
Contents

1	Introduction	1
1.1	Uncertainty Analysis of Reverberation Chamber Measurements	2
1.2	Measurement of Angle-Dependent Reflection Properties . . .	4
2	Fundamentals	7
2.1	Sound Propagation in Free Space	7
2.1.1	Wave Equation	7
2.1.2	Plane Waves	9
2.1.3	Spherical Waves	10
2.1.4	Influence of Atmospheric Conditions	12
2.2	Spherical Wave Spectrum	15
2.2.1	Spherical Harmonics	15
2.2.2	Plane and Spherical Waves	16
2.2.3	Scattering Near-Field Holography	18
2.2.4	Spherical Beamforming	20
2.2.5	Spherical Harmonics on Incomplete Spheres	21
2.3	Sound Reflection at an Extended Planar Surface	24
2.3.1	General Problem Formulation	24
2.3.2	Surface Impedance, Reflection Factor and Absorption Coefficient	26
2.3.3	Surface Impedance of Locally and Laterally Reacting Materials	28
2.3.4	Reflection of Plane and Spherical Waves	31
2.3.5	Random Sound Incidence	39
2.4	Sound Scattering	41
2.4.1	Scattering Coefficient	42
2.4.2	Diffusion Coefficient	43
2.5	Room Acoustics	44
2.6	Standardized Measurement Methods	48
2.6.1	Random-Incidence Absorption Coefficient (ISO 354)	49
2.6.2	Random-Incidence Scattering Coefficient (ISO 17497-1)	50
2.7	Uncertainty Analysis	53
2.7.1	Systematic Deviations	54
2.7.2	Random Deviations	55

3	Uncertainty Analysis of Reverberation Chamber Measurements	59
3.1	Average Room Absorption Coefficient	61
3.1.1	Sensitivity Coefficients	61
3.1.2	Systematic Deviations	64
3.1.3	Random Deviations	66
3.1.4	Influence of Higher-Order Derivatives	72
3.2	Sample Absorption Coefficient (ISO 354)	73
3.2.1	Sensitivity Coefficients	73
3.2.2	Systematic Deviations	73
3.2.3	Random Deviations	76
3.3	Sample Scattering Coefficient (ISO 17497-1)	91
3.3.1	Sensitivity Coefficients	91
3.3.2	Systematic Deviations	92
3.3.3	Random Deviations	97
3.4	Preliminary Conclusions	114
4	Measurement of Angle-Dependent Reflection properties	117
4.1	Measurement Setup	118
4.1.1	Influence of the Measurement Setup on the Sound Field	122
4.1.2	Determining Source and Receiver Positions	125
4.1.3	Measurements with a Calibrated Source	127
4.1.4	Including Source (and Receiver) Directivity	128
4.2	Separation of Incident and Reflected Sound	134
4.2.1	Subtraction Method (Time-Domain)	135
4.2.2	Optimized Subtraction Method (Frequency-Domain)	136
4.2.3	Windowing (Time-Domain)	139
4.2.4	Spatial Filtering (SH-Domain)	141
4.3	Analysis of Reflected Sound: Reflection Factor	156
4.3.1	Sound Reflection Models	157
4.3.2	A Note on Models for Lateral Reaction	163
4.3.3	Measurement Results	163
4.4	Analysis of Reflected Sound: Spatial Response	177
5	Conclusion and Outlook	183
5.1	Uncertainty Analysis of Reverberation Chamber Measurements	183
5.2	Measurement of Angle-Dependent Reflection Properties	185
	Acknowledgments	189
	Bibliography	191
	Curriculum Vitae	207