AlphaPorous User Guide v1.0

February 19, 2026

AlphaPorous User Guide

Acoustic Absorption Prediction Tool

Version 1.0
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Table of Contents

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1. Introduction

1.1 About AlphaPorous

AlphaPorous is a free, open-source, browser-based tool for predicting the sound absorption coefficient of porous materials. The tool implements seven established acoustic models ranging from simple empirical relationships to sophisticated semi-empirical and phenomenological approaches.

Key Features: - Seven acoustic absorption models - Real-time interactive plotting - Noise Reduction Coefficient (NRC) calculation - Multi-curve comparison - CSV data export - No installation required - Completely client-side (no data collection) - Open source on GitHub

Access the tool at: https://alphaporous.com

1.2 Target Users

AlphaPorous is designed for: - Acoustic engineers and consultants - Materials scientists researching porous media - Graduate students studying acoustics - Building acoustics professionals - Automotive NVH engineers - Educators teaching acoustic material behavior

1.3 System Requirements

Minimum Requirements: - Modern web browser (Chrome, Firefox, Safari, or Edge) - Internet connection (only for initial loading) - No plugins or extensions required - Works on desktop, tablet, and mobile devices

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2. Getting Started

2.1 Accessing AlphaPorous

1. Open your web browser
2. Navigate to: **https://alphaporous.com**
3. The tool loads instantly - no registration or installation needed
4. Can be used offline after first load (single HTML file)

2.2 Basic Workflow

Step 1: Select a Model - Click on a model from the sidebar (left side) - Model description appears below the selection - Input parameters update automatically

Step 2: Enter Material Parameters - Fill in the required parameters for your material - Units are displayed next to each field - Default values are provided for reference

Step 3: Add to Chart - Click **"+ Add to Chart"** button - Your absorption curve appears immediately - Repeat to compare multiple configurations

Step 4: Analyze Results - View absorption coefficient vs. frequency - Check NRC (Noise Reduction Coefficient) value - Compare multiple curves side-by-side

Step 5: Export Data (Optional) - Switch to **"Data Table"** tab - Click **"Export CSV"** to download results - Open in Excel, Python, or other analysis tools

2.3 Quick Example

Predicting absorption of fibrous material: 1. Select: **Delany-Bazley** model 2. Enter: - Flow Resistivity (σ): 10000 Pa·s/m^2 - Thickness (d): 50 mm 3. Click **"+ Add to Chart"** 4. View result: Absorption curve with NRC value

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3. Acoustic Models

AlphaPorous implements seven models across three categories:

3.1 Empirical Models

3.1.1 Delany-Bazley (1970)

Description:
Classic empirical model for fibrous materials based solely on airflow resistivity. Simple, fast, and widely used for preliminary design.

Required Parameters: - Flow Resistivity (σ): Pa·s/m² - Thickness (d): mm

Best For: - Fibrous materials (glass wool, mineral wool) - Quick estimations - Parametric studies

Limitations: - Less accurate at very low frequencies (<200 Hz) - Limited to specific material types

Equations:

Normalized impedance:

$$Z_c/Z_0 = 1 + 0.057(\rho_0 f/\sigma)^{(-0.754)} - j\cdot 0.087(\rho_0 f/\sigma)^{(-0.732)}$$

Normalized wavenumber:

$$k/k_0 = 1 + 0.0978(\rho_0 f/\sigma)^{(-0.7)} - j\cdot 0.189(\rho_0 f/\sigma)^{(-0.595)}$$

3.1.2 Miki (1990)

Description:
Modified Delany-Bazley model with updated regression coefficients for improved low-frequency accuracy.

Required Parameters: - Flow Resistivity (σ): Pa·s/m² - Thickness (d): mm

Best For: - Improved accuracy over Delany-Bazley - Low-frequency applications - Fibrous materials

Advantages over Delany-Bazley: - Better low-frequency prediction - Smoother transitions - More recent experimental validation

Equations:

$$Z_c/Z_0 = 1 + 0.0699(\rho_0 f/\sigma)^{(-0.632)} - j\cdot 0.107(\rho_0 f/\sigma)^{(-0.632)}$$
$$k/k_0 = 1 + 0.16(\rho_0 f/\sigma)^{(-0.618)} - j\cdot 0.1879(\rho_0 f/\sigma)^{(-0.618)}$$

3.2 Semi-Empirical Models

3.2.1 Johnson-Champoux-Allard (JCA)

Description:
Physics-based model accounting for both viscous and thermal dissipation in porous media. Uses microstructural parameters.

Required Parameters: - Flow Resistivity (σ): Pa·s/m² - Porosity (φ): dimensionless (0-1) - Tortuosity (α∞): dimensionless (≥1) - Viscous Characteristic Length (Λ): μm - Thermal Characteristic Length (Λ’): μm - Thickness (d): mm

Best For: - Materials with known microstructure - Research applications - High accuracy requirements - Materials beyond simple fibrous types

Key Concepts: - **Porosity (φ):** Fraction of void space - **Tortuosity (α∞):** Path complexity through pores - **Characteristic Lengths:** Relate to pore size distribution

3.2.2 JCAL (Lafarge, 1997)

Description:
Extended JCA model including static thermal permeability for enhanced low-frequency accuracy.

Required Parameters: - All JCA parameters, plus: - Static Thermal Permeability (k'_0): $\times 10^{-11}$ m²

Best For: - Maximum accuracy across full frequency range - Materials with measured thermal properties - Research validation studies

Advantages: - Best low-frequency prediction - Most physically complete model - Industry standard for advanced work

3.2.3 Biot (1956)

Description:
Full poroelastic model including solid frame elasticity. Accounts for structural vibration contribution to absorption.

Required Parameters: - All JCA parameters, plus: - Frame Young's Modulus (E): MPa - Frame Poisson's Ratio (ν): dimensionless - Frame Loss Factor (η_s): dimensionless

Best For: - Materials with rigid/elastic frames - Low-frequency applications where structure matters - Foams and consolidated materials

Special Cases: - Set E = 0 for limp frame (equivalent to JCA) - Important for materials where frame vibrates

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3.3 Phenomenological Models

3.3.1 Zwikker-Kosten

Description:
Capillary tube model with physics-based viscous and thermal effects via pore radius.

Required Parameters: - Flow Resistivity (σ): Pa·s/m² - Porosity (φ): dimensionless - Tortuosity (α∞): dimensionless - Pore Radius (r_pore): µm - Thickness (d): mm

Best For: - Tubular pore structures - Understanding physical mechanisms - Educational purposes

Physical Basis: - Models material as bundle of circular tubes - Explicit pore size dependency - Good for conceptual understanding

3.3.2 Transfer Matrix Method (TMM)

Description:
Method for layered systems. Chains two distinct material layers by multiplying acoustic impedance matrices.

Configuration: - Select model for Layer 1 - Enter parameters for Layer 1 - Select model for Layer 2 - Enter parameters for Layer 2

Best For: - Multi-layer absorbers - Backing materials + absorber combinations - Optimization studies

Applications: - Perforated facings over porous material - Multiple density configurations - Impedance matching studies

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4. Input Parameters

4.1 Common Parameters

Flow Resistivity (σ)

- **Unit:** Pa·s/m² (Pascal-seconds per square meter)
- **Typical Range:** 5,000 – 50,000
- **Measurement:** ASTM C522, ISO 9053
- **Physical Meaning:** Resistance to airflow through material
- **Higher values:** Tighter, denser materials

Thickness (d)

- **Unit:** mm (millimeters)
- **Typical Range:** 10 – 100 mm
- **Physical Meaning:** Sample depth
- **Effect:** Thicker = better low-frequency absorption

Porosity (φ)

- **Unit:** Dimensionless (0 to 1)
- **Typical Range:** 0.85 – 0.99
- **Measurement:** Gravimetric or gas pycnometry
- **Physical Meaning:** Fraction of void space
- **Calculation:** $\varphi = 1 - (\rho_{bulk} / \rho_{solid})$

Tortuosity (α∞)

- **Unit:** Dimensionless (≥ 1)
- **Typical Range:** 1.0 – 3.0
- **Measurement:** Ultrasonic method, calculated from structure
- **Physical Meaning:** Path complexity
- **Values:**
  - $\alpha_\infty = 1$: Straight pores (unrealistic)
  - $\alpha_\infty = 1.5 – 2$: Typical fibrous materials
  - $\alpha_\infty > 2$: Highly tortuous structures

4.2 Advanced Parameters (JCA/JCAL/Biot)

Viscous Characteristic Length (Λ)

- **Unit:** μm (micrometers)
- **Typical Range:** 20 – 300 μm
- **Physical Meaning:** Weighted average pore size (viscous effects)
- **Relationship:** Generally $\Lambda < \Lambda'$

Thermal Characteristic Length (Λ')

- **Unit:** μm (micrometers)
- **Typical Range:** 50 – 500 μm
- **Physical Meaning:** Weighted average pore size (thermal effects)
- **Relationship:** Usually $\Lambda' > \Lambda$

Static Thermal Permeability (k'_0)

- **Unit:** $\times 10^{-11}$ m^2 (JCAL only)
- **Typical Range:** 1 – 100
- **Physical Meaning:** Thermal conduction through solid frame
- **Measurement:** Specialized thermal methods

4.3 Frame Properties (Biot Only)

Frame Young's Modulus (E)

- **Unit:** MPa (Megapascals)
- **Range:** 0 – 100 MPa
- **Special:** E = 0 → limp frame (reduces to JCA)
- **Materials:**
  - Melamine foam: ~0.1 MPa
  - Polyurethane foam: 1-10 MPa
  - Rigid materials: > 100 MPa

Frame Poisson's Ratio (ν)

- **Unit:** Dimensionless
- **Typical:** 0.2 – 0.4
- **Physical Meaning:** Lateral strain response

Frame Loss Factor (η_s)

- **Unit:** Dimensionless
- **Typical Range:** 0.01 – 0.3
- **Physical Meaning:** Material damping

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5. Features

5.1 Interactive Plotting

Chart Controls: - **X-axis:** Frequency (100-5000 Hz default) - **Y-axis:** Absorption Coefficient (0-1) - **Logarithmic scale:** Toggle for wide frequency ranges - **Multiple curves:** Up to 10 simultaneous comparisons - **Real-time updates:** Changes reflect instantly

Curve Management: - **Toggle visibility:** Click eye icon (◉) - **Remove curve:** Click × button - **Color coding:** Automatic assignment - **Labels:** Show model name and configuration number

5.2 NRC Calculation

Noise Reduction Coefficient (NRC): - Automatically calculated for each curve - Average absorption at 250, 500, 1000, 2000 Hz - Displayed in legend with rating: - **Poor:** NRC < 0.20 - **Fair:** NRC 0.20-0.40 - **Good:** NRC 0.40-0.60 - **Very Good:** NRC 0.60-0.80 - **Excellent:** NRC > 0.80

Formula:

$$NRC = (\alpha_{250} + \alpha_{500} + \alpha_{1000} + \alpha_{2000}) / 4$$

5.3 Data Export

CSV Export Features: - Full frequency-resolved data - All active curves included - Columns: Frequency (Hz) | Model 1 | Model 2 | ... - Compatible with Excel, MATLAB, Python - Custom frequency range supported

Export Process: 1. Switch to **"Data Table"** tab 2. Review data in table format 3. Click **"Export CSV"** button 4. File downloads automatically 5. Open in analysis software

5.4 Frequency Range Control

Customization: - **Min Frequency:** Default 100 Hz - **Max Frequency:** Default 5000 Hz - **Adjustable:** Set custom range as needed - **Logarithmic axis:** Better for wide ranges

Typical Ranges by Application: - **Building acoustics:** 100-5000 Hz - **Speech frequencies:** 250-4000 Hz - **Low-frequency control:** 63-500 Hz - **Full range:** 100-10000 Hz

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6. Interpreting Results

6.1 Absorption Coefficient (α)

Definition:
Fraction of incident sound energy absorbed by the material (0 to 1).

Values: - **α = 0:** Perfect reflection (no absorption) - **α = 0.5:** Half energy absorbed - **α = 1:** Perfect absorption (theoretical maximum)

Typical Curves: - **Thin materials:** Poor low-frequency, good high-frequency - **Thick materials:** Better low-frequency absorption - **Quarter-wavelength peak:** Absorption maximum at f = c/(4d)

6.2 NRC Interpretation

Single-Number Rating: - **< 0.20:** Reflective (concrete, glass) - **0.20-0.40:** Low absorption (painted surfaces) - **0.40-0.60:** Moderate (carpets, curtains) - **0.60-0.80:** Good absorber (acoustic panels) - **> 0.80:** Excellent absorber (thick porous materials)

Limitations: - Averages across frequency (loses detail) - Doesn't capture low-frequency performance - Use full spectrum for critical applications

6.3 Model Comparison

When to Compare Models: - Validate predictions - Understand sensitivity to parameters - Choose appropriate model complexity

Typical Observations: - Delany-Bazley vs. Miki: Similar at mid-frequencies - JCA vs. JCAL: JCAL better at < 500 Hz - Empirical vs. Semi-empirical: Agreement if parameters fit

6.4 Physical Insights

Absorption Mechanisms: 1. **Viscous losses:** Air friction in pores (dominant at high-f) 2. **Thermal losses:** Heat exchange with solid (important at low-f) 3. **Frame losses:** Structural damping (Biot model)

Design Principles: - **Increase thickness:** Better low-frequency - **Increase flow resistivity:** Shift absorption peak - **Optimize backing:** Air gap enhances low-frequency - **Layer materials:** Broadband absorption

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7. Citation & Attribution

7.1 Citing AlphaPorous

When to Cite: - Using AlphaPorous in research publications - Reporting results based on AlphaPorous predictions - Comparing experimental data to AlphaPorous models - Educational or commercial applications

7.2 Citation Formats

APA Style:

```
Olajide, J. L. (2026). AlphaPorous: A browser-based tool for
acoustic
absorption prediction [Web application]. University of South Africa
(UNISA),
Department of Mechanical, Bioresources and Biomedical Engineering.
https://alphaporous.com
```

BibTeX:

```
@misc{olajide2026alphaporous,
  author      = {Olajide, Jimmy Lolu},
  title       = {AlphaPorous: A Browser-Based Tool for Acoustic
                 Absorption Prediction},
  year        = {2026},
```

```
    institution  = {University of South Africa (UNISA),
                    Department of Mechanical, Bioresources
                    and Biomedical Engineering},
    note         = {Open-access web tool. Available at:
                    https://alphaporous.com},
    url          = {https://alphaporous.com}
  }
```

EndNote (RIS):

```
TY  - COMP
AU  - Olajide, Jimmy Lolu
TI  - AlphaPorous: A Browser-Based Tool for Acoustic Absorption
Prediction
PY  - 2026
PB  - University of South Africa (UNISA)
CY  - Florida, South Africa
AB  - A free browser-based tool implementing seven acoustic models
for
      predicting sound absorption coefficients of porous materials.
UR  - https://alphaporous.com
ER  -
```

IEEE Style:

```
J. L. Olajide, "AlphaPorous: A browser-based tool for acoustic
absorption
prediction," University of South Africa (UNISA), Feb. 2026.
[Online].
Available: https://alphaporous.com
```

7.3 Open Source License

AlphaPorous is released under the MIT License: - Free to use for academic and commercial purposes - Free to modify and distribute - Attribution required (see citations above) - No warranty provided

Source Code:
https://github.com/JimmyLolu/acoustic-absorption-predictor

7.4 Model References

Original Publications:

Delany-Bazley: Delany, M. E., & Bazley, E. N. (1970). Acoustical properties of fibrous absorbent materials. Applied Acoustics, 3(2), 105-116.

Miki: Miki, Y. (1990). Acoustical properties of porous materials: Modifications of Delany-Bazley models. Journal of the Acoustical Society of Japan (E), 11(1), 19-24.

JCA: Johnson, D. L., Koplik, J., & Dashen, R. (1987). Theory of dynamic permeability and tortuosity in fluid-saturated porous media. Journal of Fluid Mechanics, 176, 379-402.

Champoux, Y., & Allard, J. F. (1991). Dynamic tortuosity and bulk modulus in air-saturated porous media. Journal of Applied Physics, 70(4), 1975-1979.

JCAL: Lafarge, D., Lemarinier, P., Allard, J. F., & Tarnow, V. (1997). Dynamic compressibility of air in porous structures at audible frequencies. Journal of the Acoustical Society of America, 102(4), 1995-2006.

Biot: Biot, M. A. (1956). Theory of propagation of elastic waves in a fluid-saturated porous solid. Journal of the Acoustical Society of America, 28(2), 168-191.

Zwikker-Kosten: Zwikker, C., & Kosten, C. W. (1949). Sound Absorbing Materials. Elsevier.

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8. Troubleshooting

8.1 Common Issues

Problem: Chart not displaying - **Cause:** No curves added yet - **Solution:** Click "+ Add to Chart" after selecting model and parameters

Problem: Absorption > 1.0 - **Cause:** Unrealistic parameter combination - **Solution:** Check input values, especially flow resistivity and thickness

Problem: Flat absorption curve (all zeros) - **Cause:** Extreme parameter values - **Solution:** Use typical ranges from Section 4

Problem: Cannot export CSV - **Cause:** Browser blocking downloads - **Solution:** Allow downloads in browser settings

Problem: Parameters not updating - **Cause:** Model not selected - **Solution:** Click on a model name in sidebar first

8.2 Parameter Guidelines

If absorption is too low: - Increase thickness - Increase flow resistivity (within limits) - Check if backing condition is appropriate

If absorption unrealistic (>1.0): - Reduce flow resistivity - Verify thickness is in mm (not m or cm) - Check porosity is between 0-1

If curves look wrong: - Verify units (especially µm vs mm) - Compare against known materials - Try simpler models first (Delany-Bazley)

8.3 Browser Compatibility

Tested Browsers: - Chrome/Chromium 90+ - Firefox 88+ - Safari 14+ - Edge 90+

Known Issues: - Internet Explorer: Not supported - Very old browsers (<2018): May not render correctly

8.4 Getting Help

Resources: - **GitHub Issues:** Report bugs or request features https://github.com/JimmyLolu/acoustic-absorption-predictor/issues - **Source Code:** Examine implementation details https://github.com/JimmyLolu/acoustic-absorption-predictor - **Contact:** Jimmy Lolu Olajide University of South Africa (UNISA)

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9. Technical Background

9.1 Acoustic Theory Fundamentals

Sound Absorption:
When a sound wave encounters a porous material: 1. Air particles oscillate in pores 2. Viscous friction converts motion to heat 3. Thermal exchange between air and solid 4. Frame vibration (if applicable) dissipates energy

Impedance:
Characteristic impedance (Zc) determines how sound enters material. Matching Zc to air impedance (Z_0) maximizes absorption.

Wavenumber:
Complex wavenumber (k) describes wave propagation through material. Imaginary part causes attenuation (absorption).

9.2 Model Implementation

Calculation Method: 1. Compute characteristic impedance (Zc) and wavenumber (k) 2. Calculate surface impedance (Zs) with backing condition 3. Compute reflection coefficient (R) 4. Calculate absorption: $\alpha = 1 - |R|^2$

Backing Condition:
AlphaPorous assumes rigid backing (typical impedance tube setup).

Frequency Resolution:
Default: 50 points logarithmically spaced Ensures smooth curves and accurate NRC

9.3 Validation

AlphaPorous predictions validated against: - Published experimental data from literature - Commercial software (where available) - Author’s impedance tube measurements

Typical Agreement: - Empirical models: ±0.05 for well-characterized materials - Semi-empirical: ±0.03 when all parameters known - Greatest uncertainty at very low frequencies (<200 Hz)

9.4 Limitations

General: - Rigid backing assumed (no air gap) - Normal incidence only - Homogeneous material assumed - No surface effects (perforations, membranes)

Model-Specific: - **Delany-Bazley/Miki:** Limited to fibrous materials - **JCA/JCAL:** Requires difficult-to-measure parameters - **Biot:** Frame properties often unknown - **TMM:** Limited to 2 layers in current implementation

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10. References

10.1 Key Publications

1. Delany, M. E., & Bazley, E. N. (1970). Acoustical properties of fibrous absorbent materials. Applied Acoustics, 3(2), 105-116.

2. Miki, Y. (1990). Acoustical properties of porous materials: Modifications of Delany-Bazley models. Journal of the Acoustical Society of Japan (E), 11(1), 19-24.

3. Johnson, D. L., Koplik, J., & Dashen, R. (1987). Theory of dynamic permeability and tortuosity in fluid-saturated porous media. Journal of Fluid Mechanics, 176, 379-402.

4. Champoux, Y., & Allard, J. F. (1991). Dynamic tortuosity and bulk modulus in air-saturated porous media. Journal of Applied Physics, 70(4), 1975-1979.

5. Lafarge, D., Lemarinier, P., Allard, J. F., & Tarnow, V. (1997). Dynamic compressibility of air in porous structures at audible frequencies. Journal of the Acoustical Society of America, 102(4), 1995-2006.

6. Biot, M. A. (1956). Theory of propagation of elastic waves in a fluid-saturated porous solid. Journal of the Acoustical Society of America, 28(2), 168-191.

7. Allard, J. F., & Atalla, N. (2009). Propagation of Sound in Porous Media: Modelling Sound Absorbing Materials (2nd ed.). Wiley.

10.2 Standards

- ASTM C384: Standard Test Method for Impedance and Absorption of Acoustical Materials by Impedance Tube Method
- ASTM C522: Standard Test Method for Airflow Resistance of Acoustical Materials
- ISO 9053: Acoustics - Materials for acoustical applications - Determination of airflow resistance
- ISO 10534-2: Acoustics - Determination of sound absorption coefficient and impedance in impedance tubes - Part 2: Transfer-function method

10.3 Related Software

Commercial: - COMSOL Multiphysics (Acoustics Module) - Actran (MSC Software) - VA One (ESI Group)

Open Source: - OpenFOAM (with acoustic solvers) - pyva (Python Vibro-Acoustics)

Appendix A: Quick Reference

Parameter Units Quick Reference

Parameter	Unit	Typical Range
Flow Resistivity (σ)	Pa·s/m²	5,000 - 50,000
Thickness (d)	mm	10 - 100
Porosity (φ)	-	0.85 - 0.99
Tortuosity (α∞)	-	1.0 - 3.0
Viscous Length (Λ)	μm	20 - 300
Thermal Length (Λ’)	μm	50 - 500
Thermal Perm (k'_0)	$\times 10^{-11}$ m²	1 - 100
Young’s Modulus (E)	MPa	0.1 - 100
Pore Radius (r)	μm	10 - 200

Model Selection Guide

Application	Recommended Model	Why
Quick estimation	Delany-Bazley	Fast, simple inputs
Fibrous materials	Miki	Better accuracy
Research validation	JCAL	Most accurate
Unknown microstructure	Delany-Bazley/Miki	Few parameters
Known microstructure	JCA/JCAL	Physics-based
Low frequency	JCAL or Biot	Includes frame effects
Multi-layer systems	TMM	Handles layering

Appendix B: Example Calculations

Example 1: Glass Wool Insulation

Material: Owens Corning 703 (or similar)

Parameters: - Flow Resistivity: 11,000 Pa·s/m² - Thickness: 50 mm - Model: Delany-Bazley

Procedure: 1. Select: Delany-Bazley 2. Enter σ = 11000 3. Enter d = 50 4. Add to Chart

Expected Results: - NRC ≈ 0.75 (Very Good) - Peak absorption ~1000 Hz - Good absorption >500 Hz

Example 2: Melamine Foam

Material: Basotect (or similar)

Parameters: - Porosity: 0.99 - Flow Resistivity: 10,000 Pa·s/m² - Tortuosity: 1.0 - Λ = 100 µm - Λ’ = 200 µm - Thickness: 30 mm - Model: JCA

Procedure: 1. Select: JCA 2. Enter all parameters 3. Add to Chart

Expected Results: - NRC ≈ 0.60 (Good) - Broadband absorption - Open-cell structure evident

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Version History

Version 1.0 (February 19, 2026) - 7 acoustic models implemented - Real-time plotting - NRC calculation - CSV export - Public launch as AlphaPorous - Updated branding and citations

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Google Scholar:
https://scholar.google.com/citations?user=HulJMpkAAAAJ

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