

Technical University of Denmark



## Boundary Element Method with Viscous and Thermal Losses: A Calibration Microphone Test Case

Cutanda Henriquez, Vicente; Barrera Figueroa, Salvador; Andersen, Peter Risby

*Publication date:*  
2017

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Cutanda Henriquez, V., Barrera Figueroa, S., & Andersen, P. R. (2017). Boundary Element Method with Viscous and Thermal Losses: A Calibration Microphone Test Case. Abstract from 13th International Conference on Theoretical and Computational Acoustics, Vienna, Austria.

**DTU Library**  
Technical Information Center of Denmark

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

ICTCA  
2017  
VIENNA

13th International  
Conference on  
Theoretical and  
Computational  
Acoustics

# Book of Abstracts

30. Juli - 03. August 2017



**Editors:**

Piotr Borejko  
Manfred Kaltenbacher  
Florian Toth

**Published by:**

Institute of Mechanics and Mechatronics, Faculty of Mechanical and Industrial Engineering  
Institute of Building Construction and Technology, Faculty of Civil Engineering  
TU Wien  
Vienna, Austria  
<http://ictca2017.conf.tuwien.ac.at>

**ISBN:**

978-3-200-05210-9

**Credits:**

Cover design: Ruth K. Tscherne  
L<sup>A</sup>T<sub>E</sub>X editors: F. Toth, C. Junger, S. Floss, S. Gombots, I. Lazarov, S. Schoder, F. Egner

Printed in Vienna by Druck & Medienwerk GmbH

July 2017

## Boundary Element Method with Viscous and Thermal Losses: A Calibration Microphone Test Case

Vicente Cutanda Henríquez<sup>1</sup>, Salvador Barrera Figueroa<sup>2</sup>, Peter Risby Andersen<sup>1</sup>

<sup>1</sup>Centre for Acoustic-Mechanical Micro Systems, Technical University of Denmark, Kgs. Lyngby, Denmark

<sup>2</sup>Danish Fundamental Metrology (DFM) A/S, Kgs. Lyngby, Denmark

A Boundary Element Method implementation including viscous and thermal losses of sound waves at the boundaries was proposed [1,2] and applied successfully to a number of cases, e.g. acoustic metamaterials and measurement microphones [3,4]. As other implementations employing the Finite Element Method, the BEM with losses is based on the linearized Navier-Stokes equations with no flow. In this presentation, a full three-dimensional BEM model of a one-inch condenser microphone designed for primary calibration, the B&K 4160, will be used for the discussion of the shortcomings of the BEM with losses [5]. This test case is particularly challenging due to its size, internal intricacy and strong coupling of internal, external and membrane domains. This model will be compared with other simpler BEM models of condenser microphones. Based on the results, possible paths for further improvement of the BEM implementation with losses will be suggested.

### References

- [1] V. Cutanda Henríquez and P. M. Juhl, *An axisymmetric boundary element formulation of sound wave propagation in fluids including viscous and thermal losses*, Journal of the Acoustical Society of America **134**(5) (2013), 3409–3418.
- [2] V. Cutanda Henríquez and P. M. Juhl, *Implementation of an acoustic 3D BEM with visco-thermal losses*, Proc. Internoise 2013, 15–18 September 2013, Innsbruck, Austria.
- [3] V. Cutanda Henríquez and P. M. Juhl, *Modelling measurement microphones using BEM with visco-thermal losses*, Proc. Joint Baltic-Nordic Acoustics Meeting, 18–20 June 2012, Odense, Denmark.
- [4] V. Cutanda-Henríquez, P. R. Andersen, J. S. Jensen, P. M. Juhl, and J. Sánchez-Dehesa, *A numerical model of an acoustic metamaterial using the Boundary Element Method including viscous and thermal losses*, Journal of Computational Acoustics **25**, 1750006 (2016).
- [5] V. Cutanda Henríquez, S. Barrera Figueroa and P. M. Juhl, *Study of the acoustical properties of a condenser microphone under an obliquely incident plane wave using a fully coupled three-dimensional numerical model*, Proc. Internoise 2015, 9–12 August 2015, San Francisco, USA.

Thursday, 10:55, **GM3** Vortmann Lecture Hall, Building BD