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Interlaboratory and proficiency tests for field measurements in Brazil

Pozzer, Talita; Wunderlich, Priscila: Monteiro, Carolina; de Frias, Juan
ProAcústica
Av. Ibirapuera 3458, São Paulo - Brazil

ABSTRACT

This paper presents the methodologies and procedures used in the interlaboratory program, as well as the results of both the interlaboratory test and the proficiency carried out in São Paulo (Brazil) during 2017 by ProAcústica - Brazilian Association for Acoustical Quality

The application of Brazilian standard series ABNT NBR 15.575: 2013, which sets acoustic requirements for dwellings, including verification field tests procedures according to ISO standards, has raised significantly the demand for sound insulation tests, as well as the number of field laboratories all around the country.

ProAcústica - Brazilian Association for Acoustical Quality is a non-profit entity which main objective is the continuous dissemination and improvement of the acoustics sector in Brazil. Aiming to meet this objective, ProAcústica organized the third edition of the "Interlaboratory program of field tests for building acoustics laboratories", which consists of a fundamental tool for acoustic field laboratories to evaluate and verify the quality of their measurement results.

In this edition participated a total number of 19 laboratories for different type of tests (airborne sound insulation and airborne facade sound insulation, impact sound level, sound pressure level from service equipment in buildings, and reverberation time). The main objectives were the evaluation of the precision of the field test methods in the Brazilian market, the analysis of the performance of the participating laboratories as a quality control tool.

Keywords: Interlaboratory test, proficiency, quality, field laboratories.

I-INCE Classification of Subject Number: 72

1. INTRODUCTION

An interlaboratory test is a collaborative test in which all the participant laboratories measure the same item, with their own methods, instrumentation and staff. The main objectives of interlaboratory tests are:

- Assess the precision and equivalence between different test methods.
- Asses the technical compliance of laboratories to carry on acoustic tests (proficiency tests) in a continuous follow up of the performance.
- Detection of problems during the measuring process and developing corrective solutions.
- Provide confidence to the market.

The proficiency test is a specific case of interlaboratory test, that aims to assess the performance of the different participant laboratories. The regular participation in proficiency tests is a fundamental tool for the quality control of measurement services offered in each laboratory portfolio, as it is the most effective way of assessing if the tests are being carried out properly.

2. BACKGROUND

2.1 General

ProAcústica is the first institution to develop a program of interlaboratory field tests for building acoustics in Brazil. All the tests were carried out in the city of São Paulo. The first one, in 2012 joined five laboratories, for the second edition (2014) the number of participants increased up to seven, and in the last one, in 2017, nineteen laboratories have participated.

The first two interlaboratory tests took place in residential buildings provided by the construction company Tecnisa, and for the last edition, the building under evaluation was lent by the company EZTec.

2.1 Third edition (2017)

The third interlaboratory program was organized in the beginning of 2017, and the measurements were carried out from February 13th, to may, 27th by the 19 participants laboratories, presented in Table 1.

Table 1. Participant laboratories. 2017 Edition

PARTICIPANT LABORATORIES	
01dB Comércio de Equipamentos Ltda.	Labacústica
Acústica Engenharia Ltda.	MMC LAB Controle Tecnológico Ltda.
Anima Acústica Tecnologia e Conhecimento Ltda. ME	Modal Acústica e Engenharia Ltda.
Associação Antônio Vieira (ASAV – UNISINOS)	Oppus Acústica Ltda.
Atenua Som Indústria e Comércio Ltda.	Pedrosa e Nascimento Engenharia e Consultoria Ltda.
Bracústica Consultoria Ltda.	Scala dB Acústica Ltda.
Echo Projetos Acústicos Ltda. ME	Síntese Arquitetura e Construção Ltda.
Environmental Solutions Consultoria SS Ltda.	Tecnisa S.A.
Grom Equipamentos Eletromecânicos Ltda.	Tecomat Engenharia Ltda.
Harmonia Acústica Ltda.	

In Table 2 the number of participants in each test is presented, as not all laboratories participated in all available tests of the program.

Table 2. Tests of the program and number of participants

Nº	TEST	NUMBER OF LABORATORIES
1	ISO 16283-1:2014 – Acoustics -- Field measurement of sound insulation in buildings and of building elements -- Part 1: Airborne sound insulation	19
2	ISO 10052:2004 – Acoustics -- Field measurements of airborne and impact sound insulation and of service equipment sound -- Survey method: airborne sound insulation between rooms	12
3	ISO 16283-3:2016 – Acoustics -- Field measurement of sound insulation in buildings and of building elements -- Part 3: Façade sound insulation	19
4	ISO 10052:2004 – Acoustics -- Field measurements of airborne and impact sound insulation and of service equipment sound -- Survey method: airborne sound insulation of facades	12
5	ISO 16283-2:2015 – Acoustics -- Field measurement of sound insulation in buildings and of building elements -- Part 2: Impact sound insulation	19
6	ISO 10052:2014 – Acoustics -- Field measurements of airborne and impact sound insulation and of service equipment sound -- Survey method: impact sound insulation of floors	12
7	ISO 3382-2:2008 – Acoustics -- Measurement of room acoustic parameters -- Part 2: Reverberation time in ordinary rooms	15
8	ISO 16032:2004 – Acoustics -- Measurement of sound pressure level from service equipment in buildings -- Engineering method	14

For each test, each participant carried out five complete repetitions of the measurement, with procedures that should comply with the corresponding ISO measurement standard. Each participant laboratory was allowed to decide some aspects as the number of positions, the location of source/microphone or the integration period.

3. RESULTS

3.1 Presented quantities

The results of the performed field measurements of each laboratory were assessed accordingly ISO 17043:2014 [2], with the following indicators as output data:

a) True value (X) and proficiency standard deviation (σp), obtained respectively from robust mean value (x*) and robust standard deviation (s*), regarding annex C of the standard ISO 13528:2015 [3].
b) Z-Score, for assessment of the performance of the participant laboratories, calculated with the following equation:

$$Z = (x - X)/\sigma p \ , \qquad (1)$$

Where x is de result obtained by each laboratory, X is the true value of the result and σp is the proficieny standard deviation.

- For $|Z| \leq 2$, the result of the individual participant is regarded as acceptable (satisfactory performance).

- For 2<|Z|≤3, the result of the individual participant is regarded questionable, being recommended to carry out an assessment of the possible causes and special caution in that values when testing.
- For |Z|>3, the result of the individual participant is regarded as non-acceptable (unsatisfactory performance).

c) Standard uncertainty of interlaboratory test (u) calculated regarding ISO 5725-1 [4] 5725-2 [5],
d) Repeatability and reproducibility of the interlaboratory test calculated regarding ISO 5725-2 [5].

3.2 Airborne sound insulation between dwellings - $D_{nT,w}$

3.2.1. ISO 16283-1:2014 - Engineering method (19 laboratories)

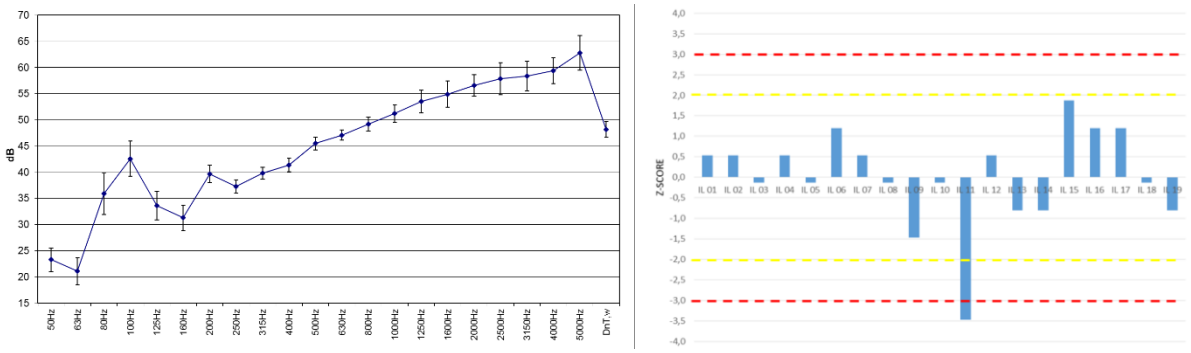

Figure 1. True value (X) and standard deviation (σp) (left), Z-Score $D_{nT,w}$ (right)

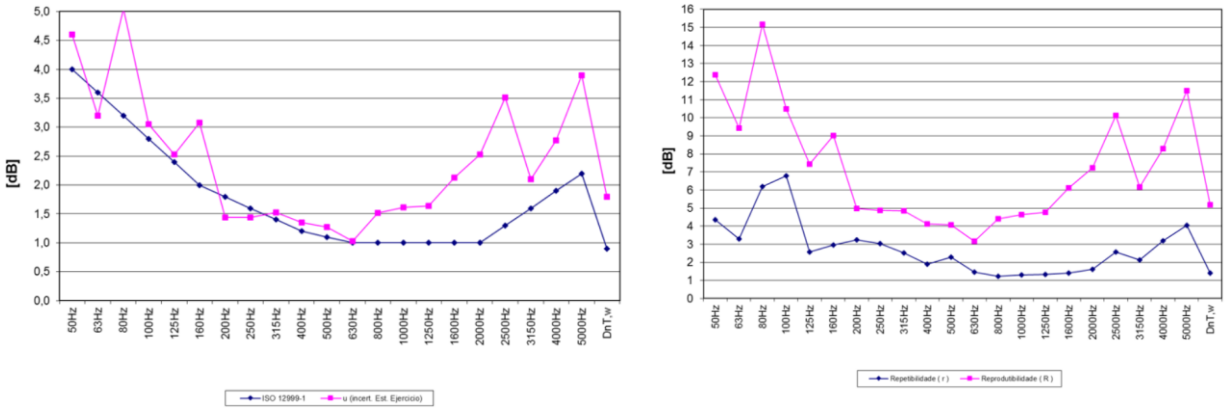

Figure 2. Comparison between standard uncertainty (u) and ISO 12999-1(left), repeatability and reproducibility (right)

3.2.2. ISO 10.152:2004 – Survey method (10 laboratories)

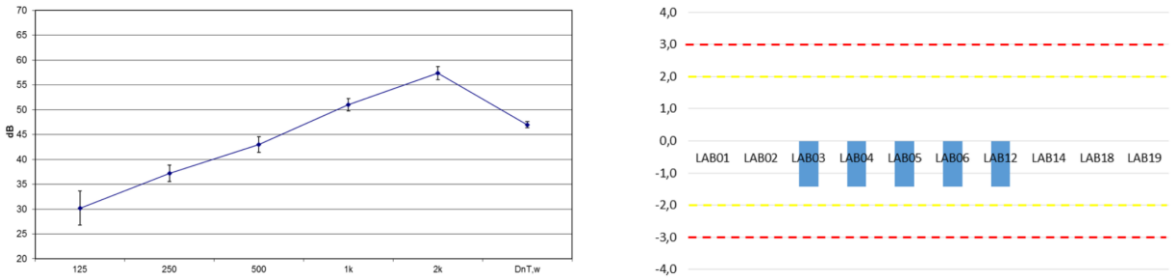

Figure 3. True value (X) and standard deviation (σp) (left), Z-Score $D_{nT,w}$ (right)

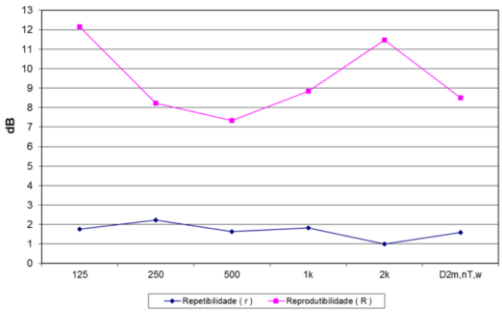

Figure 4. Repeatability and reproducibility

3.3 Impact sound insulation between dwellings – $L'_{nT,w}$

3.3.1. ISO 16283-2:2015 - Engineering method (19 laboratories)

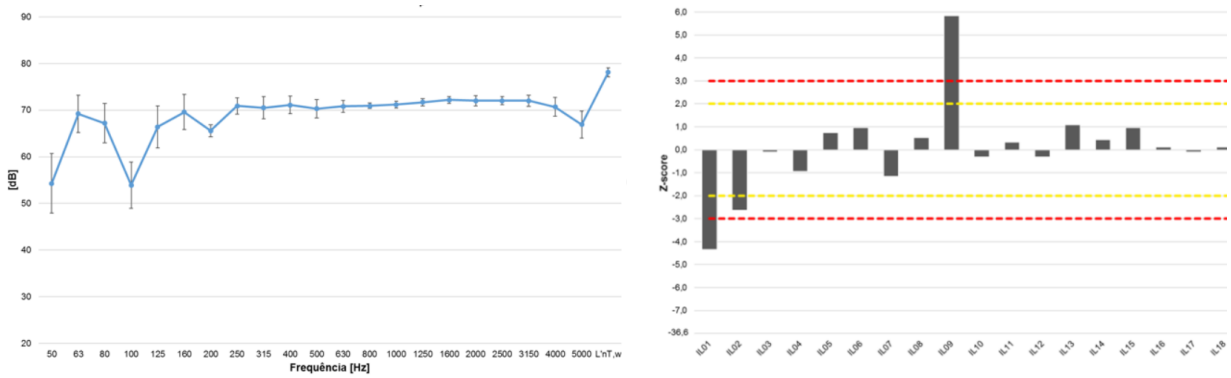

Figure 5. True value (X) and standard deviation (σp) (left), Z-Score $D_{nT,w}$ (right)

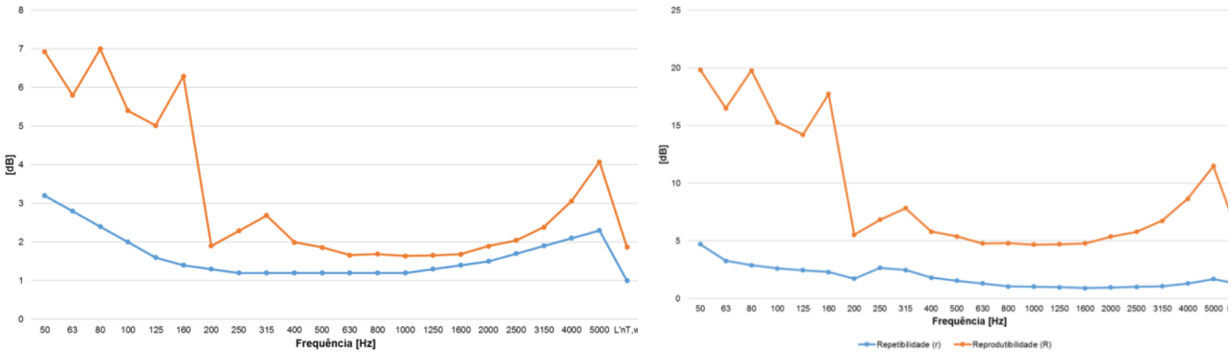

Figure 6. Comparison between standard uncertainty (u) and ISO 12999-1(left), repeatability and reproducibility (right)

3.3.2. ISO 10.152:2004 – Survey method (10 laboratories)

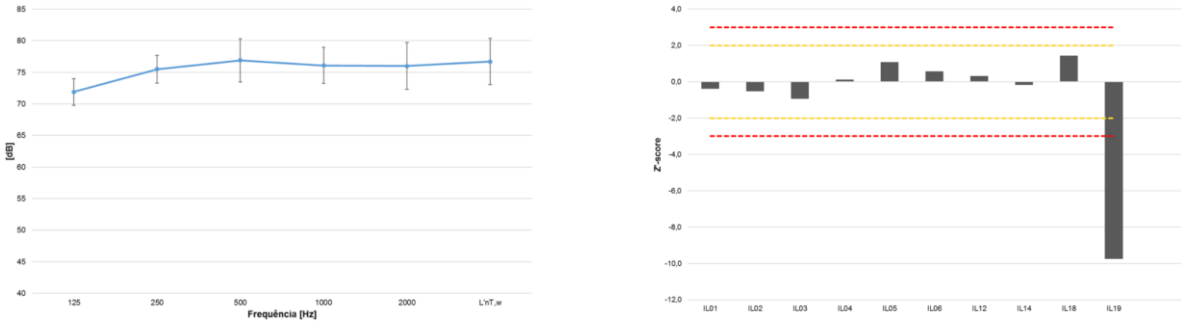

Figure 7. True value (X) and standard deviation (σp) (left), Z-Score $D_{nT,w}$ (right)

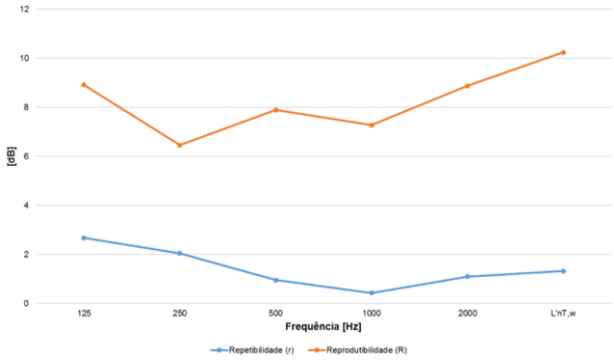

Figure 8. Repeatability and reproducibility

3.4 Airborne façade sound insulation - $D_{2m,nT,w}$

3.4.1. ISO 16283-3:2016 - Engineering method (17 laboratories)

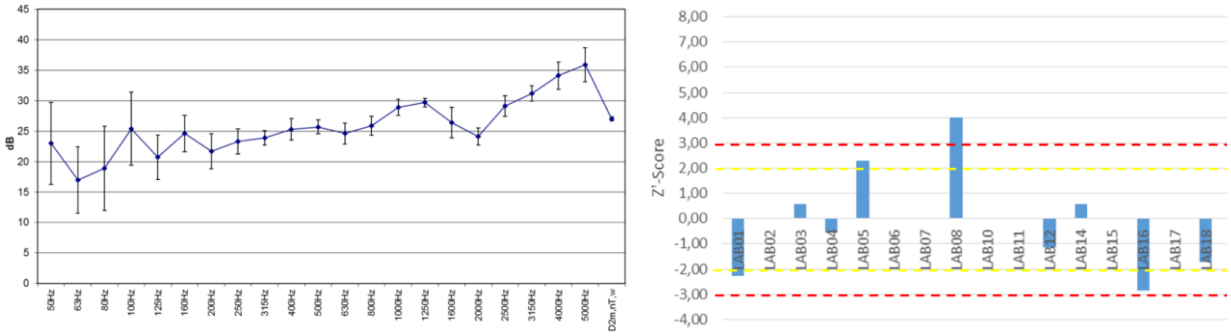

Figure 9. True value (X) and standard deviation (σp) (left), Z-Score $D_{nT,w}$ (right)

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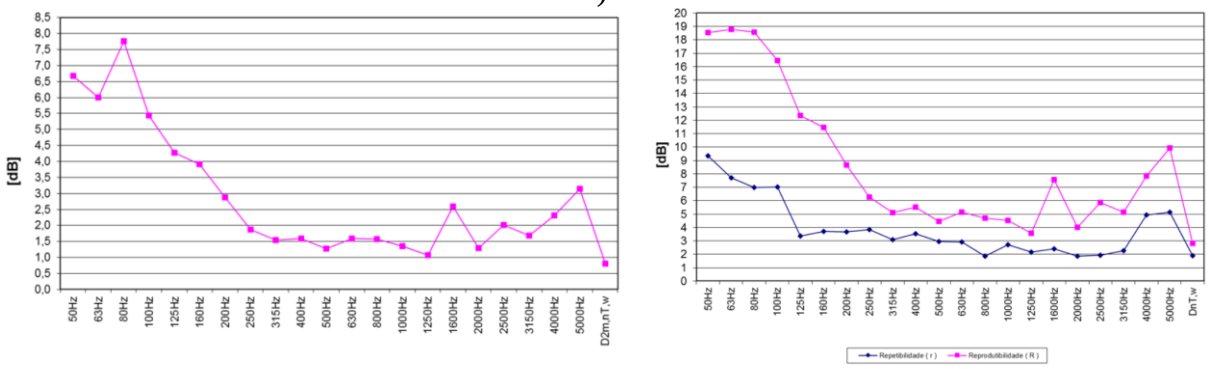


Figure 10. Standard uncertainty (u) (left), repeatability and reproducibility (right)

3.4.2. ISO 10.152:2004 – Survey method (10 laboratories)

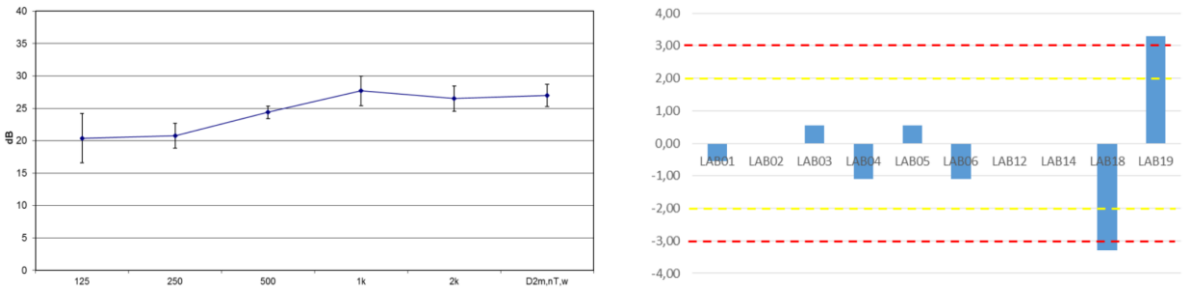


Figure 11. True value (X) and standard deviation (σp) (left), Z-Score $D_{nT,w}$ (right)

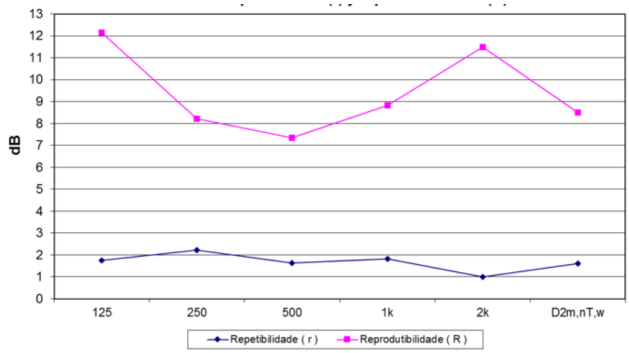


Figure 12. Repeatability and reproducibility

3.5 Noise level from service equipment - $L_{Aeq,nT}$, $L_{ASmasx,nT}$

3.5.1. ISO 16032:2004 - Engineering method (13 laboratories)

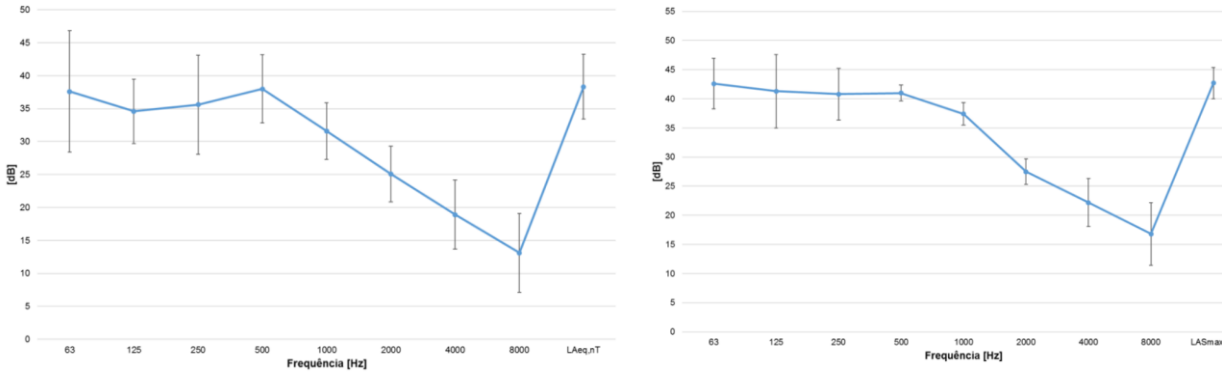


Figure 13. True value (X) and standard deviation (σp) $L_{Aeq,nT}$ (left) and $L_{ASmax,nT}$ (right)

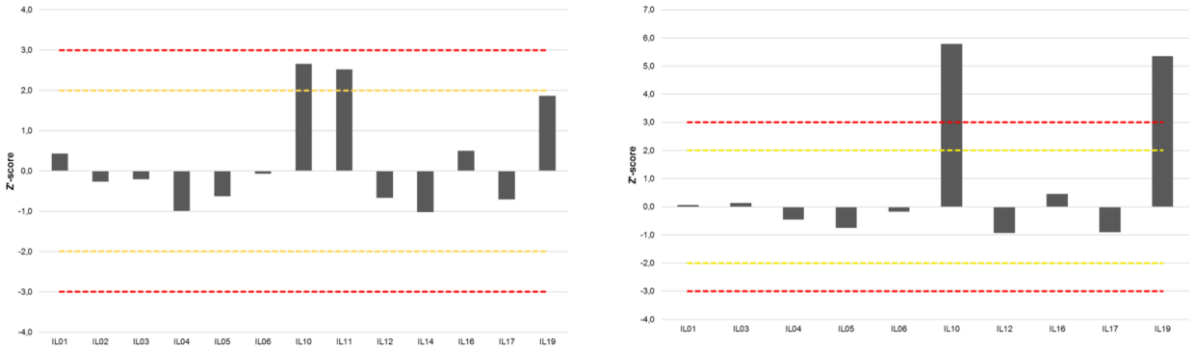


Figure 14. Z-Score $L_{Aeq,nT}$ (left) and $L_{ASmax,nT}$ (right)

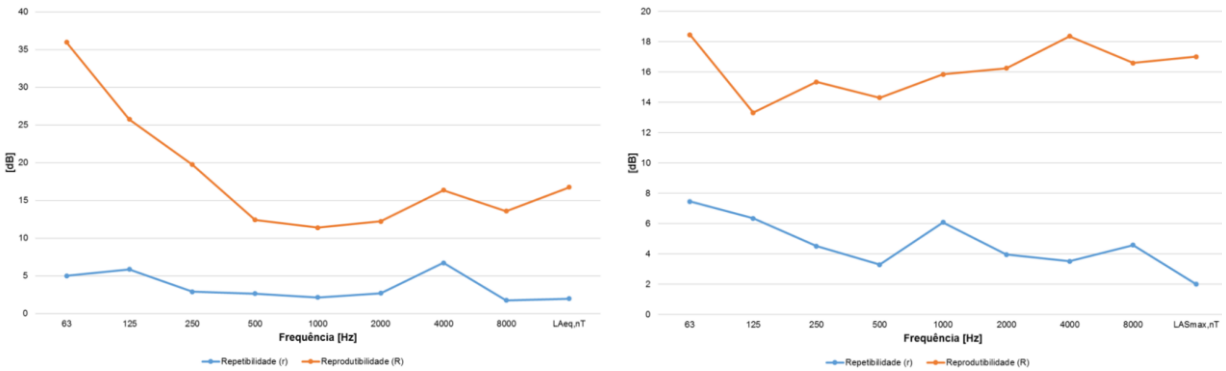
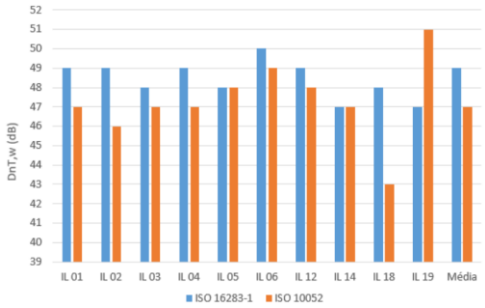


Figure 15. Repeatability and reproducibility $L_{Aeq,nT}$ (left) and $L_{ASmax,nT}$ (right)

4. COMPARISON BETWEEN ENGENEERING METHOD AND SURVEY METHOD

This section presents the comparison of single number global results of the interlaboratory tests obtained by the engineering (ISO 16283-1 and ISO 16283-2) and the survey method (ISO 10052).

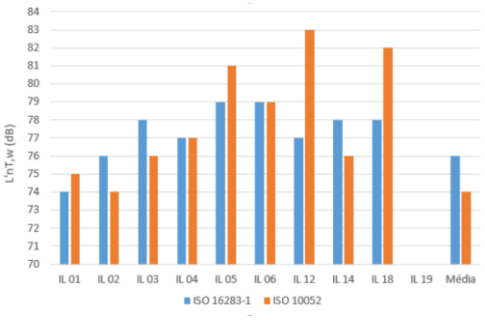
4.1 Airborne sound insulation between dwellings - $D_{nT,w}$



$D_{nT,w}$ (dB)	ISO 16283-1	ISO 10052
Average	49	47
Standard Dev.	0,96	2,05
True Value	48	47
σ_p	1,5	0,7
General Average	48	47
u	1,8	2,21
r	1,4	1,5
R	5,2	6,3

Figure 16. Comparison of results $D_{nT,w}$ ISO 16.281-1 vs. ISO 10.052

4.2 Airborne sound insulation between dwellings – $L'_{nT,w}$



$L'_{nT,w}$ (dB)	ISO 16283-1	ISO 10052
Average	76	74
Standard Dev.	10,96	11,05
True Value	78	77
σ_p	0,9	3,7
General Average	78	78
u	1,9	3,63
r	1,3	1,3
R	5,3	10,2

Figure 17. Comparison of results $L'_{nT,w}$ ISO 16.281-2 vs. ISO 10.052

4. COMPARISON BETWEEN EDITIONS (2017 VS. 2014)

This section presents the comparison of the results obtained in the 2014 edition with the former standard ISO series 140, and in 2017 with the new standard ISO series 16283.

4.1 Airborne sound insulation between dwellings 2017(19 laboratories) vs. 2014 (7 laboratories)

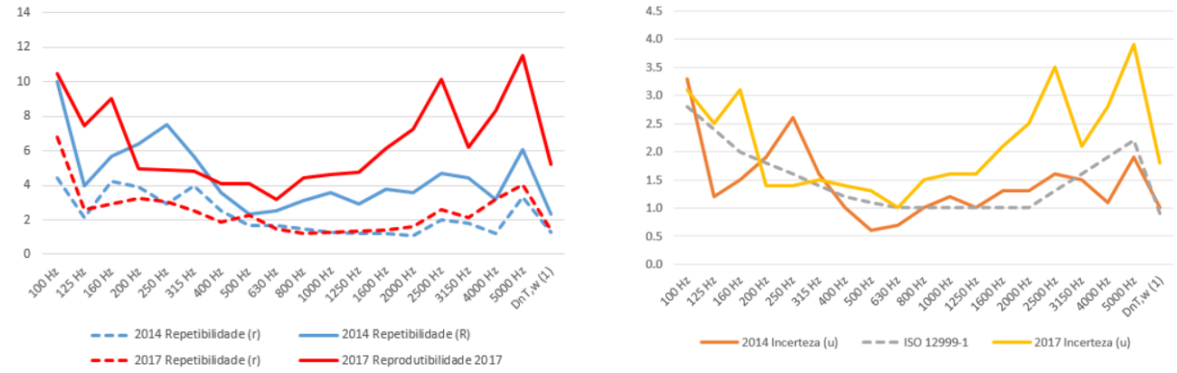


Figure 18. Comparison of repeatability and reproducibility (left) and uncertainty (right)

4.1 Impact sound insulation between dwellings 2017(19 laboratories) vs. 2014 (7 laboratories)

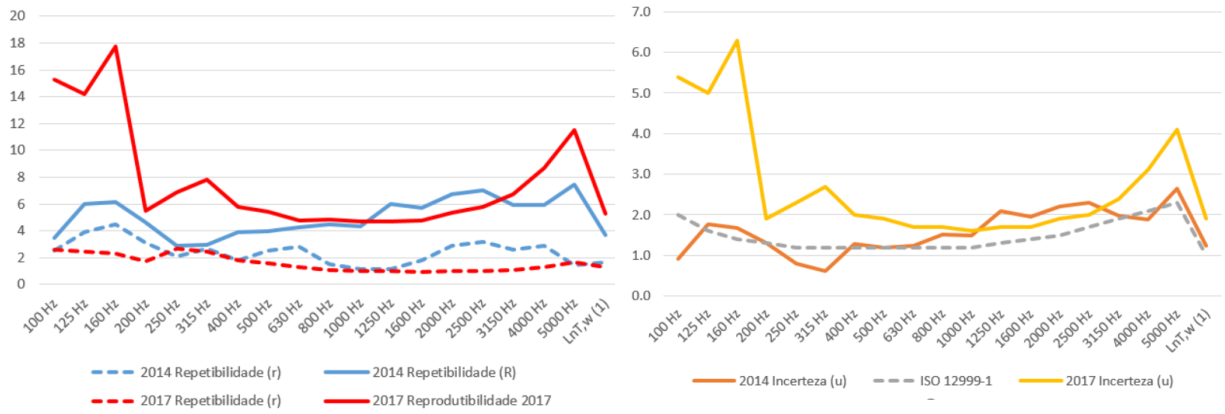


Figure 19. Comparison of repeatability and reproducibility (left) and uncertainty (right)

4. CONCLUSIONS

- Considering the number of participants, it was observed an increasing interest in participating in proficiency tests, revealing a growing market of acoustics field measurements.
- As expected, the uncertainties of the results obtained from the control method are higher than those obtained from the engineer method.
- For airborne sound insulation tests, the results for the engineering method are in general higher than for the control method.
- The uncertainties of the results of airborne sound insulation and impact sound insulation obtained by the engineering method do not comply with the reference values presented in the standard ISO 12999-1.
- The highest uncertainties values where obtained for the service equipment noise tests results, probably due to the fact that the procedure consists on an absolute measurement, the noise source is not standardized, and the SNR ratio was low during the tests due to high background noise.

- In the last edition the uncertainties were, in general, higher than in the 2014 edition, being necessary to perform further studies to evaluate the causes.

5. REFERENCES

[1] Programa de ensaios interlaboratoriais 2012 e 2014. XXV Encontro SOBRAC, Sociedade Brasileira de Acústica. Campinas, 2014.
[2] ABNT ISO 17043:2014 Avaliação da conformidade - Requisitos gerais para ensaios de proficiência.
[3] ISO 13528:2015 Statistical methods for use in proficiency testing by interlaboratory comparisons.
[4] ISO 5725-1:1994 Accuracy (trueness and precision) of measurement methods and results - - Part 1: General principles and definitions.
[5] ISO 5725-2:1994 Accuracy (trueness and precision) of measurement methods and results - - Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method.
[6] ISO 12999-1:2014 Acoustics - Determination and application of measurement uncertainties in building acoustics - Part 1: Sound insulation