3/h	0,58	0,54	0,55
160 m^3/h	0,59	0,53	0,52
200 m^3/h	0,57	0,57	0,53
240 m^3/h	0,58	0,57	0,53
2 people (off system)	0,59	0,54	0,54
4 people (off system)	0,62	0,60	0,60
6 people (off system)	0,65	0,61	0,61

Annex D

Construction of Room Model

D.1 Room Absorption Coefficient

Table D.1 Equivalent sound absorption area A_{air} and $A_{measurement}$ and equivalent absorption area $A_{approximate}$.

Band	RT_{avg}	A_{air}	$A_{meas.}$	$\overline{\alpha}_{meas.}$	$A_{approx.}$	$\overline{\alpha}_{approx.}$
[Hz]	[s]	[m^2]	[m^2]	[-]	[m^2]	[-]
50	0,83	0,0050	9,5162	0,1155	9,882	0,12
63	0,70	0,0077	11,3356	0,1376	11,529	0,14
80	0,71	0,0119	11,1710	0,1356	11,529	0,14
100	0,91	0,0180	8,6662	0,1052	9,0585	0,11
125	0,91	0,0266	8,6895	0,1055	9,0585	0,11
160	1,30	0,0381	6,0253	0,0732	5,7645	0,07
200	1,92	0,0525	4,0634	0,0493	4,1175	0,05
250	1,62	0,0695	4,7986	0,0583	4,941	0,06
315	1,85	0,0880	4,1914	0,0509	4,1175	0,05
400	1,74	0,1076	4,4428	0,0539	4,1175	0,05
500	1,95	0,1286	3,9239	0,0476	4,1175	0,05
630	2,14	0,1530	3,5455	0,0430	3,294	0,04
800	2,34	0,1844	3,1927	0,0388	3,294	0,04
1000	2,26	0,2287	3,2680	0,0397	3,294	0,04
1250	1,99	0,2950	3,6761	0,0446	3,294	0,04
1600	1,77	0,3973	4,0759	0,0495	4,1175	0,05
2000	1,66	0,5570	4,1940	0,0509	4,1175	0,05
2500	1,41	0,8078	4,7837	0,0581	4,941	0,06
3150	1,36	1,2009	4,6098	0,0560	4,941	0,06
4000	1,31	1,8150	4,2175	0,0512	4,1175	0,05
5000	1,14	2,7671	4,1448	0,0503	4,1175	0,05
6300	0,90	4,2257	4,5225	0,0549	4,1175	0,05
8000	0,79	6,4199	3,5833	0,0435	3,294	0,04
10000	0,61	9,6329	3,3933	0,0412	3,294	0,04

Table D.2 Absorption coefficient estimated from literature data.

Band	$\alpha_1^{lit.}$	$\alpha_2^{lit.}$	$\alpha_3^{lit.}$	$\alpha_4^{lit.}$	$A_1^{lit.}$	$A_2^{lit.}$	$A_3^{lit.}$	$A_4^{lit.}$	$A_{lit.}$	$\bar{\alpha}_{lit.}$
[Hz]	**[-]**	**[-]**	**[-]**	**[-]**	**[m²]**	**[m²]**	**[m²]**	**[m²]**	**[m²]**	**[-]**
50	0,08	0,01	0,14	0,1	4,6304	0,1766	0,2758	0,484	5,5668	0,0676
63	0,08	0,01	0,14	0,1	4,6304	0,1766	0,2758	0,484	5,5668	0,0676
80	0,08	0,01	0,14	0,1	4,6304	0,1766	0,2758	0,484	5,5668	0,0676
100	0,08	0,01	0,14	0,1	4,6304	0,1766	0,2758	0,484	5,5668	0,0676
125	0,08	0,01	0,14	0,1	4,6304	0,1766	0,2758	0,484	5,5668	0,0676
160	0,08	0,01	0,14	0,1	4,6304	0,1766	0,2758	0,484	5,5668	0,0676
200	0,11	0,01	0,1	0,07	6,3668	0,1766	0,197	0,3388	7,0792	0,0860
250	0,11	0,01	0,1	0,07	6,3668	0,1766	0,197	0,3388	7,0792	0,0860
315	0,11	0,01	0,1	0,07	6,3668	0,1766	0,197	0,3388	7,0792	0,0860
400	0,05	0,01	0,06	0,05	2,894	0,1766	0,1182	0,242	3,4308	0,0417
500	0,05	0,01	0,06	0,05	2,894	0,1766	0,1182	0,242	3,4308	0,0417
630	0,05	0,01	0,06	0,05	2,894	0,1766	0,1182	0,242	3,4308	0,0417
800	0,03	0,02	0,08	0,03	1,7364	0,3532	0,1576	0,1452	2,3924	0,0290
1000	0,03	0,02	0,08	0,03	1,7364	0,3532	0,1576	0,1452	2,3924	0,0290
1250	0,03	0,02	0,08	0,03	1,7364	0,3532	0,1576	0,1452	2,3924	0,0290
1600	0,02	0,02	0,1	0,02	1,1576	0,3532	0,197	0,0968	1,8046	0,0219
2000	0,02	0,02	0,1	0,02	1,1576	0,3532	0,197	0,0968	1,8046	0,0219
2500	0,02	0,02	0,1	0,02	1,1576	0,3532	0,197	0,0968	1,8046	0,0219
3150	0,03	0,02	0,1	0,02	1,7364	0,3532	0,197	0,0968	2,3834	0,0289
4000	0,03	0,02	0,1	0,02	1,7364	0,3532	0,197	0,0968	2,3834	0,0289
5000	0,03	0,02	0,1	0,02	1,7364	0,3532	0,197	0,0968	2,3834	0,0289
6300	0,03	0,02	0,1	0,02	1,7364	0,3532	0,197	0,0968	2,3834	0,0289
8000	0,03	0,02	0,1	0,02	1,7364	0,3532	0,197	0,0968	2,3834	0,0289
10000	0,03	0,02	0,1	0,02	1,7364	0,3532	0,197	0,0968	2,3834	0,0289

Table D.3 Absorption coefficient estimated from modification of literature data.

Band	$\alpha_1^{mod.}$	$\alpha_2^{mod.}$	$\alpha_3^{mod.}$	$\alpha_4^{mod.}$	$A_1^{mod.}$	$A_2^{mod.}$	$A_3^{mod.}$	$A_4^{mod.}$	$A_{mod.}$	$\bar{\alpha}_{mod.}$
[Hz]	[-]	[-]	[-]	[-]	[m²]	[m²]	[m²]	[m²]	[m²]	[m²]
50	0,14	0,02	0,22	0,17	8,1032	0,3532	0,4334	0,8228	9,7126	0,1179
63	0,16	0,02	0,29	0,2	9,2608	0,3532	0,5713	0,968	11,1533	0,1354
80	0,16	0,02	0,28	0,2	9,2608	0,3532	0,5516	0,968	11,1336	0,1352
100	0,12	0,02	0,22	0,16	6,9456	0,3532	0,4334	0,7744	8,5066	0,1033
125	0,12	0,02	0,22	0,16	6,9456	0,3532	0,4334	0,7744	8,5066	0,1033
160	0,09	0,01	0,15	0,11	5,2092	0,1766	0,2955	0,5324	6,2137	0,0754
200	0,06	0,01	0,06	0,04	3,4728	0,1766	0,1182	0,1936	3,9612	0,0481
250	0,07	0,01	0,07	0,05	4,0516	0,1766	0,1379	0,242	4,6081	0,0560
315	0,06	0,01	0,06	0,04	3,4728	0,1766	0,1182	0,1936	3,9612	0,0481
400	0,07	0,01	0,08	0,07	4,0516	0,1766	0,1576	0,3388	4,7246	0,0574
500	0,06	0,01	0,07	0,06	3,4728	0,1766	0,1379	0,2904	4,0777	0,0495
630	0,05	0,01	0,06	0,05	2,894	0,1766	0,1182	0,242	3,4308	0,0417
800	0,04	0,03	0,11	0,04	2,3152	0,5298	0,2167	0,1936	3,2553	0,0395
1000	0,04	0,03	0,11	0,04	2,3152	0,5298	0,2167	0,1936	3,2553	0,0395
1250	0,05	0,03	0,1	0,05	2,894	0,5298	0,197	0,242	3,8628	0,0469
1600	0,05	0,05	0,13	0,05	2,894	0,883	0,2561	0,242	4,2751	0,0519
2000	0,05	0,05	0,15	0,05	2,894	0,883	0,2955	0,242	4,3145	0,0524
2500	0,05	0,05	0,35	0,05	2,894	0,883	0,6895	0,242	4,7085	0,0572
3150	0,06	0,04	0,18	0,04	3,4728	0,7064	0,3546	0,1936	4,7274	0,0574
4000	0,05	0,04	0,18	0,04	2,894	0,7064	0,3546	0,1936	4,1486	0,0504
5000	0,05	0,03	0,25	0,03	2,894	0,5298	0,4925	0,1452	4,0615	0,0493
6300	0,06	0,04	0,15	0,04	3,4728	0,7064	0,2955	0,1936	4,6683	0,0567
8000	0,05	0,03	0,1	0,03	2,894	0,5298	0,197	0,1452	3,7660	0,0457
10000	0,04	0,03	0,15	0,03	2,3152	0,5298	0,2955	0,1452	3,2857	0,0399

D.2 Checking directivity

Table D.4 Resulting sound pressure level for the simulated scenes.

Band	$Lp\_{SCENE\ A}$ (Q=1)			$Lp\_{SCENE\ B}$ (Q=2)			$Lp\_{SCENE\ C}$ (Q=4)			$Lp\_{SCENE\ D}$ (Q=8)		
[Hz]	[dB]			[dB]			[dB]			[dB]		
	SPPS	TCR	Theory	SPPS	TCR	Theory	SPPS	TCR	Theory	SPPS	TCR	Theory
50	59,2	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
63	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
80	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
100	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
125	59,2	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
160	59,2	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
200	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
250	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
315	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
400	59,2	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
500	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
630	59,3	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
800	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
1000	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
1250	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
1600	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
2000	59,0	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
2500	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
3150	59,2	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
4000	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
5000	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
6300	59,2	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
8000	59,3	60,0	57,8	61,5	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
10000	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
12500	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
16000	59,1	60,0	57,8	61,6	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8
20000	59,1	60,0	57,8	61,7	60,4	60,8	64,4	60,8	63,8	67,2	61,4	66,8

Table D.5 Resulting directivity index for the simulated scenes.

Band	**DI_SCENE B (DI_{Theory} = 3)**		**Lp_SCENE C (Q=4)**		**Lp_SCENE D (Q=8)**	
[Hz]	**[dB]**		**[dB]**		**[dB]**	
	SPPS	**TCR**	**SPPS**	**TCR**	**SPPS**	**TCR**
50	2,45	0,42	5,18	0,78	7,97	1,38
63	2,56	0,42	5,27	0,78	8,08	1,38
80	2,61	0,42	5,31	0,78	8,13	1,38
100	2,52	0,42	5,28	0,78	8,09	1,38
125	2,37	0,42	5,18	0,78	7,99	1,38
160	2,40	0,42	5,22	0,78	7,99	1,38
200	2,52	0,42	5,24	0,78	8,07	1,38
250	2,57	0,42	5,32	0,78	8,10	1,38
315	2,54	0,42	5,26	0,78	8,08	1,38
400	2,41	0,42	5,26	0,78	8,01	1,38
500	2,50	0,42	5,25	0,78	8,05	1,38
630	2,43	0,42	5,16	0,78	7,96	1,38
800	2,56	0,42	5,31	0,78	8,09	1,38
1000	2,63	0,42	5,38	0,78	8,16	1,38
1250	2,59	0,42	5,34	0,78	8,12	1,38
1600	2,46	0,42	5,26	0,78	8,05	1,38
2000	2,60	0,42	5,32	0,78	8,17	1,38
2500	2,50	0,42	5,31	0,78	8,09	1,38
3150	2,42	0,42	5,22	0,78	8,01	1,38
4000	2,49	0,42	5,33	0,78	8,10	1,38
5000	2,52	0,42	5,25	0,78	8,04	1,38
6300	2,41	0,42	5,25	0,78	8,04	1,38
8000	2,29	0,42	5,17	0,78	7,95	1,38
10000	2,49	0,42	5,25	0,78	8,05	1,38
12500	2,52	0,42	5,29	0,78	8,07	1,38
16000	2,54	0,42	5,29	0,78	8,11	1,38
20000	2,59	0,42	5,33	0,78	8,10	1,38

D.3 Ventilation system as sound source in I-Simpa

Table D.6 Sound power level assigned to ventilation system grids.

	80 m³/h		120 m³/h		160 m³/h		200 m³/h		240 m³/h	
Band [Hz]	L_w^{grid} [dB]	L_{wA}^{grid} [dB(A)]	L_w^{grid} [dB]	L_{wA}^{grid} [dB(A)]	L_w^{grid} [dB]	L_{wA}^{grid} [dB(A)]	L_w^{grid} [dB]	L_{wA}^{grid} [dB(A)]	L_w^{grid} [dB]	L_{wA}^{grid} [dB(A)]
50	30,7	0,7	37,0	7,0	36,9	6,9	37,9	7,9	43,4	13,4
63	35,3	9,3	36,1	10,1	38,9	12,9	39,9	13,9	41,4	15,4
80	33,3	11,0	33,5	11,2	35,8	13,5	38,9	16,5	40,0	17,7
100	45,9	27,0	42,1	23,2	46,2	27,3	45,8	26,9	48,0	29,1
125	33,3	17,4	28,6	12,7	36,8	20,9	38,1	22,2	41,8	25,9
160	26,7	13,5	30,5	17,3	31,5	18,3	38,0	24,8	42,2	29,0
200	21,9	11,2	23,3	12,6	22,9	12,2	30,9	20,2	37,0	26,3
250	11,1	2,7	14,4	6,0	16,5	8,1	25,5	17,1	29,9	21,5
315	10,3	3,9	12,9	6,5	15,9	9,5	23,1	16,7	29,0	22,6
400	8,9	4,3	11,7	7,1	13,9	9,3	23,2	18,6	27,6	23,0
500	8,7	5,7	9,9	6,9	11,5	8,5	21,1	18,1	26,1	23,1
630	5,9	4,2	7,5	5,8	7,6	5,9	16,6	14,9	22,5	20,8
800	5,9	5,3	6,1	5,5	5,9	5,3	11,2	10,6	17,2	16,6
1000	4,8	5,0	5,5	5,7	5,4	5,6	11,8	12,0	17,0	17,2
1250	5,2	6,0	6,3	7,1	4,9	5,7	9,2	10,0	13,3	14,1
1600	5,3	6,5	7,4	8,6	5,5	6,7	8,0	9,2	12,1	13,3
2000	5,8	7,2	7,0	8,4	6,1	7,5	7,8	9,2	11,0	12,4
2500	6,5	8,0	8,0	9,5	6,7	8,2	7,7	9,2	9,6	11,1
3150	7,8	9,2	8,4	9,8	7,8	9,2	8,4	9,8	9,2	10,6
4000	8,4	9,6	8,7	9,9	8,4	9,6	8,7	9,9	9,1	10,3
5000	9,6	10,3	9,9	10,6	9,6	10,3	9,8	10,5	9,9	10,6
6300	10,9	11,0	11,0	11,1	10,9	11,0	11,0	11,1	10,9	11,0
8000	12,4	11,5	12,5	11,6	12,4	11,5	12,4	11,5	12,4	11,5
10000	14,5	12,2	14,6	12,3	14,5	12,2	14,5	12,2	14,5	12,2
Overall	46,2	28,5	42,7	26,4	46,8	29,4	47,3	31,7	50,1	35,5

Annex E

Acoustic Mapping of Laboratory Room

E.1 Preferred simulation stategy

Table E.1 Percentage difference between estimated sound absorption area $A_{measurement}$ and equivalent sound absorption area defined in I-Simpa.

Band	$A_{meas.}$	$A_{approx.}$	$\delta A_{approx.}$	$A_{liter.}$	$\delta A_{liter.}$	$A_{mod.}$	$\delta A_{mod.}$
[Hz]	[m^2]	[m^2]	[%]	[m^2]	[%]	[m^2]	[%]
50	9,52	9,88	3,84%	5,57	-41,50%	9,71	2,06%
63	11,34	11,53	1,71%	5,57	-50,89%	11,15	-1,61%
80	11,17	11,53	3,20%	5,57	-50,17%	11,13	-0,33%
100	8,67	9,06	4,53%	5,57	-35,76%	8,51	-1,84%
125	8,69	9,06	4,25%	5,57	-35,94%	8,51	-2,10%
160	6,03	5,76	-4,33%	5,57	-7,61%	6,21	3,13%
200	4,06	4,12	1,33%	7,08	74,22%	3,96	-2,51%
250	4,80	4,94	2,97%	7,08	47,53%	4,61	-3,97%
315	4,19	4,12	-1,76%	7,08	68,90%	3,96	-5,49%
400	4,44	4,12	-7,32%	3,43	-22,78%	4,72	6,34%
500	3,92	4,12	4,93%	3,43	-12,57%	4,08	3,92%
630	3,55	3,29	-7,09%	3,43	-3,24%	3,43	-3,24%
800	3,19	3,29	3,17%	2,39	-25,07%	3,26	1,96%
1000	3,27	3,29	0,80%	2,39	-26,79%	3,26	-0,39%
1250	3,68	3,29	-10,39%	2,39	-34,92%	3,86	5,08%
1600	4,08	4,12	1,02%	1,80	-55,72%	4,28	4,89%
2000	4,19	4,12	-1,82%	1,80	-56,97%	4,31	2,87%
2500	4,78	4,94	3,29%	1,80	-62,28%	4,71	-1,57%
3150	4,61	4,94	7,19%	2,38	-48,30%	4,73	2,55%
4000	4,22	4,12	-2,37%	2,38	-43,49%	4,15	-1,63%
5000	4,14	4,12	-0,66%	2,38	-42,50%	4,06	-2,01%
6300	4,52	4,12	-8,96%	2,38	-47,30%	4,67	3,22%
8000	3,58	3,29	-8,07%	2,38	-33,49%	3,77	5,10%
10000	3,39	3,29	-2,93%	2,38	-29,76%	3,29	-3,17%

Equivalent sound absorption area $A_{approximate}$

Table E.2 RT simulation results obtained applying equivalent sound absorption area $A_{approximate}$.

	Meas.	SPPS					TCR	
Band	RT_{avg}	RT_A	RT_C	RT_D	RT_{SPPS}	δRT_{SPPS}	RT_{TCR}	δRT_{SPPS}
[Hz]	[s]	[s]	[s]	[s]	[s]	[%]	[s]	[%]
50	0,83	0,85	0,83	0,83	0,839	1,03%	0,812	-2,14%
63	0,7	0,71	0,72	0,68	0,703	0,38%	0,696	-0,56%
80	0,71	0,71	0,71	0,71	0,709	-0,15%	0,696	-2,00%
100	0,910	0,90	0,91	0,90	0,905	-0,60%	0,88	-2,77%
125	0,907	0,90	0,93	0,92	0,915	0,91%	0,88	-2,50%
160	1,303	1,48	1,45	1,44	1,457	11,79%	1,38	6,18%
200	1,920	2,02	2,03	2,07	2,040	6,25%	1,93	0,30%
250	1,623	1,70	1,65	1,72	1,692	4,21%	1,60	-1,26%
315	1,847	2,00	1,98	1,99	1,989	7,73%	1,91	3,41%
400	1,737	2,03	1,99	1,98	1,998	15,07%	1,90	9,43%
500	1,950	2,02	2,05	2,03	2,032	4,21%	1,89	-3,01%
630	2,137	2,48	2,45	2,47	2,465	15,36%	2,33	9,03%
800	2,340	2,42	2,41	2,45	2,428	3,78%	2,31	-1,37%
1000	2,260	2,42	2,38	2,41	2,400	6,18%	2,28	0,87%
1250	1,990	2,35	2,35	2,32	2,342	17,70%	2,24	12,53%
1600	1,767	1,88	1,84	1,84	1,853	4,87%	1,78	0,59%
2000	1,663	1,77	1,78	1,79	1,780	7,02%	1,72	3,29%
2500	1,413	1,46	1,48	1,44	1,459	3,25%	1,40	-0,98%
3150	1,360	1,36	1,33	1,37	1,353	-0,53%	1,31	-3,63%
4000	1,310	1,34	1,35	1,38	1,357	3,59%	1,35	3,25%
5000	1,143	1,18	1,16	1,17	1,173	2,56%	1,17	2,45%
6300	0,903	0,96	0,95	0,97	0,960	6,24%	0,97	7,02%
8000	0,790	0,81	0,81	0,81	0,809	2,40%	0,82	4,15%
10000	0,607	0,61	0,62	0,60	0,612	0,81%	0,62	2,78%

Table E.3 RSS sound pressure level calculated with SPPS code and applying $A_{approximate}$.

	Meas.	**SPPS**					
Band	**Lp_avg**	**Lp_{V1}**	**Lp_{V2}**	**Lp_{V3}**	**Lp_{V4}**	**$Lp\_{(RSS)}$**	**$\delta Lp\_{(RSS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	70,9	73,5	73,5	73,5	73,5	73,5	3,65%
63	60,6	72,3	72,3	72,3	72,3	72,3	19,31%
80	62,5	71,8	71,8	71,8	71,8	71,8	14,91%
100	57,8	73,6	73,7	73,7	73,7	73,7	27,46%
125	65,0	72,6	72,6	72,6	72,6	72,6	11,72%
160	62,6	75,1	75,1	75,1	75,1	75,1	19,93%
200	71,4	77,1	77,1	77,1	77,1	77,1	8,04%
250	73,6	75,8	75,9	75,8	75,9	75,9	3,12%
315	74,1	76,8	76,7	76,7	76,8	76,8	3,58%
400	74,3	76,9	76,9	76,9	76,9	76,9	3,59%
500	75,3	77,1	77,1	77,1	77,1	77,1	2,40%
630	76,4	78,4	78,5	78,5	78,5	78,5	2,66%
800	78,3	79,9	79,9	79,9	79,9	79,9	2,09%
1000	79,2	80,8	80,8	80,7	80,8	80,8	1,92%
1250	80,5	82,3	82,3	82,3	82,3	82,3	2,22%
1600	80,8	81,6	81,6	81,6	81,6	81,6	1,03%
2000	80,6	81,7	81,6	81,7	81,7	81,7	1,27%
2500	78,5	78,8	78,8	78,8	78,8	78,8	0,33%
3150	77,3	78,0	78,0	78,0	78,0	78,0	0,97%
4000	77,1	78,0	78,1	78,1	78,1	78,1	1,29%
5000	75,5	76,5	76,5	76,5	76,5	76,5	1,26%
6300	73,5	74,6	74,5	74,5	74,6	74,6	1,44%
8000	70,4	71,9	71,9	71,9	72,0	71,9	2,20%
10000	66,3	68,5	68,6	68,6	68,6	68,6	3,38%

Table E.4 RSS sound pressure level calculated with TCR code and applying $A_{approximate}$.

	Meas.	**TCR**					
Band	**Lp_avg**	**Lp_{V1}**	**Lp_{V2}**	**Lp_{V3}**	**Lp_{V4}**	**$Lp\_{(RSS)}$**	**$\delta Lp\_{(RSS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	70,9	74,1	74,1	74,1	74,1	74,1	4,46%
63	60,6	73,0	73,0	73,0	73,0	73,0	20,51%
80	62,5	72,5	72,5	72,5	72,5	72,5	16,04%
100	57,8	74,2	74,2	74,2	74,2	74,2	28,42%
125	65,0	73,1	73,1	73,1	73,1	73,1	12,56%
160	62,6	75,4	75,4	75,4	75,4	75,4	20,43%
200	71,4	77,3	77,3	77,3	77,3	77,3	8,31%
250	73,6	76,1	76,1	76,1	76,1	76,1	3,48%
315	74,1	77,0	77,0	77,0	77,0	77,0	3,85%
400	74,3	77,1	77,1	77,1	77,1	77,1	3,89%
500	75,3	77,3	77,3	77,3	77,3	77,3	2,69%
630	76,4	78,6	78,6	78,6	78,6	78,6	2,86%
800	78,3	80,1	80,1	80,1	80,1	80,1	2,31%
1000	79,2	80,9	80,9	80,9	80,9	80,9	2,12%
1250	80,5	82,4	82,4	82,4	82,4	82,4	2,42%
1600	80,8	81,9	81,9	81,9	81,9	81,9	1,34%
2000	80,6	81,9	81,9	81,9	81,9	81,9	1,58%
2500	78,5	79,1	79,1	79,1	79,1	79,1	0,77%
3150	77,3	78,4	78,4	78,4	78,4	78,4	1,42%
4000	77,1	78,4	78,4	78,4	78,4	78,4	1,73%
5000	75,5	76,9	76,9	76,9	76,9	76,9	1,82%
6300	73,5	75,1	75,1	75,1	75,1	75,1	2,17%
8000	70,4	72,6	72,6	72,6	72,6	72,6	3,16%
10000	66,3	69,5	69,5	69,5	69,5	69,5	4,76%

Table E.5 Ventilation system (nominal flow rate 240m³/h) sound pressure level calculated with SPPS code and applying $A_{approximate}$.

	Meas.	**SPPS**				
Band	**Lp_avg**	**$Lp_{\_R1}$**	**$Lp_{\_R2}$**	**$Lp_{\_R3}$**	**$Lp_{\_(VS)}$**	**$\delta Lp_{\_(VS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	42,3	45,1	45,0	45,1	45,1	6,71%
63	29,7	42,4	42,3	42,4	42,3	42,50%
80	30,9	41,0	40,9	40,9	40,9	32,40%
100	33,0	50,1	50,1	50,2	50,1	51,94%
125	36,3	43,9	43,8	43,9	43,9	21,01%
160	33,9	46,5	46,4	46,5	46,5	36,92%
200	37,1	42,8	42,8	42,8	42,8	15,31%
250	32,6	34,9	34,8	34,9	34,9	6,84%
315	32,1	34,8	34,7	34,8	34,8	8,24%
400	30,7	33,3	33,3	33,3	33,3	8,58%
500	30,0	31,8	31,8	31,8	31,8	6,11%
630	27,0	29,2	29,1	29,2	29,2	7,88%
800	21,8	23,8	23,8	23,8	23,8	9,22%
1000	21,7	23,5	23,5	23,5	23,5	8,55%
1250	17,2	19,8	19,7	19,8	19,7	14,55%
1600	15,7	17,5	17,5	17,5	17,5	11,75%
2000	13,9	16,3	16,2	16,3	16,2	16,56%
2500	12,3	13,9	13,8	13,9	13,9	13,02%
3150	11,2	13,2	13,1	13,2	13,2	18,02%
4000	11,0	13,2	13,2	13,2	13,2	20,15%
5000	11,1	13,4	13,3	13,4	13,3	20,51%
6300	11,1	13,4	13,4	13,4	13,4	20,28%
8000	11,3	14,1	14,0	14,1	14,1	24,65%
10000	11,3	14,8	14,7	14,7	14,8	30,66%

Table E.6 Ventilation system (nominal flow rate 240m³/h) sound pressure level calculated with TCR code and applying $A_{approximate}$.

	Meas.	TCR				
Band	**Lp_avg**	**$Lp_{\_R1}$**	**$Lp_{\_R2}$**	**$Lp_{\_R3}$**	**$Lp_{\_(VS)}$**	**$\delta Lp_{\_(VS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	42,3	45,7	45,7	45,7	45,7	8,17%
63	29,7	43,1	43,0	43,1	43,1	44,91%
80	30,9	41,7	41,6	41,7	41,7	34,71%
100	33,0	50,7	50,7	50,7	50,7	53,56%
125	36,3	44,5	44,5	44,5	44,5	22,56%
160	33,9	46,8	46,8	46,8	46,8	37,81%
200	37,1	43,0	43,0	43,0	43,0	15,87%
250	32,6	35,1	35,1	35,1	35,1	7,58%
315	32,1	34,9	34,9	34,9	34,9	8,84%
400	30,7	33,5	33,5	33,5	33,5	9,26%
500	30,0	32,0	32,0	32,0	32,0	6,80%
630	27,0	29,3	29,3	29,3	29,3	8,42%
800	21,8	24,0	24,0	24,0	24,0	9,91%
1000	21,7	23,7	23,7	23,7	23,7	9,38%
1250	17,2	19,9	19,9	19,9	19,9	15,62%
1600	15,7	17,7	17,7	17,7	17,7	13,22%
2000	13,9	16,5	16,5	16,5	16,5	18,34%
2500	12,3	14,2	14,2	14,2	14,2	15,58%
3150	11,2	13,5	13,5	13,5	13,5	21,22%
4000	11,0	13,6	13,6	13,6	13,6	23,36%
5000	11,1	13,8	13,7	13,8	13,8	24,31%
6300	11,1	13,9	13,9	13,9	13,9	25,22%
8000	11,3	14,8	14,7	14,8	14,8	30,62%
10000	11,3	15,7	15,7	15,7	15,7	38,89%

Equivalent sound absorption area $A_{literature}$

Table E.7 RT simulation results obtained applying equivalent sound absorption area $A_{literature}$.

	Meas.	**SPPS**					**TCR**	
Band	**RT_{avg}**	**RT_A**	**RT_C**	**RT_D**	**RT_{SPPS}**	**δRT_{SPPS}**	**RT_{TCR}**	**δRT_{SPPS}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[%]**	**[s]**	**[%]**
50	0,83	1,50	1,46	1,54	1,500	80,78%	1,44	73,64%
63	0,7	1,54	1,55	1,50	1,532	118,79%	1,44	105,78%
80	0,71	1,46	1,48	1,45	1,464	106,14%	1,44	102,73%
100	0,910	1,49	1,47	1,49	1,481	62,79%	1,438	58,00%
125	0,907	1,50	1,49	1,52	1,503	65,76%	1,436	58,35%
160	1,303	1,45	1,45	1,45	1,448	11,08%	1,433	9,91%
200	1,920	1,10	1,10	1,11	1,104	-42,50%	1,126	-41,35%
250	1,623	1,09	1,15	1,14	1,124	-30,76%	1,123	-30,80%
315	1,847	1,08	1,10	1,11	1,097	-40,60%	1,120	-39,32%
400	1,737	2,30	2,33	2,33	2,319	33,56%	2,269	30,66%
500	1,950	2,26	2,30	2,25	2,272	16,53%	2,256	15,70%
630	2,137	2,25	2,32	2,27	2,280	6,69%	2,241	4,87%
800	2,340	3,20	3,25	3,25	3,234	38,19%	3,115	33,11%
1000	2,260	3,14	3,18	3,13	3,149	39,32%	3,064	35,56%
1250	1,990	3,01	3,08	3,07	3,052	53,36%	2,991	50,32%
1600	1,767	3,61	3,66	3,65	3,640	106,04%	3,640	106,03%
2000	1,663	3,50	3,48	3,46	3,482	109,31%	3,400	104,43%
2500	1,413	3,12	3,14	3,14	3,130	121,49%	3,086	118,34%
3150	1,360	2,32	2,24	2,27	2,275	67,25%	2,250	65,41%
4000	1,310	1,92	1,92	1,93	1,923	46,83%	1,910	45,83%
5000	1,143	1,54	1,54	1,54	1,543	34,94%	1,568	37,13%
6300	0,903	1,21	1,22	1,22	1,218	34,84%	1,222	35,25%
8000	0,790	0,89	0,87	0,87	0,877	11,00%	0,907	14,86%
10000	0,607	0,67	0,66	0,65	0,661	9,02%	0,671	10,60%

Table E.8 RSS sound pressure level calculated with SPPS code and applying $A_{literature}$.

	Meas.	SPPS					
Band	**Lp_avg**	**Lp_V1**	**Lp_V2**	**Lp_V3**	**Lp_V4**	**Lp_(RSS)**	**δLp_(RSS)**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	70,9	76,1	76,1	76,1	76,2	76,1	7,39%
63	60,6	75,7	75,7	75,7	75,7	75,7	24,96%
80	62,5	75,2	75,2	75,2	75,2	75,2	20,35%
100	57,8	75,9	75,9	75,9	75,9	75,9	31,37%
125	65,0	74,8	74,8	74,8	74,8	74,8	15,17%
160	62,6	75,2	75,2	75,2	75,2	75,2	20,12%
200	71,4	74,5	74,6	74,6	74,6	74,6	4,47%
250	73,6	74,1	74,2	74,1	74,1	74,1	0,80%
315	74,1	74,2	74,2	74,2	74,2	74,2	0,16%
400	74,3	77,7	77,7	77,7	77,7	77,7	4,62%
500	75,3	77,9	77,9	77,9	77,9	77,9	3,41%
630	76,4	78,3	78,2	78,3	78,2	78,2	2,37%
800	78,3	81,2	81,2	81,3	81,2	81,2	3,79%
1000	79,2	82,0	82,0	82,0	82,1	82,0	3,53%
1250	80,5	83,5	83,5	83,5	83,5	83,5	3,79%
1600	80,8	84,8	84,8	84,8	84,8	84,8	5,01%
2000	80,6	84,7	84,7	84,7	84,7	84,7	5,03%
2500	78,5	82,3	82,4	82,4	82,4	82,4	4,88%
3150	77,3	80,4	80,5	80,5	80,5	80,5	4,12%
4000	77,1	79,6	79,6	79,6	79,6	79,6	3,29%
5000	75,5	77,8	77,8	77,8	77,8	77,8	2,99%
6300	73,5	75,6	75,6	75,6	75,6	75,6	2,88%
8000	70,4	72,4	72,4	72,4	72,4	72,4	2,85%
10000	66,3	68,9	68,8	68,9	68,9	68,9	3,86%

Table E.9 RSS sound pressure level calculated with TCR code and applying $A_{literature}$.

	Meas.	**TCR**					
Band	**Lp_avg**	**Lp_{V1}**	**Lp_{V2}**	**Lp_{V3}**	**Lp_{V4}**	**$Lp\_{(RSS)}$**	**$\delta Lp\_{(RSS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	70,9	60,6	60,6	60,6	60,6	60,6	-14,54%
63	60,6	60,2	60,2	60,2	60,2	60,2	-0,67%
80	62,5	59,7	59,7	59,7	59,7	59,7	-4,49%
100	57,8	76,3	76,3	76,3	76,3	76,3	31,95%
125	65,0	75,2	75,2	75,2	75,2	75,2	15,69%
160	62,6	75,5	75,5	75,5	75,5	75,5	20,66%
200	71,4	75,0	75,0	75,0	75,0	75,0	5,13%
250	73,6	74,6	74,6	74,6	74,6	74,6	1,44%
315	74,1	74,7	74,7	74,7	74,7	74,7	0,81%
400	74,3	77,9	77,9	77,9	77,9	77,9	4,90%
500	75,3	78,1	78,1	78,1	78,1	78,1	3,69%
630	76,4	78,4	78,4	78,4	78,4	78,4	2,64%
800	78,3	81,4	81,4	81,4	81,4	81,4	3,95%
1000	79,2	82,2	82,2	82,2	82,2	82,2	3,71%
1250	80,5	83,7	83,7	83,7	83,7	83,7	3,96%
1600	80,8	84,9	84,9	84,9	84,9	84,9	5,14%
2000	80,6	84,8	84,8	84,8	84,8	84,8	5,20%
2500	78,5	82,5	82,5	82,5	82,5	82,5	5,06%
3150	77,3	80,7	80,7	80,7	80,7	80,7	4,39%
4000	77,1	79,9	79,9	79,9	79,9	79,9	3,63%
5000	75,5	78,1	78,1	78,1	78,1	78,1	3,45%
6300	73,5	76,1	76,1	76,1	76,1	76,1	3,51%
8000	70,4	73,0	73,0	73,0	73,0	73,0	3,74%
10000	66,3	69,8	69,8	69,8	69,8	69,8	5,21%

Table E.10 Ventilation system (nominal flow rate 240m^3/h) sound pressure level calculated with SPPS code and applying $A_{literature}$.

	Meas.	**SPPS**				
Band	**Lp_avg**	**Lp$_{_R1}$**	**Lp$_{_R2}$**	**Lp$_{_R3}$**	**Lp$_{_(VS)}$**	**δLp$_{_(VS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	42,3	47,8	47,7	47,8	47,8	13,07%
63	29,7	45,8	45,7	45,8	45,8	54,04%
80	30,9	44,4	44,3	44,4	44,4	43,50%
100	33,0	52,4	52,4	52,4	52,4	58,76%
125	36,3	46,2	46,1	46,2	46,2	27,29%
160	33,9	46,6	46,5	46,6	46,6	37,24%
200	37,1	40,3	40,2	40,2	40,2	8,45%
250	32,6	33,1	33,1	33,1	33,1	1,46%
315	32,1	32,2	32,1	32,2	32,2	0,24%
400	30,7	34,1	34,1	34,1	34,1	11,08%
500	30,0	32,6	32,6	32,6	32,6	8,69%
630	27,0	28,9	28,9	28,9	28,9	7,05%
800	21,8	25,1	25,1	25,2	25,1	15,31%
1000	21,7	24,9	24,8	24,9	24,9	14,67%
1250	17,2	21,0	21,0	21,1	21,0	22,05%
1600	15,7	20,7	20,7	20,7	20,7	32,31%
2000	13,9	19,3	19,3	19,3	19,3	38,60%
2500	12,3	17,5	17,5	17,5	17,5	42,19%
3150	11,2	15,6	15,6	15,6	15,6	40,01%
4000	11,0	14,8	14,8	14,8	14,8	34,52%
5000	11,1	14,7	14,6	14,7	14,7	32,59%
6300	11,1	14,5	14,5	14,5	14,5	30,24%
8000	11,3	14,6	14,5	14,6	14,5	28,75%
10000	11,3	15,2	15,1	15,2	15,1	33,93%

Table E.11 Ventilation system (nominal flow rate 240m^3/h) sound pressure level calculated with TCR code and applying $A_{literature}$.

	Meas.	**TCR**				
Band	**Lp_avg**	**$Lp_{\_R1}$**	**$Lp_{\_R2}$**	**$Lp_{\_R3}$**	**$Lp_{\_(VS)}$**	**$\delta Lp_{\_(VS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	42,3	48,1	48,1	48,1	48,1	13,90%
63	29,7	46,1	46,1	46,1	46,1	55,24%
80	30,9	44,7	44,7	44,7	44,7	44,63%
100	33,0	52,7	52,7	52,7	52,7	59,84%
125	36,3	46,5	46,5	46,5	46,5	28,26%
160	33,9	46,9	46,9	46,9	46,9	38,26%
200	37,1	40,7	40,7	40,7	40,7	9,70%
250	32,6	33,6	33,6	33,6	33,6	2,95%
315	32,1	32,7	32,7	32,7	32,7	1,77%
400	30,7	34,3	34,3	34,3	34,3	11,76%
500	30,0	32,8	32,8	32,8	32,8	9,34%
630	27,0	29,1	29,1	29,1	29,1	7,83%
800	21,8	25,3	25,3	25,3	25,3	15,86%
1000	21,7	25,0	25,0	25,0	25,0	15,27%
1250	17,2	21,2	21,2	21,2	21,2	22,88%
1600	15,7	20,8	20,8	20,8	20,8	32,94%
2000	13,9	19,4	19,4	19,4	19,4	39,44%
2500	12,3	17,6	17,6	17,6	17,6	43,22%
3150	11,2	15,9	15,9	15,9	15,9	41,99%
4000	11,0	15,1	15,0	15,1	15,1	36,85%
5000	11,1	15,0	15,0	15,0	15,0	35,61%
6300	11,1	14,9	14,9	14,9	14,9	34,21%
8000	11,3	15,2	15,2	15,2	15,2	34,33%
10000	11,3	16,0	16,0	16,0	16,0	41,66%

Equivalent sound absorption area $A_{modified}$

Table E. 12 RT simulation results obtained applying equivalent sound absorption area $A_{modified}$.

	Meas.	**SPPS**					**TCR**	
Band	**RT_{avg}**	**RT_A**	**RT_C**	**RT_D**	**RT_{SPPS}**	**δRT_{SPPS}**	**RT_{TCR}**	**δRT_{SPPS}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[%]**	**[s]**	**[%]**
50	0,83	0,81	0,82	0,83	0,822	-1,00%	0,826	-0,44%
63	0,7	0,70	0,72	0,71	0,708	1,08%	0,719	2,78%
80	0,71	0,70	0,69	0,73	0,708	-0,33%	0,720	1,47%
100	0,910	0,92	0,93	0,93	0,929	2,04%	0,942	3,51%
125	0,907	0,96	0,94	0,94	0,943	4,05%	0,941	3,79%
160	1,303	1,35	1,33	1,33	1,335	2,46%	1,284	-1,46%
200	1,920	2,03	2,07	2,03	2,042	6,33%	2,001	4,20%
250	1,623	1,75	1,76	1,74	1,748	7,70%	1,717	5,77%
315	1,847	1,99	1,95	1,95	1,964	6,37%	1,983	7,40%
400	1,737	1,69	1,70	1,73	1,706	-1,77%	1,662	-4,32%
500	1,950	1,99	1,94	1,96	1,965	0,79%	1,909	-2,10%
630	2,137	2,28	2,28	2,30	2,287	7,04%	2,241	4,87%
800	2,340	2,45	2,41	2,46	2,439	4,25%	2,334	-0,27%
1000	2,260	2,40	2,41	2,39	2,400	6,20%	2,305	1,98%
1250	1,990	1,96	2,00	2,01	1,991	0,04%	1,933	-2,88%
1600	1,767	1,86	1,81	1,85	1,838	4,06%	1,717	-2,80%
2000	1,663	1,71	1,69	1,70	1,701	2,26%	1,648	-0,90%
2500	1,413	1,53	1,57	1,53	1,543	9,20%	1,458	3,17%
3150	1,360	1,37	1,37	1,35	1,365	0,36%	1,358	-0,16%
4000	1,310	1,37	1,34	1,33	1,349	3,01%	1,345	2,70%
5000	1,143	1,17	1,15	1,18	1,169	2,27%	1,181	3,28%
6300	0,903	0,88	0,92	0,92	0,908	0,47%	0,907	0,36%
8000	0,790	0,77	0,77	0,78	0,775	-1,90%	0,785	-0,66%
10000	0,607	0,63	0,62	0,62	0,623	2,72%	0,624	2,84%

Table E.13 RSS sound pressure level calculated with SPPS code and applying $A_{modified}$.

	Meas.	**SPPS**					
Band	**Lp_avg**	**Lp_V1**	**Lp_V2**	**Lp_V3**	**Lp_V4**	**Lp_(RSS)**	**δLp_(RSS)**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	70,9	73,5	73,5	73,5	73,5	73,5	3,68%
63	60,6	72,4	72,5	72,5	72,5	72,5	19,57%
80	62,5	72,0	71,9	72,0	72,0	72,0	15,14%
100	57,8	73,9	73,9	74,0	74,0	74,0	27,96%
125	65,0	72,8	72,9	72,8	72,9	72,8	12,13%
160	62,6	74,7	74,7	74,7	74,7	74,7	19,33%
200	71,4	77,2	77,2	77,2	77,2	77,2	8,18%
250	73,6	76,1	76,1	76,1	76,1	76,1	3,48%
315	74,1	76,9	76,9	76,9	76,9	76,9	3,73%
400	74,3	76,3	76,3	76,3	76,3	76,3	2,71%
500	75,3	77,1	77,1	77,1	77,1	77,1	2,40%
630	76,4	78,2	78,2	78,2	78,2	78,2	2,35%
800	78,3	79,9	79,9	80,0	79,9	79,9	2,14%
1000	79,2	80,7	80,8	80,8	80,8	80,8	1,93%
1250	80,5	81,5	81,6	81,6	81,6	81,6	1,33%
1600	80,8	81,4	81,4	81,4	81,5	81,4	0,83%
2000	80,6	81,4	81,5	81,5	81,5	81,5	1,03%
2500	78,5	78,9	78,9	79,0	79,0	79,0	0,55%
3150	77,3	78,1	78,1	78,2	78,2	78,1	1,13%
4000	77,1	77,9	78,0	78,0	78,0	78,0	1,19%
5000	75,5	76,4	76,5	76,5	76,5	76,5	1,29%
6300	73,5	74,2	74,2	74,3	74,3	74,2	1,01%
8000	70,4	71,7	71,7	71,7	71,7	71,7	1,88%
10000	66,3	68,5	68,6	68,6	68,6	68,5	3,35%

Table E.14 RSS sound pressure level calculated with TCR code and applying $A_{modified}$.

	Meas.	TCR					
Band	**Lp_avg**	**Lp_V1**	**Lp_V2**	**Lp_V3**	**Lp_V4**	**Lp_(RSS)**	**δLp_(RSS)**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	70,9	74,1	74,1	74,1	74,1	74,1	4,56%
63	60,6	73,2	73,2	73,2	73,2	73,2	20,73%
80	62,5	72,7	72,7	72,7	72,7	72,7	16,27%
100	57,8	74,5	74,5	74,5	74,5	74,5	28,87%
125	65,0	73,4	73,4	73,4	73,4	73,4	12,96%
160	62,6	75,1	75,1	75,1	75,1	75,1	19,92%
200	71,4	77,5	77,5	77,5	77,5	77,5	8,54%
250	73,6	76,4	76,4	76,4	76,4	76,4	3,88%
315	74,1	77,1	77,1	77,1	77,1	77,1	4,07%
400	74,3	76,6	76,6	76,6	76,6	76,6	3,12%
500	75,3	77,4	77,4	77,4	77,4	77,4	2,75%
630	76,4	78,4	78,4	78,4	78,4	78,4	2,64%
800	78,3	80,1	80,1	80,1	80,1	80,1	2,37%
1000	79,2	81,0	81,0	81,0	81,0	81,0	2,18%
1250	80,5	81,8	81,8	81,8	81,8	81,8	1,64%
1600	80,8	81,7	81,7	81,7	81,7	81,7	1,16%
2000	80,6	81,7	81,7	81,7	81,7	81,7	1,36%
2500	78,5	79,3	79,3	79,3	79,3	79,3	0,99%
3150	77,3	78,5	78,5	78,5	78,5	78,5	1,62%
4000	77,1	78,4	78,4	78,4	78,4	78,4	1,70%
5000	75,5	76,9	76,9	76,9	76,9	76,9	1,87%
6300	73,5	74,8	74,8	74,8	74,8	74,8	1,81%
8000	70,4	72,4	72,4	72,4	72,4	72,4	2,88%
10000	66,3	69,5	69,5	69,5	69,5	69,5	4,77%

Table E. 15 Ventilation system (nominal flow rate 240m^3/h) sound pressure level calculated with SPPS code and applying $A_{modified}$.

	Meas.	**SPPS**				
Band	**Lp_avg**	**$Lp_{\_R1}$**	**$Lp_{\_R2}$**	**$Lp_{\_R3}$**	**$Lp_{\_(VS)}$**	**$\delta Lp_{\_(VS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	42,3	45,1	45,1	45,1	45,1	6,77%
63	29,7	42,4	42,3	42,5	42,4	42,76%
80	30,9	41,1	40,9	41,0	41,0	32,62%
100	33,0	50,4	50,3	50,4	50,4	52,68%
125	36,3	44,2	44,1	44,2	44,2	21,74%
160	33,9	46,1	46,0	46,1	46,1	35,72%
200	37,1	42,9	42,9	42,9	42,9	15,69%
250	32,6	35,1	35,1	35,1	35,1	7,58%
315	32,1	34,9	34,8	34,9	34,9	8,57%
400	30,7	32,7	32,6	32,7	32,7	6,46%
500	30,0	31,8	31,8	31,8	31,8	6,05%
630	27,0	28,9	28,9	28,9	28,9	7,05%
800	21,8	23,8	23,8	23,8	23,8	9,31%
1000	21,7	23,6	23,5	23,6	23,6	8,71%
1250	17,2	19,1	19,0	19,1	19,1	10,53%
1600	15,7	17,4	17,3	17,4	17,3	10,73%
2000	13,9	16,1	16,0	16,1	16,0	15,11%
2500	12,3	14,1	14,0	14,1	14,1	14,44%
3150	11,2	13,3	13,3	13,4	13,3	19,41%
4000	11,0	13,2	13,1	13,2	13,2	19,76%
5000	11,1	13,3	13,3	13,4	13,3	20,55%
6300	11,1	13,1	13,0	13,1	13,1	17,47%
8000	11,3	13,9	13,8	13,9	13,8	22,54%
10000	11,3	14,8	14,7	14,8	14,8	30,82%

Table E.16 Ventilation system (nominal flow rate 240m³/h) sound pressure level calculated with TCR code and applying $A_{modified}$.

	Meas.	TCR				
Band	**Lp_avg**	**$Lp_{\_R1}$**	**$Lp_{\_R2}$**	**$Lp_{\_R3}$**	**$Lp_{\_(VS)}$**	**$\delta Lp_{\_(VS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	42,3	45,8	45,8	45,8	45,8	8,34%
63	29,7	43,2	43,2	43,2	43,2	45,38%
80	30,9	41,8	41,8	41,8	41,8	35,18%
100	33,0	50,9	50,9	50,9	50,9	54,36%
125	36,3	44,7	44,7	44,7	44,7	23,29%
160	33,9	46,5	46,4	46,5	46,4	36,87%
200	37,1	43,1	43,1	43,1	43,1	16,31%
250	32,6	35,4	35,4	35,4	35,4	8,48%
315	32,1	35,1	35,1	35,1	35,1	9,35%
400	30,7	33,0	32,9	33,0	33,0	7,38%
500	30,0	32,0	32,0	32,0	32,0	6,93%
630	27,0	29,1	29,1	29,1	29,1	7,80%
800	21,8	24,0	24,0	24,0	24,0	10,13%
1000	21,7	23,8	23,7	23,8	23,8	9,59%
1250	17,2	19,3	19,3	19,3	19,3	11,95%
1600	15,7	17,6	17,6	17,6	17,6	12,28%
2000	13,9	16,3	16,3	16,3	16,3	17,06%
2500	12,3	14,4	14,4	14,4	14,4	17,00%
3150	11,2	13,7	13,7	13,7	13,7	22,57%
4000	11,0	13,6	13,5	13,6	13,5	23,15%
5000	11,1	13,8	13,8	13,8	13,8	24,62%
6300	11,1	13,7	13,7	13,7	13,7	22,78%
8000	11,3	14,6	14,5	14,6	14,6	28,86%
10000	11,3	15,7	15,7	15,7	15,7	38,91%

Table E.17 RSS sound pressure level (direct field) calculated with SPPS code and applying $A_{modified}$.

	Meas.	SPPS					
Band	**Lp_avg**	**Lp_{V1}**	**Lp_{V2}**	**Lp_{V3}**	**Lp_{V4}**	**$Lp\_{(RSS)}$**	**$\delta Lp\_{(RSS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	70,9	60,5	60,5	60,7	60,6	60,6	-14,53%
63	60,6	60,2	60,3	60,1	60,2	60,2	-0,67%
80	62,5	59,7	59,7	59,7	59,8	59,7	-4,47%
100	57,8	60,4	60,3	60,4	60,3	60,3	4,39%
125	65,0	59,3	59,2	59,3	59,4	59,3	-8,68%
160	62,6	59,8	59,8	59,6	59,9	59,8	-4,53%

Table E.18 RSS sound pressure level (direct field) calculated with TCR code and applying $A_{modified}$.

	Meas.	TCR					
Band	**Lp_avg**	**Lp_{V1}**	**Lp_{V2}**	**Lp_{V3}**	**Lp_{V4}**	**$Lp\_{(RSS)}$**	**$\delta Lp\_{(RSS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	70,9	60,6	60,6	60,6	60,6	60,6	-14,54%
63	60,6	60,2	60,2	60,2	60,2	60,2	-0,67%
80	62,5	59,7	59,7	59,7	59,7	59,7	-4,49%
100	57,8	60,4	60,4	60,4	60,4	60,4	4,50%
125	65,0	59,3	59,3	59,3	59,3	59,3	-8,72%
160	62,6	59,7	59,7	59,7	59,7	59,7	-4,66%

Table E.19 Ventilation system (nominal flow rate 240m³/h) sound pressure level (direct field) calculated with SPPS code and applying $A_{modified}$.

	Meas.	SPPS				
Band	**Lp_avg**	**$Lp_{\_R1}$**	**$Lp_{\_R2}$**	**$Lp_{\_R3}$**	**$Lp_{\_(VS)}$**	**$\delta Lp_{\_(VS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	42,3	30,6	29,9	29,9	30,1	-28,68%
63	29,7	28,5	27,6	27,6	27,9	-6,03%
80	30,9	27,3	26,3	26,3	26,7	-13,74%
100	33,0	35,1	34,4	34,4	34,7	5,12%
125	36,3	29,1	28,4	28,4	28,6	-21,08%
160	33,9	29,2	28,7	28,7	28,9	-14,91%

Table E.20 Ventilation system (nominal flow rate 240m³/h) sound pressure level (direct field) calculated with TCR code and applying $A_{modified}$.

	Meas.	SPPS				
Band	**Lp_avg**	**$Lp_{\_R1}$**	**$Lp_{\_R2}$**	**$Lp_{\_R3}$**	**$Lp_{\_(VS)}$**	**$\delta Lp_{\_(VS)}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[%]**
50	42,3	30,5	29,8	30,5	30,3	-28,36%
63	29,7	28,5	27,8	28,5	28,3	-4,85%
80	30,9	27,1	26,4	27,1	26,9	-13,10%
100	33,0	35,1	34,4	35,1	34,9	5,69%
125	36,3	28,9	28,2	28,9	28,7	-20,97%
160	33,9	29,3	28,6	29,3	29,1	-14,34%

E.2 Criteria for simulation results acceptability

Table E.21 Reverberation time average percentage difference and confidence interval. Simulations with SPPS code and applying $A_{modified}$.

	Simulation_1			Simulation_2			Simulation_3			δ_{RT}	Dev. Std	Err. Std.	t	I.C. 95%
Band	δ_{RT_A}	δ_{RT_C}	δ_{RT_D}	δ_{RT_A}	δ_{RT_C}	δ_{RT_D}	δ_{RT_A}	δ_{RT_C}	δ_{RT_D}					
[Hz]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]
50	-0,01	-	-0,01	-0,03	-	-0,05	-0,01	-	-0,02	-0,02	0,01	0,01	2,57	0,02
63	-0,29	1,12	-0,07	-0,28	1,04	-0,07	-0,27	1,11	-0,07	0,25	0,60	0,20	2,31	0,46
80	-0,10	0,50	-0,17	-0,11	0,49	-0,20	-0,08	0,56	-0,20	0,08	0,31	0,10	2,31	0,24
100	-0,05	0,15	-0,02	-0,01	0,19	0,02	-0,05	0,17	-0,01	0,04	0,09	0,03	2,31	0,07
125	0,08	0,15	-0,07	0,05	0,12	-0,08	0,08	0,13	-0,04	0,05	0,08	0,03	2,31	0,06
160	0,05	0,06	-0,04	0,02	0,05	-0,03	0,05	0,05	-0,05	0,02	0,04	0,01	2,31	0,03
200	0,32	0,60	-0,31	0,33	0,58	-0,30	0,33	0,57	-0,31	0,20	0,37	0,12	2,31	0,29
250	0,04	0,16	0,05	0,02	0,14	0,04	0,04	0,16	0,04	0,08	0,06	0,02	2,31	0,04
315	0,09	0,20	-0,06	0,09	0,23	-0,04	0,12	0,23	-0,04	0,09	0,11	0,04	2,31	0,08
400	-0,06	0,06	-0,05	-0,08	0,05	-0,08	-0,04	0,03	-0,08	-0,03	0,05	0,02	2,31	0,04
500	-0,02	0,11	-0,06	-0,04	0,13	-0,06	-0,04	0,11	-0,06	0,01	0,08	0,03	2,31	0,06
630	0,05	0,17	0,00	0,04	0,16	-0,01	0,05	0,17	0,01	0,07	0,07	0,02	2,31	0,05
800	-0,05	0,22	0,00	-0,05	0,23	-0,02	-0,06	0,25	-0,01	0,06	0,13	0,04	2,31	0,10
1000	0,08	0,09	0,02	0,09	0,08	0,01	0,07	0,08	0,01	0,06	0,03	0,01	2,31	0,03
1250	0,01	0,04	-0,05	0,03	0,03	-0,07	0,01	0,02	-0,06	0,00	0,04	0,01	2,31	0,03
1600	0,13	0,02	-0,02	0,08	0,00	-0,05	0,10	-0,01	-0,05	0,02	0,06	0,02	2,31	0,05
2000	0,17	0,13	0,17	0,16	0,13	0,16	0,16	0,13	0,16	0,15	0,02	0,01	2,31	0,01
2500	0,15	0,14	0,15	0,14	0,14	0,15	0,14	0,14	0,15	0,14	0,00	0,00	2,31	0,00
3150	0,19	0,19	0,21	0,19	0,19	0,20	0,19	0,19	0,20	0,19	0,01	0,00	2,31	0,01
4000	0,19	0,19	0,21	0,19	0,20	0,21	0,19	0,20	0,21	0,20	0,01	0,00	2,31	0,01
5000	0,20	0,21	0,21	0,20	0,21	0,21	0,20	0,21	0,21	0,21	0,00	0,00	2,31	0,00
6300	0,17	0,17	0,18	0,17	0,18	0,18	0,17	0,18	0,18	0,18	0,01	0,00	2,31	0,00
8000	0,23	0,22	0,23	0,23	0,22	0,23	0,23	0,22	0,23	0,23	0,00	0,00	2,31	0,00
10000	0,31	0,30	0,31	0,31	0,30	0,31	0,31	0,30	0,32	0,31	0,00	0,00	2,31	0,00

Table E.22 RSS sound pressure level average percentage difference and confidence interval. Simulations with SPPS code and applying $A_{modified}$.

	Simulation_1				**Simulation_2**				δ_{Lp}	**D.std**	**E.std**	**t**	**I.C.**
Band	δ_{Lp_V1}	δ_{Lp_V2}	δ_{Lp_V3}	δ_{Lp_V4}	δ_{Lp_V1}	δ_{Lp_V2}	δ_{Lp_V3}	δ_{Lp_V4}				**(Stud)**	**95%**
[Hz]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]
50	0,00	0,07	0,02	0,07	0,00	0,07	0,02	0,07	0,04	0,031	0,011	2,37	0,026
63	0,18	0,19	0,20	0,19	0,18	0,19	0,19	0,19	0,19	0,006	0,002	2,37	0,005
80	0,15	0,13	0,15	0,17	0,14	0,13	0,17	0,17	0,15	0,014	0,005	2,37	0,012
100	0,29	0,25	0,30	0,27	0,29	0,25	0,27	0,27	0,27	0,017	0,006	2,37	0,014
125	0,11	0,12	0,13	0,11	0,11	0,12	0,11	0,11	0,12	0,005	0,002	2,37	0,004
160	0,19	0,19	0,20	0,18	0,19	0,19	0,18	0,18	0,19	0,006	0,002	2,37	0,005
200	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,003	0,001	2,37	0,002
250	0,03	0,03	0,03	0,04	0,03	0,03	0,04	0,04	0,03	0,005	0,002	2,37	0,005
315	0,03	0,04	0,04	0,04	0,03	0,04	0,04	0,04	0,04	0,006	0,002	2,37	0,005
400	0,03	0,02	0,03	0,03	0,03	0,02	0,02	0,02	0,02	0,005	0,002	2,37	0,004
500	0,02	0,02	0,02	0,03	0,02	0,02	0,03	0,03	0,02	0,003	0,001	2,37	0,003
630	0,02	0,02	0,02	0,03	0,02	0,02	0,03	0,03	0,02	0,005	0,002	2,37	0,004
800	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,001	0,000	2,37	0,001
1000	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,001	0,000	2,37	0,001
1250	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,001	0,001	2,37	0,001
1600	0,00	0,01	0,00	0,01	0,00	0,01	0,01	0,01	0,01	0,004	0,001	2,37	0,003
2000	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,001	0,000	2,37	0,001
2500	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,001	0,000	2,37	0,001
3150	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,002	0,001	2,37	0,001
4000	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,001	0,000	2,37	0,001
5000	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,002	0,001	2,37	0,002
6300	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,002	0,001	2,37	0,001
8000	0,02	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,002	0,001	2,37	0,002
10000	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,002	0,001	2,37	0,001

Table E.23 Ventilation system sound pressure level (nominal flow rate 240 m^3/h) average percentage difference and confidence interval. Simulations with SPPS code and applying $A_{modified}$.

	Simulation_1			**Simulation_2**			**Simulation_3**			**δ_{Lp}**	**Dev. Std**	**Err. Std.**	**t**	**I.C. 95%**
Band	**δ_{Lp_1}**	**δ_{Lp_2}**	**δ_{Lp_3}**	**δ_{Lp_1}**	**δ_{Lp_2}**	**δ_{Lp_3}**	**δ_{Lp_1}**	**δ_{Lp_2}**	**δ_{Lp_3}**					
[Hz]	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**	**[-]**
50	0,11	0,26	-0,01	0,11	0,26	-0,01	0,11	0,26	-0,01	0,12	0,11	0,04	2,31	0,09
63	0,39	0,39	0,56	0,39	0,39	0,55	0,39	0,39	0,56	0,44	0,08	0,03	2,31	0,06
80	0,36	0,22	0,60	0,36	0,22	0,60	0,36	0,22	0,60	0,39	0,16	0,05	2,31	0,12
100	0,56	0,53	0,50	0,56	0,53	0,50	0,55	0,53	0,50	0,53	0,02	0,01	2,31	0,02
125	0,18	0,26	0,22	0,18	0,26	0,22	0,18	0,26	0,22	0,22	0,03	0,01	2,31	0,02
160	0,35	0,36	0,36	0,35	0,37	0,36	0,35	0,37	0,36	0,36	0,01	0,00	2,31	0,00
200	0,17	0,22	0,11	0,17	0,21	0,11	0,17	0,21	0,11	0,17	0,04	0,01	2,31	0,03
250	0,10	0,08	0,05	0,10	0,08	0,05	0,10	0,08	0,05	0,08	0,02	0,01	2,31	0,02
315	0,10	0,07	0,09	0,10	0,08	0,09	0,10	0,08	0,09	0,09	0,01	0,00	2,31	0,01
400	0,09	0,05	0,06	0,09	0,05	0,06	0,09	0,05	0,06	0,07	0,01	0,00	2,31	0,01
500	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,00	0,00	2,31	0,00
630	0,09	0,05	0,07	0,09	0,05	0,08	0,09	0,05	0,08	0,07	0,02	0,01	2,31	0,01
800	0,11	0,11	0,06	0,11	0,11	0,06	0,11	0,11	0,06	0,09	0,03	0,01	2,31	0,02
1000	0,11	0,08	0,08	0,11	0,08	0,08	0,11	0,08	0,08	0,09	0,01	0,00	2,31	0,01
1250	0,12	0,09	0,11	0,12	0,09	0,11	0,12	0,09	0,11	0,11	0,01	0,00	2,31	0,01
1600	0,12	0,10	0,11	0,11	0,10	0,11	0,11	0,10	0,11	0,11	0,00	0,00	2,31	0,00
2000	0,17	0,13	0,17	0,16	0,13	0,16	0,16	0,13	0,16	0,15	0,02	0,01	2,31	0,01
2500	0,15	0,14	0,15	0,14	0,14	0,15	0,14	0,14	0,15	0,14	0,00	0,00	2,31	0,00
3150	0,19	0,19	0,21	0,19	0,19	0,20	0,19	0,19	0,20	0,19	0,01	0,00	2,31	0,01
4000	0,19	0,19	0,21	0,19	0,20	0,21	0,19	0,20	0,21	0,20	0,01	0,00	2,31	0,01
5000	0,20	0,21	0,21	0,20	0,21	0,21	0,20	0,21	0,21	0,21	0,00	0,00	2,31	0,00
6300	0,17	0,17	0,18	0,17	0,18	0,18	0,17	0,18	0,18	0,18	0,01	0,00	2,31	0,00
8000	0,23	0,22	0,23	0,23	0,22	0,23	0,23	0,22	0,23	0,23	0,00	0,00	2,31	0,00
10000	0,31	0,30	0,31	0,31	0,30	0,31	0,31	0,30	0,32	0,31	0,00	0,00	2,31	0,00

Table E.24 RSS sound pressure level average percentage difference and confidence interval. Simulations with SPPS code (only direct field) and applying $A_{modified}$.

		50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz
Simulation 1	δ_{Lp_V1} [-]	-0,17462	-0,01634	-0,04936	0,054101	-0,09188	-0,04777
	δ_{Lp_V2} [-]	-0,11808	-0,00822	-0,06132	0,022034	-0,09342	-0,04928
	δ_{Lp_V3} [-]	-0,15577	-0,00166	-0,04327	0,061511	-0,07919	-0,04026
	δ_{Lp_V4} [-]	-0,11533	-0,01149	-0,03079	0,034305	-0,09174	-0,05222
Simulation 2	δ_{Lp_V1} [-]	-0,17226	-0,01814	-0,04909	0,053653	-0,0937	-0,04996
	δ_{Lp_V2} [-]	-0,11508	-0,00713	-0,06199	0,025069	-0,09054	-0,04897
	δ_{Lp_V3} [-]	-0,15583	-0,01136	-0,03309	0,036359	-0,09	-0,0555
	δ_{Lp_V4} [-]	-0,11319	-0,0125	-0,03149	0,036222	-0,09065	-0,05543
Simulation 3	δ_{Lp_V1} [-]	-0,17437	-0,01586	-0,0486	0,054534	-0,09258	-0,04877
	δ_{Lp_V2} [-]	-0,11591	-0,00732	-0,06218	0,025128	-0,09295	-0,05213
	δ_{Lp_V3} [-]	-0,15908	-0,00052	-0,04288	0,06081	-0,07854	-0,03734
	δ_{Lp_V4} [-]	-0,11405	-0,01107	-0,03218	0,037159	-0,09371	-0,05541
Simulation 4	δ_{Lp_V1} [-]	-0,17417	-0,01433	-0,0467	0,055483	-0,09273	-0,04965
	δ_{Lp_V2} [-]	-0,11519	-0,0105	-0,06298	0,024907	-0,08947	-0,05222
	δ_{Lp_V3} [-]	-0,1558	-0,00064	-0,04496	0,062733	-0,07675	-0,04001
	δ_{Lp_V4} [-]	-0,11389	-0,01213	-0,03412	0,037213	-0,09086	-0,05671
δ_{Lp} [-]		-0,14016	-0,00995	-0,04594	0,042576	-0,08929	-0,04948
Dev. Std [-]		0,025837	0,005252	0,011256	0,014171	0,005512	0,005631
Err. Std. [-]		0,006459	0,001313	0,002814	0,003543	0,001378	0,001408
t- Student [-]		2,131	2,131	2,131	2,131	2,131	2,131
I.C. 95% [-]		0,013764	0,002798	0,005997	0,00755	0,002937	0,003

Table E.25 Ventilation system sound pressure level (nominal flow rate 240 m^3/h) average percentage difference and confidence interval. Simulations with SPPS code (only direct field) and applying $A_{modified}$.

		50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz
Simulation 1	δ_{Lp_R1} [-]	-0,24444	-0,06863	-0,09603	0,083333	-0,22193	-0,1437
	δ_{Lp_R2} [-]	-0,16246	-0,09508	-0,21726	0,045593	-0,18857	-0,14837
	δ_{Lp_R3} [-]	-0,34286	0,010989	0,023346	0,02381	-0,2133	-0,15588
Simulation 2	δ_{Lp_R1} [-]	-0,24906	-0,07104	-0,09788	0,086865	-0,2248	-0,1358
	δ_{Lp_R2} [-]	-0,1607	-0,08916	-0,21493	0,046442	-0,20102	-0,15649
	δ_{Lp_R3} [-]	-0,32824	0,037881	0,054916	0,047347	-0,19876	-0,13988
Simulation 3	δ_{Lp_R1} [-]	-0,25002	-0,06586	-0,10092	0,085947	-0,22933	-0,13749
	δ_{Lp_R2} [-]	-0,16345	-0,09137	-0,2086	0,0446	-0,19719	-0,15406
	δ_{Lp_R3} [-]	-0,33387	0,04493	0,060954	0,043437	-0,2024	-0,13781
Simulation 4	δ_{Lp_R1} [-]	-0,25139	-0,06767	-0,10281	0,083907	-0,22546	-0,13936
	δ_{Lp_R2} [-]	-0,16877	-0,09533	-0,21712	0,040729	-0,19638	-0,15779
	δ_{Lp_R3} [-]	-0,32823	0,041089	0,054728	0,044601	-0,19974	-0,13681
Simulation 5	δ_{Lp_R1} [-]	-0,24735	-0,06514	-0,099	0,090325	-0,22429	-0,14193
	δ_{Lp_R2} [-]	-0,16704	-0,08634	-0,21215	0,048313	-0,19322	-0,15368
	δ_{Lp_R3} [-]	-0,14887	-0,05728	-0,1926	0,069942	-0,16977	-0,12926
Simulation 6	δ_{Lp_R1} [-]	-0,24685	-0,06992	-0,10783	0,084378	-0,22645	-0,13745
	δ_{Lp_R2} [-]	-0,16451	-0,08765	-0,2178	0,040595	-0,19415	-0,1527
	δ_{Lp_R3} [-]	-0,14385	-0,0639	-0,1901	0,06574	-0,17193	-0,12953
δ_{Lp} [-]		-0,22789	-0,05219	-0,11562	0,059772	-0,20437	-0,14378
Dev. Std [-]		0,06854	0,047703	0,100106	0,020616	0,017746	0,009093
Err. Std. [-]		0,016155	0,011244	0,023595	0,004859	0,004183	0,002143
t- Student [-]		2,11	2,11	2,11	2,11	2,11	2,11
I.C. 95% [-]		0,034087	0,023724	0,049786	0,010253	0,008826	0,004522

*Table E.26 Summary of the average percentage difference and confidence intervals calculated by applying **SPPS code (total sound field)** and $A_{modified}$.*

Band	δRT_{min}	δRT	δRT_{max}	δLp_{min}	$\delta Lp_{(RSS)}$	δLp_{max}	δLp_{min}	$\delta Lp_{(VS)}$	δLp_{max}
[Hz]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
50	-3,86%	-2,30%	-0,73%	1,65%	4,23%	6,80%	3,77%	12,27%	20,78%
63	-21,63%	24,74%	71,12%	18,54%	19,05%	19,56%	38,28%	44,37%	50,46%
80	-16,29%	7,81%	31,92%	13,89%	15,09%	16,28%	27,16%	39,15%	51,13%
100	-2,71%	4,41%	11,54%	26,00%	27,39%	28,78%	51,08%	52,81%	54,53%
125	-1,66%	4,67%	10,99%	11,26%	11,69%	12,12%	19,74%	22,21%	24,68%
160	-1,31%	1,90%	5,10%	18,26%	18,79%	19,33%	35,27%	35,72%	36,17%
200	-8,55%	20,27%	49,10%	7,64%	7,86%	8,09%	13,20%	16,55%	19,89%
250	3,34%	7,63%	11,92%	3,01%	3,46%	3,92%	6,05%	7,82%	9,60%
315	0,73%	9,16%	17,58%	3,12%	3,62%	4,13%	7,92%	8,61%	9,30%
400	-6,83%	-2,63%	1,58%	2,04%	2,44%	2,85%	5,37%	6,51%	7,65%
500	-5,09%	0,95%	7,00%	2,04%	2,30%	2,55%	5,87%	6,12%	6,37%
630	1,81%	7,12%	12,44%	1,91%	2,30%	2,69%	5,72%	7,12%	8,52%
800	-4,13%	5,62%	15,37%	1,86%	1,94%	2,03%	7,53%	9,49%	11,44%
1000	3,25%	5,88%	8,51%	1,65%	1,75%	1,86%	7,75%	8,79%	9,84%
1250	-3,53%	-0,40%	2,74%	1,07%	1,19%	1,32%	9,51%	10,62%	11,74%
1600	-2,42%	2,27%	6,96%	0,45%	0,75%	1,06%	10,39%	10,74%	11,10%
2000	-0,23%	2,19%	4,62%	0,72%	0,82%	0,91%	13,82%	15,19%	16,55%
2500	4,75%	9,14%	13,53%	0,28%	0,35%	0,42%	14,12%	14,36%	14,60%
3150	-3,71%	1,14%	5,99%	0,78%	0,93%	1,07%	18,71%	19,30%	19,89%
4000	-0,03%	3,42%	6,86%	0,90%	0,99%	1,07%	19,07%	19,81%	20,56%
5000	0,43%	3,13%	5,83%	0,87%	1,06%	1,24%	20,32%	20,62%	20,93%
6300	-4,30%	-0,69%	2,91%	0,68%	0,82%	0,96%	17,12%	17,51%	17,90%
8000	-6,20%	-3,13%	-0,06%	1,49%	1,67%	1,85%	22,28%	22,64%	23,00%
10000	-0,29%	1,95%	4,19%	3,05%	3,20%	3,35%	30,45%	30,81%	31,17%

Table E.27 Summary of the average percentage difference calculated by applying ***TCR code (total sound field)*** *and $A_{modified}$.*

Band	δRT_{max}	δRT_{saf}	$\pm\delta RT$	δLp_{max}	δLp_{saf}	$\pm\delta Lp_{(RSS)}$	δLp_{max}	$\delta Lp_{saf.}$	$\pm\delta Lp_{(VS)}$
[Hz]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
50	3,79%	5%	8,79%	28,87%	5%	33,87%	54,36%	5%	59,36%
63	3,79%	5%	8,79%	28,87%	5%	33,87%	54,36%	5%	59,36%
80	3,79%	5%	8,79%	28,87%	5%	33,87%	54,36%	5%	59,36%
100	3,79%	5%	8,79%	28,87%	5%	33,87%	54,36%	5%	59,36%
125	3,79%	5%	8,79%	28,87%	5%	33,87%	54,36%	5%	59,36%
160	3,79%	5%	8,79%	28,87%	5%	33,87%	54,36%	5%	59,36%
200	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
250	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
315	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
400	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
500	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
630	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
800	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
1000	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
1250	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
1600	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
2000	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
2500	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
3150	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
4000	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
5000	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
6300	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
8000	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%
10000	4,87%	5%	9,87%	8,54%	5%	13,54%	16,31%	5%	21,31%

Table E.28 Summary of the average percentage difference and confidence intervals calculated by applying ***SPPS code (direct sound field for f < 200Hz)*** *and $A_{modified}$.*

Band	δLp_{min}	δ$Lp_{(RSS)}$	δLp_{max}	δLp_{min}	δ$Lp_{(VS)}$	δLp_{max}
[Hz]	[%]	[%]	[%]	[%]	[%]	[%]
50	-15,39%	-14,02%	-12,64%	-26,20%	-22,79%	-19,38%
63	-1,30%	-1,00%	-0,69%	-7,59%	-5,22%	-2,85%
80	-5,24%	-4,59%	-3,94%	-16,54%	-11,56%	-6,58%
100	3,44%	4,26%	5,07%	4,95%	5,98%	7,00%
125	-9,25%	-8,93%	-8,61%	-21,32%	-20,44%	-19,55%
160	-5,27%	-4,95%	-4,62%	-14,83%	-14,38%	-13,93%
200	7,64%	7,86%	8,09%	13,20%	16,55%	19,89%
250	3,01%	3,46%	3,92%	6,05%	7,82%	9,60%
315	3,12%	3,62%	4,13%	7,92%	8,61%	9,30%
400	2,04%	2,44%	2,85%	5,37%	6,51%	7,65%
500	2,04%	2,30%	2,55%	5,87%	6,12%	6,37%
630	1,91%	2,30%	2,69%	5,72%	7,12%	8,52%
800	1,86%	1,94%	2,03%	7,53%	9,49%	11,44%
1000	1,65%	1,75%	1,86%	7,75%	8,79%	9,84%
1250	1,07%	1,19%	1,32%	9,51%	10,62%	11,74%
1600	0,45%	0,75%	1,06%	10,39%	10,74%	11,10%
2000	0,72%	0,82%	0,91%	13,82%	15,19%	16,55%
2500	0,28%	0,35%	0,42%	14,12%	14,36%	14,60%
3150	0,78%	0,93%	1,07%	18,71%	19,30%	19,89%
4000	0,90%	0,99%	1,07%	19,07%	19,81%	20,56%
5000	0,87%	1,06%	1,24%	20,32%	20,62%	20,93%
6300	0,68%	0,82%	0,96%	17,12%	17,51%	17,90%
8000	1,49%	1,67%	1,85%	22,28%	22,64%	23,00%
10000	3,05%	3,20%	3,35%	30,45%	30,81%	31,17%

Table E.29 Summary of the average percentage difference calculated by applying ***TCR code (direct sound field)*** *and* $A_{modified}$.

Band	**δLp$_{max}$**	**δLp$_{saf}$**	**±δLp$_{(RSS)}$**	**δLp$_{max}$**	**δLp$_{saf.}$**	**±δLp$_{(VS)}$**
[Hz]	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
50	14,54%	5%	19,54%	28,36%	5%	33,36%
63	14,54%	5%	19,54%	28,36%	5%	33,36%
80	14,54%	5%	19,54%	28,36%	5%	33,36%
100	14,54%	5%	19,54%	28,36%	5%	33,36%
125	14,54%	5%	19,54%	28,36%	5%	33,36%
160	14,54%	5%	19,54%	28,36%	5%	33,36%
200	8,54%	5%	13,54%	16,31%	5%	21,31%
250	8,54%	5%	13,54%	16,31%	5%	21,31%
315	8,54%	5%	13,54%	16,31%	5%	21,31%
400	8,54%	5%	13,54%	16,31%	5%	21,31%
500	8,54%	5%	13,54%	16,31%	5%	21,31%
630	8,54%	5%	13,54%	16,31%	5%	21,31%
800	8,54%	5%	13,54%	16,31%	5%	21,31%
1000	8,54%	5%	13,54%	16,31%	5%	21,31%
1250	8,54%	5%	13,54%	16,31%	5%	21,31%
1600	8,54%	5%	13,54%	16,31%	5%	21,31%
2000	8,54%	5%	13,54%	16,31%	5%	21,31%
2500	8,54%	5%	13,54%	16,31%	5%	21,31%
3150	8,54%	5%	13,54%	16,31%	5%	21,31%
4000	8,54%	5%	13,54%	16,31%	5%	21,31%
5000	8,54%	5%	13,54%	16,31%	5%	21,31%
6300	8,54%	5%	13,54%	16,31%	5%	21,31%
8000	8,54%	5%	13,54%	16,31%	5%	21,31%
10000	8,54%	5%	13,54%	16,31%	5%	21,31%

E.3 Acoustic mapping of laboratory CORE-CARE

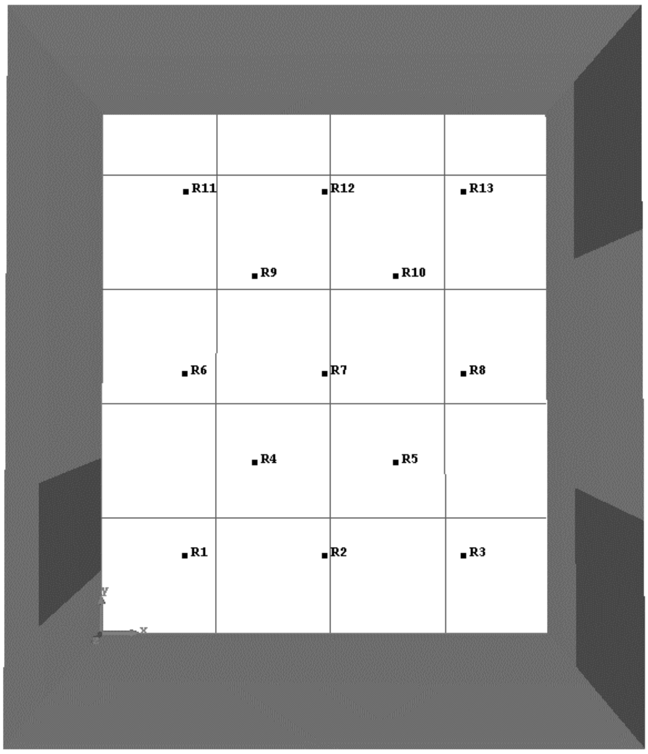


Figure E.1 Receivers disposition for acoustical mapping of laboratory room.

Table E.30 Coordinates of receivers defined for acoustical mapping of laboratory room

Receiver	Direction x [m]	Direction y [m]	Direction z [m]
R_1	0,9	0,9	1,3
R_2	1,945	0,9	1,3
R_3	2,99	0,9	1,3
R_4	1,42	1,6	1,3
R_5	2,48	1,6	1,3
R_6	0,9	2,27	1,3
R_7	1,945	2,27	1,3
R_8	2,99	2,27	1,3
R_9	1,42	3	1,3
R_10	2,48	3	1,3
R_11	0,9	3,64	1,3
R_12	1,945	3,64	1,3
R_13	2,99	3,64	1,3

Table E.31 Simulated reverberation time and corresponding measurement data for point R1.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,789	0,807	0,821	0,795	0,826	0,754	0,899
63	0,711	0,570	0,907	0,416	0,719	0,656	0,783
80	0,690	0,640	0,824	0,523	0,720	0,657	0,784
100	0,952	0,912	0,978	0,853	0,942	0,859	1,025
125	0,952	0,910	0,968	0,858	0,941	0,858	1,024
160	1,324	1,300	1,342	1,260	1,284	1,171	1,397
200	2,055	1,709	2,247	1,378	2,001	1,803	2,198
250	1,734	1,611	1,678	1,549	1,717	1,547	1,886
315	2,021	1,852	2,006	1,719	1,983	1,788	2,179
400	1,714	1,760	1,839	1,687	1,662	1,498	1,826
500	1,942	1,924	2,046	1,815	1,909	1,721	2,098
630	2,284	2,132	2,243	2,031	2,241	2,020	2,462
800	2,406	2,278	2,509	2,085	2,334	2,103	2,564
1000	2,414	2,280	2,338	2,225	2,305	2,077	2,532
1250	1,958	1,966	2,029	1,906	1,933	1,742	2,123
1600	1,808	1,768	1,853	1,690	1,717	1,548	1,887
2000	1,711	1,674	1,715	1,635	1,648	1,486	1,811
2500	1,531	1,403	1,461	1,348	1,458	1,314	1,602
3150	1,363	1,348	1,416	1,286	1,358	1,224	1,492
4000	1,345	1,300	1,345	1,258	1,345	1,213	1,478
5000	1,184	1,148	1,178	1,118	1,181	1,064	1,297
6300	0,885	0,892	0,925	0,860	0,907	0,817	0,996
8000	0,774	0,799	0,825	0,775	0,785	0,707	0,862
10000	0,613	0,601	0,615	0,588	0,624	0,562	0,685

Table E.32 Simulated reverberation time and corresponding measurement data for point R2.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,825	0,844	0,858	0,831	0,826	0,754	0,899
63	0,688	0,551	0,878	0,402	0,719	0,656	0,783
80	0,697	0,647	0,833	0,528	0,720	0,657	0,784
100	0,915	0,876	0,940	0,820	0,942	0,859	1,025
125	0,945	0,903	0,961	0,852	0,941	0,858	1,024
160	1,295	1,270	1,312	1,232	1,284	1,171	1,397
200	2,039	1,695	2,230	1,368	2,001	1,803	2,198
250	1,731	1,608	1,675	1,546	1,717	1,547	1,886
315	2,013	1,844	1,998	1,712	1,983	1,788	2,179
400	1,663	1,708	1,785	1,637	1,662	1,498	1,826
500	1,927	1,909	2,031	1,801	1,909	1,721	2,098
630	2,289	2,137	2,248	2,035	2,241	2,020	2,462
800	2,383	2,256	2,486	2,066	2,334	2,103	2,564
1000	2,421	2,287	2,345	2,231	2,305	2,077	2,532
1250	1,963	1,971	2,035	1,911	1,933	1,742	2,123
1600	1,794	1,755	1,839	1,678	1,717	1,548	1,887
2000	1,705	1,668	1,709	1,629	1,648	1,486	1,811
2500	1,539	1,410	1,469	1,355	1,458	1,314	1,602
3150	1,376	1,360	1,429	1,298	1,358	1,224	1,492
4000	1,367	1,322	1,368	1,280	1,345	1,213	1,478
5000	1,189	1,152	1,183	1,123	1,181	1,064	1,297
6300	0,881	0,887	0,921	0,856	0,907	0,817	0,996
8000	0,781	0,806	0,832	0,781	0,785	0,707	0,862
10000	0,630	0,618	0,632	0,605	0,624	0,562	0,685

Table E.33 Simulated reverberation time and corresponding measurement data for point R3.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,808	0,827	0,840	0,814	0,826	0,754	0,899
63	0,718	0,575	0,916	0,419	0,719	0,656	0,783
80	0,710	0,659	0,848	0,538	0,720	0,657	0,784
100	0,921	0,882	0,947	0,826	0,942	0,859	1,025
125	0,945	0,903	0,961	0,852	0,941	0,858	1,024
160	1,309	1,285	1,326	1,246	1,284	1,171	1,397
200	2,016	1,676	2,205	1,352	2,001	1,803	2,198
250	1,784	1,657	1,726	1,594	1,717	1,547	1,886
315	2,029	1,859	2,014	1,726	1,983	1,788	2,179
400	1,682	1,728	1,806	1,656	1,662	1,498	1,826
500	1,919	1,901	2,022	1,793	1,909	1,721	2,098
630	2,261	2,111	2,221	2,011	2,241	2,020	2,462
800	2,384	2,257	2,487	2,067	2,334	2,103	2,564
1000	2,406	2,273	2,331	2,218	2,305	2,077	2,532
1250	1,970	1,978	2,042	1,918	1,933	1,742	2,123
1600	1,787	1,747	1,831	1,671	1,717	1,548	1,887
2000	1,697	1,661	1,701	1,622	1,648	1,486	1,811
2500	1,511	1,384	1,442	1,331	1,458	1,314	1,602
3150	1,361	1,345	1,413	1,284	1,358	1,224	1,492
4000	1,383	1,337	1,383	1,294	1,345	1,213	1,478
5000	1,181	1,145	1,176	1,116	1,181	1,064	1,297
6300	0,904	0,910	0,945	0,878	0,907	0,817	0,996
8000	0,780	0,805	0,832	0,781	0,785	0,707	0,862
10000	0,607	0,596	0,609	0,583	0,624	0,562	0,685

Table E.34 Simulated reverberation time and corresponding measurement data for point R4.

	SPPS				TCR		
Band	$RT_{simul.}$	$RT_{meas.}$	RT_{lower}	RT_{upper}	$RT_{simul.}$	RT_{lower}	RT_{upper}
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,810	0,829	0,843	0,816	0,826	0,754	0,899
63	0,716	0,574	0,914	0,419	0,719	0,656	0,783
80	0,695	0,644	0,830	0,526	0,720	0,657	0,784
100	0,949	0,909	0,975	0,851	0,942	0,859	1,025
125	0,957	0,915	0,973	0,863	0,941	0,858	1,024
160	1,337	1,312	1,355	1,272	1,284	1,171	1,397
200	2,020	1,680	2,209	1,355	2,001	1,803	2,198
250	1,751	1,627	1,695	1,565	1,717	1,547	1,886
315	2,028	1,858	2,014	1,725	1,983	1,788	2,179
400	1,673	1,718	1,796	1,647	1,662	1,498	1,826
500	1,932	1,914	2,035	1,805	1,909	1,721	2,098
630	2,289	2,136	2,248	2,035	2,241	2,020	2,462
800	2,394	2,267	2,497	2,075	2,334	2,103	2,564
1000	2,399	2,266	2,324	2,211	2,305	2,077	2,532
1250	1,978	1,986	2,050	1,925	1,933	1,742	2,123
1600	1,787	1,748	1,832	1,671	1,717	1,548	1,887
2000	1,728	1,691	1,732	1,652	1,648	1,486	1,811
2500	1,524	1,396	1,455	1,342	1,458	1,314	1,602
3150	1,365	1,350	1,418	1,288	1,358	1,224	1,492
4000	1,374	1,329	1,374	1,286	1,345	1,213	1,478
5000	1,199	1,163	1,194	1,133	1,181	1,064	1,297
6300	0,891	0,897	0,931	0,865	0,907	0,817	0,996
8000	0,763	0,788	0,814	0,764	0,785	0,707	0,862
10000	0,608	0,596	0,610	0,584	0,624	0,562	0,685

Table E.35 Simulated reverberation time and corresponding measurement data for point R5.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,805	0,824	0,837	0,811	0,826	0,754	0,899
63	0,712	0,571	0,909	0,416	0,719	0,656	0,783
80	0,703	0,652	0,840	0,533	0,720	0,657	0,784
100	0,951	0,911	0,978	0,853	0,942	0,859	1,025
125	0,942	0,900	0,958	0,849	0,941	0,858	1,024
160	1,291	1,267	1,308	1,228	1,284	1,171	1,397
200	2,023	1,682	2,212	1,357	2,001	1,803	2,198
250	1,753	1,628	1,696	1,566	1,717	1,547	1,886
315	2,026	1,856	2,011	1,723	1,983	1,788	2,179
400	1,671	1,716	1,794	1,645	1,662	1,498	1,826
500	1,942	1,924	2,046	1,815	1,909	1,721	2,098
630	2,278	2,126	2,237	2,026	2,241	2,020	2,462
800	2,395	2,268	2,498	2,076	2,334	2,103	2,564
1000	2,443	2,307	2,366	2,251	2,305	2,077	2,532
1250	1,976	1,984	2,048	1,923	1,933	1,742	2,123
1600	1,826	1,786	1,871	1,707	1,717	1,548	1,887
2000	1,735	1,698	1,739	1,658	1,648	1,486	1,811
2500	1,537	1,408	1,467	1,354	1,458	1,314	1,602
3150	1,376	1,360	1,429	1,298	1,358	1,224	1,492
4000	1,345	1,301	1,346	1,259	1,345	1,213	1,478
5000	1,177	1,142	1,172	1,112	1,181	1,064	1,297
6300	0,883	0,889	0,923	0,858	0,907	0,817	0,996
8000	0,780	0,805	0,832	0,781	0,785	0,707	0,862
10000	0,613	0,602	0,615	0,589	0,624	0,562	0,685

Table E.36 Simulated reverberation time and corresponding measurement data for point R6.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,815	0,834	0,847	0,821	0,826	0,754	0,899
63	0,700	0,561	0,893	0,409	0,719	0,656	0,783
80	0,704	0,653	0,841	0,534	0,720	0,657	0,784
100	0,934	0,895	0,960	0,837	0,942	0,859	1,025
125	0,935	0,893	0,950	0,842	0,941	0,858	1,024
160	1,339	1,314	1,357	1,274	1,284	1,171	1,397
200	2,035	1,692	2,226	1,365	2,001	1,803	2,198
250	1,722	1,600	1,667	1,539	1,717	1,547	1,886
315	1,991	1,824	1,977	1,693	1,983	1,788	2,179
400	1,704	1,750	1,829	1,677	1,662	1,498	1,826
500	1,947	1,929	2,052	1,820	1,909	1,721	2,098
630	2,285	2,134	2,245	2,033	2,241	2,020	2,462
800	2,367	2,241	2,469	2,052	2,334	2,103	2,564
1000	2,419	2,285	2,343	2,230	2,305	2,077	2,532
1250	1,971	1,979	2,043	1,919	1,933	1,742	2,123
1600	1,784	1,744	1,828	1,668	1,717	1,548	1,887
2000	1,712	1,675	1,716	1,636	1,648	1,486	1,811
2500	1,528	1,400	1,458	1,345	1,458	1,314	1,602
3150	1,368	1,352	1,420	1,290	1,358	1,224	1,492
4000	1,332	1,287	1,332	1,246	1,345	1,213	1,478
5000	1,194	1,158	1,189	1,128	1,181	1,064	1,297
6300	0,898	0,904	0,939	0,873	0,907	0,817	0,996
8000	0,788	0,814	0,840	0,789	0,785	0,707	0,862
10000	0,615	0,604	0,617	0,591	0,624	0,562	0,685

Table E.37 Simulated reverberation time and corresponding measurement data for point R7.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,819	0,838	0,852	0,825	0,826	0,754	0,899
63	0,718	0,576	0,916	0,420	0,719	0,656	0,783
80	0,690	0,640	0,824	0,523	0,720	0,657	0,784
100	0,949	0,909	0,975	0,851	0,942	0,859	1,025
125	0,946	0,904	0,962	0,852	0,941	0,858	1,024
160	1,337	1,312	1,355	1,273	1,284	1,171	1,397
200	2,033	1,691	2,223	1,364	2,001	1,803	2,198
250	1,723	1,601	1,667	1,540	1,717	1,547	1,886
315	1,985	1,819	1,971	1,689	1,983	1,788	2,179
400	1,655	1,699	1,776	1,629	1,662	1,498	1,826
500	1,932	1,914	2,036	1,806	1,909	1,721	2,098
630	2,282	2,131	2,242	2,030	2,241	2,020	2,462
800	2,414	2,286	2,518	2,093	2,334	2,103	2,564
1000	2,378	2,246	2,303	2,191	2,305	2,077	2,532
1250	1,967	1,975	2,039	1,914	1,933	1,742	2,123
1600	1,806	1,766	1,851	1,688	1,717	1,548	1,887
2000	1,737	1,700	1,741	1,661	1,648	1,486	1,811
2500	1,523	1,396	1,454	1,342	1,458	1,314	1,602
3150	1,389	1,373	1,442	1,310	1,358	1,224	1,492
4000	1,332	1,288	1,332	1,246	1,345	1,213	1,478
5000	1,188	1,152	1,182	1,122	1,181	1,064	1,297
6300	0,903	0,909	0,943	0,877	0,907	0,817	0,996
8000	0,779	0,804	0,831	0,780	0,785	0,707	0,862
10000	0,618	0,606	0,620	0,593	0,624	0,562	0,685

Table E.38 Simulated reverberation time and corresponding measurement data for point R8.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,800	0,819	0,833	0,806	0,826	0,754	0,899
63	0,722	0,579	0,921	0,422	0,719	0,656	0,783
80	0,703	0,652	0,839	0,533	0,720	0,657	0,784
100	0,916	0,877	0,941	0,821	0,942	0,859	1,025
125	0,933	0,891	0,948	0,840	0,941	0,858	1,024
160	1,329	1,305	1,347	1,265	1,284	1,171	1,397
200	2,056	1,710	2,249	1,379	2,001	1,803	2,198
250	1,730	1,608	1,674	1,546	1,717	1,547	1,886
315	2,017	1,848	2,002	1,715	1,983	1,788	2,179
400	1,688	1,733	1,811	1,661	1,662	1,498	1,826
500	1,937	1,919	2,041	1,810	1,909	1,721	2,098
630	2,287	2,135	2,246	2,034	2,241	2,020	2,462
800	2,391	2,264	2,494	2,072	2,334	2,103	2,564
1000	2,393	2,260	2,318	2,206	2,305	2,077	2,532
1250	1,968	1,976	2,040	1,916	1,933	1,742	2,123
1600	1,810	1,770	1,855	1,692	1,717	1,548	1,887
2000	1,724	1,687	1,728	1,648	1,648	1,486	1,811
2500	1,522	1,394	1,453	1,340	1,458	1,314	1,602
3150	1,386	1,370	1,439	1,308	1,358	1,224	1,492
4000	1,364	1,319	1,364	1,276	1,345	1,213	1,478
5000	1,182	1,147	1,177	1,117	1,181	1,064	1,297
6300	0,895	0,901	0,935	0,869	0,907	0,817	0,996
8000	0,778	0,803	0,829	0,778	0,785	0,707	0,862
10000	0,626	0,614	0,628	0,601	0,624	0,562	0,685

Table E.39 Simulated reverberation time and corresponding measurement data for point R9.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,824	0,844	0,858	0,831	0,826	0,754	0,899
63	0,713	0,572	0,910	0,417	0,719	0,656	0,783
80	0,708	0,656	0,845	0,536	0,720	0,657	0,784
100	0,954	0,913	0,980	0,855	0,942	0,859	1,025
125	0,963	0,920	0,980	0,868	0,941	0,858	1,024
160	1,294	1,270	1,311	1,231	1,284	1,171	1,397
200	2,046	1,701	2,237	1,372	2,001	1,803	2,198
250	1,705	1,584	1,650	1,523	1,717	1,547	1,886
315	2,024	1,854	2,009	1,721	1,983	1,788	2,179
400	1,691	1,737	1,815	1,665	1,662	1,498	1,826
500	1,920	1,902	2,023	1,794	1,909	1,721	2,098
630	2,270	2,119	2,230	2,019	2,241	2,020	2,462
800	2,401	2,273	2,504	2,081	2,334	2,103	2,564
1000	2,399	2,266	2,324	2,211	2,305	2,077	2,532
1250	1,955	1,963	2,026	1,903	1,933	1,742	2,123
1600	1,804	1,764	1,849	1,686	1,717	1,548	1,887
2000	1,704	1,668	1,708	1,629	1,648	1,486	1,811
2500	1,499	1,374	1,431	1,320	1,458	1,314	1,602
3150	1,356	1,341	1,408	1,279	1,358	1,224	1,492
4000	1,371	1,326	1,372	1,283	1,345	1,213	1,478
5000	1,190	1,154	1,185	1,125	1,181	1,064	1,297
6300	0,900	0,906	0,940	0,875	0,907	0,817	0,996
8000	0,783	0,808	0,835	0,783	0,785	0,707	0,862
10000	0,632	0,620	0,633	0,606	0,624	0,562	0,685

Table E.40 Simulated reverberation time and corresponding measurement data for point R10.

	SPPS				TCR		
Band	$RT_{simul.}$	$RT_{meas.}$	RT_{lower}	RT_{upper}	$RT_{simul.}$	RT_{lower}	RT_{upper}
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,804	0,823	0,836	0,810	0,826	0,754	0,899
63	0,698	0,560	0,891	0,408	0,719	0,656	0,783
80	0,715	0,663	0,854	0,542	0,720	0,657	0,784
100	0,940	0,900	0,966	0,843	0,942	0,859	1,025
125	0,944	0,902	0,960	0,850	0,941	0,858	1,024
160	1,316	1,292	1,334	1,253	1,284	1,171	1,397
200	2,000	1,663	2,187	1,341	2,001	1,803	2,198
250	1,710	1,589	1,655	1,528	1,717	1,547	1,886
315	2,019	1,850	2,005	1,717	1,983	1,788	2,179
400	1,679	1,725	1,802	1,653	1,662	1,498	1,826
500	1,956	1,938	2,061	1,828	1,909	1,721	2,098
630	2,268	2,117	2,227	2,017	2,241	2,020	2,462
800	2,418	2,290	2,523	2,096	2,334	2,103	2,564
1000	2,384	2,252	2,309	2,197	2,305	2,077	2,532
1250	1,947	1,955	2,018	1,895	1,933	1,742	2,123
1600	1,801	1,761	1,846	1,684	1,717	1,548	1,887
2000	1,735	1,698	1,739	1,658	1,648	1,486	1,811
2500	1,516	1,389	1,447	1,335	1,458	1,314	1,602
3150	1,351	1,336	1,403	1,275	1,358	1,224	1,492
4000	1,353	1,308	1,353	1,266	1,345	1,213	1,478
5000	1,203	1,166	1,198	1,137	1,181	1,064	1,297
6300	0,912	0,919	0,953	0,886	0,907	0,817	0,996
8000	0,777	0,802	0,828	0,777	0,785	0,707	0,862
10000	0,631	0,619	0,633	0,606	0,624	0,562	0,685

Table E.41 Simulated reverberation time and corresponding measurement data for point R11.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,822	0,841	0,855	0,828	0,826	0,754	0,899
63	0,691	0,554	0,881	0,404	0,719	0,656	0,783
80	0,707	0,656	0,845	0,536	0,720	0,657	0,784
100	0,956	0,915	0,982	0,857	0,942	0,859	1,025
125	0,939	0,898	0,955	0,846	0,941	0,858	1,024
160	1,351	1,326	1,369	1,286	1,284	1,171	1,397
200	2,020	1,679	2,209	1,355	2,001	1,803	2,198
250	1,713	1,592	1,658	1,531	1,717	1,547	1,886
315	2,035	1,864	2,020	1,731	1,983	1,788	2,179
400	1,691	1,737	1,815	1,665	1,662	1,498	1,826
500	1,925	1,906	2,028	1,799	1,909	1,721	2,098
630	2,261	2,111	2,221	2,011	2,241	2,020	2,462
800	2,408	2,280	2,512	2,087	2,334	2,103	2,564
1000	2,401	2,267	2,325	2,212	2,305	2,077	2,532
1250	1,997	2,005	2,070	1,944	1,933	1,742	2,123
1600	1,797	1,757	1,841	1,680	1,717	1,548	1,887
2000	1,697	1,661	1,701	1,622	1,648	1,486	1,811
2500	1,495	1,370	1,427	1,317	1,458	1,314	1,602
3150	1,354	1,338	1,406	1,277	1,358	1,224	1,492
4000	1,383	1,337	1,383	1,294	1,345	1,213	1,478
5000	1,214	1,177	1,208	1,147	1,181	1,064	1,297
6300	0,902	0,908	0,943	0,877	0,907	0,817	0,996
8000	0,780	0,805	0,832	0,780	0,785	0,707	0,862
10000	0,604	0,592	0,606	0,580	0,624	0,562	0,685

Table E.42 Simulated reverberation time and corresponding measurement data for point R12.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,829	0,848	0,862	0,835	0,826	0,754	0,899
63	0,696	0,558	0,889	0,407	0,719	0,656	0,783
80	0,698	0,647	0,834	0,529	0,720	0,657	0,784
100	0,973	0,932	1,000	0,872	0,942	0,859	1,025
125	0,962	0,919	0,978	0,867	0,941	0,858	1,024
160	1,296	1,272	1,313	1,233	1,284	1,171	1,397
200	2,028	1,686	2,218	1,360	2,001	1,803	2,198
250	1,734	1,611	1,678	1,549	1,717	1,547	1,886
315	2,052	1,880	2,037	1,745	1,983	1,788	2,179
400	1,666	1,711	1,788	1,640	1,662	1,498	1,826
500	1,960	1,942	2,066	1,832	1,909	1,721	2,098
630	2,240	2,091	2,200	1,992	2,241	2,020	2,462
800	2,401	2,273	2,504	2,081	2,334	2,103	2,564
1000	2,388	2,255	2,312	2,200	2,305	2,077	2,532
1250	1,951	1,959	2,022	1,899	1,933	1,742	2,123
1600	1,780	1,740	1,824	1,664	1,717	1,548	1,887
2000	1,750	1,712	1,754	1,673	1,648	1,486	1,811
2500	1,514	1,387	1,446	1,334	1,458	1,314	1,602
3150	1,363	1,348	1,416	1,286	1,358	1,224	1,492
4000	1,342	1,298	1,343	1,256	1,345	1,213	1,478
5000	1,193	1,157	1,188	1,127	1,181	1,064	1,297
6300	0,898	0,905	0,939	0,873	0,907	0,817	0,996
8000	0,777	0,802	0,828	0,777	0,785	0,707	0,862
10000	0,593	0,581	0,594	0,569	0,624	0,562	0,685

Table E.43 Simulated reverberation time and corresponding measurement data for point R13.

	SPPS				TCR		
Band	**$RT_{simul.}$**	**$RT_{meas.}$**	**RT_{lower}**	**RT_{upper}**	**$RT_{simul.}$**	**RT_{lower}**	**RT_{upper}**
[Hz]	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**	**[s]**
50	0,826	0,845	0,859	0,832	0,826	0,754	0,899
63	0,698	0,559	0,890	0,408	0,719	0,656	0,783
80	0,697	0,646	0,832	0,528	0,720	0,657	0,784
100	0,944	0,904	0,970	0,846	0,942	0,859	1,025
125	0,915	0,874	0,930	0,824	0,941	0,858	1,024
160	1,318	1,294	1,336	1,254	1,284	1,171	1,397
200	2,007	1,669	2,195	1,346	2,001	1,803	2,198
250	1,721	1,599	1,665	1,537	1,717	1,547	1,886
315	2,003	1,835	1,988	1,703	1,983	1,788	2,179
400	1,678	1,724	1,801	1,652	1,662	1,498	1,826
500	1,936	1,917	2,039	1,809	1,909	1,721	2,098
630	2,253	2,103	2,213	2,003	2,241	2,020	2,462
800	2,409	2,281	2,513	2,088	2,334	2,103	2,564
1000	2,453	2,317	2,376	2,261	2,305	2,077	2,532
1250	1,954	1,962	2,026	1,902	1,933	1,742	2,123
1600	1,766	1,727	1,810	1,652	1,717	1,548	1,887
2000	1,742	1,705	1,746	1,665	1,648	1,486	1,811
2500	1,526	1,398	1,456	1,344	1,458	1,314	1,602
3150	1,381	1,366	1,434	1,303	1,358	1,224	1,492
4000	1,361	1,316	1,361	1,273	1,345	1,213	1,478
5000	1,198	1,162	1,193	1,132	1,181	1,064	1,297
6300	0,893	0,899	0,933	0,867	0,907	0,817	0,996
8000	0,772	0,797	0,823	0,773	0,785	0,707	0,862
10000	0,618	0,607	0,620	0,594	0,624	0,562	0,685

Table E.44 Simulated ventilation system sound pressure level and corresponding measurement data for point R1. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								**TCR**					
	Total sound field				**Direct field (for f<200Hz)**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,3	43,6	37,4	31,2	40,4	42,3	38,7	45,8	18,6	73	31,1	20,7	49,6
63	42,5	29,5	30,8	28,3	29,3	30,9	31,7	30,2	43,2	17,6	68,9	29,1	19,4	46,4
80	41,2	29,6	32,4	27,3	27,8	31,4	33,3	29,8	41,8	17	66,7	27,7	18,5	44,1
100	50,5	33,0	33,4	32,7	35,8	33,8	34,1	33,4	51	20,7	81,2	35,7	23,8	56,9
125	44,3	36,2	37,0	35,5	29,6	37,2	37,6	36,8	44,8	18,2	71,3	29,5	19,7	47,0
160	46,1	34,0	34,1	33,9	30,0	35,1	35,3	34,9	46,5	18,9	74	29,9	19,9	47,6
200	43,0	36,9	37,9	35,8	43,0	36,9	37,9	35,8	43,2	34	52,4	43,2	34	52,4
250	35,2	32,6	33,2	32,1	35,2	32,6	33,2	32,1	35,4	27,9	42,9	35,4	27,9	42,9
315	34,9	32,2	32,4	32,0	34,9	32,2	32,4	32,0	35,1	27,6	42,6	35,1	27,6	42,6
400	32,7	30,7	31,0	30,4	32,7	30,7	31,0	30,4	33	25,9	40	33	25,9	40,0
500	31,8	30,0	30,1	29,9	31,8	30,0	30,1	29,9	32,1	25,2	38,9	32,1	25,2	38,9
630	29,0	27,0	27,4	26,7	29,0	27,0	27,4	26,7	29,1	22,9	35,4	29,1	22,9	35,3
800	23,9	21,8	22,2	21,4	23,9	21,8	22,2	21,4	24	18,9	29,1	24	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,3	17,5	17,1	19,1	17,3	17,5	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,4	15,7	15,7	15,6	17,4	15,7	15,7	15,6	17,6	13,9	21,4	17,6	13,9	21,4
2000	16,1	14,0	14,1	13,8	16,1	14,0	14,1	13,8	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,1	12,3	12,3	12,3	14,1	12,3	12,3	12,3	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,4	11,2	11,3	11,2	13,4	11,2	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,2	11,1	11,1	11,0	13,2	11,1	11,1	11,0	13,6	10,7	16,5	13,6	10,7	16,5
5000	13,4	11,1	11,1	11,1	13,4	11,1	11,1	11,1	13,8	10,9	16,8	13,8	10,9	16,7
6300	13,2	11,2	11,3	11,2	13,2	11,2	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
8000	14,0	11,4	11,5	11,4	14,0	11,4	11,5	11,4	14,6	11,5	17,7	14,6	11,5	17,7
10000	14,9	11,4	11,5	11,4	14,9	11,4	11,5	11,4	15,7	12,4	19,1	15,7	12,4	19,0
Over.	54,4	45,1	46,9	43,9	46,0	45,6	46,6	44,7	54,9	37,3	83,1	46,1	37,5	60,0

Table E.45 Simulated ventilation system sound pressure level and corresponding measurement data for point R2. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								TCR					
	Total sound field				Direct field (for f<200Hz)				Total sound field			Direct field		
Band	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,3	40,3	43,6	37,5	31,3	40,6	42,4	38,9	45,8	18,6	73	31,4	20,9	50,0
63	42,6	29,5	30,8	28,3	29,3	30,9	31,7	30,2	43,2	17,6	68,9	29,4	19,6	46,9
80	41,2	29,6	32,4	27,3	28,0	31,7	33,6	30,0	41,8	17	66,7	28	18,6	44,6
100	50,5	33,1	33,4	32,7	36,0	33,9	34,3	33,6	51	20,7	81,2	36	24	57,4
125	44,3	36,2	37,0	35,5	29,7	37,4	37,8	36,9	44,8	18,2	71,3	29,8	19,8	47,5
160	46,2	34,0	34,1	33,9	30,2	35,3	35,4	35,1	46,5	18,9	74,1	30,2	20,1	48,1
200	43,0	36,9	38,0	35,8	43,0	36,9	38,0	35,8	43,2	34	52,4	43,2	34	52,4
250	35,2	32,6	33,2	32,1	35,2	32,6	33,2	32,1	35,4	27,9	43	35,4	27,9	42,9
315	34,9	32,2	32,4	32,0	34,9	32,2	32,4	32,0	35,1	27,6	42,6	35,1	27,6	42,6
400	32,7	30,7	31,1	30,4	32,7	30,7	31,1	30,4	33	25,9	40	33	25,9	40,0
500	31,8	30,0	30,1	29,9	31,8	30,0	30,1	29,9	32,1	25,2	38,9	32,1	25,2	38,9
630	29,0	27,0	27,4	26,7	29,0	27,0	27,4	26,7	29,1	22,9	35,4	29,1	22,9	35,3
800	23,9	21,8	22,2	21,4	23,9	21,8	22,2	21,4	24	18,9	29,1	24	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,3	17,5	17,1	19,1	17,3	17,5	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,4	15,7	15,8	15,7	17,4	15,7	15,8	15,7	17,6	13,9	21,4	17,6	13,9	21,4
2000	16,1	14,0	14,1	13,8	16,1	14,0	14,1	13,8	16,3	12,9	19,8	16,3	12,9	19,8
2500	14,1	12,4	12,4	12,3	14,1	12,4	12,4	12,3	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,4	11,2	11,3	11,2	13,4	11,2	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,3	11,1	11,2	11,0	13,3	11,1	11,2	11,0	13,6	10,7	16,5	13,6	10,7	16,5
5000	13,4	11,1	11,2	11,1	13,4	11,1	11,2	11,1	13,8	10,9	16,8	13,8	10,9	16,7
6300	13,2	11,3	11,3	11,2	13,2	11,3	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
8000	14,0	11,4	11,4	11,4	14,0	11,4	11,4	11,4	14,6	11,5	17,7	14,6	11,5	17,7
10000	15,0	11,5	11,5	11,4	15,0	11,5	11,5	11,4	15,7	12,4	19,1	15,7	12,4	19,0
Over.	54,4	45,2	46,9	43,9	46,0	45,7	46,7	44,8	54,9	37,3	83,1	46,2	37,5	60,3

Table E.46 Simulated ventilation system sound pressure level and corresponding measurement data for point R3. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								**TCR**					
	Total sound field				**Direct field (for f<200Hz)**				**Total sound field**			**Direct field**		
Band	**Lp$_{s.}$**	**Lp$_{m.}$**	**Lp$_{l.}$**	**Lp$_{up.}$**	**Lp$_{s.}$**	**Lp$_{m.}$**	**Lp$_{l.}$**	**Lp$_{up.}$**	**Lp$_{s.}$**	**Lp$_{l.}$**	**Lp$_{up.}$**	**Lp$_{s.}$**	**Lp$_{l.}$**	**Lp$_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,3	43,6	37,5	31,1	40,3	42,2	38,6	45,8	18,6	73	31,1	20,7	49,6
63	42,6	29,5	30,8	28,3	29,2	30,8	31,5	30,0	43,2	17,6	68,9	29,1	19,4	46,4
80	41,2	29,6	32,4	27,3	27,6	31,2	33,1	29,6	41,8	17	66,7	27,7	18,5	44,1
100	50,5	33,0	33,4	32,7	35,7	33,7	34,0	33,3	51	20,7	81,2	35,7	23,8	56,9
125	44,3	36,3	37,0	35,6	29,6	37,2	37,6	36,8	44,8	18,2	71,3	29,5	19,7	47,0
160	46,2	34,0	34,1	33,9	30,0	35,0	35,2	34,8	46,5	18,9	74	29,9	19,9	47,6
200	43,0	36,9	38,0	35,8	43,0	36,9	38,0	35,8	43,2	34	52,4	43,2	34	52,4
250	35,2	32,6	33,2	32,1	35,2	32,6	33,2	32,1	35,4	27,9	42,9	35,4	27,9	42,9
315	34,9	32,2	32,4	32,0	34,9	32,2	32,4	32,0	35,1	27,6	42,6	35,1	27,6	42,6
400	32,7	30,7	31,0	30,4	32,7	30,7	31,0	30,4	33	25,9	40	33	25,9	40,0
500	31,9	30,0	30,1	30,0	31,9	30,0	30,1	30,0	32,1	25,2	38,9	32,1	25,2	38,9
630	29,0	27,1	27,4	26,7	29,0	27,1	27,4	26,7	29,1	22,9	35,4	29,1	22,9	35,3
800	23,9	21,8	22,2	21,4	23,9	21,8	22,2	21,4	24	18,9	29,1	24	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,3	17,5	17,1	19,1	17,3	17,5	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,4	15,7	15,8	15,7	17,4	15,7	15,8	15,7	17,6	13,9	21,4	17,6	13,9	21,4
2000	16,1	14,0	14,2	13,8	16,1	14,0	14,2	13,8	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,2	12,4	12,4	12,4	14,2	12,4	12,4	12,4	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,4	11,3	11,3	11,2	13,4	11,3	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,3	11,1	11,2	11,0	13,3	11,1	11,2	11,0	13,6	10,7	16,5	13,6	10,7	16,5
5000	13,5	11,2	11,2	11,2	13,5	11,2	11,2	11,2	13,8	10,9	16,8	13,8	10,9	16,7
6300	13,2	11,3	11,3	11,2	13,2	11,3	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
8000	14,0	11,4	11,5	11,4	14,0	11,4	11,5	11,4	14,6	11,5	17,7	14,6	11,5	17,7
10000	15,0	11,4	11,5	11,4	15,0	11,4	11,5	11,4	15,7	12,4	19,1	15,7	12,4	19,0
Over.	54,4	45,2	46,9	43,9	46,0	45,5	46,5	44,7	54,9	37,3	83,1	46,1	37,5	60,0

Table E.47 Simulated ventilation system sound pressure level and corresponding measurement data for point R4. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								TCR					
	Total sound field				Direct field (for f<200Hz)				Total sound field			Direct field		
Band	Lps.	Lpm.	Lpl.	Lpup.	Lps.	Lpm.	Lpl.	Lpup.	Lps.	Lpl.	Lpup.	Lps.	Lpl.	Lpup.
[Hz]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
50	45,1	40,2	43,5	37,4	30,2	39,1	40,9	37,4	45,8	18,6	72,9	30,2	20,1	48,1
63	42,4	29,4	30,7	28,2	28,2	29,8	30,6	29,1	43,2	17,6	68,8	28,2	18,8	44,9
80	41,0	29,5	32,2	27,1	26,9	30,4	32,2	28,8	41,8	17,0	66,6	26,8	17,8	42,7
100	50,3	32,9	33,3	32,6	34,8	32,9	33,2	32,6	50,9	20,7	81,2	34,8	23,2	55,5
125	44,1	36,1	36,9	35,4	28,6	35,9	36,4	35,6	44,7	18,2	71,3	28,6	19,0	45,6
160	46,0	33,9	34,0	33,8	29,0	33,9	34,1	33,7	46,4	18,9	74,0	29,0	19,3	46,2
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	34,0	52,3	43,1	34,0	52,3
250	35,1	32,6	33,1	32,0	35,1	32,6	33,1	32,0	35,4	27,8	42,9	35,4	27,8	42,9
315	34,9	32,1	32,3	31,9	34,9	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,7	30,7	31,0	30,3	32,7	30,7	31,0	30,3	32,9	25,9	40,0	32,9	25,9	39,9
500	31,8	30,0	30,0	29,9	31,8	30,0	30,0	29,9	32,0	25,2	38,9	32,0	25,2	38,8
630	28,9	27,0	27,4	26,7	28,9	27,0	27,4	26,7	29,1	22,9	35,3	29,1	22,9	35,3
800	23,8	21,7	22,1	21,4	23,8	21,7	22,1	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,2	17,4	17,1	19,1	17,2	17,4	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,3	15,7	15,7	15,6	17,3	15,7	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,0	13,9	14,1	13,7	16,0	13,9	14,1	13,7	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,0	12,3	12,3	12,2	14,0	12,3	12,3	12,2	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,3	11,2	11,2	11,1	13,3	11,2	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,2	11,0	11,1	10,9	13,2	11,0	11,1	10,9	13,5	10,7	16,4	13,5	10,7	16,4
5000	13,3	11,1	11,1	11,0	13,3	11,1	11,1	11,0	13,8	10,9	16,7	13,8	10,9	16,7
6300	13,1	11,1	11,2	11,1	13,1	11,1	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
8000	13,8	11,3	11,3	11,3	13,8	11,3	11,3	11,3	14,6	11,5	17,7	14,6	11,5	17,7
10000	14,8	11,3	11,3	11,3	14,8	11,3	11,3	11,3	15,7	12,3	19,0	15,7	12,3	19,0
Over.	54,3	45,1	46,8	43,8	45,7	44,8	45,7	43,9	54,8	37,3	83,0	45,9	37,4	58,9

Table E.48 Simulated ventilation system sound pressure level and corresponding measurement data for point R5. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								**TCR**					
	Total sound field				**Direct field (for f<200Hz)**				**Total sound field**			**Direct field**		
Band	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,2	43,5	37,4	30,1	39,0	40,8	37,4	45,8	18,6	72,9	30,2	20,1	48,1
63	42,4	29,4	30,7	28,2	28,2	29,7	30,5	29,0	43,2	17,6	68,8	28,2	18,8	44,9
80	41,0	29,5	32,3	27,1	26,8	30,3	32,2	28,7	41,8	17,0	66,6	26,8	17,8	42,7
100	50,3	32,9	33,3	32,6	34,7	32,7	33,0	32,4	50,9	20,7	81,2	34,8	23,2	55,5
125	44,2	36,1	36,9	35,4	28,6	35,9	36,3	35,5	44,7	18,2	71,3	28,6	19,0	45,6
160	46,1	33,9	34,1	33,8	29,0	33,9	34,1	33,7	46,4	18,9	74,0	29,0	19,3	46,2
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	34,0	52,3	43,1	34,0	52,3
250	35,1	32,6	33,1	32,0	35,1	32,6	33,1	32,0	35,4	27,8	42,9	35,4	27,8	42,9
315	34,9	32,1	32,3	31,9	34,9	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,6	30,6	31,0	30,3	32,6	30,6	31,0	30,3	32,9	25,9	40,0	32,9	25,9	39,9
500	31,8	29,9	30,0	29,9	31,8	29,9	30,0	29,9	32,0	25,2	38,9	32,0	25,2	38,8
630	28,9	27,0	27,3	26,6	28,9	27,0	27,3	26,6	29,1	22,9	35,3	29,1	22,9	35,3
800	23,8	21,8	22,1	21,4	23,8	21,8	22,1	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,2	17,4	17,1	19,1	17,2	17,4	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,3	15,7	15,7	15,6	17,3	15,7	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,0	13,9	14,1	13,8	16,0	13,9	14,1	13,8	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,1	12,3	12,3	12,3	14,1	12,3	12,3	12,3	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,3	11,2	11,2	11,1	13,3	11,2	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,2	11,0	11,1	10,9	13,2	11,0	11,1	10,9	13,5	10,7	16,4	13,5	10,7	16,4
5000	13,4	11,1	11,1	11,0	13,4	11,1	11,1	11,0	13,8	10,9	16,7	13,8	10,9	16,7
6300	13,1	11,1	11,2	11,1	13,1	11,1	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
8000	13,9	11,3	11,3	11,3	13,9	11,3	11,3	11,3	14,6	11,5	17,7	14,6	11,5	17,7
10000	14,8	11,3	11,3	11,3	14,8	11,3	11,3	11,3	15,7	12,3	19,0	15,7	12,3	19,0
Over.	54,3	45,1	46,8	43,8	45,7	44,7	45,7	43,9	54,8	37,3	83,0	45,9	37,4	58,9

Table E.49 Simulated ventilation system sound pressure level and corresponding measurement data for point R6. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								TCR					
	Total sound field				Direct field (for f<200Hz)				Total sound field			Direct field		
Band	Lps.	Lpm.	Lpl.	Lpup.	Lps.	Lpm.	Lpl.	Lpup.	Lps.	Lpl.	Lpup.	Lps.	Lpl.	Lpup.
[Hz]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
50	45,1	40,1	43,4	37,3	29,3	38,0	39,8	36,4	45,8	18,6	72,9	29,4	19,6	46,9
63	42,3	29,3	30,6	28,1	27,5	29,0	29,7	28,3	43,2	17,5	68,8	27,4	18,3	43,7
80	40,9	29,4	32,2	27,1	26,0	29,4	31,2	27,9	41,8	17,0	66,6	26,0	17,3	41,4
100	50,3	32,9	33,3	32,5	34,2	32,2	32,5	31,9	50,9	20,7	81,1	34,0	22,7	54,2
125	44,1	36,1	36,8	35,4	27,9	35,1	35,4	34,7	44,7	18,2	71,2	27,8	18,5	44,3
160	46,0	33,9	34,0	33,8	28,3	33,0	33,2	32,8	46,4	18,9	74,0	28,2	18,8	44,9
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	33,9	52,3	43,1	33,9	52,3
250	35,1	32,5	33,1	32,0	35,1	32,5	33,1	32,0	35,4	27,8	42,9	35,4	27,8	42,9
315	34,8	32,1	32,3	31,9	34,8	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,6	30,6	30,9	30,3	32,6	30,6	30,9	30,3	32,9	25,9	40,0	32,9	25,9	39,9
500	31,7	29,9	30,0	29,8	31,7	29,9	30,0	29,8	32,0	25,2	38,9	32,0	25,2	38,8
630	28,9	27,0	27,3	26,6	28,9	27,0	27,3	26,6	29,1	22,9	35,3	29,1	22,9	35,3
800	23,8	21,7	22,1	21,4	23,8	21,7	22,1	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,6	21,6	21,9	21,4	23,6	21,6	21,9	21,4	23,7	18,7	28,8	23,7	18,7	28,8
1250	19,0	17,2	17,4	17,0	19,0	17,2	17,4	17,0	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,3	15,6	15,7	15,6	17,3	15,6	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,0	13,9	14,1	13,7	16,0	13,9	14,1	13,7	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,0	12,2	12,3	12,2	14,0	12,2	12,3	12,2	14,4	11,3	17,4	14,4	11,3	17,5
3150	13,3	11,1	11,2	11,1	13,3	11,1	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,1	10,9	11,0	10,9	13,1	10,9	11,0	10,9	13,5	10,6	16,4	13,5	10,6	16,4
5000	13,3	11,0	11,0	11,0	13,3	11,0	11,0	11,0	13,8	10,8	16,7	13,8	10,8	16,7
6300	13,0	11,1	11,1	11,1	13,0	11,1	11,1	11,1	13,7	10,7	16,6	13,7	10,7	16,6
8000	13,8	11,2	11,3	11,2	13,8	11,2	11,3	11,2	14,5	11,4	17,6	14,5	11,4	17,6
10000	14,7	11,3	11,3	11,2	14,7	11,3	11,3	11,2	15,7	12,3	19,0	15,7	12,3	19,0
Over.	54,2	45,0	46,8	43,8	45,6	44,2	45,1	43,4	54,8	37,3	83,0	45,8	37,4	58,0

Table E.50 Simulated ventilation system sound pressure level and corresponding measurement data for point R7. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								**TCR**					
	Total sound field				**Direct field (for f<200Hz)**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,0	40,1	43,4	37,3	29,8	38,6	40,4	37,0	45,8	18,6	72,9	29,8	19,9	47,5
63	42,4	29,3	30,6	28,2	27,8	29,3	30,0	28,6	43,2	17,5	68,8	27,8	18,5	44,3
80	41,0	29,4	32,2	27,1	26,5	29,9	31,7	28,3	41,8	17,0	66,6	26,4	17,6	42,1
100	50,3	32,9	33,3	32,6	34,4	32,4	32,8	32,1	50,9	20,7	81,1	34,4	22,9	54,8
125	44,1	36,1	36,8	35,4	28,2	35,4	35,8	35,0	44,7	18,2	71,3	28,2	18,8	44,9
160	46,0	33,9	34,0	33,8	28,6	33,4	33,6	33,3	46,4	18,9	74,0	28,6	19,1	45,6
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	33,9	52,3	43,1	33,9	52,3
250	35,1	32,5	33,1	32,0	35,1	32,5	33,1	32,0	35,4	27,8	42,9	35,4	27,8	42,9
315	34,8	32,1	32,3	31,9	34,8	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,6	30,6	31,0	30,3	32,6	30,6	31,0	30,3	32,9	25,9	40,0	32,9	25,9	39,9
500	31,8	29,9	30,0	29,9	31,8	29,9	30,0	29,9	32,0	25,2	38,9	32,0	25,2	38,8
630	28,9	27,0	27,3	26,6	28,9	27,0	27,3	26,6	29,1	22,9	35,3	29,1	22,9	35,3
800	23,8	21,7	22,1	21,4	23,8	21,7	22,1	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,5	21,6	21,9	21,4	23,5	21,6	21,9	21,4	23,7	18,7	28,8	23,7	18,7	28,8
1250	19,0	17,2	17,4	17,0	19,0	17,2	17,4	17,0	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,3	15,6	15,7	15,6	17,3	15,6	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,0	13,9	14,1	13,7	16,0	13,9	14,1	13,7	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,0	12,3	12,3	12,2	14,0	12,3	12,3	12,2	14,4	11,3	17,4	14,4	11,3	17,5
3150	13,3	11,1	11,2	11,1	13,3	11,1	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,1	11,0	11,0	10,9	13,1	11,0	11,0	10,9	13,5	10,7	16,4	13,5	10,7	16,4
5000	13,3	11,0	11,1	11,0	13,3	11,0	11,1	11,0	13,8	10,8	16,7	13,8	10,8	16,7
6300	13,0	11,1	11,1	11,0	13,0	11,1	11,1	11,0	13,7	10,7	16,6	13,7	10,7	16,6
8000	13,8	11,3	11,3	11,2	13,8	11,3	11,3	11,2	14,5	11,4	17,6	14,5	11,4	17,6
10000	14,7	11,2	11,3	11,2	14,7	11,2	11,3	11,2	15,7	12,3	19,0	15,7	12,3	19,0
Over.	54,2	45,0	46,8	43,8	45,6	44,4	45,4	43,7	54,8	37,3	83,0	45,9	37,4	58,5

Table E.51 Simulated ventilation system sound pressure level and corresponding measurement data for point R8. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								TCR					
	Total sound field				Direct field (for f<200Hz)				Total sound field			Direct field		
Band	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,1	43,4	37,3	29,4	38,1	39,8	36,5	45,8	18,6	72,9	29,4	19,6	46,9
63	42,3	29,3	30,6	28,1	27,5	29,0	29,8	28,3	43,2	17,5	68,8	27,4	18,3	43,7
80	41,0	29,4	32,2	27,1	26,0	29,4	31,2	27,9	41,8	17,0	66,6	26,0	17,3	41,4
100	50,3	32,9	33,3	32,6	33,9	32,0	32,3	31,7	50,9	20,7	81,1	34,0	22,7	54,2
125	44,1	36,1	36,8	35,4	27,9	35,0	35,4	34,6	44,7	18,2	71,2	27,8	18,5	44,3
160	46,0	33,9	34,0	33,8	28,3	33,0	33,2	32,8	46,4	18,9	74,0	28,2	18,8	44,9
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	33,9	52,3	43,1	33,9	52,3
250	35,1	32,5	33,1	32,0	35,1	32,5	33,1	32,0	35,4	27,8	42,9	35,4	27,8	42,9
315	34,8	32,1	32,3	31,9	34,8	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,6	30,6	31,0	30,3	32,6	30,6	31,0	30,3	32,9	25,9	40,0	32,9	25,9	39,9
500	31,8	29,9	30,0	29,9	31,8	29,9	30,0	29,9	32,0	25,2	38,9	32,0	25,2	38,8
630	28,9	27,0	27,3	26,6	28,9	27,0	27,3	26,6	29,1	22,9	35,3	29,1	22,9	35,3
800	23,8	21,7	22,1	21,4	23,8	21,7	22,1	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,5	21,6	21,9	21,4	23,5	21,6	21,9	21,4	23,7	18,7	28,8	23,7	18,7	28,8
1250	19,0	17,2	17,4	17,0	19,0	17,2	17,4	17,0	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,3	15,6	15,7	15,6	17,3	15,6	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,0	13,9	14,1	13,7	16,0	13,9	14,1	13,7	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,0	12,2	12,3	12,2	14,0	12,2	12,3	12,2	14,4	11,3	17,4	14,4	11,3	17,5
3150	13,3	11,1	11,2	11,1	13,3	11,1	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,1	11,0	11,0	10,9	13,1	11,0	11,0	10,9	13,5	10,6	16,4	13,5	10,6	16,4
5000	13,3	11,0	11,0	11,0	13,3	11,0	11,0	11,0	13,8	10,8	16,7	13,8	10,8	16,7
6300	13,0	11,1	11,1	11,0	13,0	11,1	11,1	11,0	13,7	10,7	16,6	13,7	10,7	16,6
8000	13,8	11,2	11,3	11,2	13,8	11,2	11,3	11,2	14,5	11,4	17,6	14,5	11,4	17,6
10000	14,7	11,2	11,3	11,2	14,7	11,2	11,3	11,2	15,7	12,3	19,0	15,7	12,3	19,0
Over.	54,2	45,0	46,8	43,8	45,6	44,2	45,1	43,4	54,8	37,3	83,0	45,8	37,4	58,0

Table E.52 Simulated ventilation system sound pressure level and corresponding measurement data for point R9. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								TCR					
	Total sound field				Direct field (for f<200Hz)				Total sound field			Direct field		
Band	Lps.	Lpm.	Lpl.	Lpup.	Lps.	Lpm.	Lpl.	Lpup.	Lps.	Lpl.	Lpup.	Lps.	Lpl.	Lpup.
[Hz]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
50	45,1	40,2	43,5	37,3	30,0	38,9	40,7	37,3	45,8	18,6	72,9	30,1	20,0	48,0
63	42,4	29,4	30,7	28,2	28,3	29,9	30,6	29,1	43,2	17,6	68,8	28,1	18,7	44,8
80	41,0	29,5	32,3	27,1	26,8	30,3	32,1	28,7	41,8	17,0	66,6	26,7	17,8	42,5
100	50,3	32,9	33,3	32,6	34,7	32,7	33,1	32,4	50,9	20,7	81,2	34,7	23,1	55,3
125	44,1	36,1	36,9	35,4	28,5	35,8	36,2	35,4	44,7	18,2	71,3	28,5	19,0	45,4
160	46,0	33,9	34,0	33,8	28,9	33,8	33,9	33,6	46,4	18,9	74,0	28,9	19,2	46,1
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	33,9	52,3	43,1	33,9	52,3
250	35,1	32,6	33,1	32,0	35,1	32,6	33,1	32,0	35,4	27,8	42,9	35,4	27,8	42,9
315	34,9	32,1	32,3	31,9	34,9	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,6	30,6	31,0	30,3	32,6	30,6	31,0	30,3	32,9	25,9	40,0	32,9	25,9	39,9
500	31,8	30,0	30,0	29,9	31,8	30,0	30,0	29,9	32,0	25,2	38,9	32,0	25,2	38,8
630	28,9	27,0	27,4	26,6	28,9	27,0	27,4	26,6	29,1	22,9	35,3	29,1	22,9	35,3
800	23,8	21,8	22,2	21,4	23,8	21,8	22,2	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,2	17,4	17,1	19,1	17,2	17,4	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,3	15,7	15,7	15,6	17,3	15,7	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,0	13,9	14,1	13,8	16,0	13,9	14,1	13,8	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,1	12,3	12,3	12,3	14,1	12,3	12,3	12,3	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,3	11,1	11,2	11,1	13,3	11,1	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,2	11,0	11,1	10,9	13,2	11,0	11,1	10,9	13,5	10,7	16,4	13,5	10,7	16,4
5000	13,3	11,1	11,1	11,0	13,3	11,1	11,1	11,0	13,8	10,8	16,7	13,8	10,8	16,7
6300	13,1	11,1	11,2	11,1	13,1	11,1	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
8000	13,8	11,3	11,3	11,3	13,8	11,3	11,3	11,3	14,6	11,5	17,7	14,6	11,5	17,7
10000	14,8	11,3	11,3	11,3	14,8	11,3	11,3	11,3	15,7	12,3	19,0	15,7	12,3	19,0
Over.	54,3	45,1	46,8	43,8	45,7	44,7	45,6	43,9	54,8	37,3	83,0	45,9	37,4	58,8

Table E.53 Simulated ventilation system sound pressure level and corresponding measurement data for point R10. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								**TCR**					
	Total sound field				**Direct field (for f<200Hz)**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,2	43,4	37,3	30,0	38,8	40,6	37,2	45,8	18,6	72,9	30,1	20,0	48,0
63	42,4	29,3	30,6	28,2	28,1	29,7	30,4	28,9	43,2	17,6	68,8	28,1	18,7	44,8
80	41,0	29,4	32,2	27,1	26,7	30,2	32,0	28,6	41,8	17,0	66,6	26,7	17,8	42,5
100	50,3	32,9	33,3	32,6	34,8	32,8	33,2	32,5	50,9	20,7	81,2	34,7	23,1	55,3
125	44,1	36,1	36,8	35,4	28,5	35,8	36,2	35,4	44,7	18,2	71,3	28,5	19,0	45,4
160	46,0	33,9	34,0	33,8	28,9	33,8	33,9	33,6	46,4	18,9	74,0	28,9	19,2	46,1
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	33,9	52,3	43,1	33,9	52,3
250	35,1	32,6	33,1	32,0	35,1	32,6	33,1	32,0	35,4	27,8	42,9	35,4	27,8	42,9
315	34,9	32,1	32,3	31,9	34,9	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,6	30,6	31,0	30,3	32,6	30,6	31,0	30,3	32,9	25,9	40,0	32,9	25,9	39,9
500	31,8	30,0	30,0	29,9	31,8	30,0	30,0	29,9	32,0	25,2	38,9	32,0	25,2	38,8
630	28,9	27,0	27,4	26,6	28,9	27,0	27,4	26,6	29,1	22,9	35,3	29,1	22,9	35,3
800	23,8	21,8	22,1	21,4	23,8	21,8	22,1	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,0	17,2	17,4	17,0	19,0	17,2	17,4	17,0	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,3	15,7	15,7	15,6	17,3	15,7	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,0	13,9	14,1	13,8	16,0	13,9	14,1	13,8	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,0	12,3	12,3	12,3	14,0	12,3	12,3	12,3	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,3	11,2	11,2	11,1	13,3	11,2	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,2	11,0	11,1	10,9	13,2	11,0	11,1	10,9	13,5	10,7	16,4	13,5	10,7	16,4
5000	13,3	11,1	11,1	11,0	13,3	11,1	11,1	11,0	13,8	10,8	16,7	13,8	10,8	16,7
6300	13,1	11,1	11,2	11,1	13,1	11,1	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
8000	13,8	11,3	11,3	11,2	13,8	11,3	11,3	11,2	14,6	11,5	17,7	14,6	11,5	17,7
10000	14,8	11,3	11,3	11,3	14,8	11,3	11,3	11,3	15,7	12,3	19,0	15,7	12,3	19,0
Over.	54,3	45,0	46,8	43,8	45,7	44,6	45,6	43,8	54,8	37,3	83,0	45,9	37,4	58,8

Table E.54 Simulated ventilation system sound pressure level and corresponding measurement data for point R11. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								**TCR**					
	Total sound field				**Direct field (for f<200Hz)**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,3	43,6	37,4	30,5	39,5	41,4	37,9	45,8	18,6	73,0	30,5	20,4	48,6
63	42,5	29,4	30,7	28,2	28,5	30,1	30,9	29,3	43,2	17,6	68,8	28,5	19,0	45,4
80	41,1	29,6	32,3	27,2	27,1	30,6	32,4	29,0	41,8	17,0	66,6	27,1	18,1	43,2
100	50,4	33,0	33,4	32,6	35,2	33,2	33,5	32,9	50,9	20,7	81,2	35,1	23,4	55,9
125	44,2	36,2	36,9	35,5	29,1	36,6	37,0	36,2	44,7	18,2	71,3	28,9	19,3	46,1
160	46,1	34,0	34,1	33,9	29,3	34,2	34,4	34,0	46,5	18,9	74,0	29,3	19,6	46,7
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	34,0	52,3	43,1	34,0	52,3
250	35,1	32,6	33,1	32,1	35,1	32,6	33,1	32,1	35,4	27,9	42,9	35,4	27,9	42,9
315	34,9	32,1	32,3	31,9	34,9	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,7	30,7	31,0	30,4	32,7	30,7	31,0	30,4	33,0	25,9	40,0	33,0	25,9	40,0
500	31,8	30,0	30,1	29,9	31,8	30,0	30,1	29,9	32,0	25,2	38,9	32,0	25,2	38,8
630	29,0	27,0	27,4	26,7	29,0	27,0	27,4	26,7	29,1	22,9	35,3	29,1	22,9	35,3
800	23,9	21,8	22,2	21,4	23,9	21,8	22,2	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,3	17,4	17,1	19,1	17,3	17,4	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,4	15,7	15,7	15,6	17,4	15,7	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,1	14,0	14,1	13,8	16,1	14,0	14,1	13,8	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,2	12,4	12,4	12,4	14,2	12,4	12,4	12,4	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,4	11,2	11,3	11,2	13,4	11,2	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,2	11,1	11,1	11,0	13,2	11,1	11,1	11,0	13,6	10,7	16,4	13,6	10,7	16,5
5000	13,4	11,1	11,2	11,1	13,4	11,1	11,2	11,1	13,8	10,9	16,7	13,8	10,9	16,7
6300	13,2	11,2	11,2	11,2	13,2	11,2	11,2	11,2	13,7	10,8	16,6	13,7	10,8	16,6
8000	13,9	11,3	11,4	11,3	13,9	11,3	11,4	11,3	14,6	11,5	17,7	14,6	11,5	17,7
10000	14,9	11,4	11,4	11,4	14,9	11,4	11,4	11,4	15,7	12,4	19,1	15,7	12,4	19,0
Over.	54,4	45,1	46,9	43,9	45,8	45,0	46,0	44,2	54,8	37,3	83,1	46,0	37,5	59,2

Table E.55 Simulated ventilation system sound pressure level and corresponding measurement data for point R12. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								**TCR**					
	Total sound field				**Direct field (for f<200Hz)**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,3	43,6	37,4	31,0	40,1	42,0	38,4	45,8	18,6	73,0	30,9	20,6	49,2
63	42,5	29,5	30,7	28,3	28,9	30,5	31,3	29,8	43,2	17,6	68,9	28,9	19,3	46,1
80	41,1	29,5	32,3	27,2	27,6	31,2	33,1	29,6	41,8	17,0	66,6	27,5	18,3	43,8
100	50,4	33,0	33,4	32,6	35,6	33,6	33,9	33,2	50,9	20,7	81,2	35,5	23,7	56,6
125	44,2	36,2	36,9	35,5	29,3	36,8	37,2	36,4	44,7	18,2	71,3	29,3	19,5	46,7
160	46,1	34,0	34,1	33,9	29,7	34,6	34,8	34,5	46,5	18,9	74,0	29,7	19,8	47,3
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,2	34,0	52,4	43,2	34,0	52,4
250	35,1	32,6	33,1	32,1	35,1	32,6	33,1	32,1	35,4	27,9	42,9	35,4	27,9	42,9
315	34,9	32,1	32,3	31,9	34,9	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,7	30,7	31,0	30,4	32,7	30,7	31,0	30,4	33,0	25,9	40,0	33,0	25,9	40,0
500	31,8	30,0	30,1	29,9	31,8	30,0	30,1	29,9	32,1	25,2	38,9	32,1	25,2	38,9
630	28,9	27,0	27,4	26,7	28,9	27,0	27,4	26,7	29,1	22,9	35,3	29,1	22,9	35,3
800	23,9	21,8	22,2	21,4	23,9	21,8	22,2	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,3	17,4	17,1	19,1	17,3	17,4	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,4	15,7	15,7	15,6	17,4	15,7	15,7	15,6	17,6	13,8	21,4	17,6	13,8	21,4
2000	16,1	14,0	14,1	13,8	16,1	14,0	14,1	13,8	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,1	12,3	12,4	12,3	14,1	12,3	12,4	12,3	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,3	11,2	11,2	11,1	13,3	11,2	11,2	11,1	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,2	11,1	11,1	11,0	13,2	11,1	11,1	11,0	13,6	10,7	16,4	13,6	10,7	16,5
5000	13,4	11,1	11,2	11,1	13,4	11,1	11,2	11,1	13,8	10,9	16,7	13,8	10,9	16,7
6300	13,2	11,2	11,3	11,2	13,2	11,2	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
8000	13,9	11,4	11,4	11,3	13,9	11,4	11,4	11,3	14,6	11,5	17,7	14,6	11,5	17,7
10000	14,9	11,4	11,4	11,4	14,9	11,4	11,4	11,4	15,7	12,4	19,1	15,7	12,4	19,0
Over.	54,4	45,1	46,9	43,9	45,9	45,3	46,4	44,5	54,8	37,3	83,1	46,1	37,5	59,7

Table E.56 Simulated ventilation system sound pressure level and corresponding measurement data for point R13. Direct sound pressure level is calculated only for frequencies between 50 and 160 Hz.

	SPPS								**TCR**					
	Total sound field				**Direct field (for f<200Hz)**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,2	43,5	37,4	30,6	39,7	41,5	38,0	45,8	18,6	73,0	30,5	20,4	48,6
63	42,5	29,4	30,7	28,2	28,7	30,2	31,0	29,5	43,2	17,6	68,8	28,5	19,0	45,4
80	41,1	29,5	32,3	27,2	27,2	30,8	32,6	29,2	41,8	17,0	66,6	27,1	18,1	43,2
100	50,4	33,0	33,4	32,6	35,1	33,1	33,5	32,8	50,9	20,7	81,2	35,1	23,4	55,9
125	44,2	36,2	36,9	35,5	29,2	36,7	37,1	36,3	44,7	18,2	71,3	28,9	19,3	46,1
160	46,1	34,0	34,1	33,8	29,5	34,4	34,6	34,3	46,5	18,9	74,0	29,3	19,6	46,7
200	42,9	36,8	37,9	35,8	42,9	36,8	37,9	35,8	43,1	34,0	52,3	43,1	34,0	52,3
250	35,1	32,6	33,1	32,1	35,1	32,6	33,1	32,1	35,4	27,9	42,9	35,4	27,9	42,9
315	34,9	32,1	32,3	31,9	34,9	32,1	32,3	31,9	35,1	27,6	42,6	35,1	27,6	42,6
400	32,7	30,7	31,0	30,4	32,7	30,7	31,0	30,4	33,0	25,9	40,0	33,0	25,9	40,0
500	31,8	30,0	30,1	29,9	31,8	30,0	30,1	29,9	32,0	25,2	38,9	32,0	25,2	38,8
630	29,0	27,0	27,4	26,7	29,0	27,0	27,4	26,7	29,1	22,9	35,3	29,1	22,9	35,3
800	23,9	21,8	22,2	21,4	23,9	21,8	22,2	21,4	24,0	18,9	29,1	24,0	18,9	29,1
1000	23,6	21,7	21,9	21,5	23,6	21,7	21,9	21,5	23,8	18,7	28,8	23,8	18,7	28,9
1250	19,1	17,3	17,4	17,1	19,1	17,3	17,4	17,1	19,3	15,2	23,4	19,3	15,2	23,4
1600	17,4	15,7	15,7	15,6	17,4	15,7	15,7	15,6	17,6	13,8	21,3	17,6	13,8	21,4
2000	16,1	14,0	14,1	13,8	16,1	14,0	14,1	13,8	16,3	12,8	19,8	16,3	12,8	19,8
2500	14,1	12,3	12,4	12,3	14,1	12,3	12,4	12,3	14,4	11,3	17,5	14,4	11,3	17,5
3150	13,4	11,2	11,3	11,2	13,4	11,2	11,3	11,2	13,7	10,8	16,6	13,7	10,8	16,6
4000	13,2	11,0	11,1	11,0	13,2	11,0	11,1	11,0	13,6	10,7	16,4	13,6	10,7	16,5
5000	13,4	11,1	11,1	11,1	13,4	11,1	11,1	11,1	13,8	10,9	16,7	13,8	10,9	16,7
6300	13,2	11,2	11,2	11,2	13,2	11,2	11,2	11,2	13,7	10,8	16,6	13,7	10,8	16,6
8000	13,9	11,4	11,4	11,3	13,9	11,4	11,4	11,3	14,6	11,5	17,7	14,6	11,5	17,7
10000	14,9	11,4	11,4	11,3	14,9	11,4	11,4	11,3	15,7	12,4	19,1	15,7	12,4	19,0
Over.	54,3	45,1	46,8	43,9	45,8	45,1	46,1	44,3	54,8	37,3	83,1	46,0	37,5	59,2

Table E.57 Simulated VS sound pressure level and corresponding measurement data for point R1, R2 and R3.

R1	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,3	43,6	37,4	31,2	40,4	42,3	38,7	45,8	18,6	73,0	31,1	20,7	49,6
63	42,5	29,5	30,8	28,3	29,3	30,9	31,7	30,2	43,2	17,6	68,9	29,1	19,4	46,4
80	41,2	29,6	32,4	27,3	27,8	31,4	33,3	29,8	41,8	17,0	66,7	27,7	18,5	44,1
100	50,5	33,0	33,4	32,7	35,8	33,8	34,1	33,4	51,0	20,7	81,2	35,7	23,8	56,9
125	44,3	36,2	37,0	35,5	29,6	37,2	37,6	36,8	44,8	18,2	71,3	29,5	19,7	47
160	46,1	34,0	34,1	33,9	30,0	35,1	35,3	34,9	46,5	18,9	74,0	29,9	19,9	47,6
Over.	53,9	43,3	45,5	41,6	39,3	43,9	45,1	42,9	54,4	26,4	83,1	39,2	28,5	58,8

R2	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,3	40,3	43,6	37,5	31,3	40,6	42,4	38,9	45,8	18,6	73,0	31,4	20,9	50
63	42,6	29,5	30,8	28,3	29,3	30,9	31,7	30,2	43,2	17,6	68,9	29,4	19,6	46,9
80	41,2	29,6	32,4	27,3	28,0	31,7	33,6	30,0	41,8	17,0	66,7	28,0	18,6	44,6
100	50,5	33,1	33,4	32,7	36,0	33,9	34,3	33,6	51,0	20,7	81,2	36,0	24,0	57,4
125	44,3	36,2	37,0	35,5	29,7	37,4	37,8	36,9	44,8	18,2	71,3	29,8	19,8	47,5
160	46,2	34,0	34,1	33,9	30,2	35,3	35,4	35,1	46,5	18,9	74,1	30,2	20,1	48,1
Over.	53,9	43,3	45,5	41,7	39,4	44,0	45,2	43,1	54,4	26,4	83,1	39,4	28,7	59,3

R3	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,3	43,6	37,5	31,1	40,3	42,2	38,6	45,8	18,6	73,0	31,1	20,7	49,6
63	42,6	29,5	30,8	28,3	29,2	30,8	31,5	30,0	43,2	17,6	68,9	29,1	19,4	46,4
80	41,2	29,6	32,4	27,3	27,6	31,2	33,1	29,6	41,8	17,0	66,7	27,7	18,5	44,1
100	50,5	33,0	33,4	32,7	35,7	33,7	34,0	33,3	51,0	20,7	81,2	35,7	23,8	56,9
125	44,3	36,3	37,0	35,6	29,6	37,2	37,6	36,8	44,8	18,2	71,3	29,5	19,7	47
160	46,2	34,0	34,1	33,9	30,0	35,0	35,2	34,8	46,5	18,9	74,0	29,9	19,9	47,6
Over.	53,9	43,3	45,5	41,7	39,2	43,8	45,0	42,8	54,4	26,4	83,1	39,2	28,5	58,8

Table E.58 Simulated VS sound pressure level and corresponding measurement data for point R4 and R5.

R4	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,2	43,5	37,4	30,2	39,1	40,9	37,4	45,8	18,6	72,9	30,2	20,1	48,1
63	42,4	29,4	30,7	28,2	28,2	29,8	30,6	29,1	43,2	17,6	68,8	28,2	18,8	44,9
80	41,0	29,5	32,2	27,1	26,9	30,4	32,2	28,8	41,8	17,0	66,6	26,8	17,8	42,7
100	50,3	32,9	33,3	32,6	34,8	32,9	33,2	32,6	50,9	20,7	81,2	34,8	23,2	55,5
125	44,1	36,1	36,9	35,4	28,6	35,9	36,4	35,6	44,7	18,2	71,3	28,6	19,0	45,6
160	46,0	33,9	34,0	33,8	29,0	33,9	34,1	33,7	46,4	18,9	74,0	29,0	19,3	46,2
Over.	53,7	43,2	45,4	41,5	38,3	42,7	43,8	41,7	54,3	26,4	83,0	38,3	27,9	57,4

R5	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,2	43,5	37,4	30,1	39,0	40,8	37,4	45,8	18,6	72,9	30,2	20,1	48,1
63	42,4	29,4	30,7	28,2	28,2	29,7	30,5	29,0	43,2	17,6	68,8	28,2	18,8	44,9
80	41,0	29,5	32,3	27,1	26,8	30,3	32,2	28,7	41,8	17,0	66,6	26,8	17,8	42,7
100	50,3	32,9	33,3	32,6	34,7	32,7	33,0	32,4	50,9	20,7	81,2	34,8	23,2	55,5
125	44,2	36,1	36,9	35,4	28,6	35,9	36,3	35,5	44,7	18,2	71,3	28,6	19,0	45,6
160	46,1	33,9	34,1	33,8	29,0	33,9	34,1	33,7	46,4	18,9	74,0	29,0	19,3	46,2
Over.	53,7	43,2	45,4	41,6	38,2	42,6	43,8	41,7	54,3	26,4	83,0	38,2	27,9	57,4

Table E.59 Simulated VS sound pressure level and corresponding measurement data for point R6, R7 and R8.

R6	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,1	43,4	37,3	29,3	38,0	39,8	36,4	45,8	18,6	72,9	29,4	19,6	46,9
63	42,3	29,3	30,6	28,1	27,5	29,0	29,7	28,3	43,2	17,5	68,8	27,4	18,3	43,7
80	40,9	29,4	32,2	27,1	26,0	29,4	31,2	27,9	41,8	17,0	66,6	26,0	17,3	41,4
100	50,3	32,9	33,3	32,5	34,2	32,2	32,5	31,9	50,9	20,7	81,1	34,0	22,7	54,2
125	44,1	36,1	36,8	35,4	27,9	35,1	35,4	34,7	44,7	18,2	71,2	27,8	18,5	44,3
160	46,0	33,9	34,0	33,8	28,3	33,0	33,2	32,8	46,4	18,9	74,0	28,2	18,8	44,9
Over.	53,7	43,1	45,4	41,5	37,6	41,7	42,8	40,8	54,3	26,4	83,0	37,5	27,4	56,1

R7	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,0	40,1	43,4	37,3	29,8	38,6	40,4	37,0	45,8	18,6	72,9	29,8	19,9	47,5
63	42,4	29,3	30,6	28,2	27,8	29,3	30,0	28,6	43,2	17,5	68,8	27,8	18,5	44,3
80	41,0	29,4	32,2	27,1	26,5	29,9	31,7	28,3	41,8	17,0	66,6	26,4	17,6	42,1
100	50,3	32,9	33,3	32,6	34,4	32,4	32,8	32,1	50,9	20,7	81,1	34,4	22,9	54,8
125	44,1	36,1	36,8	35,4	28,2	35,4	35,8	35,0	44,7	18,2	71,3	28,2	18,8	44,9
160	46,0	33,9	34,0	33,8	28,6	33,4	33,6	33,3	46,4	18,9	74,0	28,6	19,1	45,6
Over.	53,7	43,1	45,3	41,5	37,9	42,2	43,3	41,2	54,3	26,4	83,0	37,9	27,6	56,7

R8	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpm.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**	**Lps.**	**Lpl.**	**Lpup.**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,1	43,4	37,3	29,4	38,1	39,8	36,5	45,8	18,6	72,9	29,4	19,6	46,9
63	42,3	29,3	30,6	28,1	27,5	29,0	29,8	28,3	43,2	17,5	68,8	27,4	18,3	43,7
80	41,0	29,4	32,2	27,1	26,0	29,4	31,2	27,9	41,8	17,0	66,6	26,0	17,3	41,4
100	50,3	32,9	33,3	32,6	33,9	32,0	32,3	31,7	50,9	20,7	81,1	34,0	22,7	54,2
125	44,1	36,1	36,8	35,4	27,9	35,0	35,4	34,6	44,7	18,2	71,2	27,8	18,5	44,3
160	46,0	33,9	34,0	33,8	28,3	33,0	33,2	32,8	46,4	18,9	74,0	28,2	18,8	44,9
Over.	53,7	43,1	45,4	41,5	37,5	41,7	42,8	40,8	54,3	26,4	83,0	37,5	27,4	56,1

Table E.60 Simulated VS sound pressure level and corresponding measurement data for point R9 and R10.

R9	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,2	43,5	37,3	30,0	38,9	40,7	37,3	45,8	18,6	72,9	30,1	20,0	48
63	42,4	29,4	30,7	28,2	28,3	29,9	30,6	29,1	43,2	17,6	68,8	28,1	18,7	44,8
80	41,0	29,5	32,3	27,1	26,8	30,3	32,1	28,7	41,8	17,0	66,6	26,7	17,8	42,5
100	50,3	32,9	33,3	32,6	34,7	32,7	33,1	32,4	50,9	20,7	81,2	34,7	23,1	55,3
125	44,1	36,1	36,9	35,4	28,5	35,8	36,2	35,4	44,7	18,2	71,3	28,5	19,0	45,4
160	46,0	33,9	34,0	33,8	28,9	33,8	33,9	33,6	46,4	18,9	74,0	28,9	19,2	46,1
Over.	53,7	43,1	45,4	41,5	38,2	42,5	43,7	41,6	54,3	26,4	83,0	38,2	27,8	57,2

R10	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,1	40,2	43,4	37,3	30,0	38,8	40,6	37,2	45,8	18,6	72,9	30,1	20,0	48
63	42,4	29,3	30,6	28,2	28,1	29,7	30,4	28,9	43,2	17,6	68,8	28,1	18,7	44,8
80	41,0	29,4	32,2	27,1	26,7	30,2	32,0	28,6	41,8	17,0	66,6	26,7	17,8	42,5
100	50,3	32,9	33,3	32,6	34,8	32,8	33,2	32,5	50,9	20,7	81,2	34,7	23,1	55,3
125	44,1	36,1	36,8	35,4	28,5	35,8	36,2	35,4	44,7	18,2	71,3	28,5	19,0	45,4
160	46,0	33,9	34,0	33,8	28,9	33,8	33,9	33,6	46,4	18,9	74,0	28,9	19,2	46,1
Over.	53,7	43,1	45,4	41,5	38,2	42,5	43,6	41,5	54,3	26,4	83,0	38,2	27,8	57,2

Table E.61 Simulated VS sound pressure level and corresponding measurement data for point R11, R12, R13.

R11	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,3	43,6	37,4	30,5	39,5	41,4	37,9	45,8	18,6	73,0	30,5	20,4	48,6
63	42,5	29,4	30,7	28,2	28,5	30,1	30,9	29,3	43,2	17,6	68,8	28,5	19,0	45,4
80	41,1	29,6	32,3	27,2	27,1	30,6	32,4	29,0	41,8	17,0	66,6	27,1	18,1	43,2
100	50,4	33,0	33,4	32,6	35,2	33,2	33,5	32,9	50,9	20,7	81,2	35,1	23,4	55,9
125	44,2	36,2	36,9	35,5	29,1	36,6	37,0	36,2	44,7	18,2	71,3	28,9	19,3	46,1
160	46,1	34,0	34,1	33,9	29,3	34,2	34,4	34,0	46,5	18,9	74,0	29,3	19,6	46,7
Over.	53,8	43,2	45,5	41,6	38,6	43,1	44,2	42,1	54,3	26,4	83,1	38,6	28,1	57,8

R12	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,3	43,6	37,4	31,0	40,1	42,0	38,4	45,8	18,6	73,0	30,9	20,6	49,2
63	42,5	29,5	30,7	28,3	28,9	30,5	31,3	29,8	43,2	17,6	68,9	28,9	19,3	46,1
80	41,1	29,5	32,3	27,2	27,6	31,2	33,1	29,6	41,8	17,0	66,6	27,5	18,3	43,8
100	50,4	33,0	33,4	32,6	35,6	33,6	33,9	33,2	50,9	20,7	81,2	35,5	23,7	56,6
125	44,2	36,2	36,9	35,5	29,3	36,8	37,2	36,4	44,7	18,2	71,3	29,3	19,5	46,7
160	46,1	34,0	34,1	33,9	29,7	34,6	34,8	34,5	46,5	18,9	74,0	29,7	19,8	47,3
Over.	53,8	43,2	45,5	41,6	39,0	43,6	44,7	42,6	54,4	26,4	83,1	39,0	28,4	58,5

R13	**SPPS**								**TCR**					
	Total sound field				**Direct field**				**Total sound field**			**Direct field**		
Band	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{m.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**	**$Lp_{s.}$**	**$Lp_{l.}$**	**$Lp_{up.}$**
[Hz]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
50	45,2	40,2	43,5	37,4	30,6	39,7	41,5	38,0	45,8	18,6	73,0	30,5	20,4	48,6
63	42,5	29,4	30,7	28,2	28,7	30,2	31,0	29,5	43,2	17,6	68,8	28,5	19,0	45,4
80	41,1	29,5	32,3	27,2	27,2	30,8	32,6	29,2	41,8	17,0	66,6	27,1	18,1	43,2
100	50,4	33,0	33,4	32,6	35,1	33,1	33,5	32,8	50,9	20,7	81,2	35,1	23,4	55,9
125	44,2	36,2	36,9	35,5	29,2	36,7	37,1	36,3	44,7	18,2	71,3	28,9	19,3	46,1
160	46,1	34,0	34,1	33,8	29,5	34,4	34,6	34,3	46,5	18,9	74,0	29,3	19,6	46,7
Over.	53,8	43,2	45,4	41,6	38,7	43,2	44,4	42,3	54,3	26,4	83,1	38,6	28,1	57,8

Table E.62 Summary of simulated RT at frequency 1000 Hz and corresponding plausible measurement data.

	SPPS code				TCR code		
	$RT_{simul.}$	**$RT_{meas.}$**	**$RT_{I.C.(95\%)}$**	**$RT_{I.C.(95\%)}$**	**$RT_{simul.}$**	**$RT_{(lower\ limit)}$**	**$RT_{(upper\ limit)}$**
	[dB]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
R1	2,414	2,280	2,338	2,225	2,305	2,077	2,532
R2	2,421	2,287	2,345	2,231	2,305	2,077	2,532
R3	2,406	2,273	2,331	2,218	2,305	2,077	2,532
R4	2,399	2,266	2,324	2,211	2,305	2,077	2,532
R5	2,443	2,307	2,366	2,251	2,305	2,077	2,532
R6	2,419	2,285	2,343	2,230	2,305	2,077	2,532
R7	2,378	2,246	2,303	2,191	2,305	2,077	2,532
R8	2,393	2,260	2,318	2,206	2,305	2,077	2,532
R9	2,399	2,266	2,324	2,211	2,305	2,077	2,532
R10	2,384	2,252	2,309	2,197	2,305	2,077	2,532
R11	2,401	2,267	2,325	2,212	2,305	2,077	2,532
R12	2,388	2,255	2,312	2,200	2,305	2,077	2,532
R13	2,453	2,317	2,376	2,261	2,305	2,077	2,532

Table E.63 Summary of VS overall sound pressure level and corresponding plausible measurement data calculated with ***SPPS code****.*

	Total sound field				Direct field (only for *f* < 200Hz)			
	$Lp_{simul.}$	**$Lp_{meas.}$**	**$Lp_{I.C.(95\%)}$**	**$Lp_{I.C.(95\%)}$**	**$Lp_{simul.}$**	**$Lp_{meas.}$**	**Lp_{lower}**	**Lp_{upper}**
	[dB]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
R1	54,4	45,1	46,9	43,9	46,0	45,6	46,6	44,7
R2	54,4	45,2	46,9	43,9	46,0	45,7	46,7	44,8
R3	54,4	45,2	46,9	43,9	46,0	45,5	46,5	44,7
R4	54,3	45,1	46,8	43,8	45,7	44,8	45,7	43,9
R5	54,3	45,1	46,8	43,8	45,7	44,7	45,7	43,9
R6	54,2	45,0	46,8	43,8	45,6	44,2	45,1	43,4
R7	54,2	45,0	46,8	43,8	45,6	44,4	45,4	43,7
R8	54,2	45,0	46,8	43,8	45,6	44,2	45,1	43,4
R9	54,3	45,1	46,8	43,8	45,7	44,7	45,6	43,9
R10	54,3	45,0	46,8	43,8	45,7	44,6	45,6	43,8
R11	54,4	45,1	46,9	43,9	45,8	45,0	46,0	44,2
R12	54,4	45,1	46,9	43,9	45,9	45,3	46,4	44,5
R13	54,3	45,1	46,8	43,9	45,8	45,1	46,1	44,3

*Table E.64 Summary of VS overall sound pressure level and corresponding plausible measurement data calculated with **TCR code**.*

	Total sound field			Direct field (only for *f* < 200Hz)		
	$Lp_{simulation}$	$Lp_{(lower\ limit)}$	$Lp_{(upper\ limit)}$	$Lp_{simulation}$	$Lp_{(lower\ limit)}$	$Lp_{(upper\ limit)}$
	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
R1	54,9	37,3	83,1	46,1	37,5	46,1
R2	54,9	37,3	83,1	46,2	37,5	46,2
R3	54,9	37,3	83,1	46,1	37,5	46,1
R4	54,8	37,3	83,0	45,9	37,4	45,9
R5	54,8	37,3	83,0	45,9	37,4	45,9
R6	54,8	37,3	83,0	45,8	37,4	45,8
R7	54,8	37,3	83,0	45,9	37,4	45,9
R8	54,8	37,3	83,0	45,8	37,4	45,8
R9	54,8	37,3	83,0	45,9	37,4	45,9
R10	54,8	37,3	83,0	45,9	37,4	45,9
R11	54,8	37,3	83,1	46,0	37,5	46,0
R12	54,8	37,3	83,1	46,1	37,5	46,1
R13	54,8	37,3	83,1	46,0	37,5	46,0

*Table E.65 Summary of VS overall (**frequency 50÷160 Hz**) sound pressure level and corresponding plausible measurement data calculated with **SPPS code**.*

	Total sound field				Direct field (only for *f* < 200Hz)			
	$Lp_{simul.}$	$Lp_{meas.}$	$Lp_{I.C.(95\%)}$	$Lp_{I.C.(95\%)}$	$Lp_{simul.}$	$Lp_{meas.}$	$Lp_{I.C.(95\%)}$	$Lp_{I.C.(95\%)}$
	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
R1	53,9	45,1	46,9	43,9	46,0	45,6	46,6	44,7
R2	54,4	45,2	46,9	43,9	46,0	45,7	46,7	44,8
R3	54,4	45,2	46,9	43,9	46,0	45,5	46,5	44,7
R4	54,3	45,1	46,8	43,8	45,7	44,8	45,7	43,9
R5	54,3	45,1	46,8	43,8	45,7	44,7	45,7	43,9
R6	54,2	45,0	46,8	43,8	45,6	44,2	45,1	43,4
R7	54,2	45,0	46,8	43,8	45,6	44,4	45,4	43,7
R8	54,2	45,0	46,8	43,8	45,6	44,2	45,1	43,4
R9	54,3	45,1	46,8	43,8	45,7	44,7	45,6	43,9
R10	54,3	45,0	46,8	43,8	45,7	44,6	45,6	43,8
R11	54,4	45,1	46,9	43,9	45,8	45,0	46,0	44,2
R12	54,4	45,1	46,9	43,9	45,9	45,3	46,4	44,5
R13	54,3	45,1	46,8	43,9	45,8	45,1	46,1	44,3

*Table E.66 Summary of VS (**frequency 50÷160 Hz**) overall sound pressure level and corresponding plausible measurement data calculated with **TCR code**.*

	Total sound field			**Direct field (only for *f* < 200Hz)**		
	$Lp_{simulation}$	**$Lp_{(lower\ limit)}$**	**$Lp_{(upper\ limit)}$**	**$Lp_{simulation}$**	**$Lp_{(lower\ limit)}$**	**$Lp_{(upper\ limit)}$**
	[dB]	**[dB]**	**[dB]**	**[dB]**	**[dB]**	**[dB]**
R1	54,4	26,4	83,1	39,2	28,5	60
R2	54,4	26,4	83,1	39,4	28,7	60,3
R3	54,4	26,4	83,1	39,2	28,5	60
R4	54,3	26,4	83	38,3	27,9	58,9
R5	54,3	26,4	83	38,2	27,9	58,9
R6	54,3	26,4	83	37,5	27,4	58
R7	54,3	26,4	83	37,9	27,6	58,5
R8	54,3	26,4	83	37,5	27,4	58
R9	54,3	26,4	83	38,2	27,8	58,8
R10	54,3	26,4	83	38,2	27,8	58,8
R11	54,3	26,4	83,1	38,6	28,1	59,2
R12	54,4	26,4	83,1	39	28,4	59,7
R13	54,3	26,4	83,1	38,6	28,1	59,2

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