Annoyance evaluation of subway interior noise based on psychoacoustical indices

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The subjective and objective method of sound quality evaluation (SQE) in respect of subway interior noise is discussed in this paper. A sample subway of Shanghai Metro Line 9 is considered. The noise signals at four locations and two sets of dummy head heights are measured under three common working conditions of the subway. The measured noises are subjectively evaluated for annoyance values by using the grouped pair-comparison method. Several objective psychoacoustical parameters of these samples are calculated. Accordingly, a mathematical model of sound annoyance is established by using the correlation analysis and multi-dimensional linear regression method, in which the loudness, sharpness, etc., are taken as the variables. The experimental verifications show that there has a strong correlation between the model predicted and subjectively evaluated results, which suggest a good prediction accuracy of the newly presented model.

1. INTRODUCTION

The subway is regarded as the focal point for city transportation development and becomes the priority for public travel with its advantages of high speed, large carrying capacity, low energy consumption, less pollution and punctuality, comfort, energy saving etc. However, subway interior noise, which seriously affects the ride comfort, has become a great threat for human health. In some previous studies, the subway interior noises have been evaluated according to sound pressure level (SPL) and frequency characteristics [1]. The vehicle industry has succeeded in reducing the A-weighted SPL in the subways to a mean of less than 70dB [2-4]. However, the subway SPL is still not enough for a satisfactory acoustical environment. Even when the A-weighted SPL is only about 35dB, people may feel annoyed by conditions such as fluctuations of pitch and a localized sound source [5]. Various types of noise combined in a subway can annoy the passengers and reduce the speech intelligibility. Therefore, it is necessary to further study the SQE of subway interior noise based on psychoacoustical indices, in order to provide a basis to improve subway ride comfort.

As Shanghai subway's total mileage is the longest in the world, the Line 9 is taken as an example in this paper. A jury is organized to evaluate the 42 samples of interior noise of a subway working under the normal conditions. Correlations between the subjectively and objectively evaluated results and their multi-dimensional linear regression analysis are conducted to build mathematical models for evaluation of the subway interior noise based on the objective index which is calculated by Brüel&Kjær (B & K)'s Sound Quality software.

2. SUBWAY INTERIOR NOISE ACQUISITION

2.1 ACQUISITION EXPERIMENTAL SETUP

Currently, there has no specific standard to follow in measurement of a subway

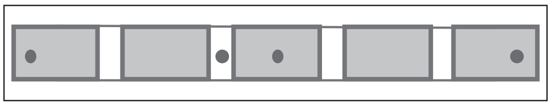

Figure 1. Positions of interior noise acquisition

interior noise. As a reference, the vehicle measurement standard in Ref. [6] is taken into account. The measurement positions are set as follows: the head and rear of the vehicle, the middle and joint of the carriage, as presented in Figure 1. The height of the binaural microphone is 1.5m and 1.1m (the height for the carriage joint is only 1.5m), corresponding to passenger ears of standing and sitting approximately. Three working conditions including acceleration, deceleration, and uniform velocity are selected. Besides, two conditions of subway running in the tunnel and on elevated rails are also considered.

2.2 ACQUISITION EQUIPMENT AND DATA PREPROCESSING

In the measurements, the PULSE multi-channel test system produced by B & K Company of Denmark, which includes a recorder for data acquisition, a laptop, etc., is adopted, together with some auxiliary data acquisition devices, such as a Sound Level Meter NA-28 and a dummy head with two microphones inserted at the entrances of the outer ears. The measurement procedures are conducted under weather conditions of no rain, no snow, the wind speed is less than 5 m/s, and the interior radio is avoided.

Under each measurement condition, the noise signals with length of 10 seconds are measured three times at a sampling rate of 44100 Hz. All measured signals will be replayed and analyzed objectively. In this way, the noise samples can be affected little by other factors. According to the subjective perception formation process of the human auditory, the length of sound signal can be set to 5 seconds [7]. We finally obtained 42 noise samples, which will be used for both subjective and objective evaluations in the following text.

Figure 2 shows A-weighted SPLs of one-third octave bands under different conditions when the train in tunnel, on the measurement position at head, 1.5 m height of the dummy head. It can be seen that the A-weighted SPLs in each frequency band under uniform velocity are the highest, comparing with those of the acceleration and deceleration conditions, and the SPL values of the acceleration are higher than those of the deceleration. The subway interior noise is mainly concentrated on the range of 125Hz-1600Hz, the peak occurred at 800Hz.

3. SUBJECTIVE EVALUATION

The subjective evaluation methods in

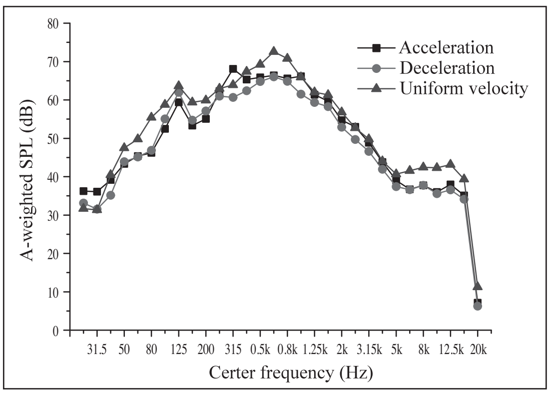

Figure 2. A-weighted SPL of one-third octave bands under different conditions

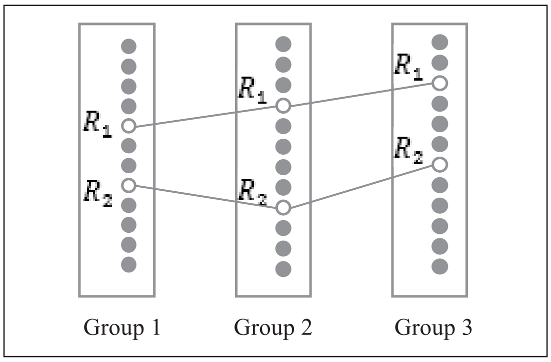

Figure 3. Establishment for data relationship among groups (R1, R2 for associative samples)

common use are rank order, scoring response (rating) scales, paired comparison method, semantic differential [8-10]. For different evaluation purposes, one should chose different evaluation methods to make more accurate and reliable results [11]. In this work, the noise samples are obtained under normal running conditions, the signal characteristics are correlated with each other and are difficult to discriminate. Thus, the paired comparison method is more appropriate here. Following the procedure of the paired comparison method, the measured noise samples are presented in pairs, and the jury members are asked to make relative judgments on the paired sounds. Through this kind of comparison, it is easy to distinguish the slight difference between the auditory events. This evaluation method is very easy to realize [12]. Considering the large number of noise samples, the grouped pair-comparison method is used in subjective evaluation in this paper.

3.1 THEORY OF GROUPED PAIR-COMPARISON METHOD

Grouped pair-comparison method is to divide the samples into N groups which are related based on the samples amount and the evaluation time for each group. Through this method, the evaluation workload of experiment can be effectively reduced [13]. Concerning the integrity of the evaluation, associative samples need to be set, which means to establish the relations among groups. The process is represented by Figure 3.

The evaluated final value ξ of sample can be inverted and rebuilt through equation (1),

$$\xi_{ij} = \frac{\alpha}{(T_{2j} - T_{1j})}(T_{ij} - T_{1j}) + \beta \qquad (1)$$

where, j is the group number, while the i is the number of samples within each group, T_{1j} and T_{2j} represent the original evaluation value of the associative samples of R_1 and R_2 respectively, α is proportional coefficient which used for adjusting the scope of the value of evaluation results, while β is the adjusted value of translation scale of evaluation results. The final evaluation results can be controlled in appropriate scale range through the adjustment of α and β [14].

3.2 VERIFICATION OF THE EVALUATED RESULTS

It would be often misjudged on the situation in paired comparison experiments. Effectiveness verification of the evaluation results from each evaluator is necessary, before evaluation data is reconstructed. Error check of paired comparisons includes three cases: same event comparison error check (*i-i* comparison), different playback sequence comparison error check (*ij-ji* comparison) and triangle loop error checking. Integrated three kinds of error check the weighting consistency coefficient is used [9]. It can be calculated as,

$$\xi_w = 1 - \frac{\sum C_i E_i}{\sum E_i} \qquad (2)$$

where, E_i is the number of misjudgment may occur, C_i is the rate of actually generated misjudgment.

The reliability is poor for a sample whose weighting consistency coefficient is lower in subjective evaluation experiments. This sample should be removed in the data analysis. Generally, excluded 10% of the evaluators' data with lower consistency will not affect the objectivity of the evaluation results [15].

3.3 IMPLEMENTATION OF SUBJECTIVE EVALUATION TESTS

Considering the characteristics of sound quality of the noise samples, the 7th and 33th samples are selected as associative samples, and then the other 40 samples are divided into 4 groups according to the suitability of experimental work. The objective parameters of the two associative samples are listed in table 3. Without affecting of efficient evaluation test, the semi-matrix scheme is adopted in order to reduce the workload and increase efficiency. To judge the reliability of the evaluation results, 12 pairs same event comparison and 22 pairs making comparison by changing the playback order aided design for each experiment, so each group has 100 pairs of evaluation. Annoyance as evaluation index to organize 22 healthy evaluators with normal hearing, 15 males and 7 females respectively, their average age is 28, and most people often take the subway and have a general idea of evaluation of noise.

3.4 Test results processing and analysis

Before the evaluation being processed, the weighting consistency coefficient is calculated for each member's evaluation results in order to judge the reliability of the data. 18 evaluation results of each group will be retained for convenience statistics, the minimum value of the weighting consistency coefficient show in Table 1. As can be seen, the coefficients are all above 0.6, which is in line with international standards that the credibility index is greater than 0.6 to 0.7 [16] on evaluation experiment judgment.

Table 1. Minimum value of the weighting consistency coefficients

Group A	Group B	Group C	Group D
0.647059	0.676471	0.735294	0.647059

Assuming that there are two noise samples in each evaluation pair A and B, if A>B (A is more annoyance than B) then A gets 2 points and B gets 0 point; if A<B (B is more annoyance than A) then B gets 2 points and A gets 0 point; if A=B (A and B are the same annoyance) then A and B get 1 point respectively. Statistics of all evaluations means that every noise sample could get a score. According to equation (1) the scores of the noise samples are inverted and rebuilt that could get the subjective annoyance value of 42 noise samples list in Table 2 (only the subway running in

Table 2. Subjective annoyance evaluation value

NO.	Value	NO.	Value	NO.	Value
01	3.2946	08	1.4274	15	3.6456
02	3.3671	09	2.0758	16	0.8214
03	3.1439	10	2.4091	17	1.1696
04	1.6786	11	2.4924	18	2.4051
05	1.4107	12	2.0909	19	1.2500
06	3.0759	13	3.0427	20	1.2045
07	1.0000	14	1.7848	21	1.8939

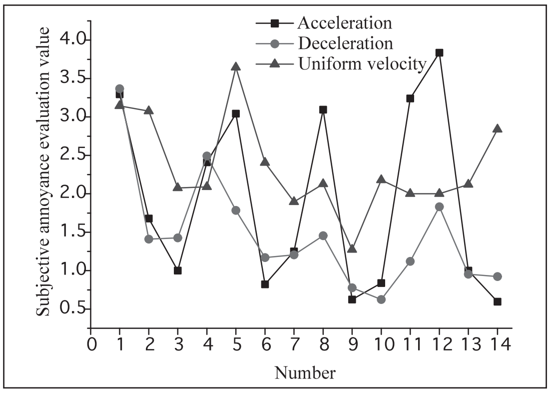

Figure 4. Subjective annoyance evaluation value for different position under different conditions

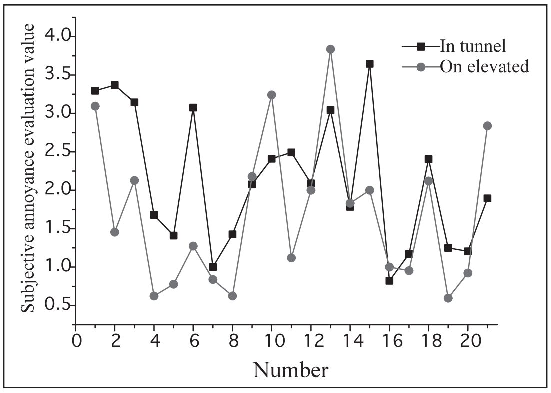

Figure 5. ubjective annoyance evaluation value for different position in tunnel or on elevated railway

the tunnel), here $\alpha = 1$ and $\beta = 1$. The value bigger suggests that the noise more annoyance to person.

The subjective annoyance value of the noise samples are divided into three groups according to operating conditions as showed in Figure 4. As can be seen from the figure, the noise is most annoying when in constant speed, because the subway runs at high speed; the annoyance value is relatively fluctuated when in accelerated speed, it may because the data measurements are not in the same subway, and not with the same accelerated speed, resulting in a difference from the evaluation results. In deceleration conditions, characteristics of noise sound quality of mainly objective parameters decreases and the subway close to the platform, which caused subjective bias caused by human, and therefore the subjective annoyance value is relatively low generally. To sum up, the annoyance caused by the noise generated by the vehicle in high speed operation should be reduced, so to improve the ride comfort.

The samples are divided into two groups as showed in Figure 5. From the figure, we can see the annoyance values in most locations of subway when it is running in a tunnel is higher than corresponding points when it is running on elevated rails. So, through improving the tunnel structure and absorption effects, the sound quality can be enhanced in the subway.

4. MATHEMATICAL MODELING FOR ANNOYANCE

4.1 CALCULATION OF PSYCHOACOUSTIC INDICES

Psychoacoustic indices for objective evaluation are a kind of physical quantities which can be used to describe the difference degree of subjective feelings. Four main psychoacoustic indices, such as the loudness, sharpness, roughness, fluctuation strength, and two kinds of SPL for analysis are chosen in this paper. The sound quality module of the PULSE system is used to calculate four psychoacoustic index values of 42 noise samples and the corresponding A-weighted and linear SPLs. For loudness synthesis of the two channels, the shielding effect should be considered, instead of directly taking the arithmetic mean or mono values. Through a lot of repeated tests and calculations, HONDA company in Japan gives a loudness synthesis expression in Eq. (3) [17], this equation is used in this paper to obtain binaural loudness evaluation value. The other objective index binaural values are averaged. Specific values as is shown in Table 3. Note that only a part of sample values are listed, due to the limited space.

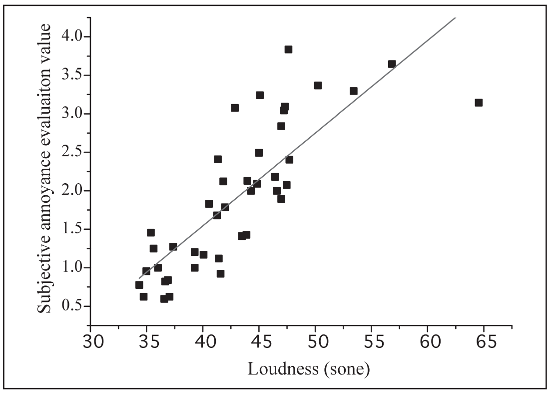

Figure 6. *Correlation between the subjective annoyance evaluation values and the loudness*

$$N_B = (N_L^{1/0.669} + N_R^{1/0.669})^{0.6669} \quad (3)$$

In this equation, N_B is the loudness for both ears; N_L is the left, and N_R is the right.

4.2 CORRELATION ANALYSIS

In order to determine which objective parameter has a great impact on the subjective annoyance of subway interior noise, the SPSS statistical software is adopted. The correlation coefficients among the subjectively evaluated annoyances and the objective psychoacoustic parameters are calculated and listed in Table 4. It can be seen that there are two psychoacoustic objective parameters among the four which have obvious correlation with subjective annoyance, namely, loudness and sharpness. In another two SPL, the A-weighted SPL's relevance with the subjective annoyance value is greater. The scatter diagram in Figure 6 shows the linear correlation between the subjective annoyance evaluation values and loudness intuitively.

4.3 MULTI-DIMENSIONAL LINEAR REGRESSION.

°th a clear understanding of the above correlation, a mathematical model for subjective annoyance may be established in the SPSS software by performing the multi-dimensional linear regression analysis. The linear regression analysis is a statistical analysis technique, which may be used to formulate a quantitative expression between one dependent variable and some independent variable. The

Table 3. *Objective parameters value*

Number	Loudness/ sone	Sharpness/ acum	Roughness/ asper	Fluctuation strength/vacil	A-weighted SPL/dB	Linear SPL/ dB
01	53.4241	1.0700	0.7215	2.1250	75.0792	86.9952
02	50.2442	1.0500	0.5985	2.5500	73.2772	85.3080
03	64.5544	1.0650	0.6105	2.5500	78.0058	88.1732
04	41.2601	1.1100	0.6075	2.1150	71.7204	89.5857
05	43.4860	1.0700	0.6025	1.6950	71.9919	92.1268
06	42.8500	1.0500	0.6035	1.6500	72.7042	90.1233
07	39.2763	1.0800	0.5695	2.5350	69.6375	91.1072
08	43.8855	1.1100	0.7595	3.2000	71.6409	91.8380
09	47.4680	1.0450	0.6050	1.9650	74.1588	91.0974
10	41.3406	1.0550	0.5990	2.0600	70.8923	88.8259
11	44.9967	1.0100	0.6080	1.9250	71.9422	93.1692
12	44.8394	0.9890	0.5715	1.6750	72.3895	88.1213
33	46.5883	1.0100	0.5130	2.1600	89.8894	72.2051

Table 4. Correlations between the subjective values and the objective parameters values

Objective parameters	Loudness	Sharpness	Roughness	Fluctuation strength	A-weighted SPL	Linear SPL
Correlation coefficient	0.808**	-0.570**	0.318*	0.116	0.802**	0.056

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Table 5. Model summary and regressive coefficients

Model	*R*	*R* Square	Unstandardized Coefficients		Standardized Coefficients	t	Sig./%
			B	Std. Error	Beta		
Constant	0.841	0.708	-8.106	6.804	—	-1.191	0.244
Loudness			0.040	0.047	0.290	0.851	0.402
Sharpness			-3.114	1.768	-0.196	-1.761	0.090
A-weighted SPL		0.163	0.116	0.481	1.412	0.170	

dependent variable in this model is subjective annoyance, while the independent variables are the loudness, sharpness and A-weighted SPL, 30 samples are selected randomly. The modeling procedure is performed in the SPSS software, the result showed in Table 5. It can be seen from Table 5, the correlation index of the model evaluation result with the subjective evaluation result is 0.841; the determination coefficient is 0.708, which showed the fitting effect is remarkable. The hypothesis test *t* values of the regression coefficient and confidence probability values showed significant linear regression.

According to the unstandardized coefficients in Table 5, the multi-dimensional linear regression equation is obtained as follows,

$$SA = 0.04 \times L - 3.114 \times S + 0.163 \times A - 8.106 \quad (4)$$

where, SA is the subjective annoyance of subway interior noise, L is the loudness, S is the sharpness, and A is the A-weighted SPL.

Equation 4 shows that the subjective annoyance of subway interior noise can be described by the loudness, sharpness and A-weighted SPL. In order to improve the sound quality of subway interior, the loudness, sharpness and A-weighted SPL should be controlled. Furthermore the standardized coefficient of A-weighted SPL in Table 5 is 0.481 that is greater than the value of loudness and sharpness, which shows that A-weighted SPL is the most affected to the subjective annoyance of subway interior noise under the condition of test of this paper.

4.4 ANNOYANCE MODEL VALIDATION

The mathematical model of annoyance is used to calculate the evaluation value of the remaining 12 noise samples and the result are compared with those from subjectively evaluated values. The scatter diagram in Figure 7 shows the correlation between them, the correlation index is 0.824, which proves that this model is capable of calculating the subjective annoyance of the subway interior noise.

5. SUMMARY AND CONCLUSIONS

This paper presents a complete procedure for subjective and objective SQE of subway interior noise. The subway interior noise acquisitions are considered under different

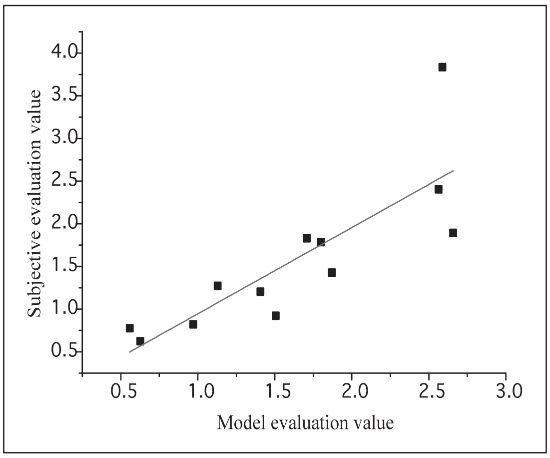

Figure 7. Correlation between the sound quality model evaluation result and the subjective evaluation result

measurement positions and vehicle working conditions. The Shanghai Subway Line 9 is chosen as an example. 42 noise samples are selected. The subjective evaluation for annoyance of subway interior noise is concocted by the jury test using the grouped pair-comparison method. The calculation results show that annoyance value is higher when the subway runs in uniform velocity than in acceleration and deceleration, and the value is lower when the subway runs on elevated rails than in the tunnel.

The mathematical model of sound subjective annoyance, which uses objective indices to describe subjective evaluation results, is established by using correlation and multi-dimensional linear regression analysis of the subjective evaluation results and objective parameters. It can be seen from the model the subjective annoyance of subway interior noise is mainly influenced by the loudness, sharpness and the A-weighted SPL. The noise samples, which are not used in model building, are used to verify the feasibility and accuracy of the evaluation model. The results indicate that there exists a strong correlation between the model predicated and subjectively evaluated values. So the model is beneficial for vehicle acoustical design and improvement.

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REFERENCES

[1] Zheng D, Cai X, Song H, et al. Study on personal noise exposure in China. *Applied Acoustics*, 1996, 48(1), 59-70.

[2] Soeta Y, Shimokura R. Survey of interior noise characteristics in various types of trains. *Applied Acoustics*, 2013, 74(10), 1160-1166.

[3] Hardy A E J. Measurement and assessment of noise within passenger trains. *Journal of Sound and Vibration*, 2000, 231(3), 819-829.

[4] Soeta Y, Shimokura R. The impact of external environments on noise inside a train car. *Noise Control Engineering Journal*, 2011, 59(6), 581-590.

[5] Kitamura T, Shimokura R, Sato S, et al. Measurement of temporal and spatial factors of a flushing toilet noise in a downstairs bedroom. *Journal of Temporal Design in Architecture and the Environment*, 2002, 2(1), 13.

[6] GBT 3449-2011 *Measurement of noise inside railbound vehicles*. Beijing: Standard Press of China, 2012.

[7] Otto N, Amman S, Eaton C, et al. Guidelines for jury evaluations of automotive sounds. *SAE transactions*, 2000, 108(6; PART 2), 3015-3034.

[8] Bodden M, Heinrichs R, Linow A, et al. Sound quality evaluation of interior vehicle noise using an efficient psychoacoustic method. *Proc. of the 3rd European Conference on Noise Control-Euronoise*. 1998, 98, 609-614.

[9] Buss S, Schulte-Fortkamp B, Muckel P. Combining methods to evaluate sound quality. *Proceedings of the 29th International Congress and Exposition on Noise control engineering (Inter-Noise 2000)*, Nice, France. 2000, 27-30.

[10] Cardozo B L, Van Lieshout R. Estimates of annoyance of sounds of different character. *Applied Acoustics*, 1981, 14(5), 323-329.

[11] Blauert J, Jekosch U. Sound-quality evaluation a multi-layered problem. *Acta acustica united with acustica*, 1997, 83(5), 747-753.

[12] Otto N, Amman S, Eaton C, et al. Guidelines for jury evaluations of automotive sounds. *SAE transactions*, 2000, 108(6; PART 2), 3015-3034.

[13] MAO Dong-xing, GAO Ya-li, YU Wu-zhou, etal, Grouped pair-wise comparison for subjective sound quality evaluation. *ACTA ACUSTICA*. 2005,30(6), 515-520.

[14] MAO Dong-xing, YU Wu-zhou, WANG Zuo-min, Statistical validation and criterion for paired comparsion data in sound quality evaluation. *ACTA ACUSTICA*. 2005, 30(5), 468-472.

[15] Otto N. A subjective evaluation and analysis of automotive starter sounds. *Noise Control Engineering Journal*, 1993, 41(3), 377-382.

[16] Parizet E. Paired comparison listening tests and circular error rates. *acta acustica united with acustica*, 2002, 88(4), 594-59.

[17] Noumura K, Yoshida J. Perception modeling and quantification of sound quality in cabin. *SAE Transactions*, 2003, 112(6), 1790-1799.

DUBLIN PORT TERMINAL TWICE AS LOUD AS WHO GUIDELINES

A new study says that noise levels at part of the Dublin port near a residential area exceeds guidelines set by the World Health Organisation. The study was undertaken by Enda Murphy from University College Dublin's school of geography, planning and environmental policy, and Eoin King of Hartford University in the US. The terminal on Pigeon House Road that they studied is operated by Marine Terminals Ltd (MTL). The MTL facility is directly across from an area where 11 residents have their homes. A number of residents of Pigeon House Road are involved in a High Court case over noise levels at the terminal. Murphy said that when you factor in the fact there is a low frequency component, the noise at the terminal "exceeds WHO guidelines by 11db", going from 40 to 51db. While in normal parlance this would represent a 25 per cent difference, it is in fact a 100 per cent increase, doubling sound pressure levels. This is "twice as loud as what the WHO guideline limits suggest", he said. There is also intermittent noise at night time, as containers operate some nights in the early hours. Dublin City Council (DCC) said that studies in many EU cities have indicated that WHO guideline ambient noise levels are regularly exceeded, which "is consistent with Dublin City Council's own noise mapping study" which show that these guidelines are exceeded at many locations throughout the city. The council's spokesman added: "Furthermore, the High Court has found that it was not reasonable to expect adherence to these guideline limits for a specific noise source when it accepted that ambient noise levels were already in excess of that level throughout the Dublin area. Dublin City Council therefore uses other methodologies for assessing noise nuisance. Our findings, based on these methodologies, did not indicate that legal proceedings were merited."

REAL TIME MINING NOISE MONITORING

Mount Thorley Warkworth open-cut mine (NSW, Australia) will be the first Hunter mine to trial the latest noise monitoring technology. A new directional noise monitoring system will be installed in the southern area of Bulga village to assist with monitoring and managing noise from the mine. The environmental noise compass will enhance Coal & Allied's existing noise monitoring system, which currently involves eight monitoring devices surrounding the mine. The compass uses an array of 26 microphones and advanced acoustic signal processing methods to detect and assess multiple noise sources in real time with greater accuracy. Coal & Allied NSW environmental services manager Andrew Speechly said the new system would allow Mount Thorley Warkworth to be more effective in its real-time management of noise by measuring the sound energy of mining activities as they happen and responding accordingly.

WHO SURVEY: MANY COUNTRIES LACK CAPACITY TO PREVENT AND TREAT HEARING LOSS

Many of the countries who responded to a new World Health Organization (WHO) survey lack the capacity to prevent and care for hearing loss, according to a new report published on International Ear Care Day, 3 March. WHO estimates that over 5% of the world's population – 360 million people – has disabling hearing loss. The highest prevalence is found in the Asia Pacific, South Asia and sub-Saharan Africa. About half of all cases of hearing loss worldwide are easily prevented or treated. Just 32 of the 76 countries who responded have developed plans and programmes to prevent and control ear diseases and hearing loss. According to the report, many lack trained health personnel, educational facilities, data and national plans to address the needs of those living with ear and hearing problems. The information received also indicates that the gap between need and services is greatest in sub-Saharan Africa. "The results of this survey are a clear call to action for governments and partners to invest in hearing care especially at community and primary level," says Dr Etienne Krug, Director of the WHO Department of Violence and Injury Prevention and Disability. "The programmes must aim to benefit all, including disadvantaged parts of the population who are least able to access hearing services."

CINEMA NOISE BAN SOUGHT IN CONNECTICUT

Connecticut is aiming to become the first US state to impose a ban on excessive sound levels at public film screenings. A bill is currently before the state legislature's Public Safety and Security Committee that would ban the showing of any film or trailer that exceeds 85 decibels. The ban attempt was initiated by chemical industry consultant William Young, a Stamford resident who was quoted as saying: "Why they need such loud sounds is beyond me … Hopefully this will be a wakeup call to the theater owners and the MPAA to get their act together and do something that's good for the public and still will satisfy their needs." Democratic senator Carlo Leone, who helped introduce the bill, said: "I support the concept moving forward … If there are other corrective measures without legislation and it takes care of the problem, that would be the better choice." The industry body Motion Picture Association of America opposes a ban, with senior vice president Vans Stevenson saying: "Certainly no one is going to do anything that would have a hint of being harmful … We've gone to great lengths to make sure that average is in an acceptable range that is not harmful." In 1999 the National Association of Theatre Owners introduced the TASA (Trailer Audio Standards Association) standard, a voluntary certification to limit sound pressure to 85 Leq. Young, however, says a limit is needed as cinemas do not stick to the TASA standard, claiming his tests have shown sound levels have risen to 100 decibels. "Who wants to sit there in pain? These companies shouldn't subject people to harmful sounds."