

Naval Submarine Medical Research Laboratory

NSMRL/F1016/TM—2022-1372

January 24, 2022



Impulse Assessment of the Moldex® Camo Plugs® Earplug

Alexa H. Koliass, AuD ^{1,2}
Jacob J. See, BS ^{1,2}
Derek W. Schwaller, BS ¹
Stephanie J. Karch, AuD, PhD ¹
Jeremy S. Federman, PhD ¹

¹ Naval Submarine Medical Research Laboratory, Groton, CT, United States

² Leidos, Inc., Reston, VA, United States

Approved and Released by:
K. K. Shobe, CAPT, MSC, USN
Commanding Officer
NAVSUBMEDRSCHLAB

DISTRIBUTION A. Approved for public release: distribution unlimited.

REPORT DOCUMENTATION PAGE*Form Approved
OMB No. 0704-0188*

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services and Communications Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.

1. REPORT DATE (DD-MM-YYYY)		2. REPORT TYPE		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code)

[THIS PAGE INTENTIONALLY LEFT BLANK]

Impulse Assessment of the Moldex[®] Camo Plugs[®] Earplug

Alexa H. Kolas, AuD^{1,2}

Jacob J. See, BS^{1,2}

Derek W. Schwaller, BS¹

Stephanie J. Karch, AuD, PhD¹

Jeremy S. Federman, PhD¹

¹ Naval Submarine Medical Research Laboratory, Groton, CT, United States

² Leidos, Inc., Reston, VA, United States

Naval Submarine Medical Research Laboratory

Approved and Released by:

CAPT K. K. Shobe, MSC, USN

Commanding Officer

Naval Submarine Medical Research Laboratory

Submarine Base New London Box 900

Groton, CT 06349-5900

This work was supported by the U.S. Navy Bureau of Medicine and Surgery funding work unit F1016 and the Office of Naval Research funding work unit F2002. The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government. This work was prepared by employees of the U.S. Government as part of their official duties. Title 17 U.S.C. §105 provides that 'Copyright protection under this title is not available for any work of the United States Government.' Title 17 U.S.C. §101 defines a U.S. Government work as a work prepared by a military service member or employee of the U.S. Government as part of that person's official duties.

DISTRIBUTION A. Approved for public release: distribution unlimited.

[THIS PAGE INTENTIONALLY LEFT BLANK]

Acknowledgements

The authors would like to thank Ms. Rachael Maten for assistance in the collection of resource materials.

CONTENTS

ACKNOWLEDGEMENTS	iii
EXECUTIVE SUMMARY	1
INTRODUCTION	2
METHODS	2
RESULTS	6
DISCUSSION	7
CONCLUSIONS.....	7
REFERENCES	8
APPENDIX A.....	9
APPENDIX B	14
APPENDIX C	19
APPENDIX D.....	24
APPENDIX E	29
APPENDIX F.....	34
APPENDIX G.....	39
APPENDIX H.....	42
APPENDIX I	45

Executive Summary

The impulse peak insertion loss (IPIL) is the standard measure of attenuation provided by hearing protection devices (HPDs) in response to an impulsive noise. This technical memorandum describes the IPIL testing conducted and the calculated mean IPIL values for the Moldex[®] Camo Plugs[®] Earplug (Camo Plugs[®]; Model: 6609). Testing was completed in accordance with the American National Standards Institute (ANSI) standard S12.42-2010, “Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise Using Microphone-in-Real-Ear or Acoustic Test Fixture Procedures.” All device samples were tested at the nominal levels of 150, 160, and 170 decibel peak (dB_P, re: 20 μPa). A total of five samples were fitted to an acoustic test fixture two times each for a total of 10 trials per test level. No samples of the HPD were rejected. The mean and standard deviation (SD) IPIL values were 57.0 (2.2) dB SPL at 150 dB_P, 57.0 (2.5) dB SPL at 160 dB_P, and 59.0 (2.4) dB SPL at 170 dB_P (see Table 1). These results suggest that, when properly fit and functional, the Camo Plugs[®] will adequately protect (i.e., reduce exposure to less than 140 dB_P) against impulses below 180.0 dB_P.

Table 1.

Camo Plugs[®] mean (SD) IPIL value (in dB) for all test conditions.

150 dB_P	160 dB_P	170 dB_P
57.0 (2.2)	57.0 (2.5)	59.0 (2.4)

Introduction

The corded Moldex[®] Camo Plugs[®] Earplug (Camo Plugs[®]; Moldex-Metric Inc., Culver City, CA) is a passive, one-size-fits-most, disposable tapered earplug. The Camo Plugs[®] earplug is composed of polyvinyl chloride-free (PVC-free) low-pressure foam (Moldex-Metric, Inc., n.d.).

The Department of Defense Instruction 6055.12 (2019) Hearing Conservation Program (HCP) limits impulse noise exposure to 140 peak decibels (dBP). Therefore, should an impulse noise meet or exceed 140 dBP (e.g., artillery fire, grenade, small arm weapon fire, large caliber weapon fire), hearing conservation efforts to prevent hearing loss resulting from occupational and operational illness and injury are mandated. One conservation measure used to reduce the user's noise hazard below the 140 dBP limit is the use of hearing protection devices (HPDs) (e.g., earplug or earmuff).

In order to calculate whether the issued HPD will reduce the noise exposure below the 140 dBP limit, the impulse peak insertion loss (IPIL) value of the issued and/or used HPD should be subtracted from the impulse noise level (Department of Defense, 2015). The IPIL value is the standard metric (ANSI/ASA S12.42) used to determine the amount of protection afforded by an HPD in response to impulse noise. At present, the IPIL value of the Camo Plugs[®] at 150, 160, and 170 dBP is unknown. This report describes the methods and results used to determine the IPIL value for the Moldex[®] Camo Plugs[®] Earplug. In addition to reporting an overall device IPIL, ear-specific IPILs are reported for the tested nominal levels.

Methods

Facility

IPIL testing described herein was completed in the Naval Submarine Medical Research Laboratory (NSMRL) 1000 m³ anechoic chamber in order to minimize any effects of sound reflections.

Equipment

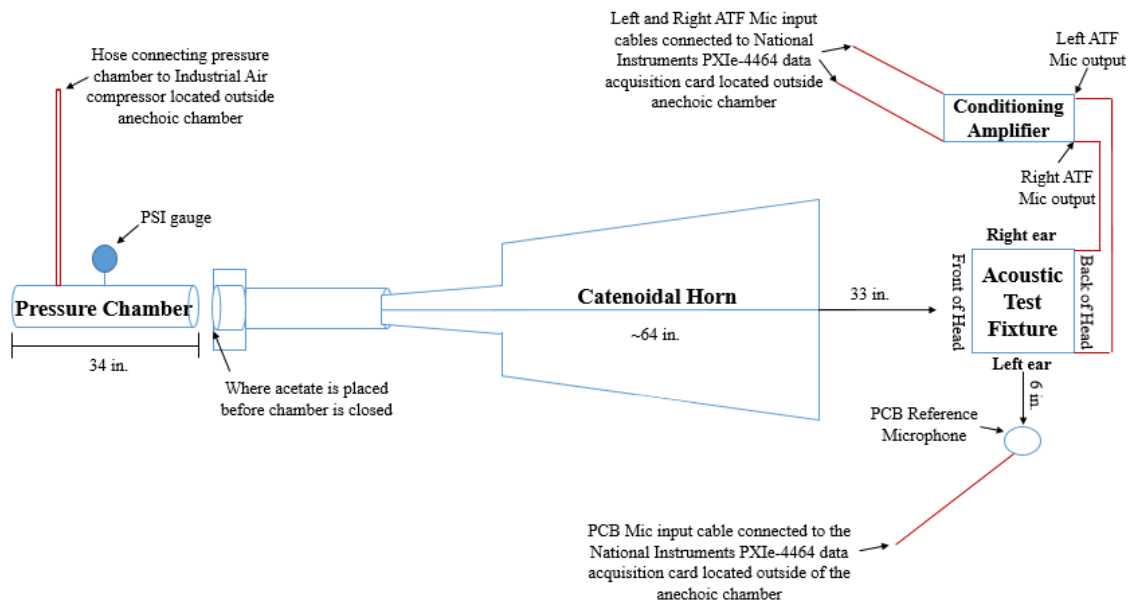
Hardware. Acoustic impulses were generated by NSMRL's 4 inch (in., 10.2 centimeters [cm]) shock tube (B/C Precision, Inc., Greendale, IN). The shock tube pressure chamber is approximately 34 in. (86.4 cm) long, with an inner diameter of 4 in. (10.2 cm). A 64 in. (162.6 cm) long catenoidal tube horn consisting of four welded steel flat-projection sheets forming a square cross section was connected to the shock tube using a PVC 4.5 in. (11.4 cm) coupler. An industrial air compressor (ILA#1883054; Industrial Air Corporation, Memphis, TN) supplied pressurized air (900 kilopascal) to the shock tube.

For each trial at 150 dBP, a 7 in. (17.8 cm) by 7 in. (17.8 cm) polyester sheet (SEVA Technical Services, Inc, Newport News, VA) was used as a membrane between the pressurized chamber and the catenoidal tube horn to enable pressurization of the air chamber. Each polyester sheet was 0.001 in. (1.0 mil, 25.4 micrometer [μm]) thick. For each trial at 160 and 170 dBP, a 7 in. (17.8 cm) by 7 in. (17.8 cm) acetate sheet (Grafix Plastic, Maple Heights, OH) was used as a membrane to enable pressurization of the air chamber. Each acetate sheet was 0.002 in. (2.0 mil, 50.8 micrometer [μm]) thick.

All waveforms were recorded with the ANSI/ASA S12.42 (2010) compliant GRAS 45CB acoustic test fixture (ATF) along with GRAS RA0045-S7 Ear Simulators (GRAS Sound and Vibration, Twinsburg, OH). The ATF was connected to a conditioning amplifier which served as the power supply (GRAS Type 12AA; GRAS Sound and Vibration, Twinsburg, OH). As required by ANSI/ASA S12.42/2010, the ATF was placed to front-face (i.e., nose facing) the catenoidal tube horn at 0° elevation and 0° azimuth.

A reference microphone (Type 378C20; PCB Piezotronics Inc., Depew, NY) was placed 6 in. (15.2 cm) from the ATF left pinna. The reference microphone, the left ATF microphone, and the right ATF microphone were calibrated each morning prior to data collection at 124 dB sound pressure level (SPL) using a 250 hertz (Hz) tone. A diagram depicting the aerial view of the NSMRL 4 in. (10.2 cm) shock tube and test system is presented in Figure 1.

Figure 1.
Diagram of the NSMRL Acoustic Shock Tube and ATF.



Data Acquisition System. The data acquisition system (NI chassis PXIe-1071 with NI PXIe-4460 and NI PXIe-4464; National Instruments Corp., Austin, TX) was controlled by a standalone laptop computer running project specific software (LabVIEW; National Instruments Corp., Austin, TX). The data acquisition system was connected to the laptop using an MXI cord and host interface card (NI PXIe-8360). The software controlled the acquisition of waveforms from the three source microphones (left ATF microphone, right ATF microphone, and a reference microphone) at a sampling rate of 204.8 k Samples/second during each impulse recording. Pre-trigger settings were 1024 samples per 0.005 seconds, with a trigger level of 110 dB SPL. Each recording was 0.3 seconds in duration.

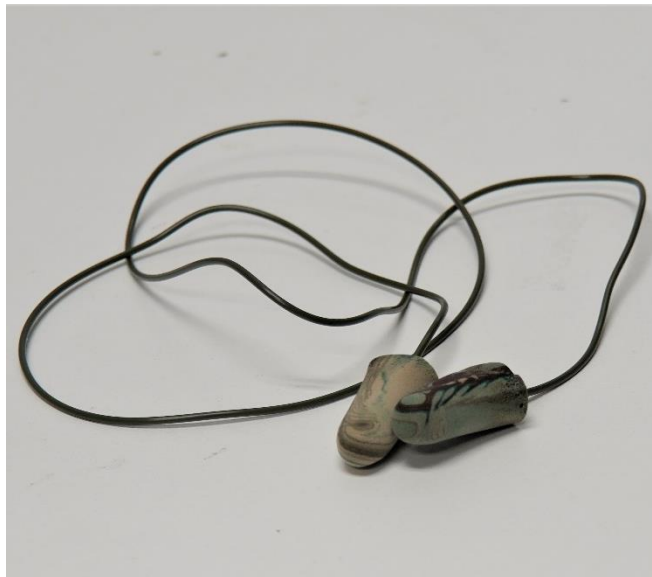
Rather than using an ANSI/ASA S12.42-2010 standardized in-line analog external Bessel filter (6th order, corner frequency 20.0 kHz [3 dB down]) to filter impulses during data acquisition, anti-alias filtering was accomplished by an analog filter and a digital filter. First, an electronic analog anti-aliasing filter (corner frequency of 93.0 kHz [3 dB down]) was applied to all waveforms by the National Instruments data acquisition system during data collection. This deviation was made due to equipment and software limitations.

The custom-written software program saved all recorded waveforms as files (*.tdms), which were exported and converted to data files using an additional custom software programming script. The script compiled the reference PCB microphone, left ATF microphone, and right ATF microphone channels into a file (*.mat) that saved variables for input to analysis script (MATLAB) similar to the script provided in Annex H of the ANSI/ASA S12.42-2010 standard. Minor alterations were made to the analysis script in order to accept 150 dBP, 160 dBP, and 170 dBP data (see Data Analysis below).

Hearing Protection Device Samples. Five samples (See Figure 2 for example) of the corded Moldex[®] Camo Plugs[®] Earplugs (Manufacturer Product Number: 6609) were tested in accordance with ANSI/ASA S12.42-2010. Each sample, consisting of one set of two earplugs, was randomly assigned a number 1 through 5. Each earplug in the sampled set was labeled 'L' for left or 'R' for right to indicate which ATF ear they were to be inserted for all trials.

Figure 2.

Photograph of a Camo Plugs[®] Earplug Sample.



Procedure

Each HPD sample (left and right earplug pair) was fitted to the ATF twice, resulting in two trials (trials A and B) per sample, and 10 total trials per nominal level test condition (150, 160, and 170 dBP). No samples of the HPD were rejected. To

achieve an appropriate fit that would provide maximum attenuation, each sample was expertly fitted to the ATF in accordance with instructions on the device packaging. The manufacturer fitting guidelines stated that all samples be inspected for any wear, extreme hardness, or damage prior to use. Once inspected, each earplug was rolled down into a narrow cylinder, inserted into the ear canal tapered-end first, and held in place until expanded. Earplugs were given at least two minutes to fully expand in the ATF ear canal before impulse testing was performed.

Testing at the 130 dBP nominal level was omitted, and the nominal level of 160 dBP was incorporated as impulses generated with the NSMRL 4 in. (10.2 cm) shock tube at levels below the nominal level of 150 dBP were found to be without a shock front. Measurement of IPIL at 160 dBP was included in order to provide accurate guidance for exposures between 155 and 165 dBP. At the measured levels described herein, all generated impulses had a shock front. In addition, the action level for the DoD is 140 dBP for impulse noises. Therefore, IPIL values below 140 dBP are of marginal value to the DoD. Due to non-linear effects of HPDs on IPIL, it is best to use IPIL values measured close to the level of the predicted exposure (Department of Defense, 2015).

Impulse noises were presented to the ATF in the occluded (i.e., HPD inserted) and unoccluded (i.e., without the HPD inserted) test configurations. For all occluded measures, the earplugs were fitted on the ATF in accordance with the specifications outlined in ANSI/ASA S12.42-2010. Each HPD sample was exposed to two impulses at each tested nominal level. Adequate pressure for each impulse was determined by increasing pressure (measured in pounds per square inch [psi]) to a point within a pre-specified range necessary for producing either 150 dBP (8.9 to 9.3 psi, 61 to 64 kilopascals [kPa]), 160 dBP (19.5 to 22.1 psi, 134 to 152 kPa), or 170 dBP (28.5 to 29.5 psi, 197 to 203 kPa). The acetate was then punctured using a manual trigger, releasing pressurized air into the catenoidal horn, which created an impulse wave through the catenoidal horn to the ATF. The peak decibel level emitted was dependent upon the amount of air pressure released.

In place of the ANSI/ASA S12.42-2010 standardized calibration impulses at 130 dBP, six calibration impulses were generated at the 150 dBP and 160 dBP nominal levels in the unoccluded (i.e., without HPD) test configuration. Three of these impulses were generated before testing, and three were generated after testing at 150 dBP and 160 dBP. Calibrations were not completed at the 170 dBP nominal level due to exposure limitations of the ATF right and left microphones.

Data Analysis

MATLAB (Natick, MA) was used to calculate IPIL values at the 150, 160, and 170 dBP nominal levels and to generate all waveform graphs (See Appendices A to I). The mean pressure of each waveform was subtracted from the waveforms to remove any constant offset. The peak levels were then calculated by converting the maximum absolute value of each waveform into dB SPL. The transfer functions of the free-field probe to each ear of the ATF was calculated for the unoccluded waveforms gathered at the 160 dBP nominal levels. The mean transfer function for each ear at each level was then calculated, and the first elements of the transfer functions were set to zero in order to avoid calculations at 0 Hz. The fit of the mean transfer function was tested by

applying the mean transfer function for each ear to the free-field probe data gathered in the 150 and 160 dB nominal level. The difference of the maximum absolute values of the calculated values and the measured values was then calculated, converted to dB SPL, and displayed.

The calculated IPIL value (in dB) equaled the mean difference of the maximum absolute value of the waveforms from the ears of the ATF in dB SPL and the maximum absolute value of the estimated values of the unoccluded ears in dB SPL. The estimated values of the unoccluded ears are the waveforms from the free-field probe with the mean transfer function applied to them. These values were calculated for each ear in each trial and condition. The mean values were calculated across both ears and trials, resulting in a displayed mean for each nominal level (i.e., 150 dB, 160 dB, and 170 dB). Every waveform was plotted with time on the x-axis and pressure on the y-axis. The transfer functions were not plotted.

Deviating from ANSI/ASA S12.42-2010, a second digital Butterworth filter (6th order, low-pass, corner frequency of 20 kHz [3 dB down]) was applied to all recordings by the MATLAB post-processing script. This digital filter was used to mimic the effect of the ANSI/ASA S12.42-2010 standard required anti-aliasing Bessel filter which was omitted due to equipment limitations.

Results

As shown in Table 2, the overall mean (SD) IPIL value was 57.0 (2.2) dB for the 150 dB test condition, 57.0 (2.5) dB for the 160 dB test condition, and 59.0 (2.4) dB for the 170 dB test condition. Calculated IPIL values for all individual sample trials ranged between 52.7 and 61.5 dB at 150 dB, between 53.5 and 61.5 dB at 160 dB, and between 54.4 and 62.5 dB at 170 dB. The waveforms for all trials with the Camo Plugs[®] are provided in Appendices A to I.

[THIS SPACE INTENTIONALLY LEFT BLANK]

Table 2.*Mean (SD) IPIL values (in dB) for Tested Camo Plugs® Samples.*

	150 dBP		160 dBP		170 dBP	
	<i>Right</i>	<i>Left</i>	<i>Right</i>	<i>Left</i>	<i>Right</i>	<i>Left</i>
HPD 1, Trial A	56.0	55.7	56.6	54.2	60.9	58.3
HPD 1, Trial B	54.6	54.4	53.6	61.5	57.0	56.9
HPD 2, Trial A	57.7	59.5	59.6	59.0	61.9	62.5
HPD 2, Trial B	57.5	57.3	57.4	55.7	60.5	57.8
HPD 3, Trial A	57.9	59.9	58.6	60.2	60.3	61.7
HPD 3, Trial B	57.0	58.9	56.2	58.6	57.8	60.0
HPD 4, Trial A	58.7	57.4	59.5	57.3	61.1	58.7
HPD 4, Trial B	55.8	57.2	54.3	55.7	57.6	59.4
HPD 5, Trial A	54.8	61.5	53.5	59.9	55.2	62.2
HPD 5, Trial B	52.7	54.5	53.5	55.1	54.4	55.5
Ear Specific Mean (SD)	56.3 (1.8)	57.6 (2.3)	56.3 (2.5)	57.7 (2.5)	58.7 (2.6)	59.3 (2.3)
Level Overall Mean (SD)	57.0 (2.2)		57.0 (2.5)		59.0 (2.4)	

Discussion

The overall mean IPIL value was 57.0 dB at 150 dBP, 57.0 dB at 160 dBP, and 59.0 dB at 170 dBP. Across ears, the individual trial mean IPIL values were found to vary as much as 8.8 dB at 150 dBP, 8.0 dB at 160 dBP, and 8.1 dB at 170 dBP. This may be due to a combination of inherent variance within the impulse system and/or variability in fit as a result of each HPD sample being fitted twice.

It is important to note that these results do not guarantee similar Moldex® Camo Plugs® product performance across all users and environments. Product performance may be impacted by factors such as variability in physical fit of the device and HPD configuration (e.g., single, double- or triple- configuration).

Conclusions

This report described the determination of the mean impulse peak insertion loss (IPIL) values provided by the Moldex® Camo Plugs® Earplug (Camo Plugs®) at 150, 160, and 170 dBP nominal levels. The calculated overall mean (SD) IPIL values for the Camo Plugs® were found to be 57.0 (2.2) dB at 150 dBP, 57.0 (2.5) at 160 dBP, and 59.0 (2.4) dB at 170 dBP. The results of this effort imply that, when properly fit and functional, the Camo Plugs® will adequately protect (i.e., reduce the exposure below 140 dBP) the user from impulses below 180 dBP. This value is based on the 180 dBP limit of the applicability of IPIL values measured at 170 dBP in MIL-STD-1474E B.5.3.3 (Department of Defense, 2015).

References

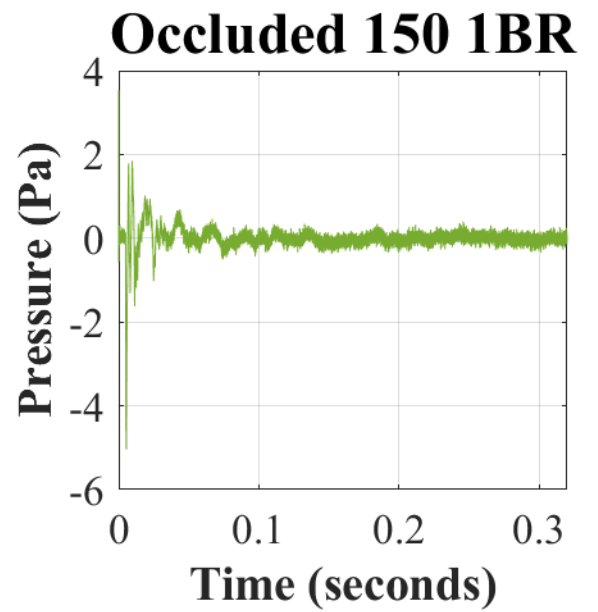
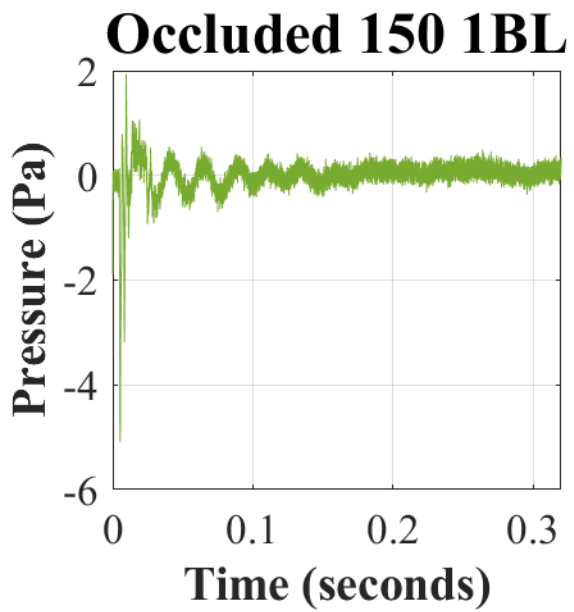
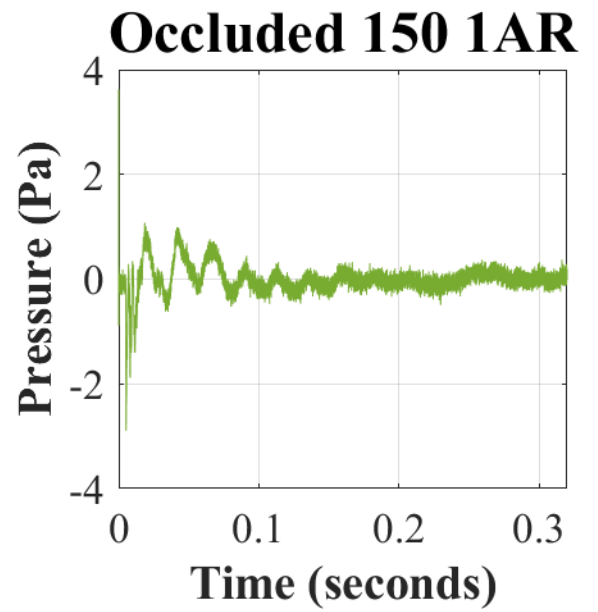
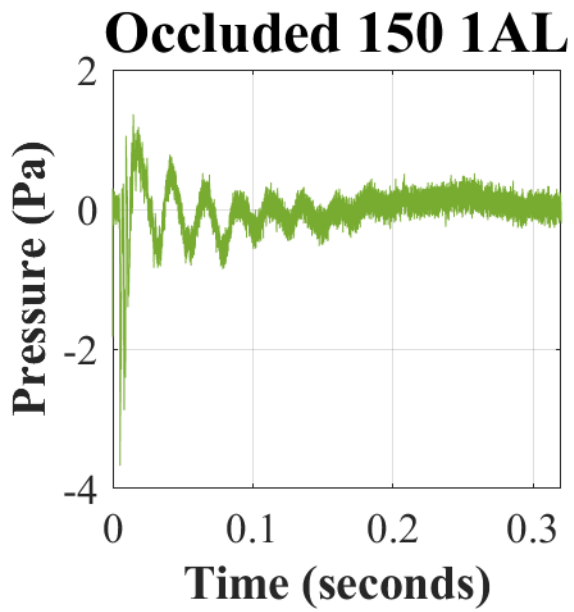
American National Standards Institute, Inc. (2010). *ANSI S12.42-2010: Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise Using Microphone-in-Real-Ear or Acoustic Test Fixture Procedures*. Acoustical Society of America.

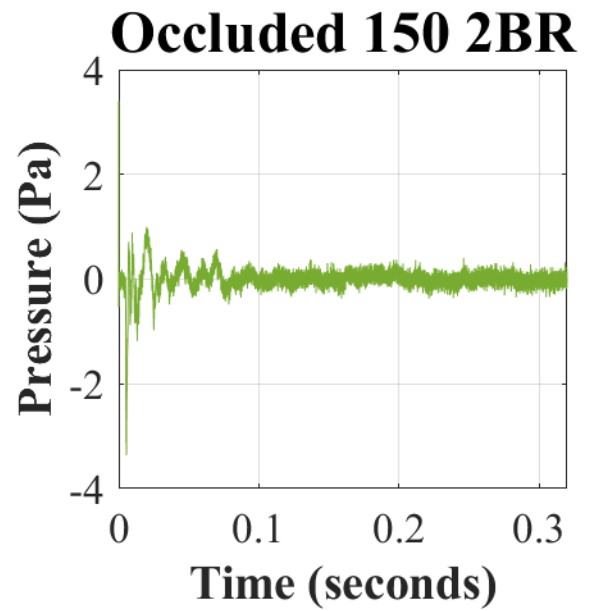
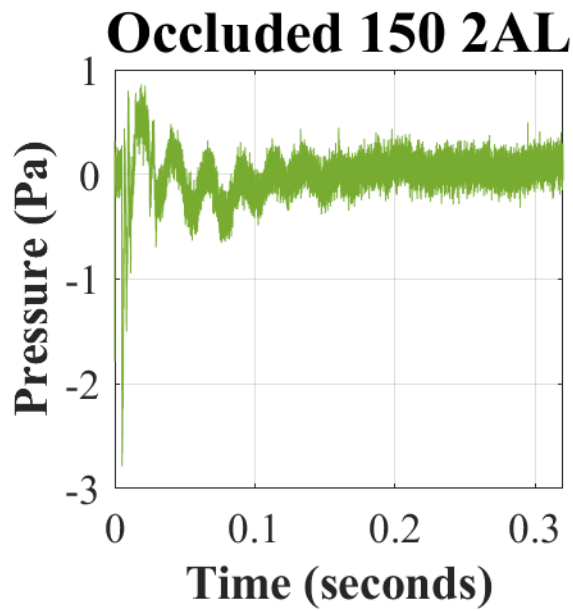
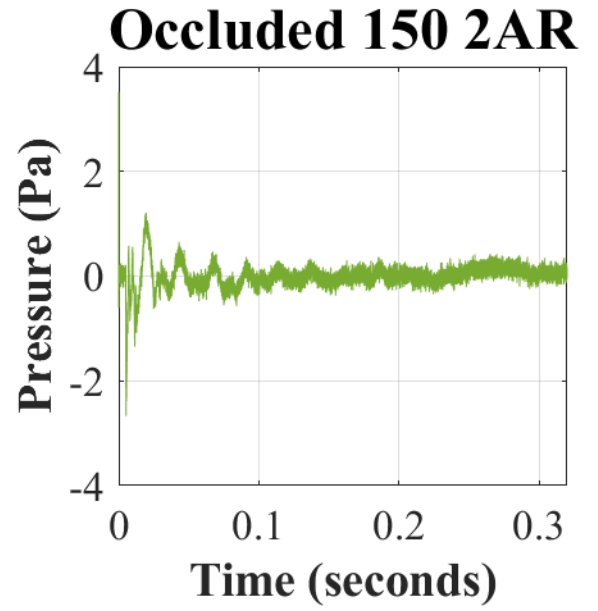
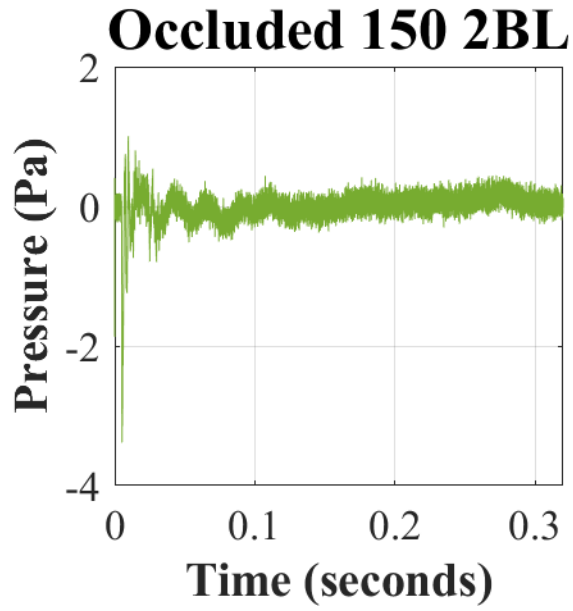
Department of Defense (2015). *MIL-STD-1474E Department of Defense Design Criteria Standard Noise Limits*. Department of Defense.

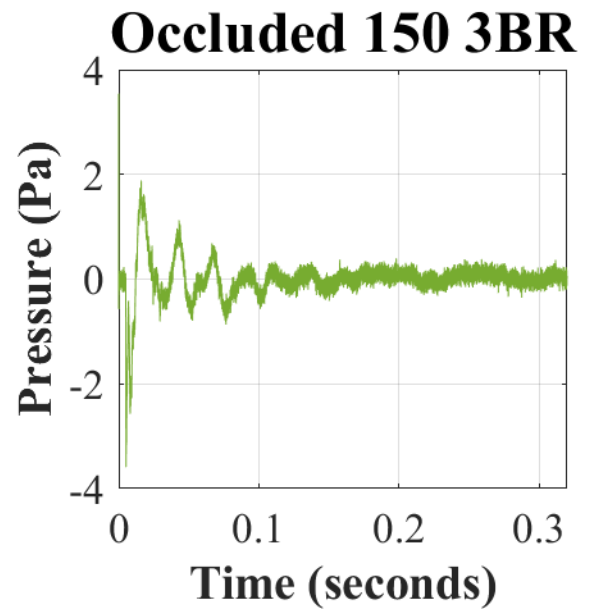
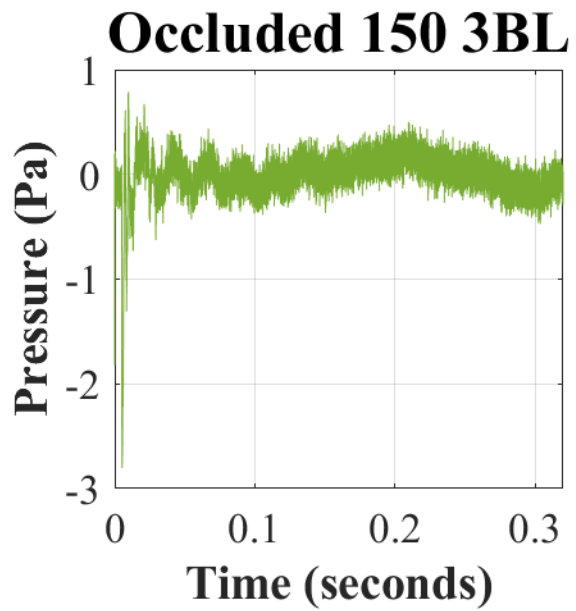
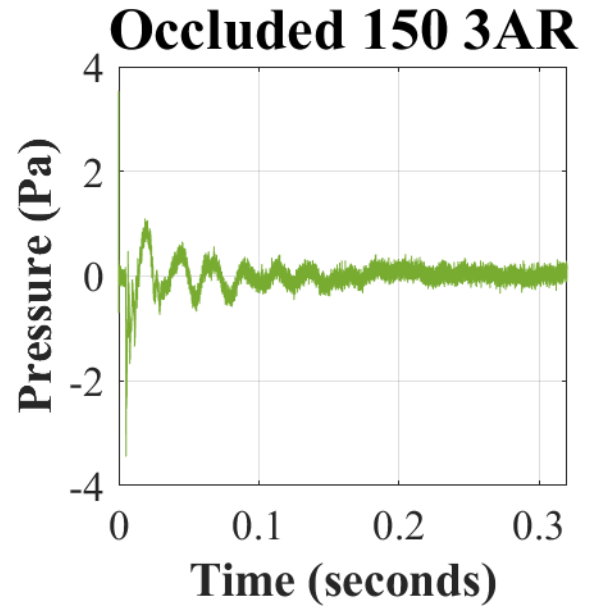
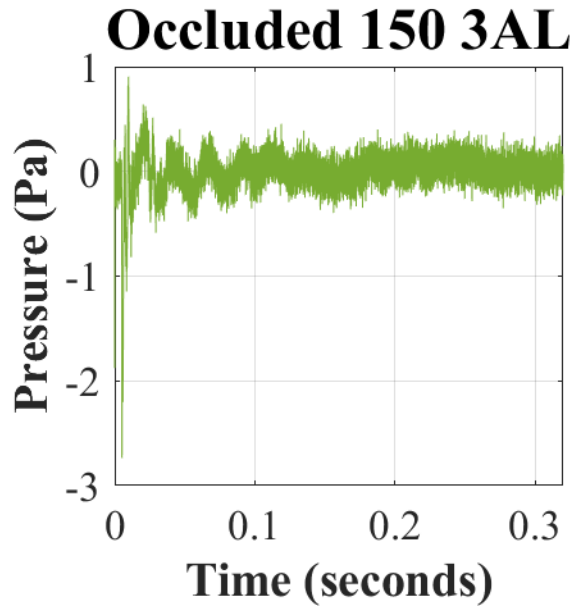
Moldex-Metric, Inc. (n.d.). *Camo Plugs Disposable Earplugs*. Culver City, CA: Moldex-Metric, Inc

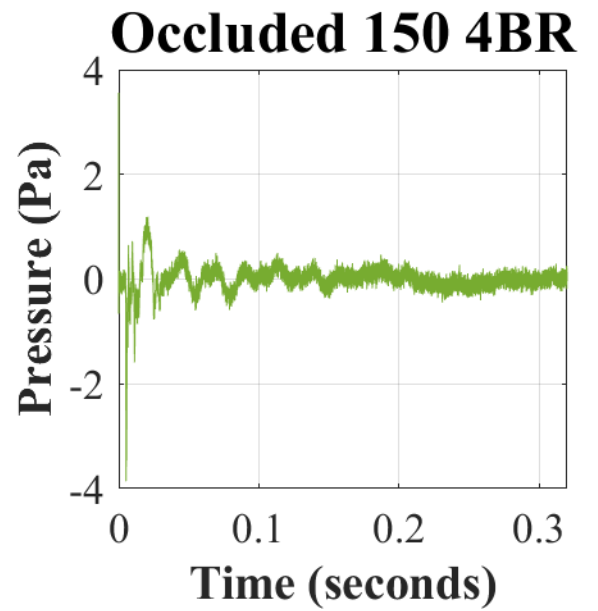
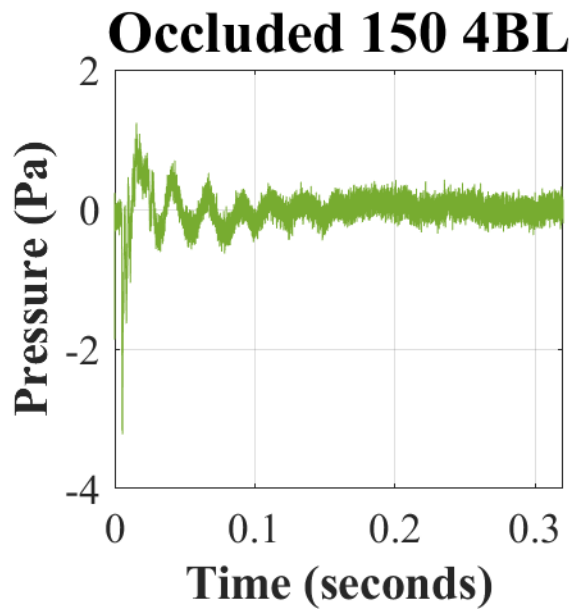
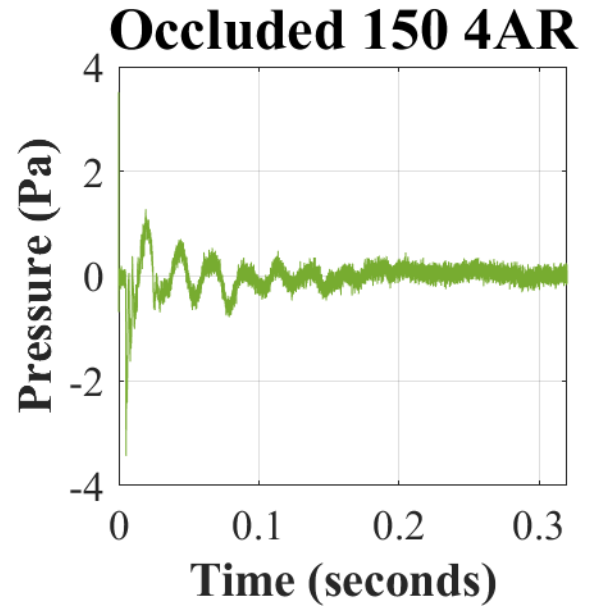
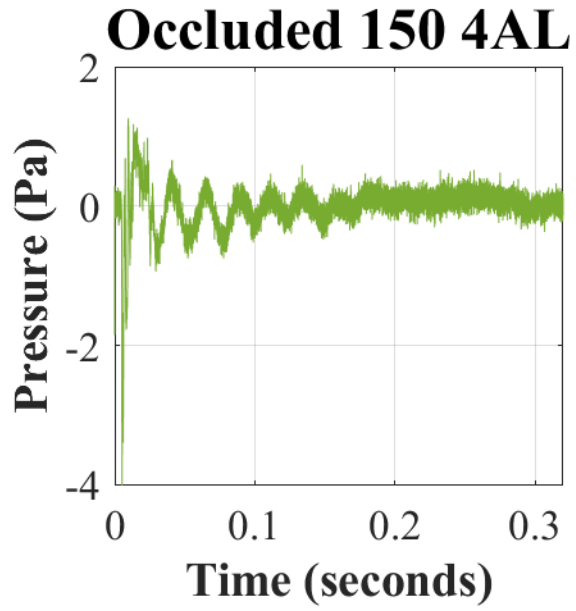
Office of the Under Secretary of Defense for Personnel and Readiness (2019). *DoD Instruction 6055.12 Hearing Conservation Program (HCP)*. Department of Defense.

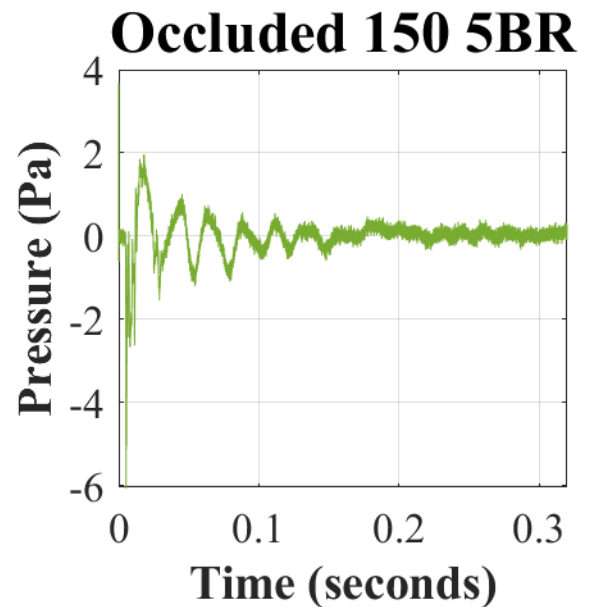
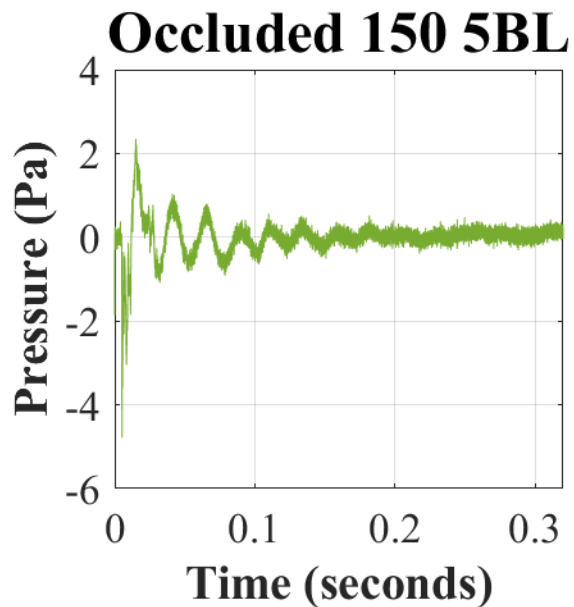
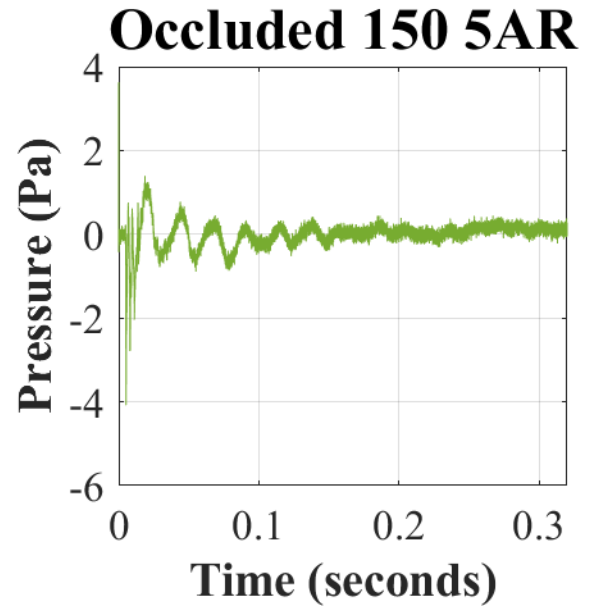
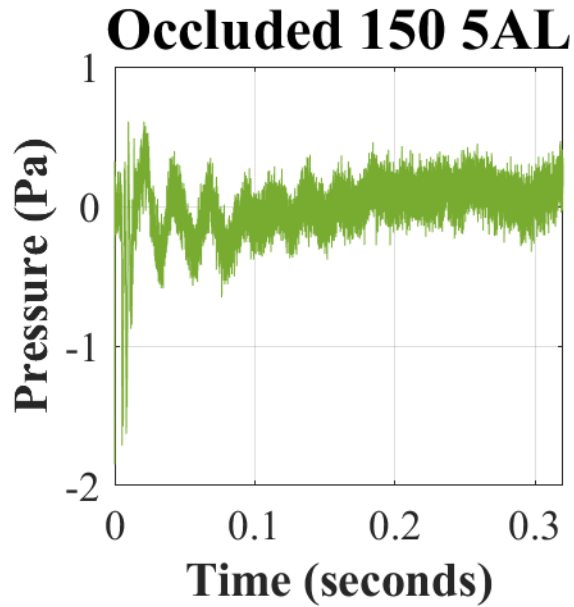
Appendix A. Recorded occluded (closed-ear) waveforms (in pascals [Pa]) over time (in seconds [s]) in response to 150 dBP with the Camo Plugs® Earplugs.





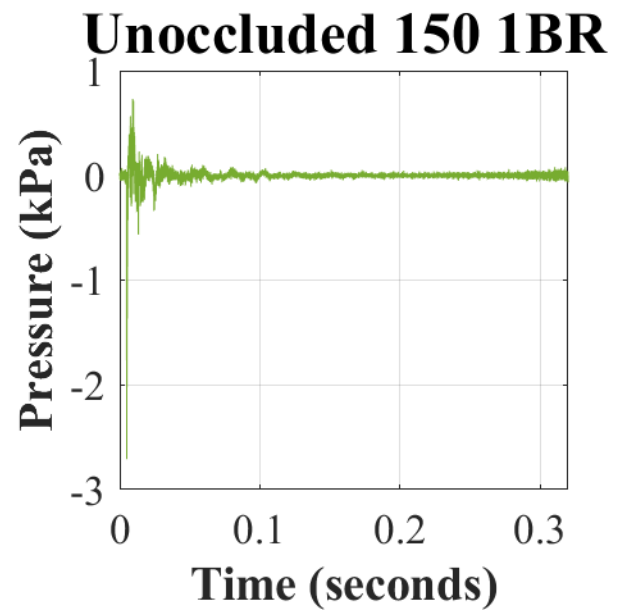
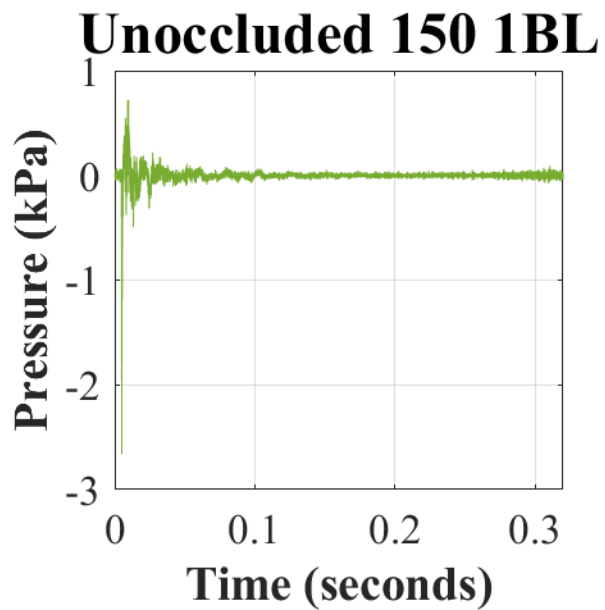
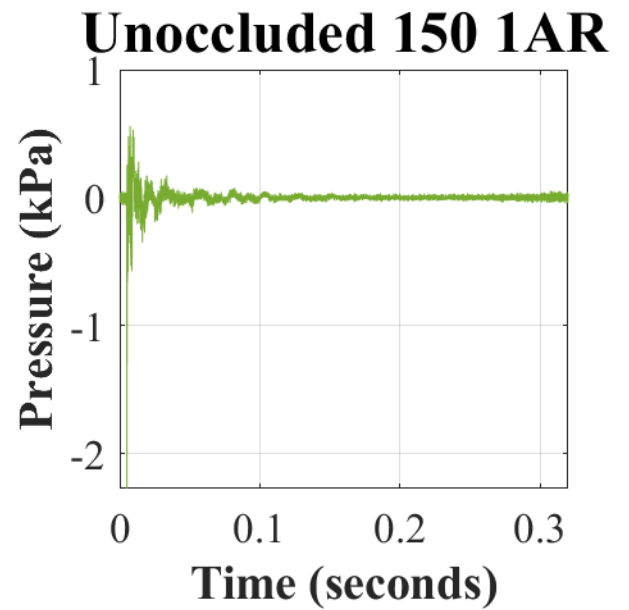
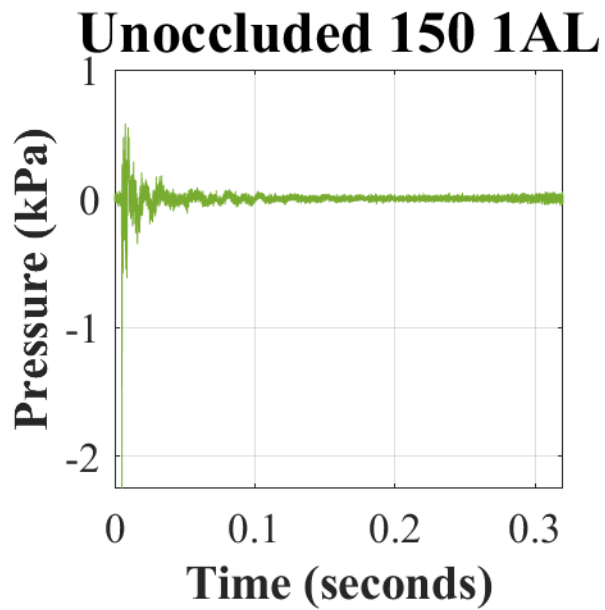


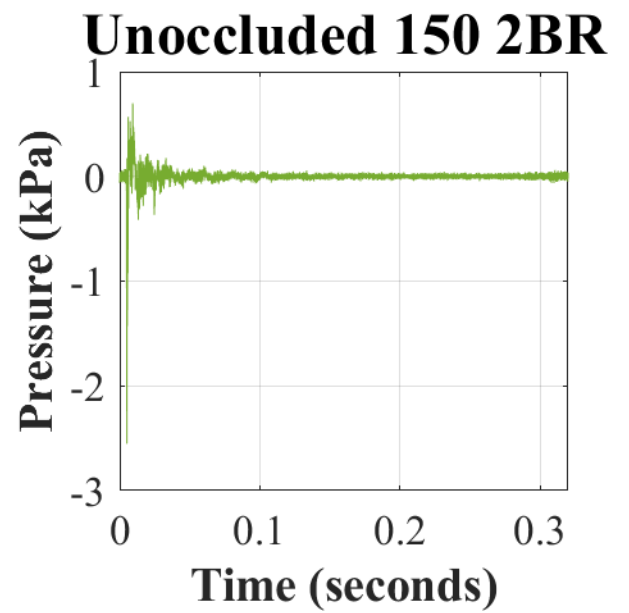
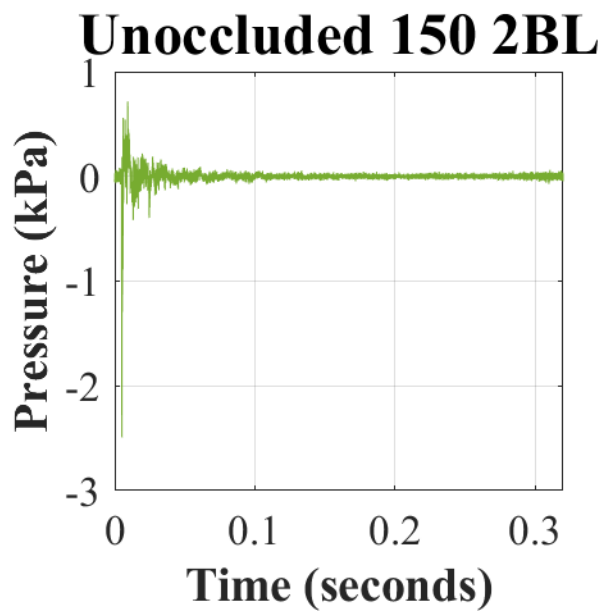
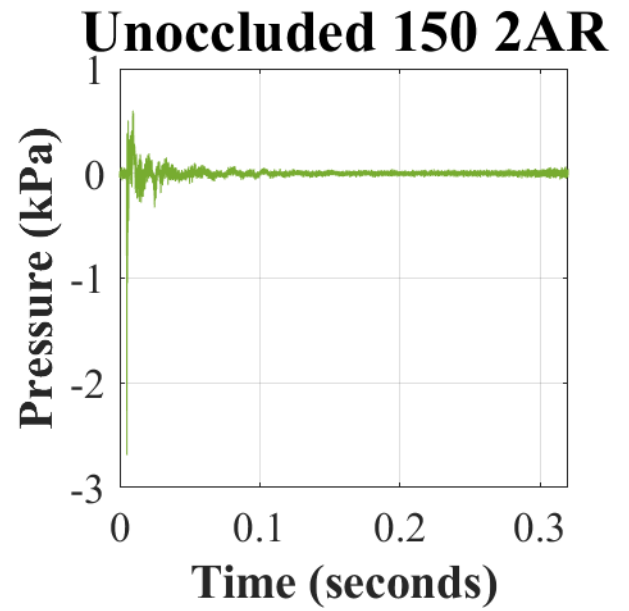
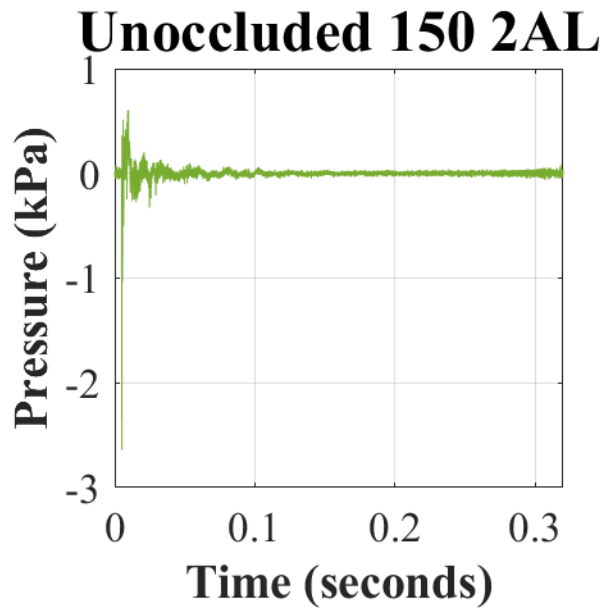


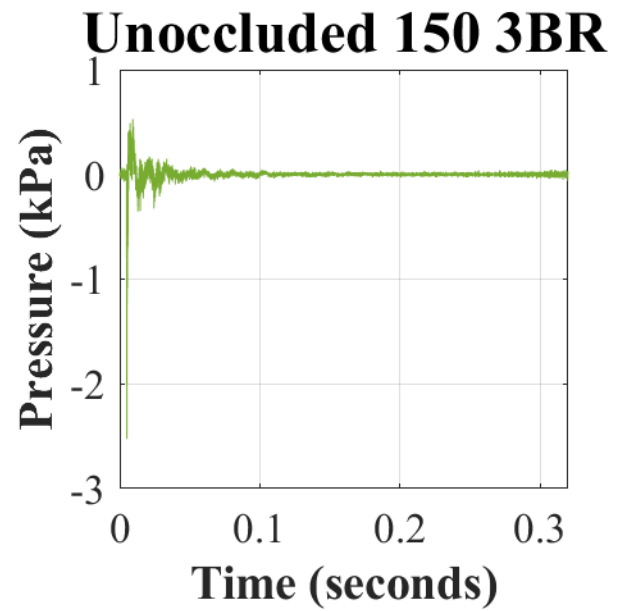
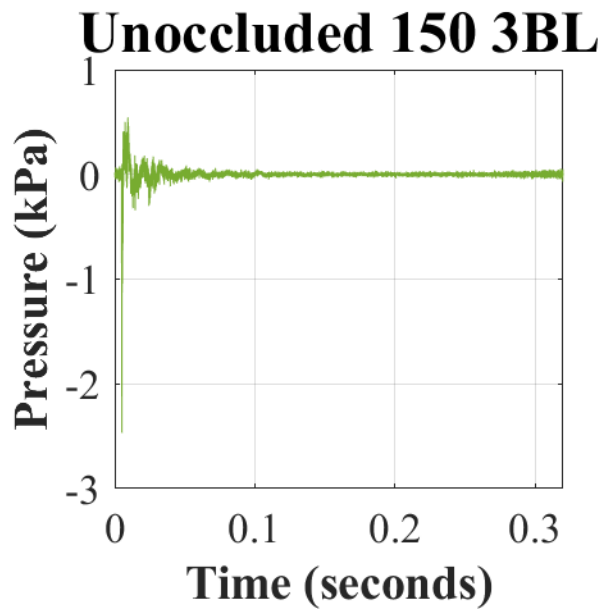
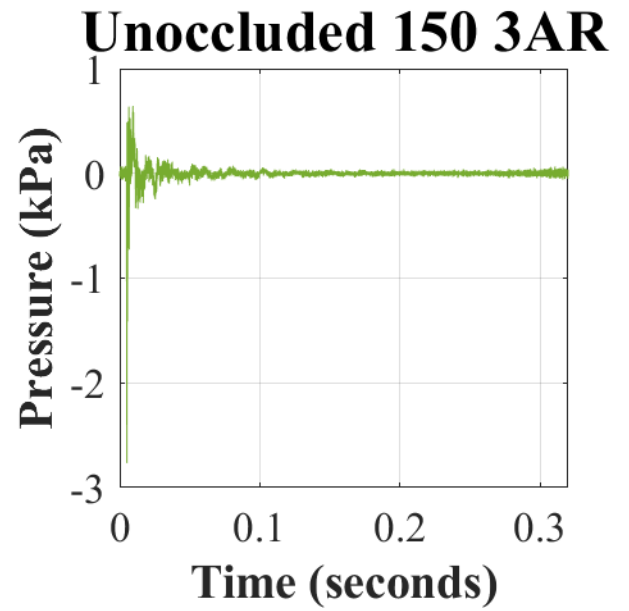
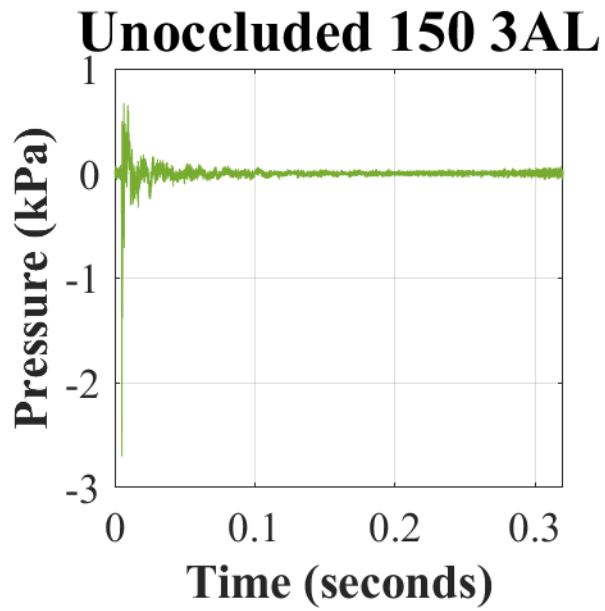


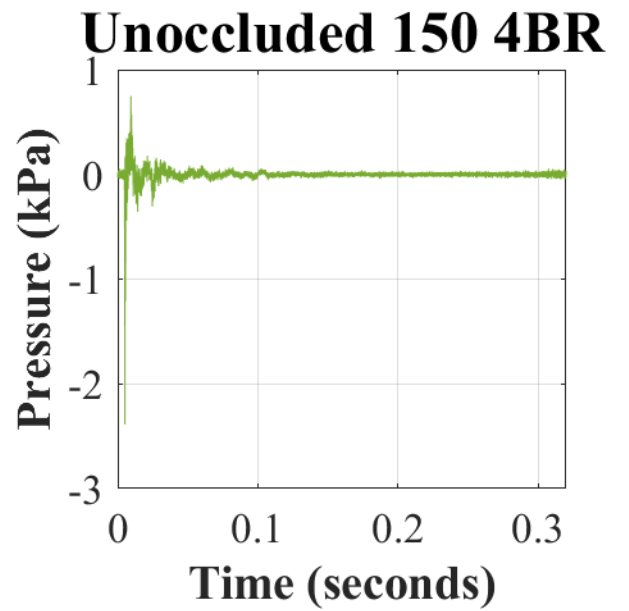
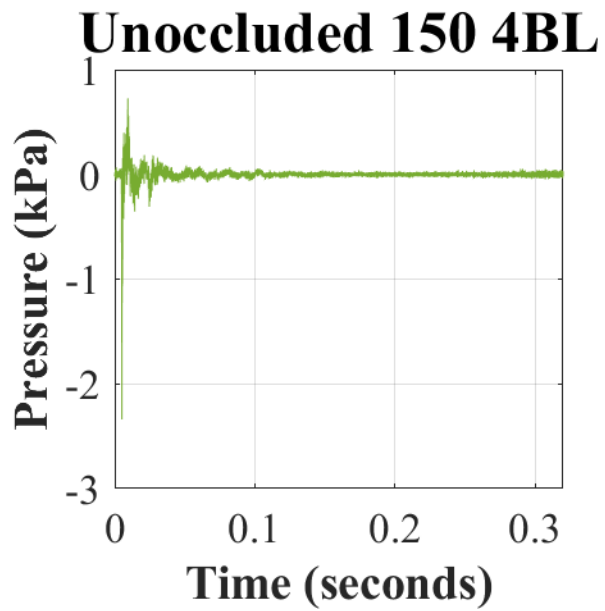
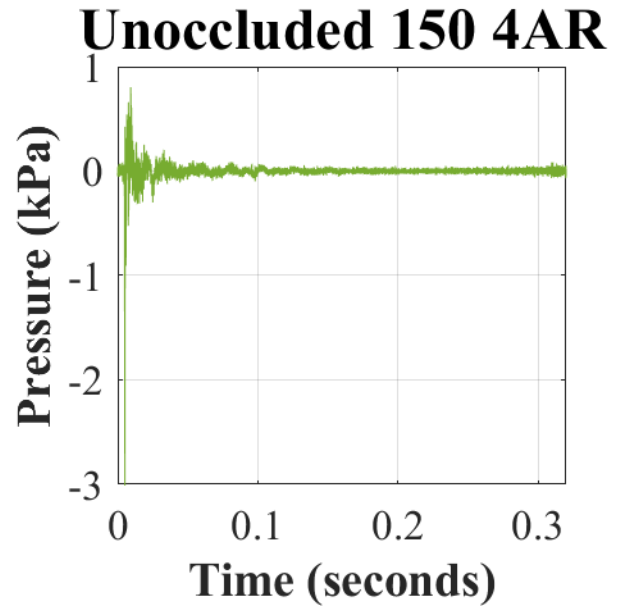
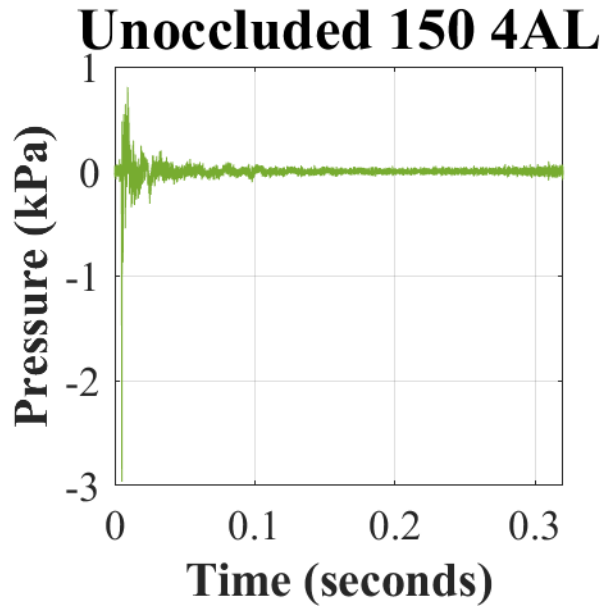
Note. The naming convention for all occluded waveforms is “Occluded LvL NnX”, where ‘Occluded’ is the test condition (i.e., ATF has the HPD donned), ‘LvL’ is the nominal test level (i.e., 150, 160 or 170 dBp), ‘N’ is the sample number (i.e., 1 to 5) of the device tested, ‘n’ is the trial (i.e., A or B) indicating HPD fit (i.e., first or second, respectively), and ‘X’ indicates from what ATF microphone the recording is from (i.e., right [R] or left [L] pinnae).

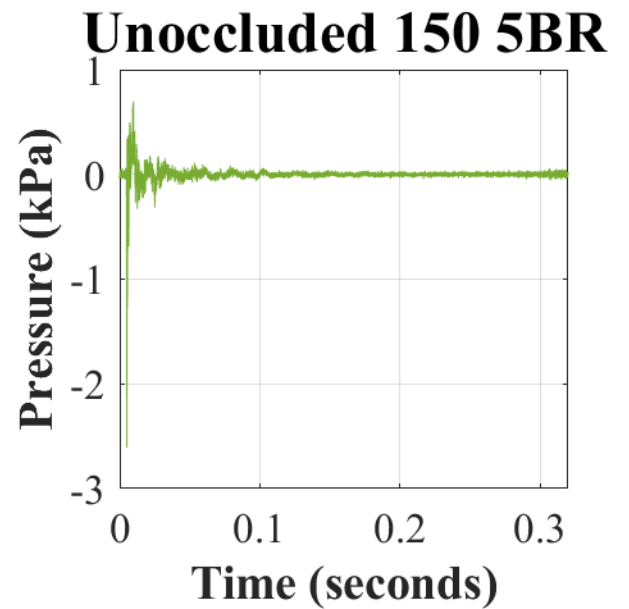
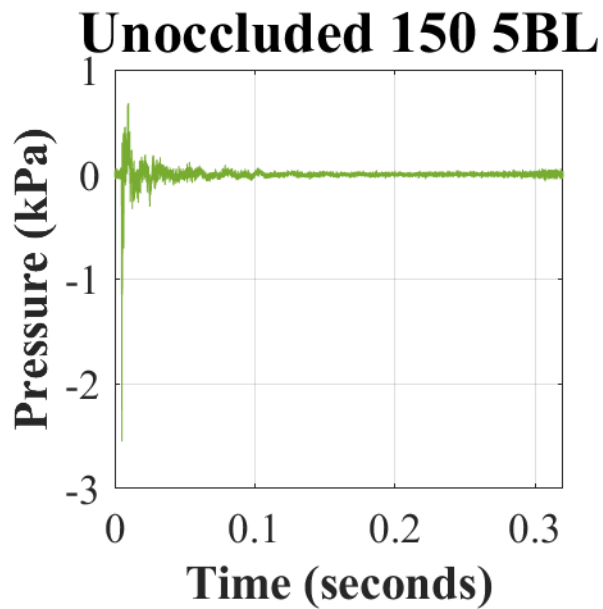
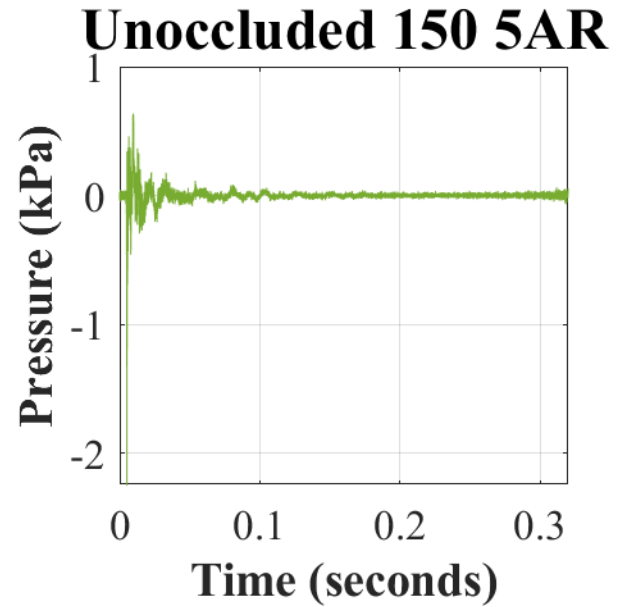
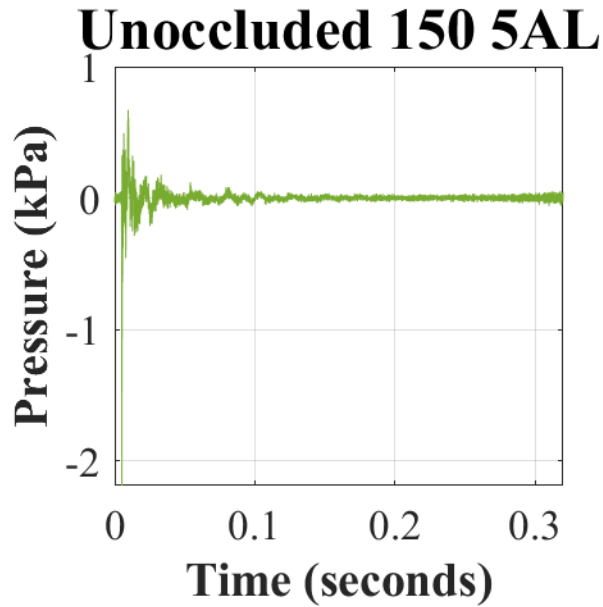
Appendix B. Estimated unoccluded (open-ear) waveforms (in kilopascals [kPa]) over time (in seconds [s]) in response to 150 dBp with the Camo Plugs® Earplugs.





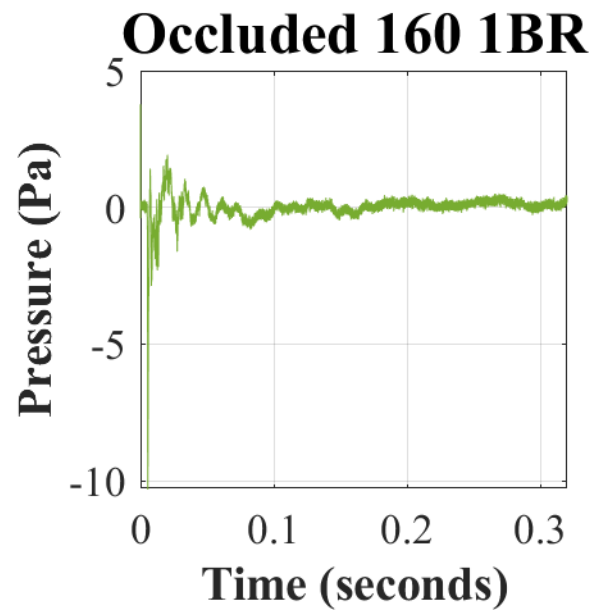
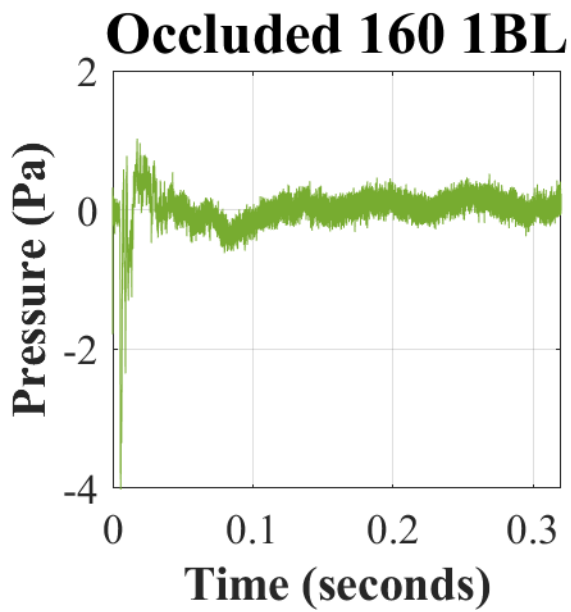
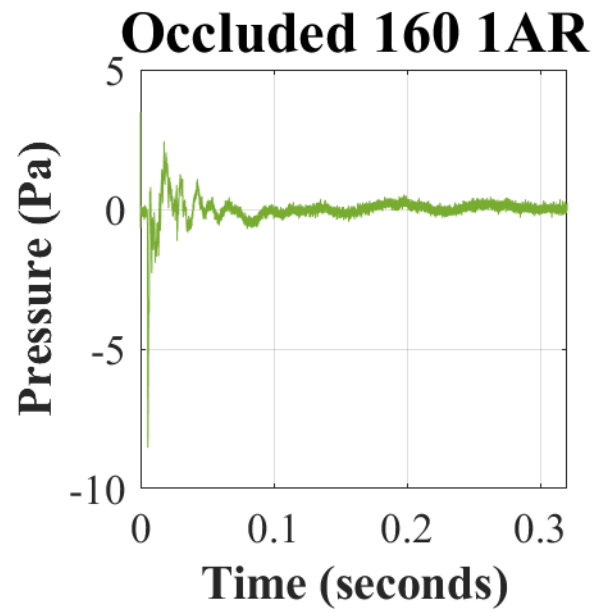
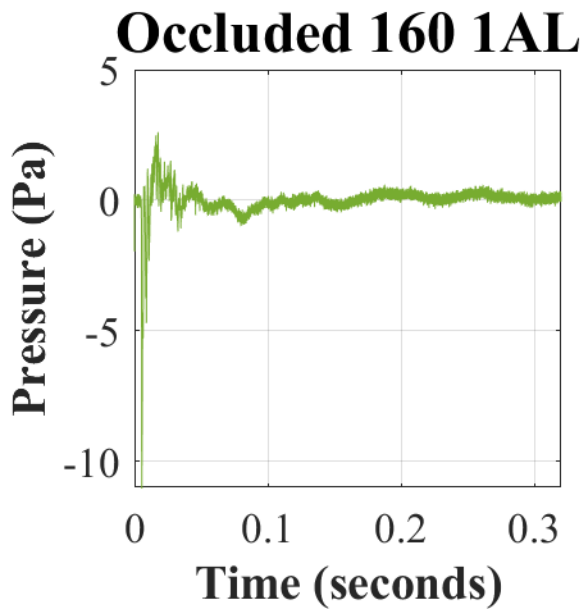




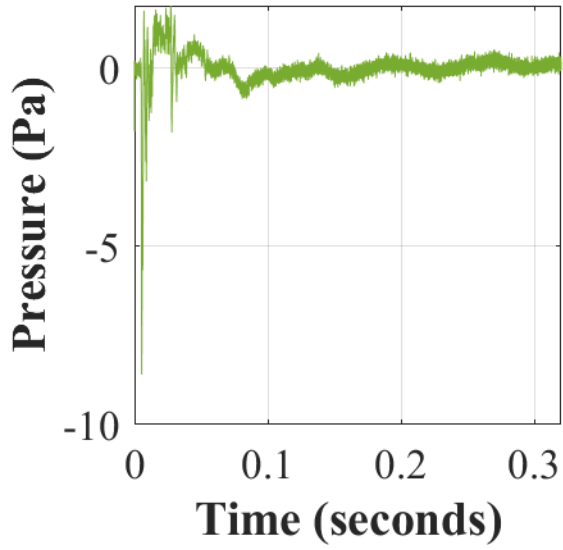


Note. The naming convention for all occluded waveforms is “Unoccluded LvL NnX”, where ‘Unoccluded’ is the test condition (i.e., ATF has the HPD doffed), ‘LvL’ is the nominal test level (i.e., 150, 160 or 170 dBp), ‘N’ is the sample number (i.e., 1 to 5) of the device tested, ‘n’ is the trial (i.e., A or B) indicating HPD fit (i.e., first or second, respectively), and ‘X’ indicates from what ATF microphone the recording is from (i.e., right [R] or left [L] pinnae).

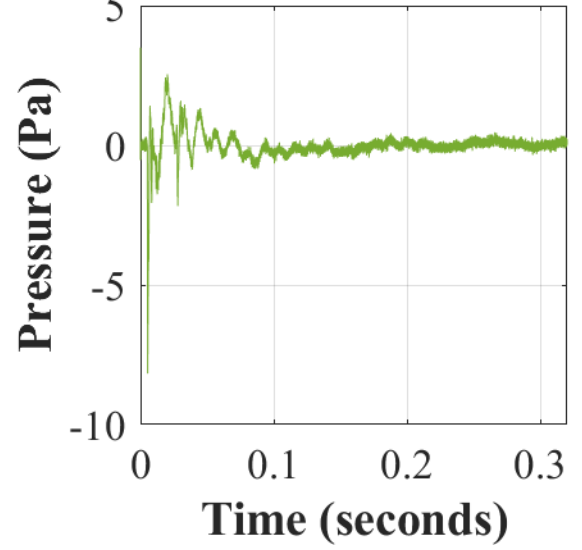
Appendix C. Recorded occluded (closed-ear) waveforms (in pascals [Pa]) over time (in seconds [s]) in response to 160 dBp with the Camo Plugs[®] Earplugs.



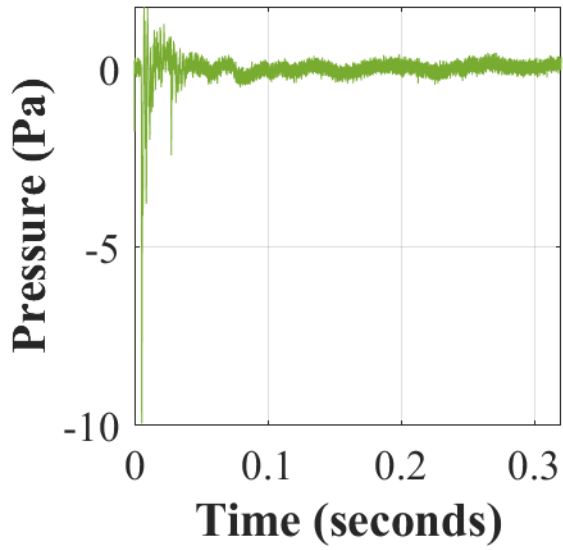
Occluded 160 2AL



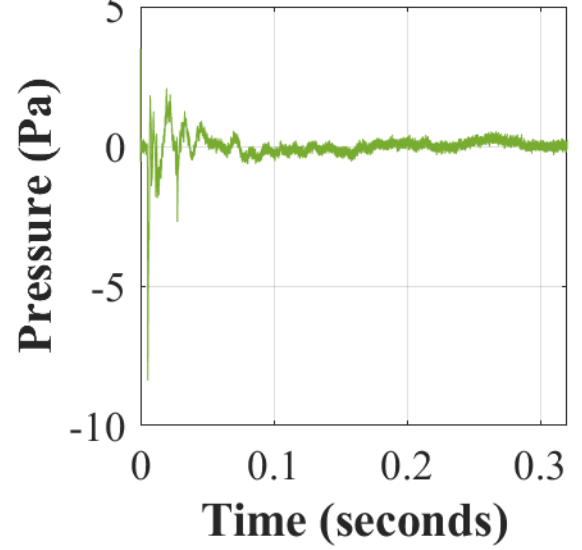
Occluded 160 2AR

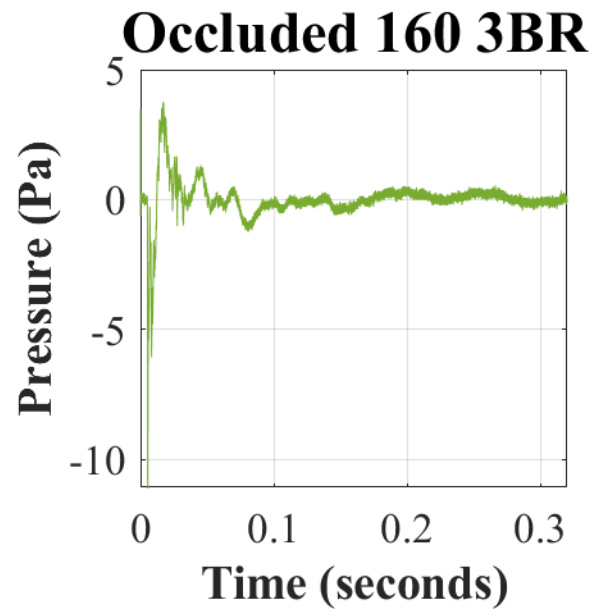
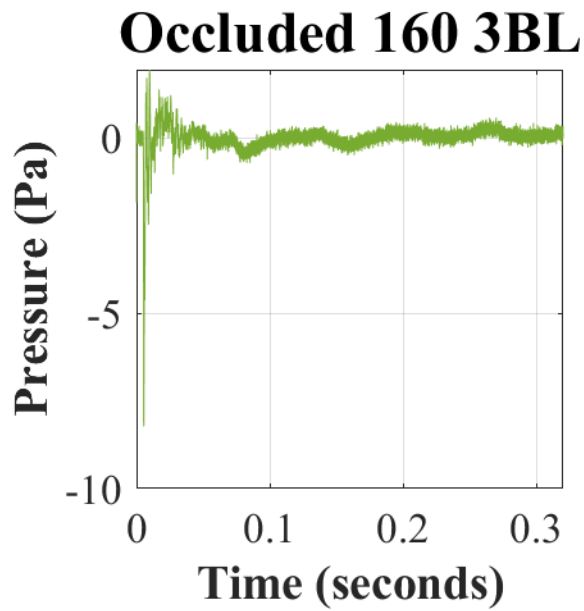
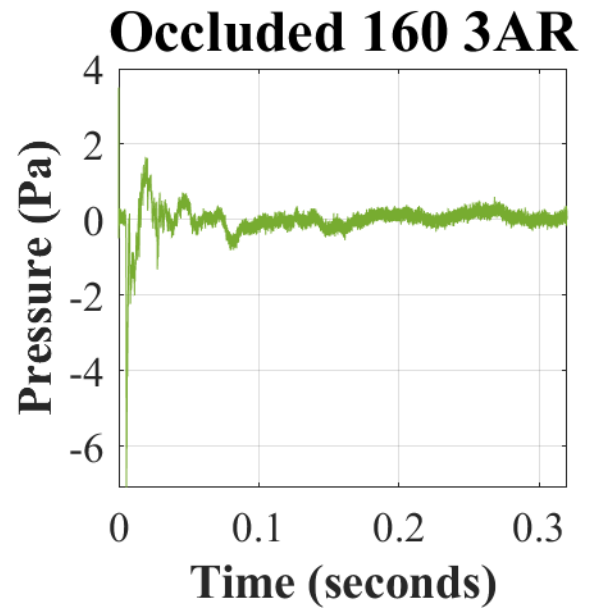
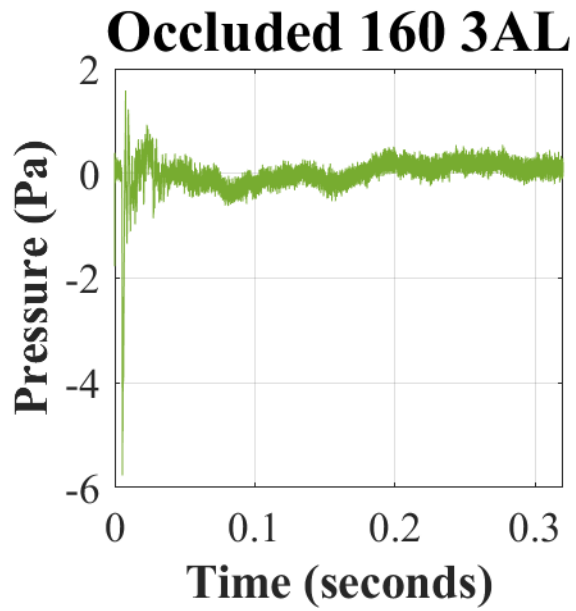


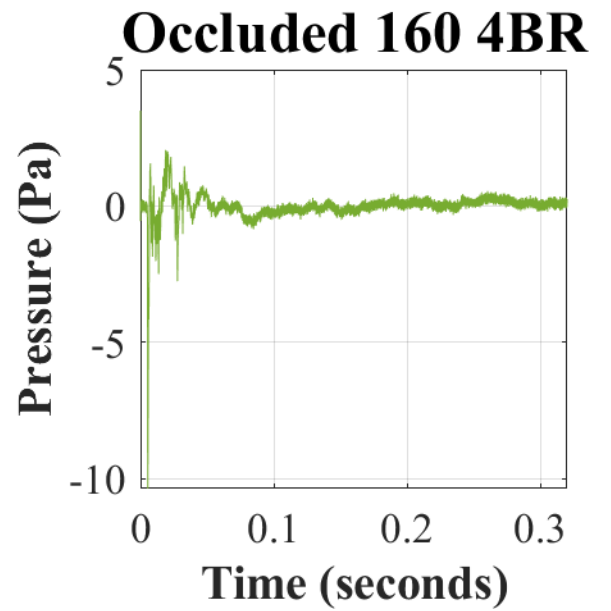
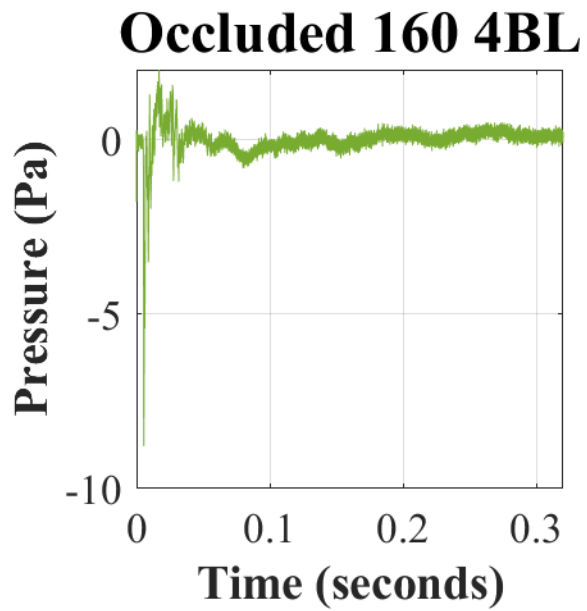
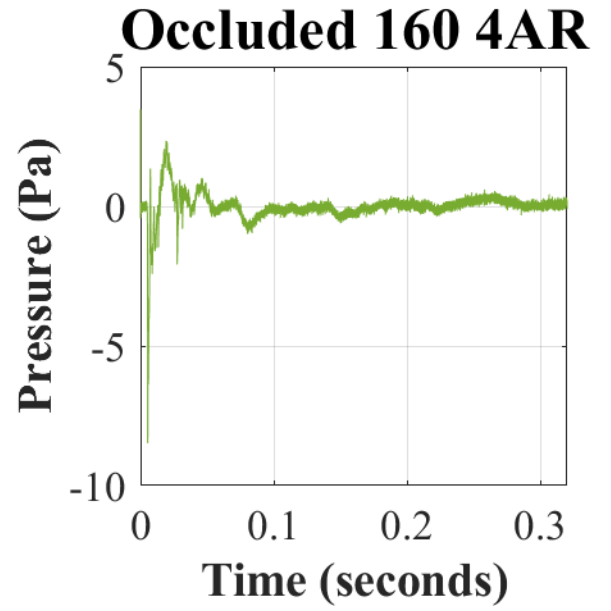
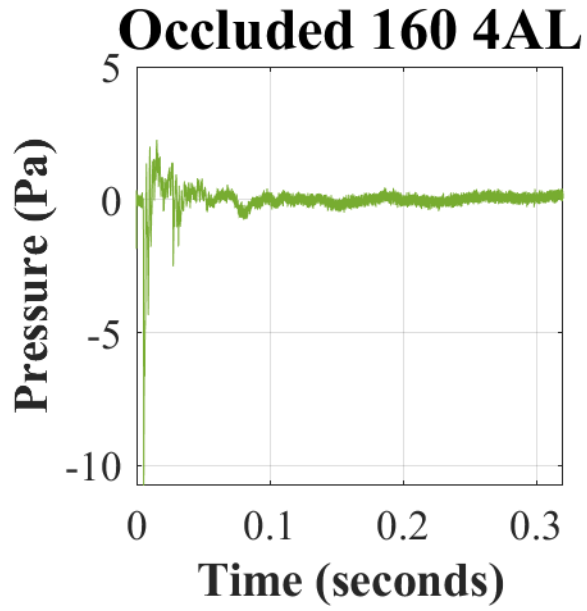
Occluded 160 2BL

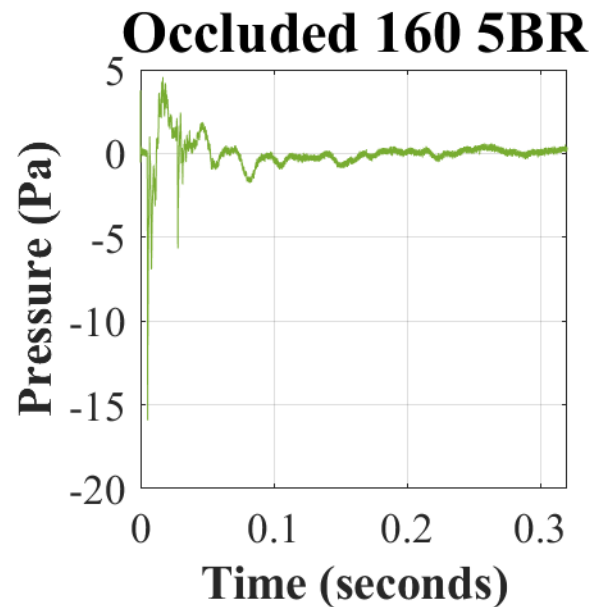
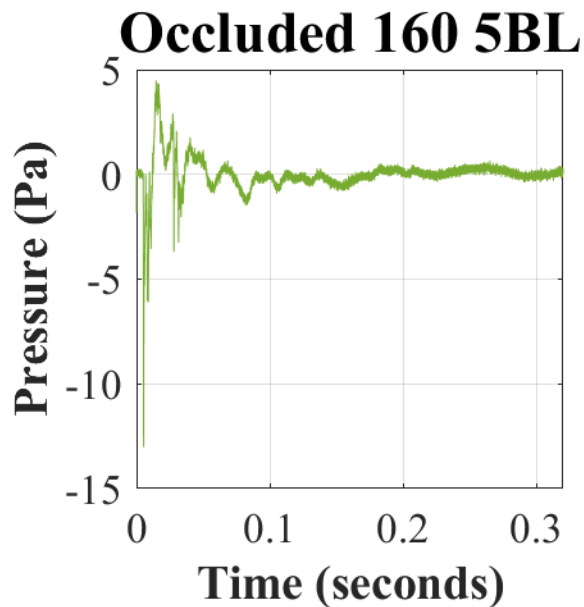
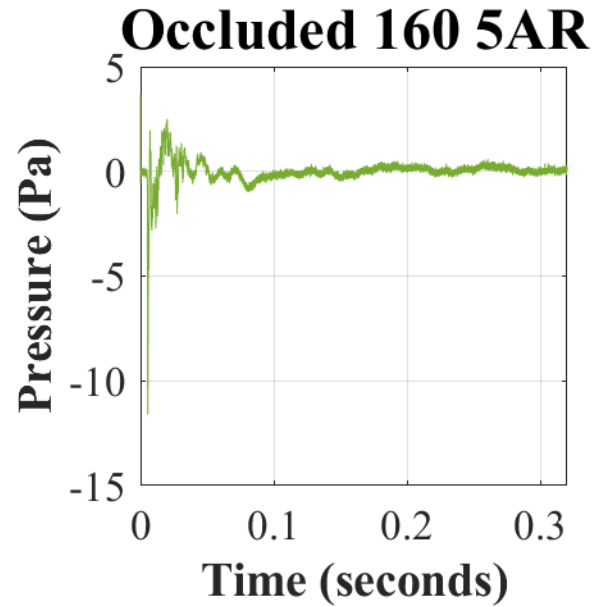
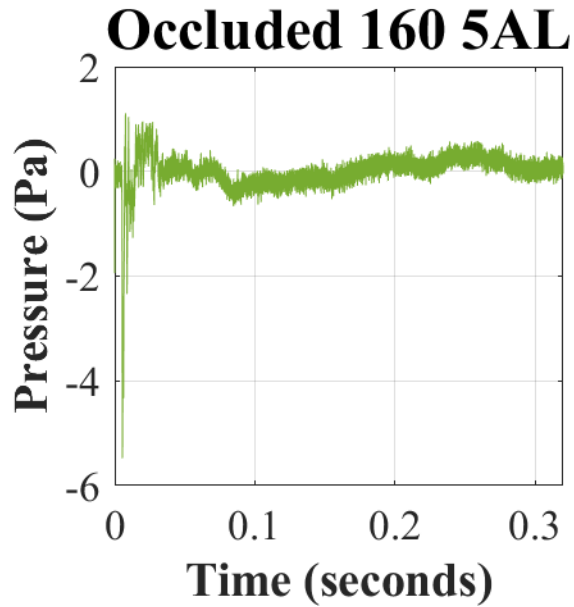


Occluded 160 2BR



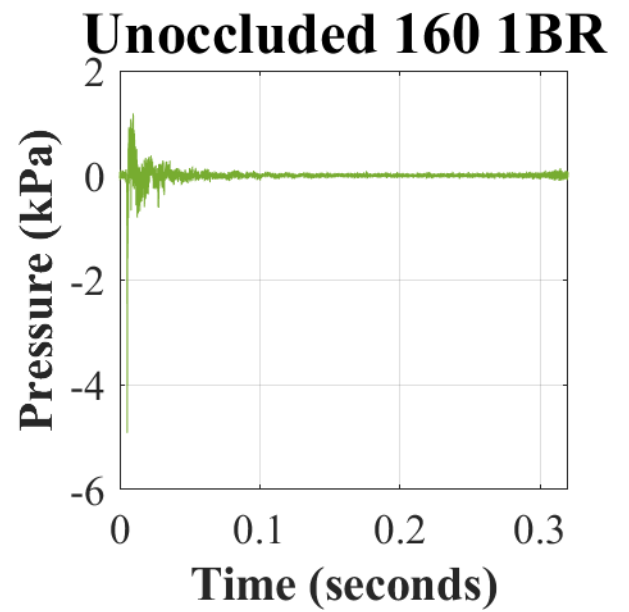
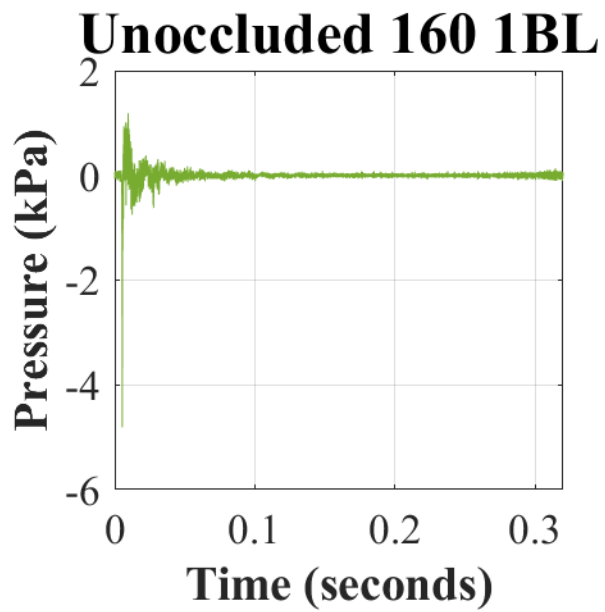
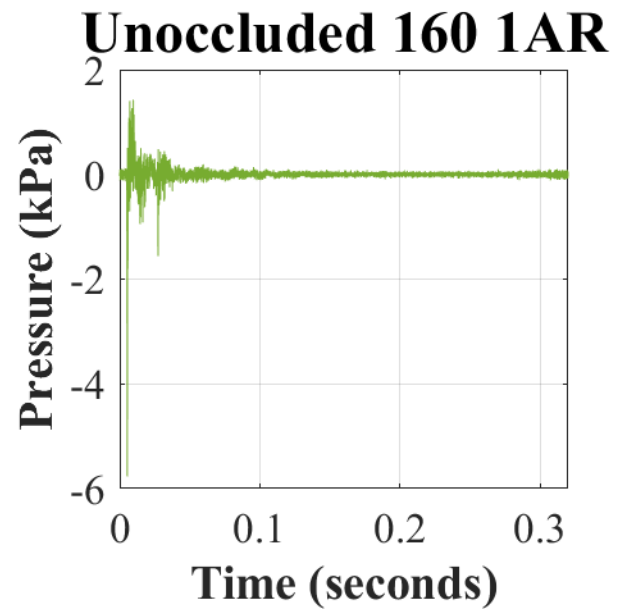
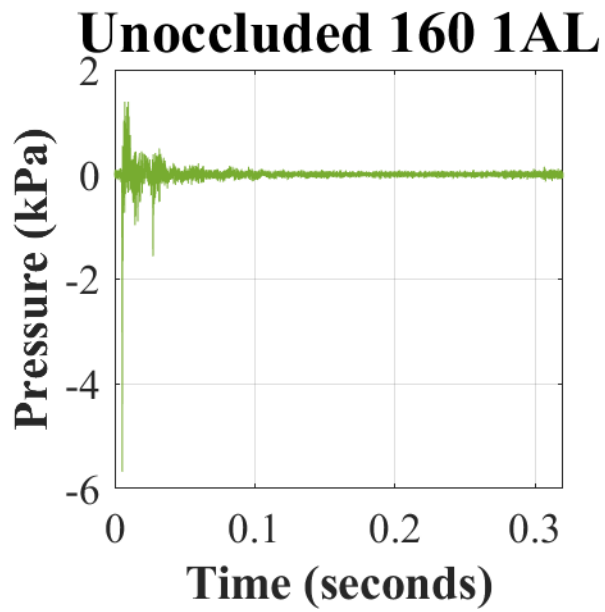


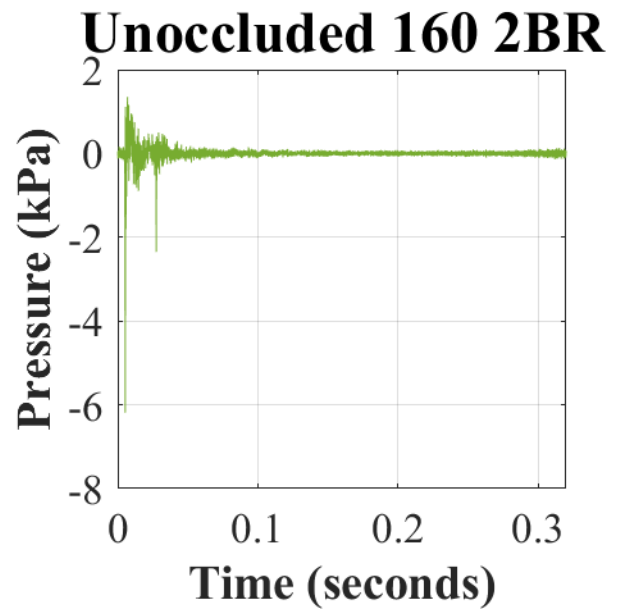
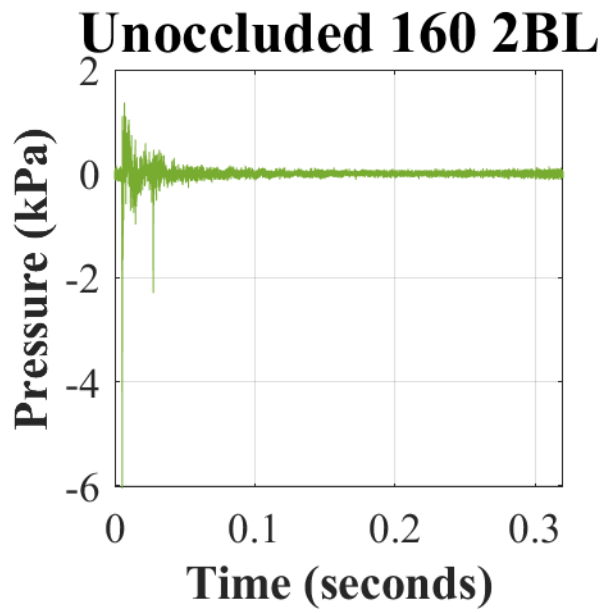
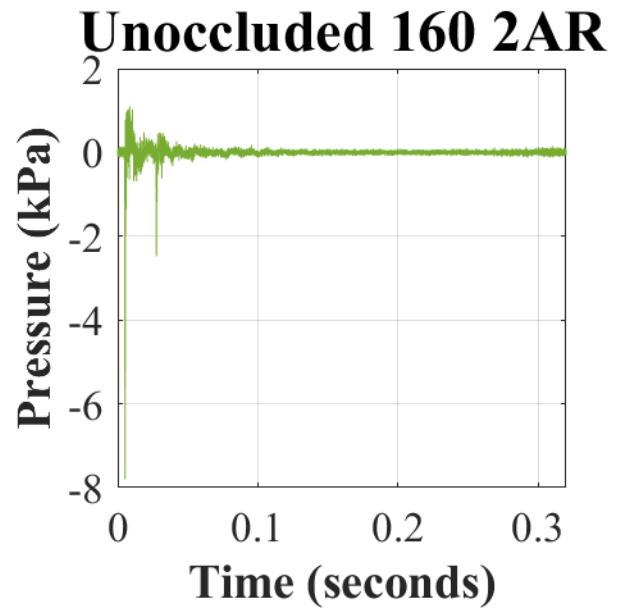
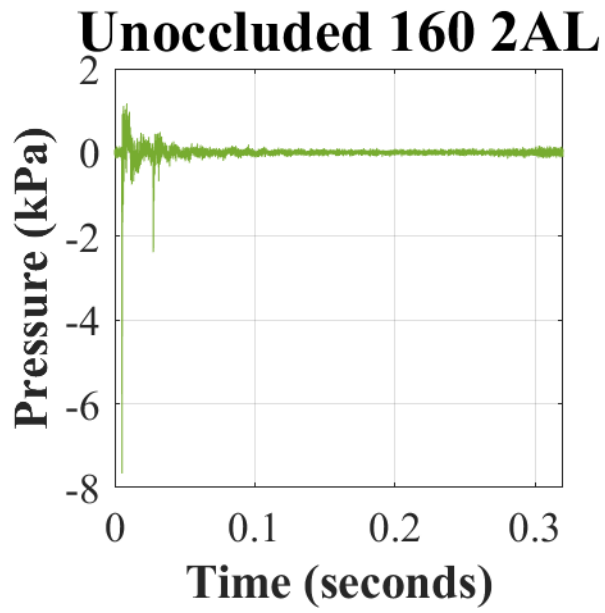


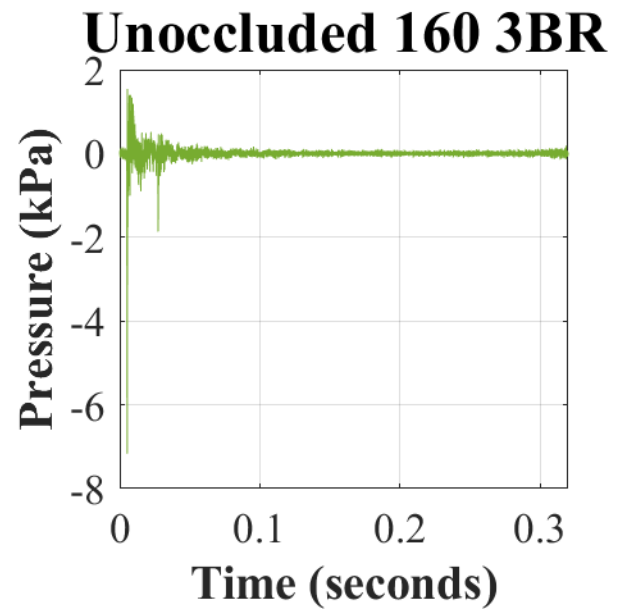
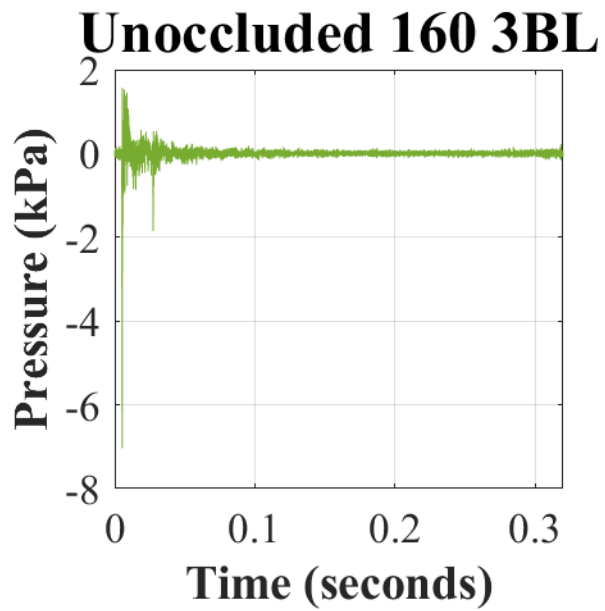
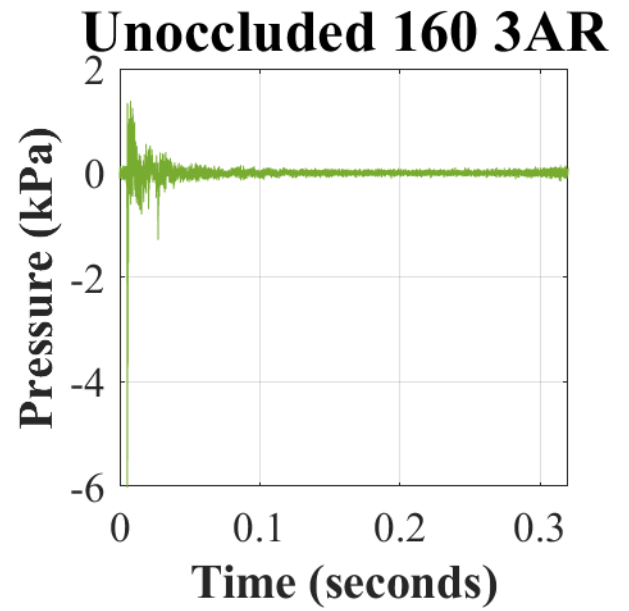
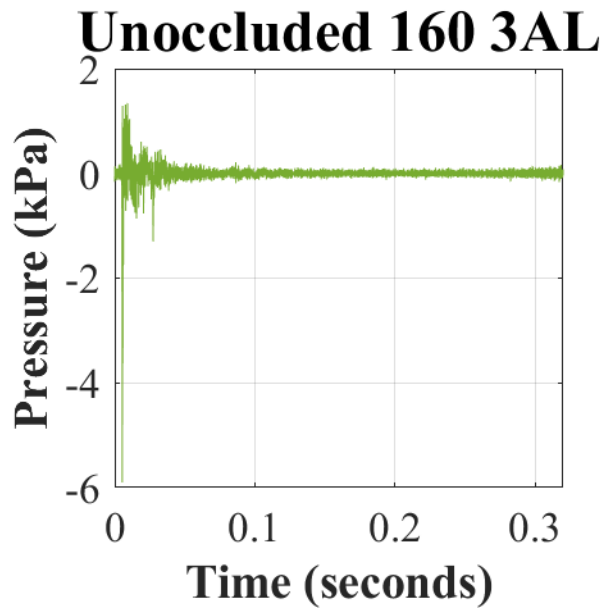


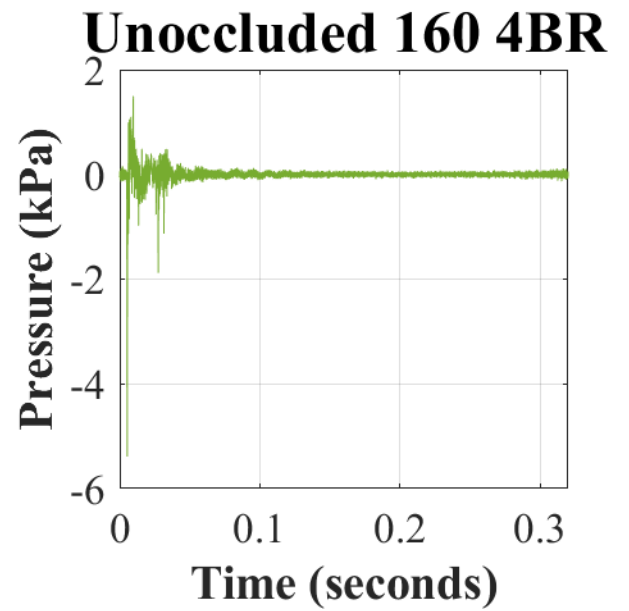
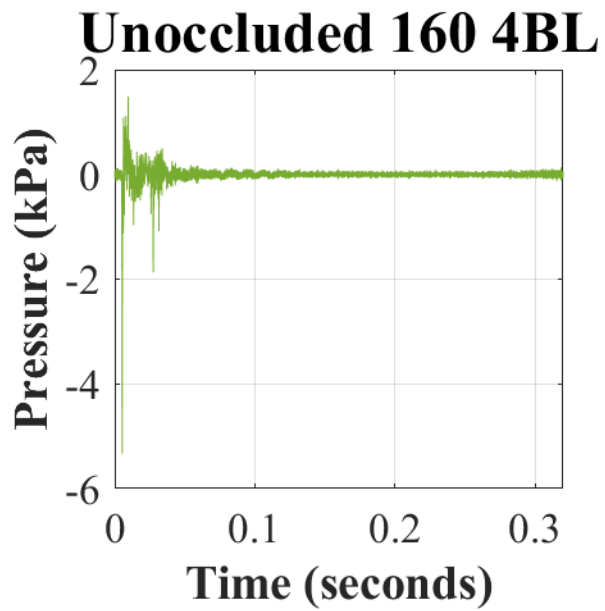
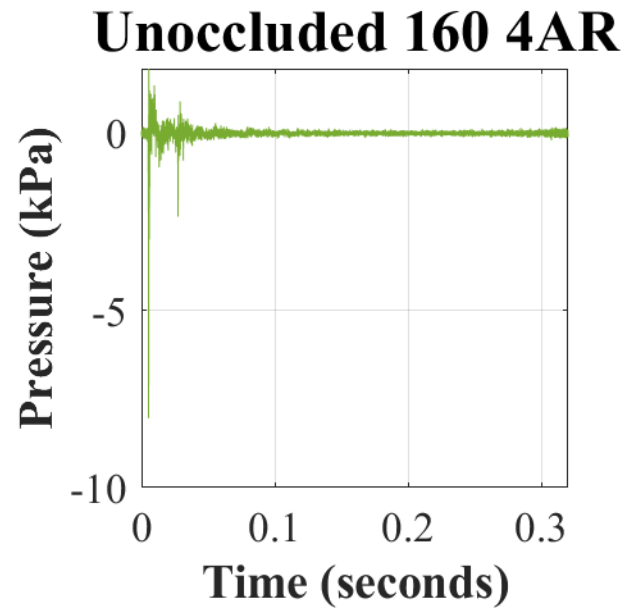
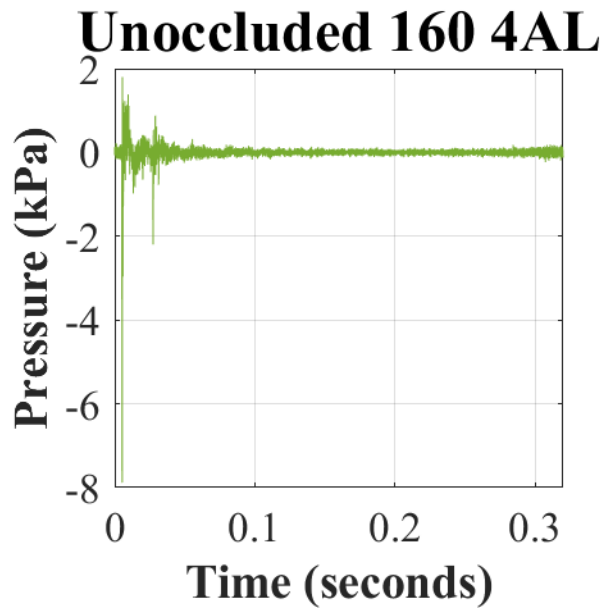
Note. The naming convention for all occluded waveforms is “Occluded LvL NnX”, where ‘Occluded’ is the test condition (i.e., ATF has the HPD donned), ‘LvL’ is the nominal test level (i.e., 150, 160 or 170 dBp), ‘N’ is the sample number (i.e., 1 to 5) of the device tested, ‘n’ is the trial (i.e., A or B) indicating HPD fit (i.e., first or second, respectively), and ‘X’ indicates from what ATF microphone the recording is from (i.e., right [R] or left [L] pinnae).

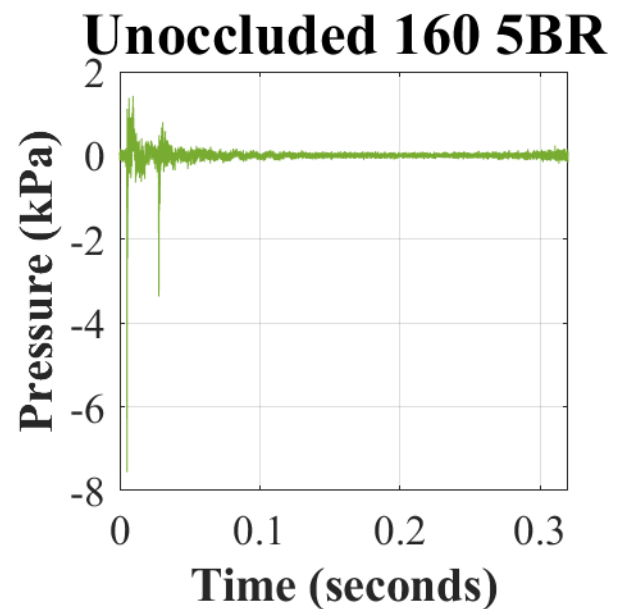
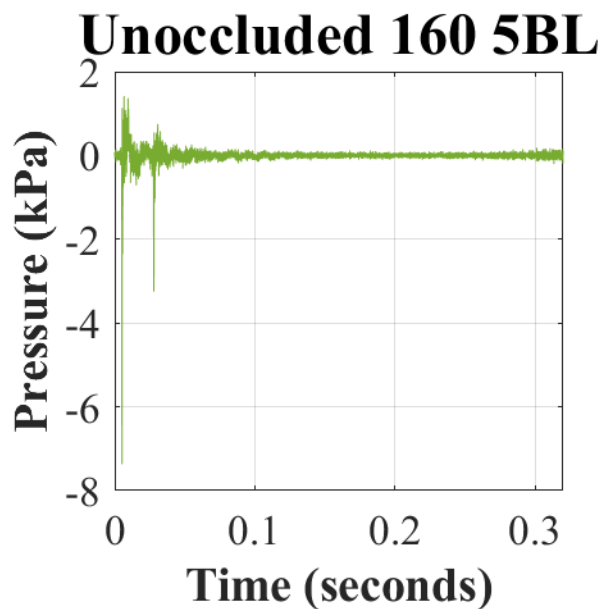
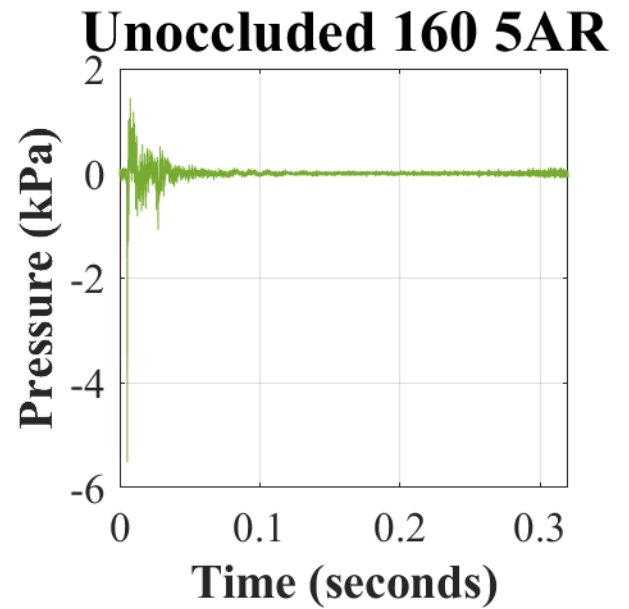
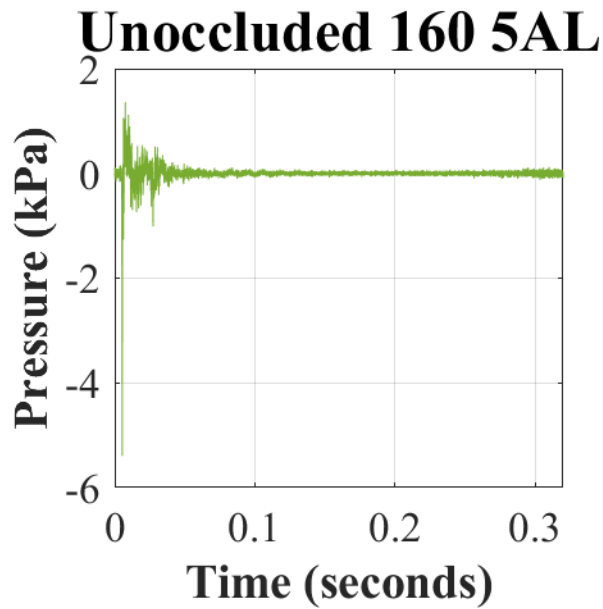
Appendix D. Estimated unoccluded (open-ear) waveforms (in kilopascals [kPa]) over time (in seconds [s]) in response to 160 dBp with the Camo Plugs® Earplugs.





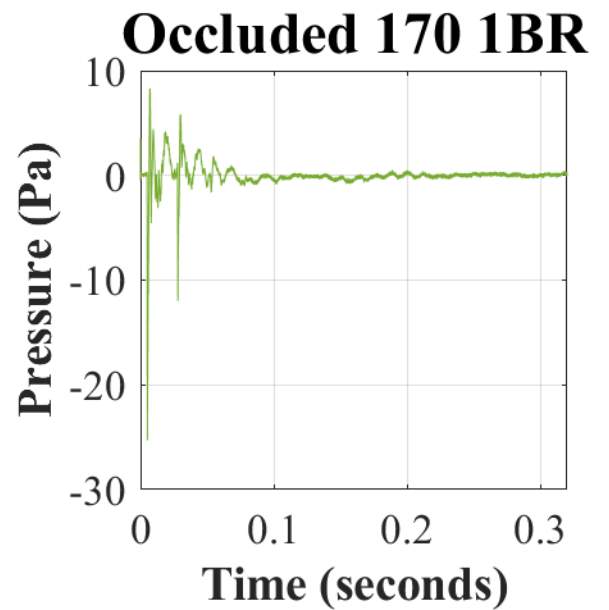
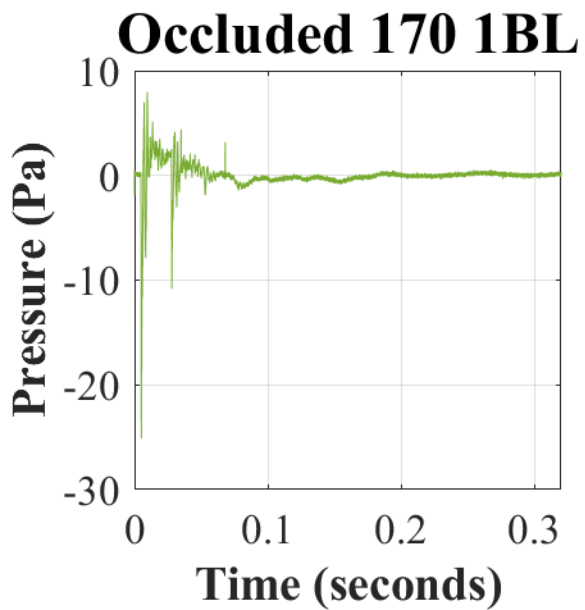
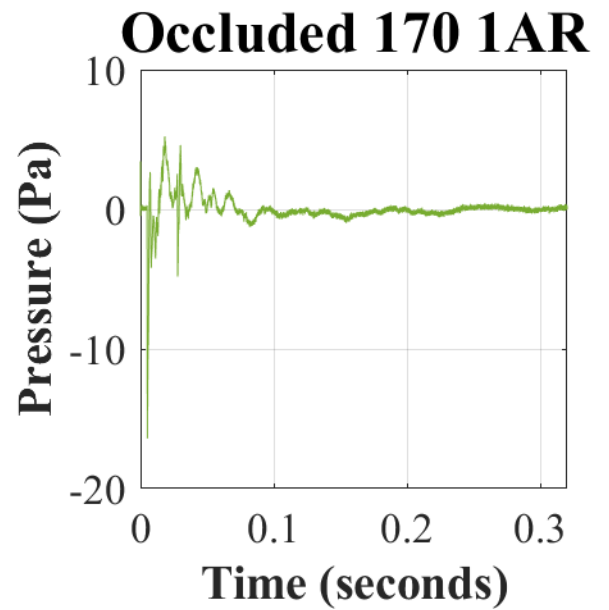
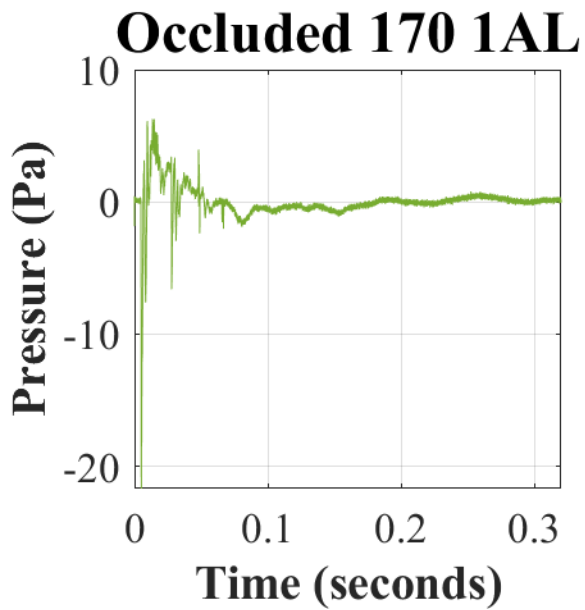


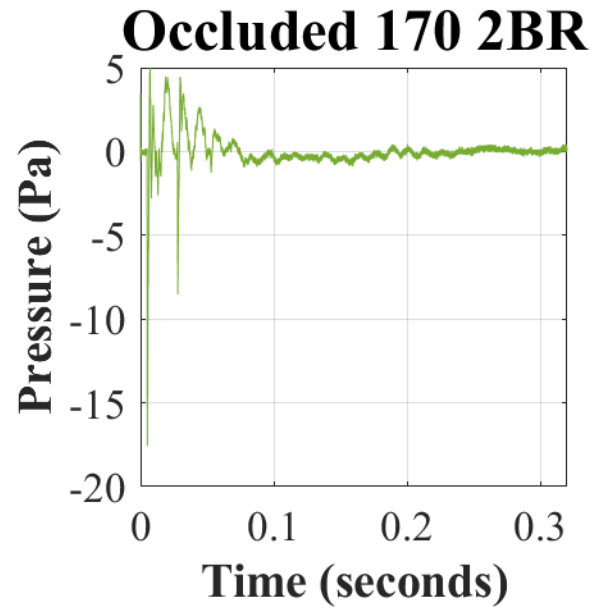
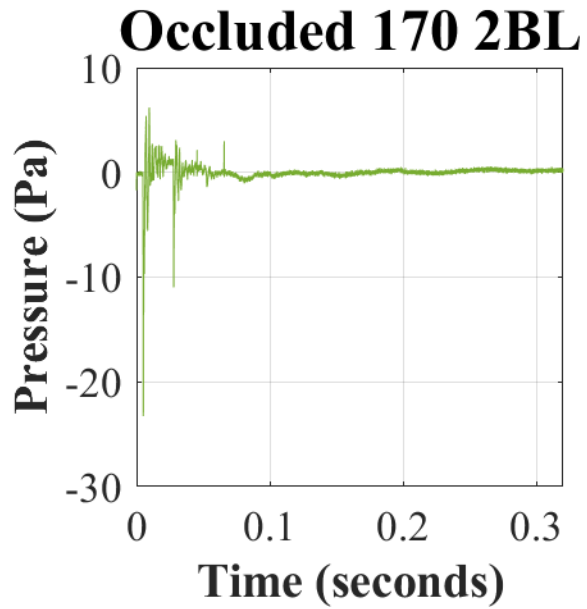
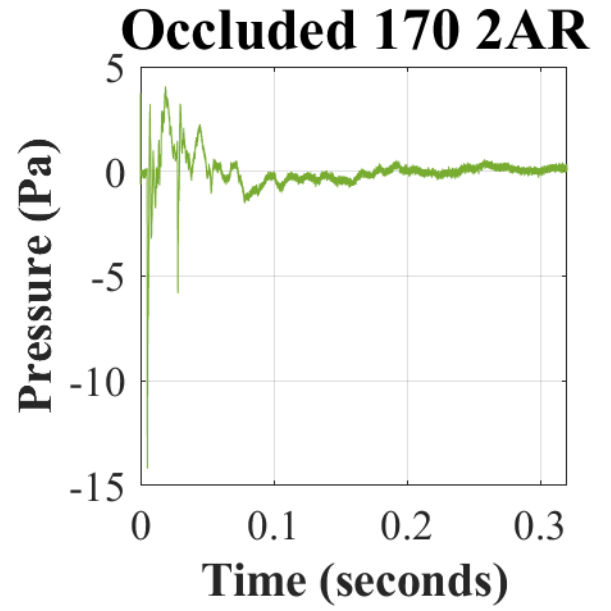
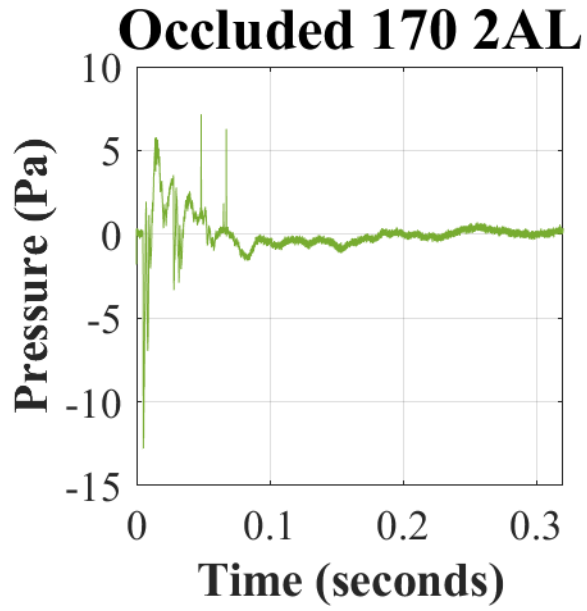


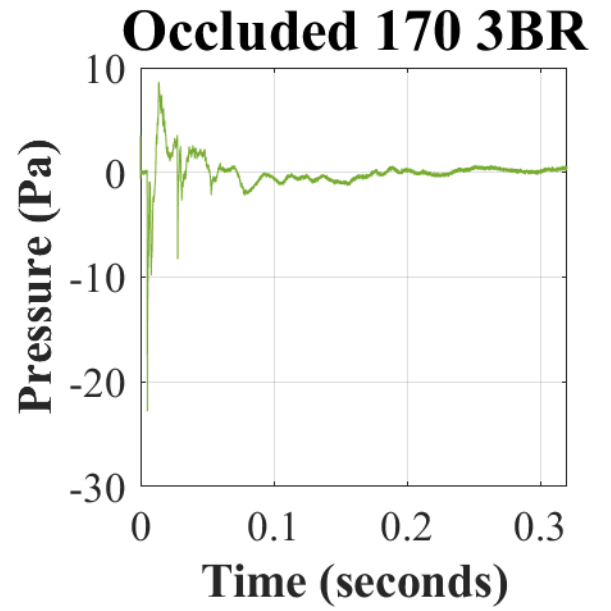
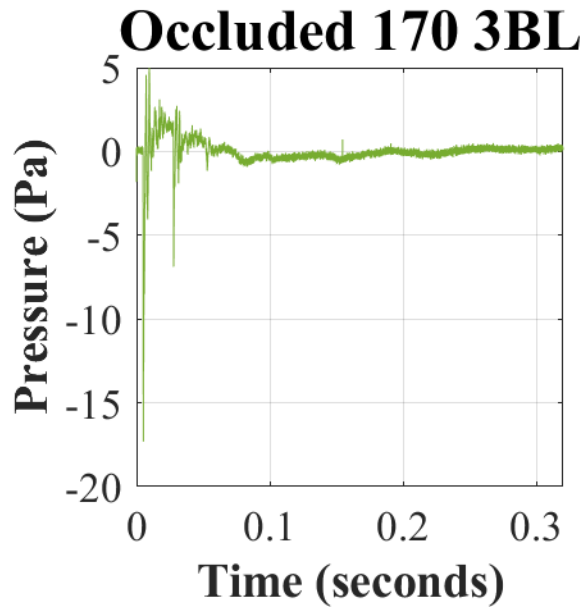
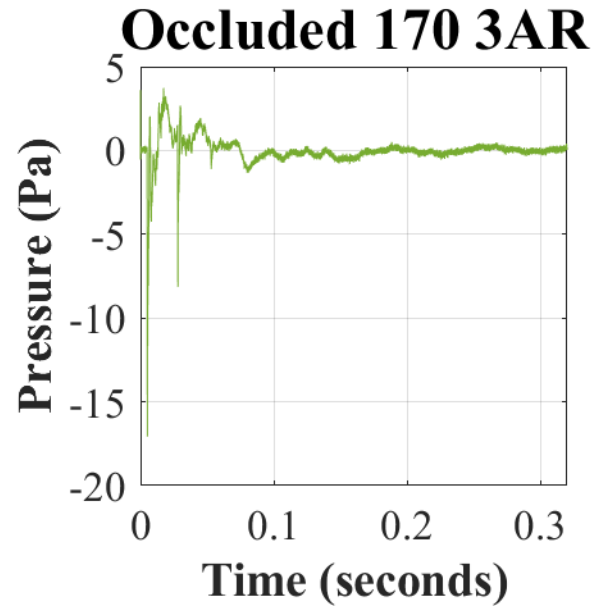
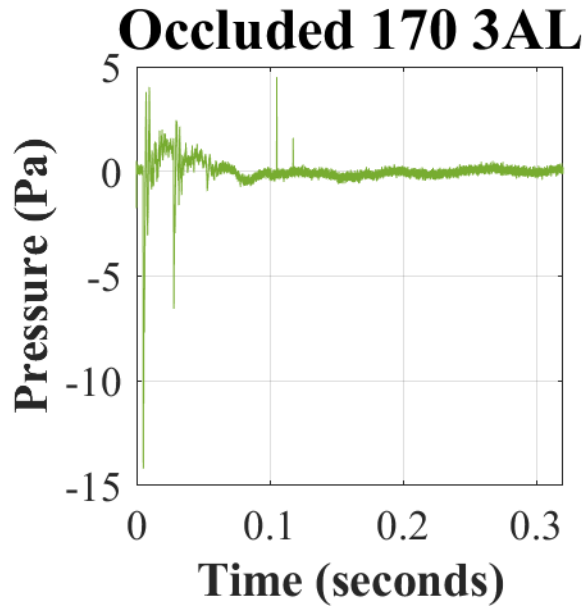


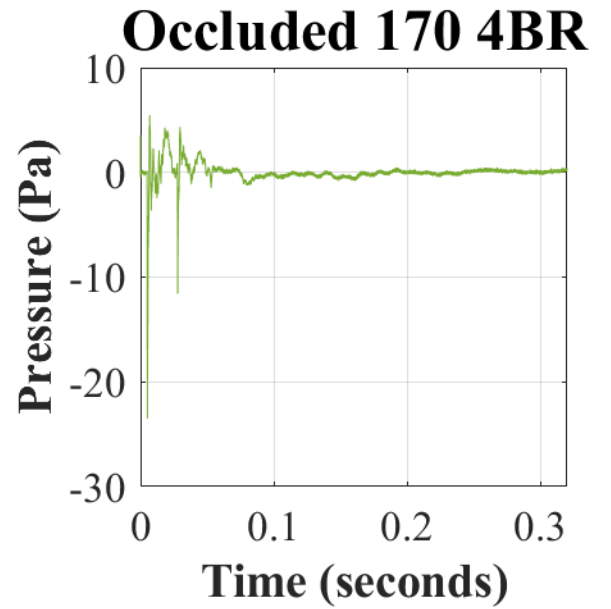
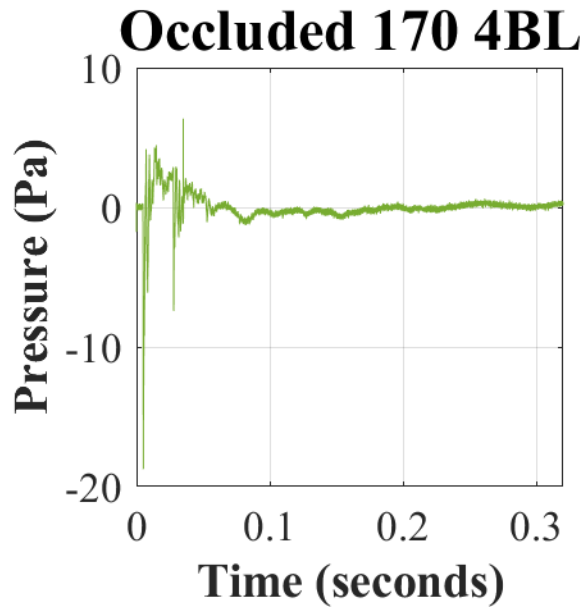
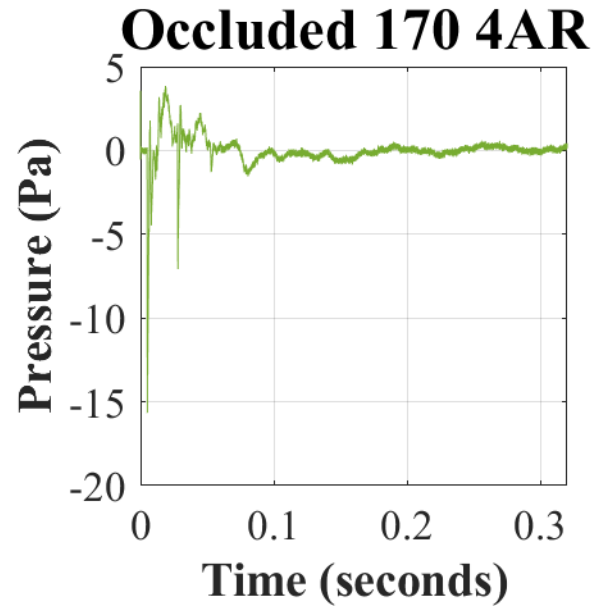
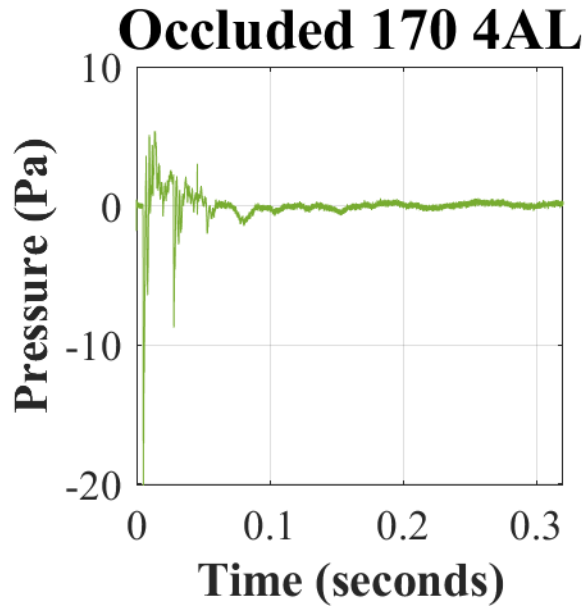
Note. The naming convention for all occluded waveforms is “Unoccluded LvL NnX”, where ‘Unoccluded’ is the test condition (i.e., ATF has the HPD doffed), ‘LvL’ is the nominal test level (i.e., 150, 160 or 170 dBp), ‘N’ is the sample number (i.e., 1 to 5) of the device tested, ‘n’ is the trial (i.e., A or B) indicating HPD fit (i.e., first or second, respectively), and ‘X’ indicates from what ATF microphone the recording is from (i.e., right [R] or left [L] pinnae).

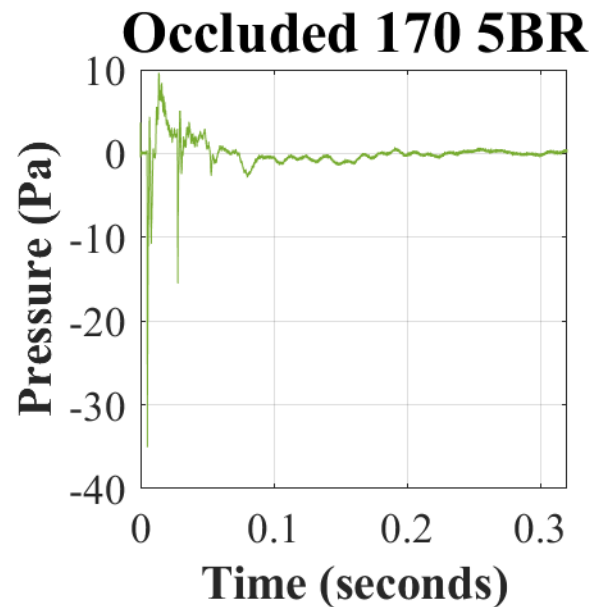
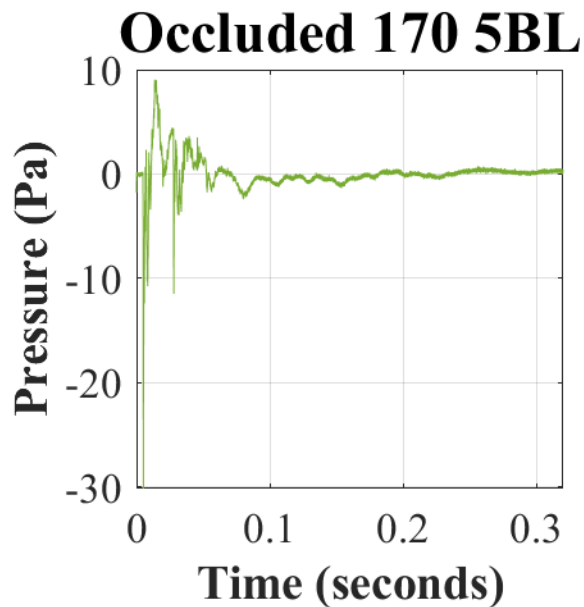
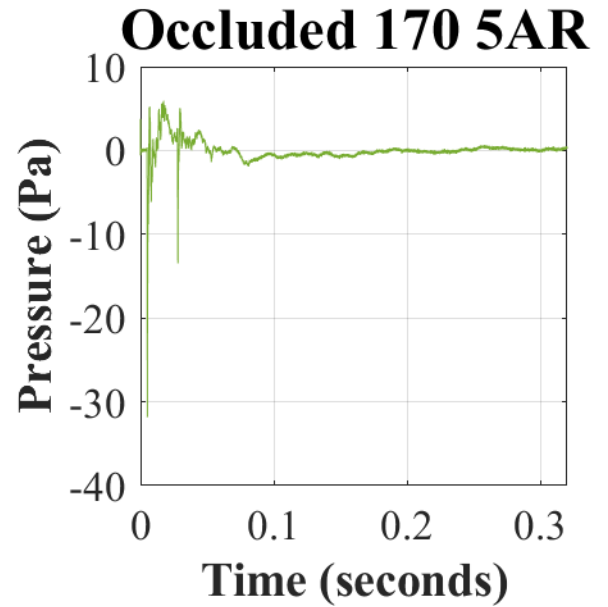
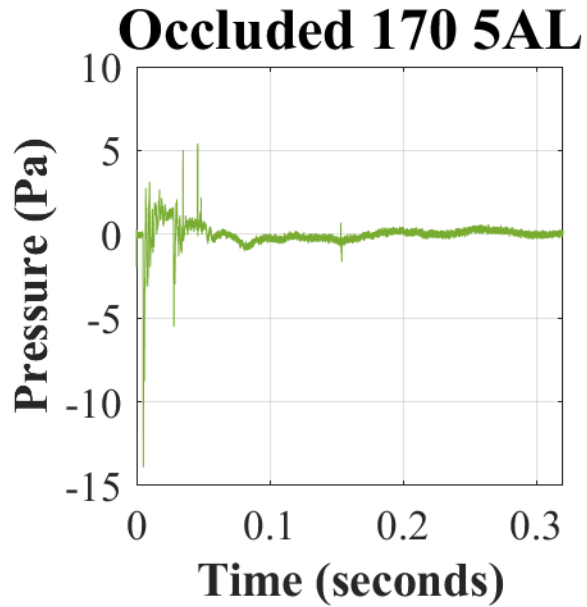
Appendix E. Recorded occluded (closed-ear) waveforms (in pascals [Pa]) over time (in seconds [s]) in response to 170 dBp with the Camo Plugs[®] Earplugs.





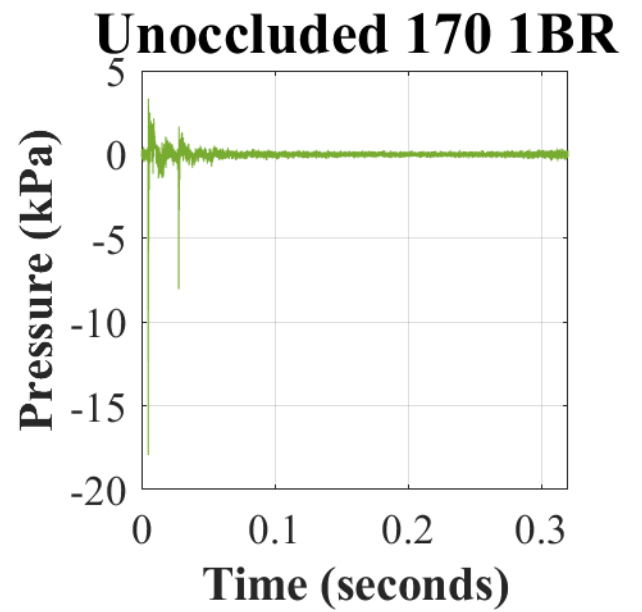
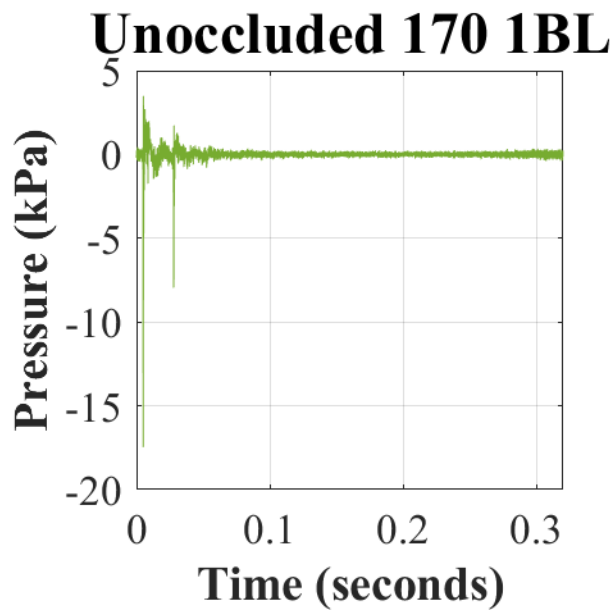
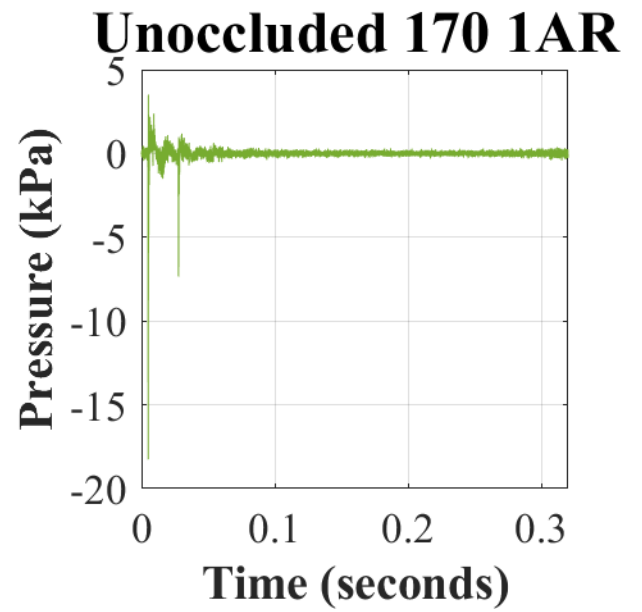
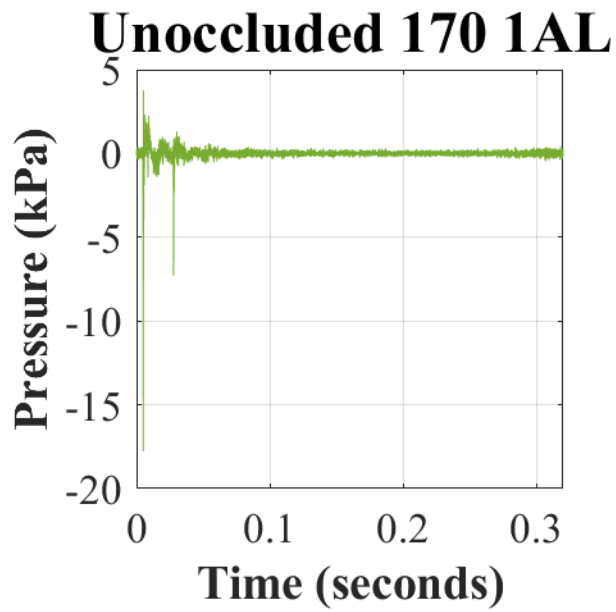


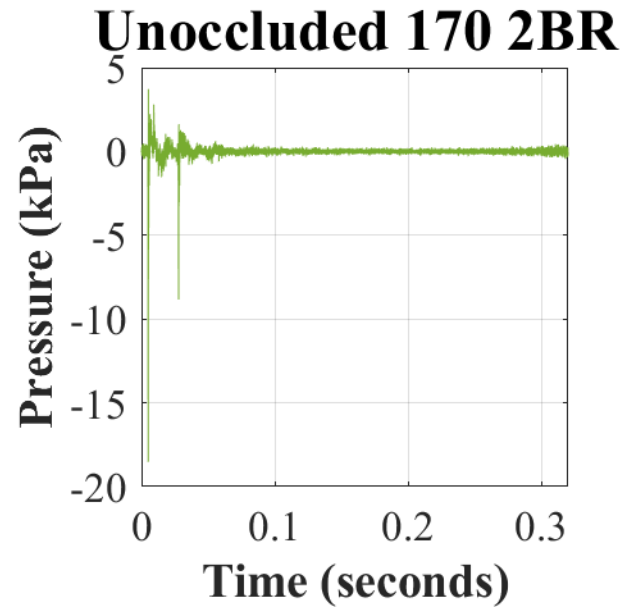
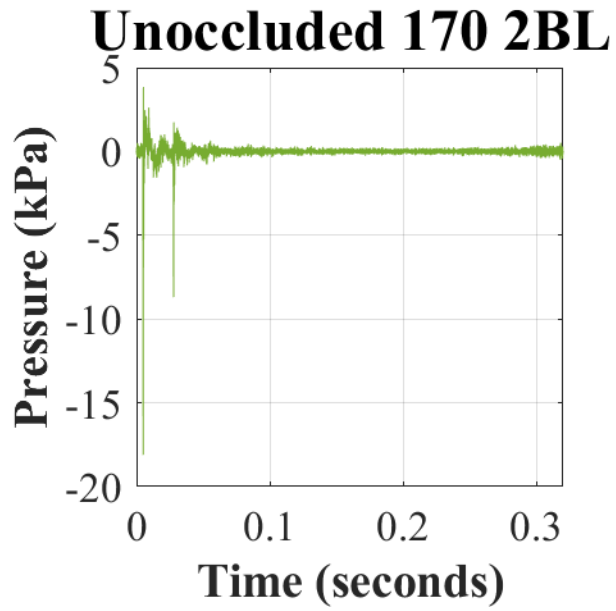
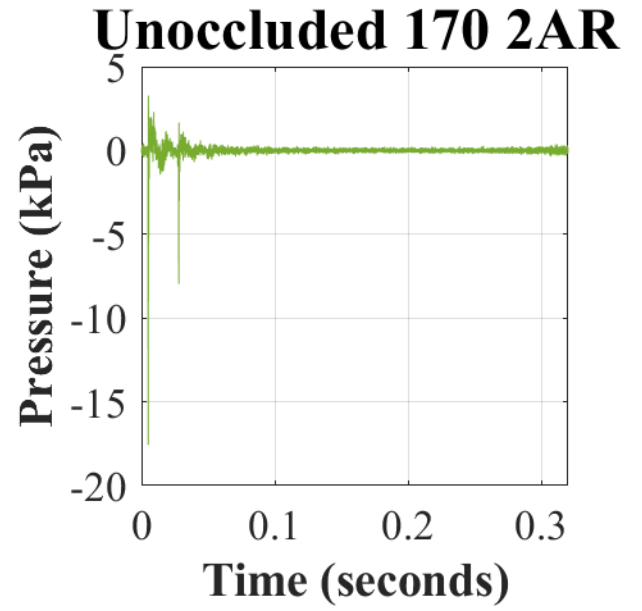
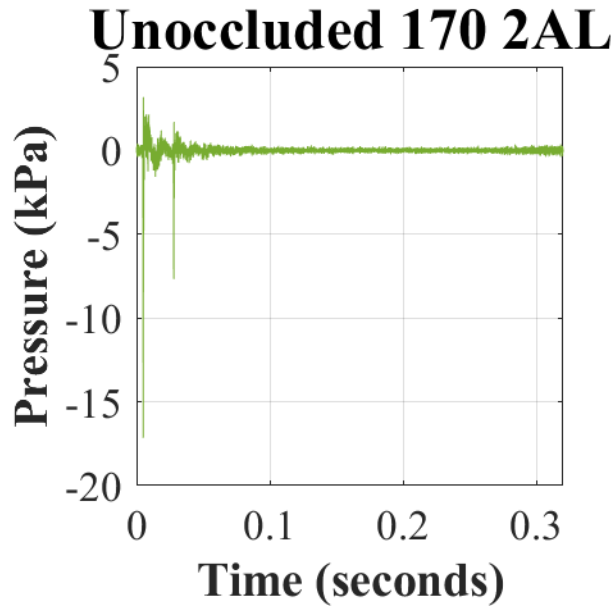


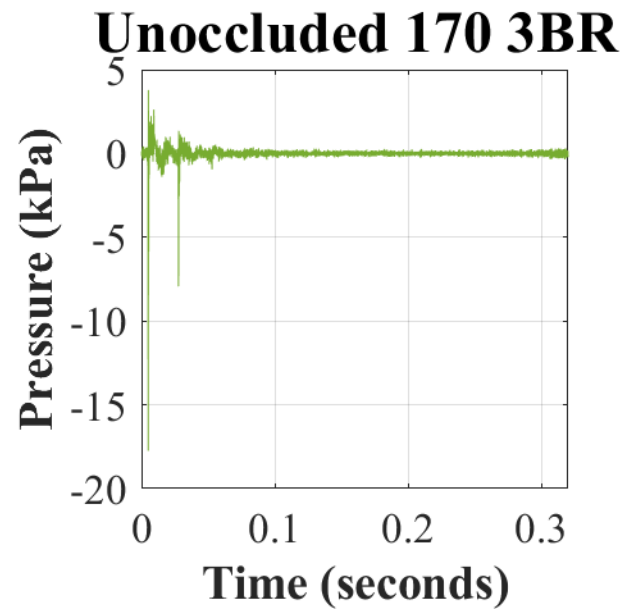
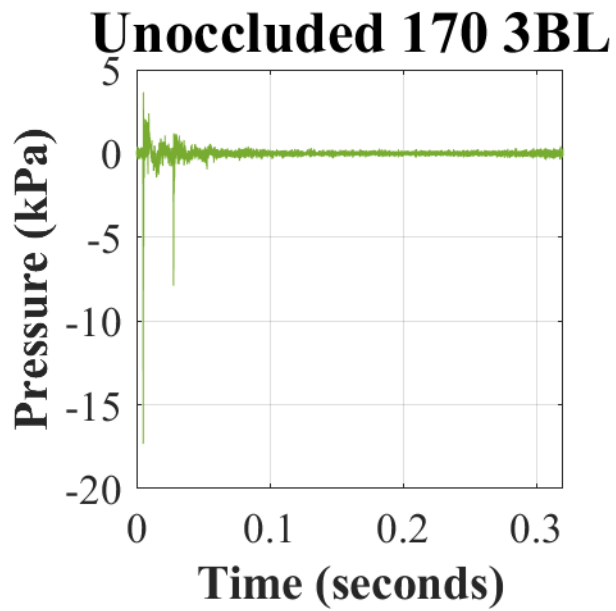
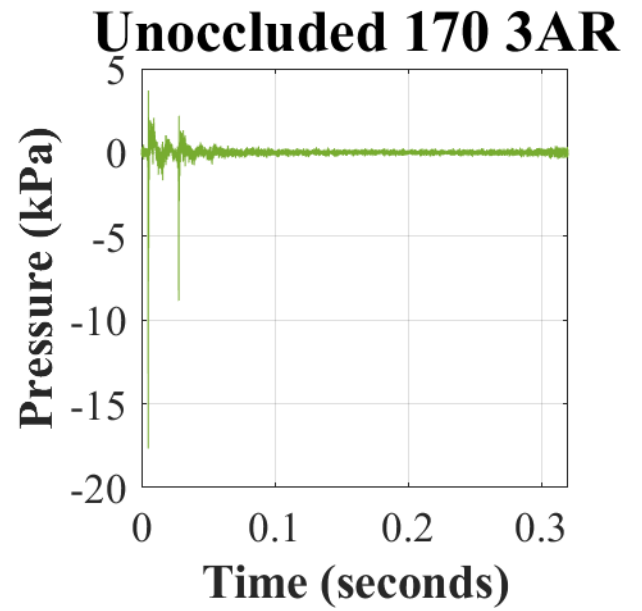
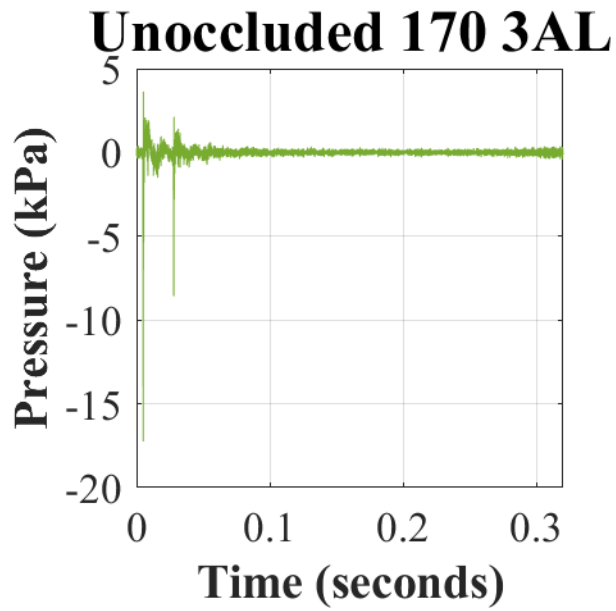


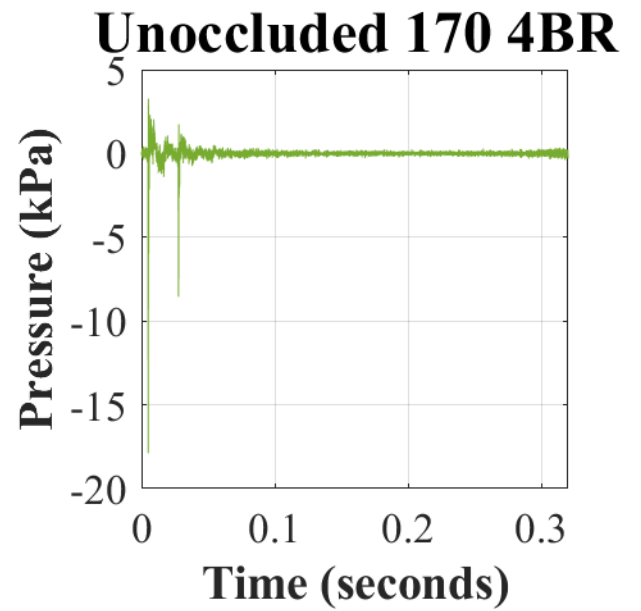
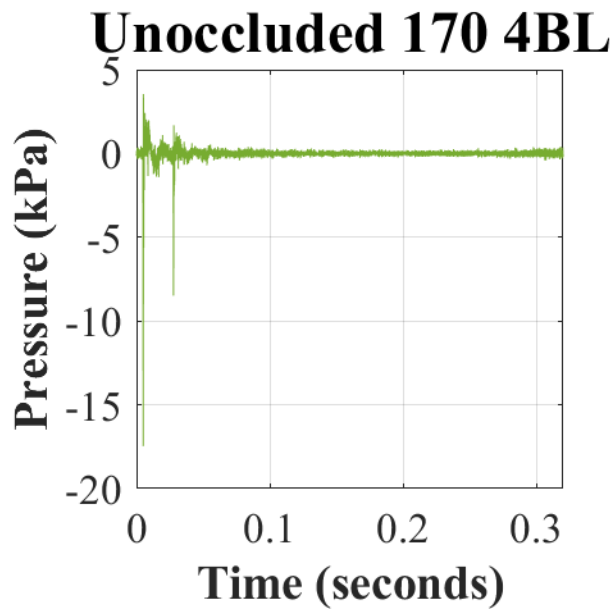
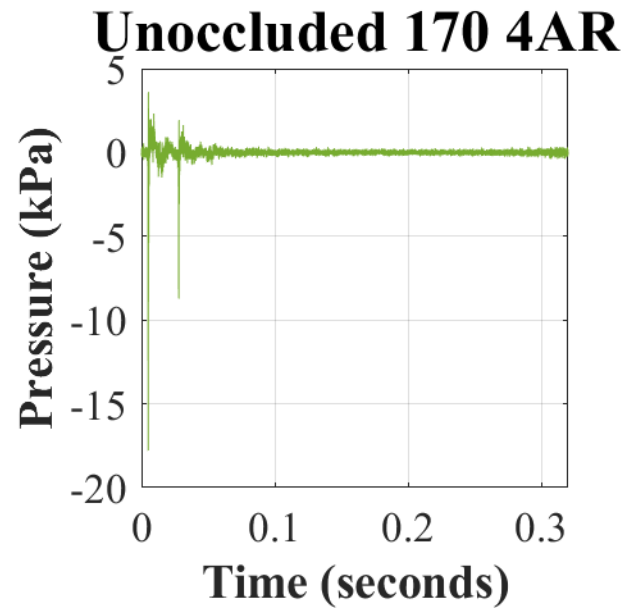
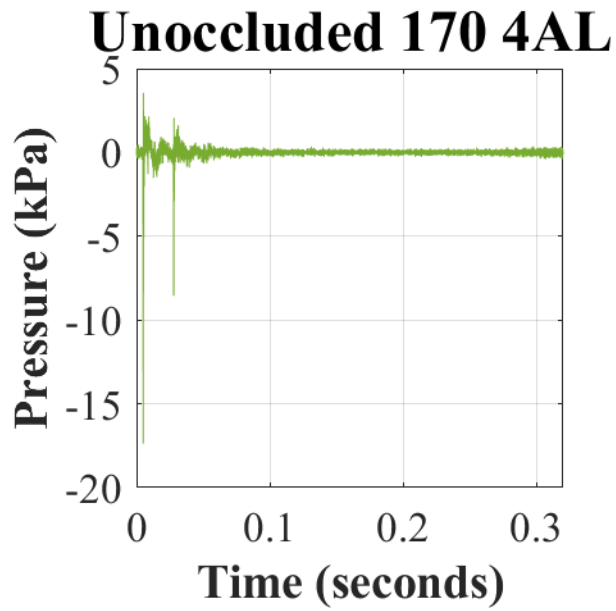
Note. The naming convention for all occluded waveforms is “Occluded LvL NnX”, where ‘Occluded’ is the test condition (i.e., ATF has the HPD donned), ‘LvL’ is the nominal test level (i.e., 150, 160 or 170 dBp), ‘N’ is the sample number (i.e., 1 to 5) of the device tested, ‘n’ is the trial (i.e., A or B) indicating HPD fit (i.e., first or second, respectively), and ‘X’ indicates from what ATF microphone the recording is from (i.e., right [R] or left [L] pinnae).

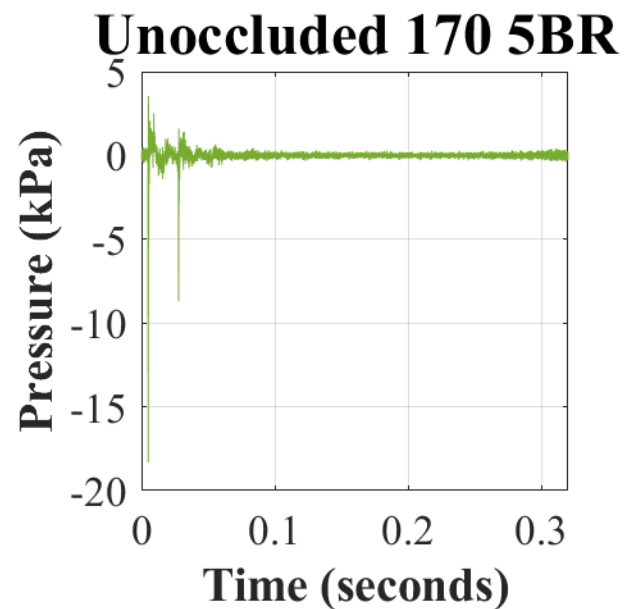
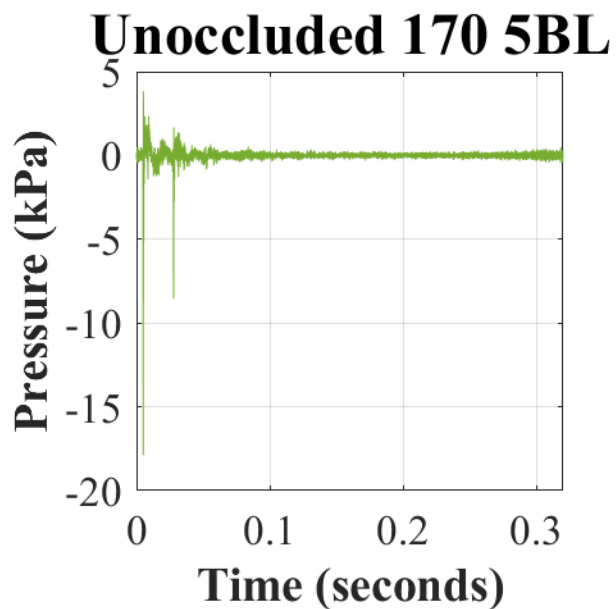
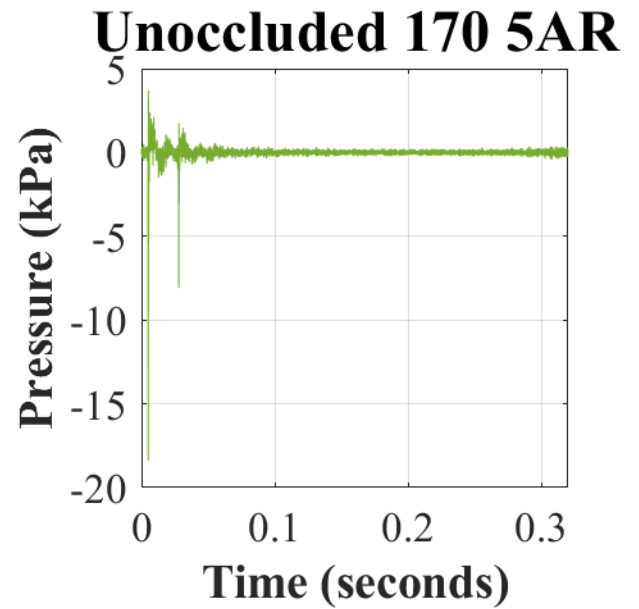
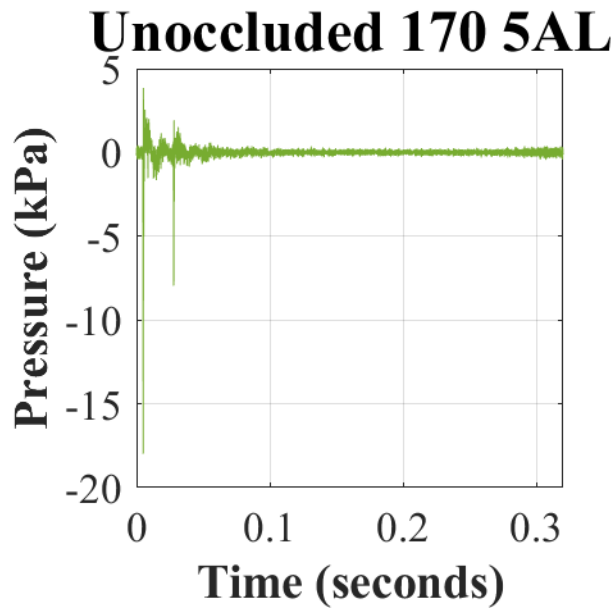
Appendix F. Estimated unoccluded (open-ear) waveforms (in kilopascals [kPa]) over time (in seconds [s]) in response to 170 dBp with the Camo Plugs® Earplugs.







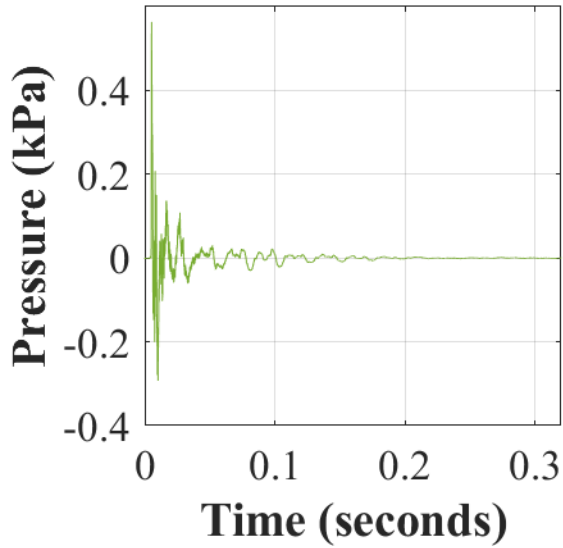




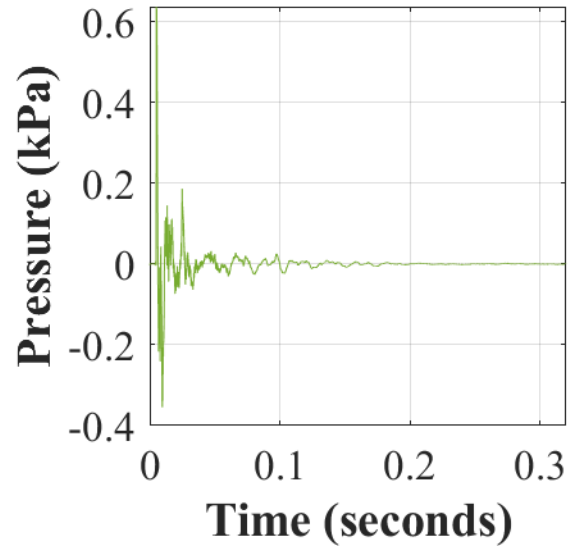
Note. The naming convention for all occluded waveforms is “Unoccluded LvL NnX”, where ‘Unoccluded’ is the test condition (i.e., ATF has the HPD doffed), ‘LvL’ is the nominal test level (i.e., 150, 160 or 170 dBp), ‘N’ is the sample number (i.e., 1 to 5) of the device tested, ‘n’ is the trial (i.e., A or B) indicating HPD fit (i.e., first or second, respectively), and ‘X’ indicates from what ATF microphone the recording is from (i.e., right [R] or left [L] pinnae).

Appendix G. Recorded waveform (in kilopascals [kPa]) over time (in seconds [s]) of the impulse measured with the free-field probe at 150 dB and the Camo Plugs[®] donned.

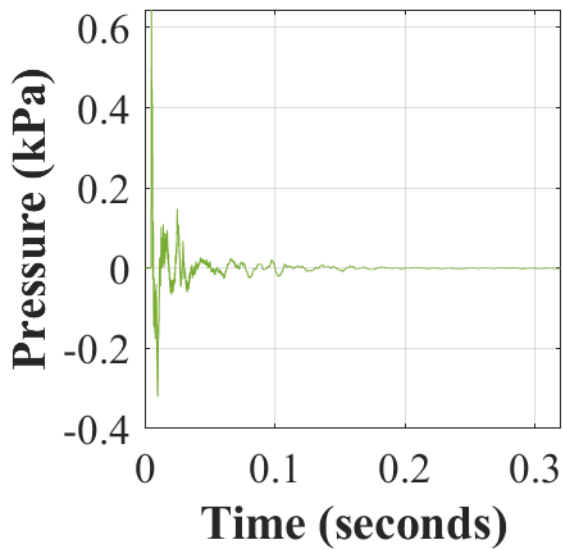
Free Field 150 1A



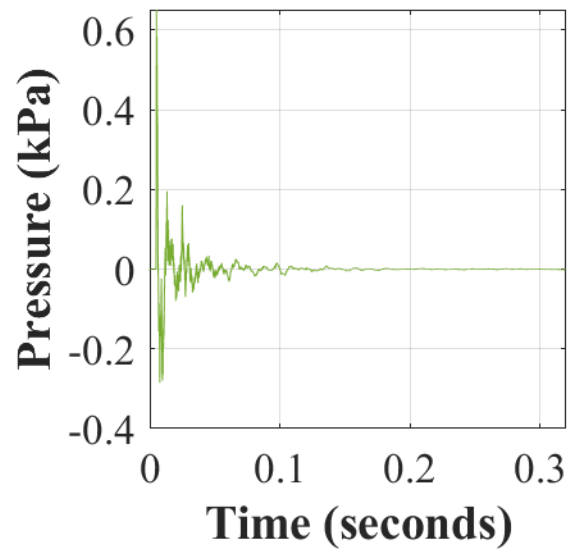
Free Field 150 1B



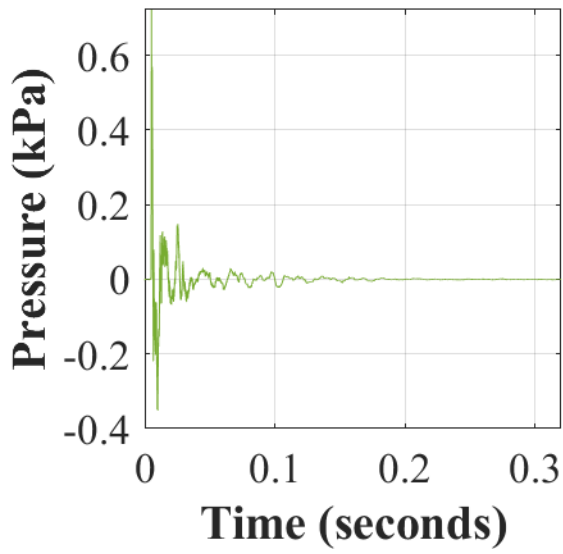
Free Field 150 2A



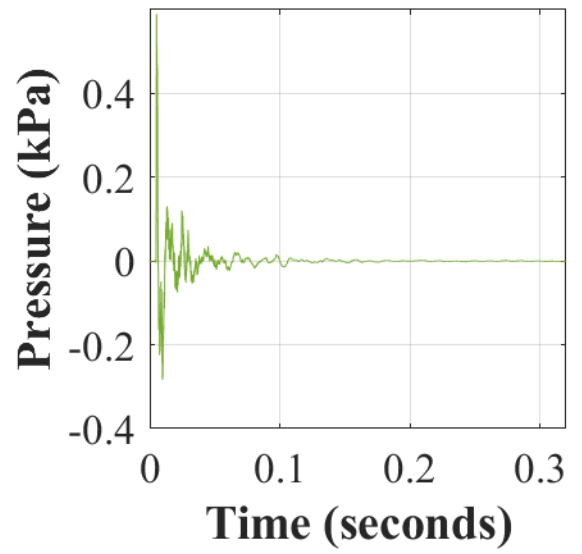
Free Field 150 2B



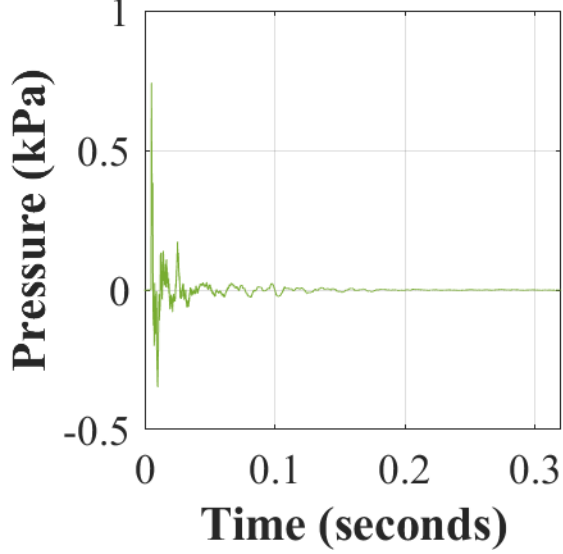
Free Field 150 3A



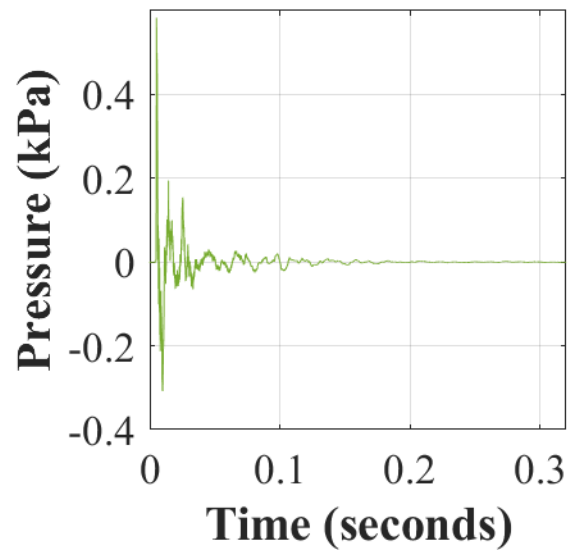
Free Field 150 3B



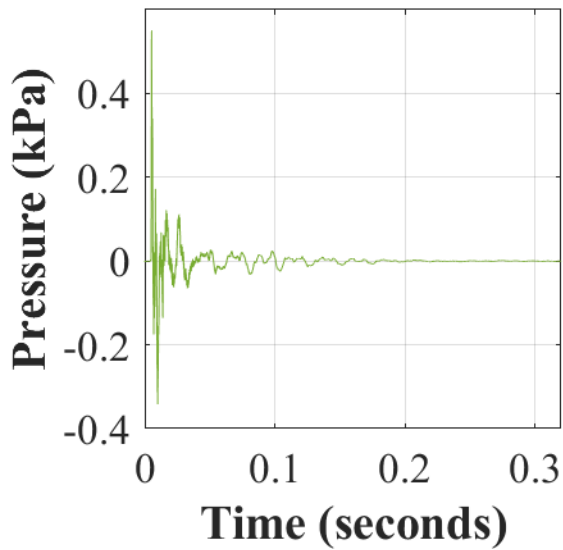
Free Field 150 4A



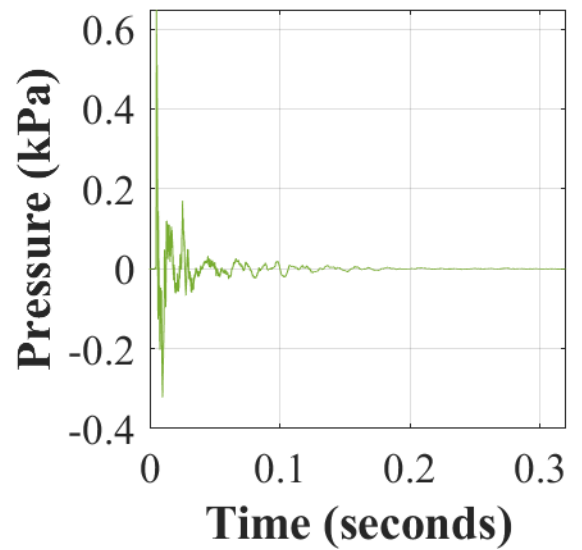
Free Field 150 4B



Free Field 150 5A

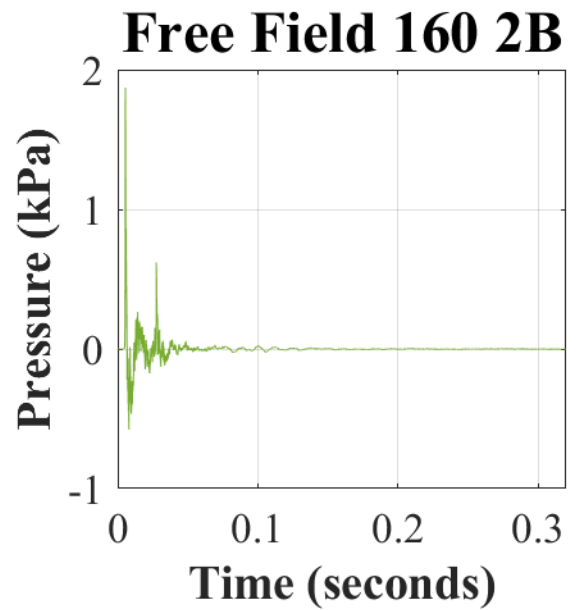
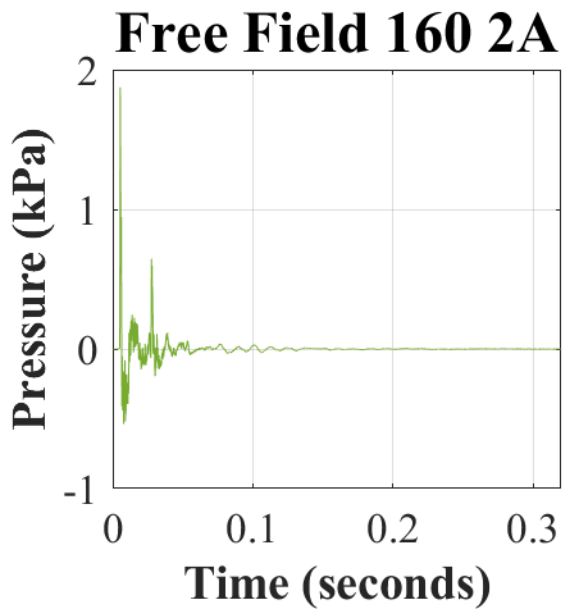
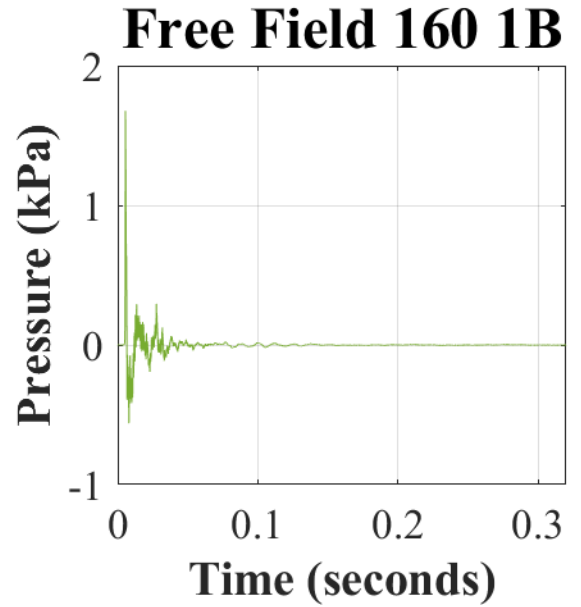
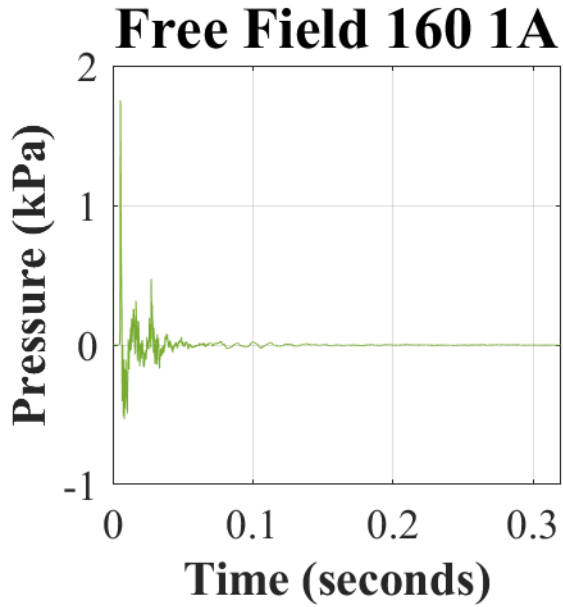


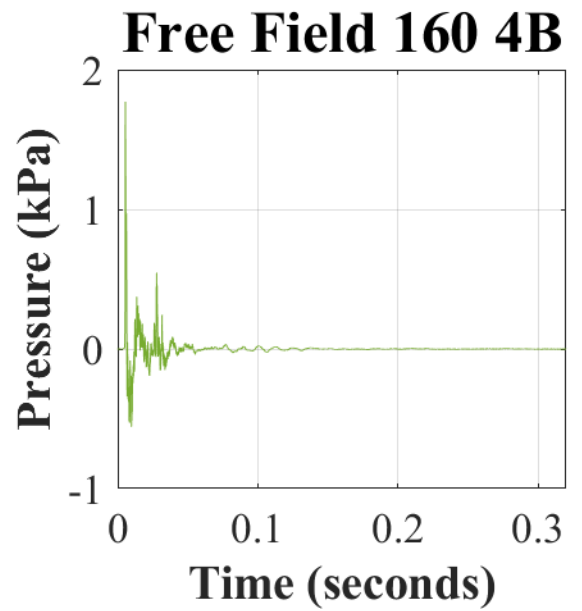
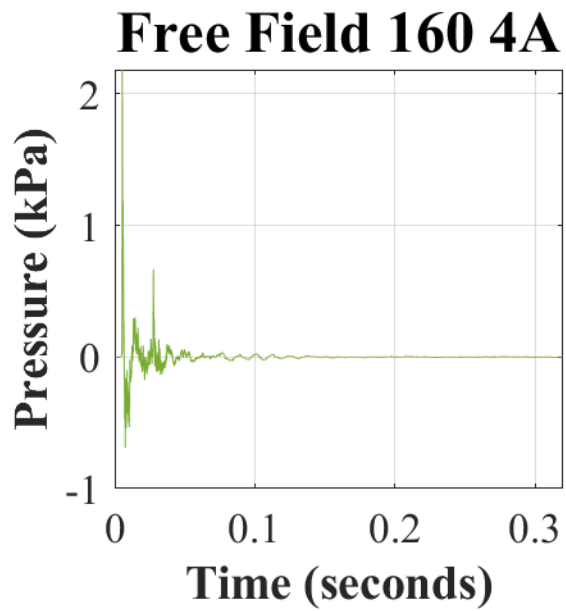
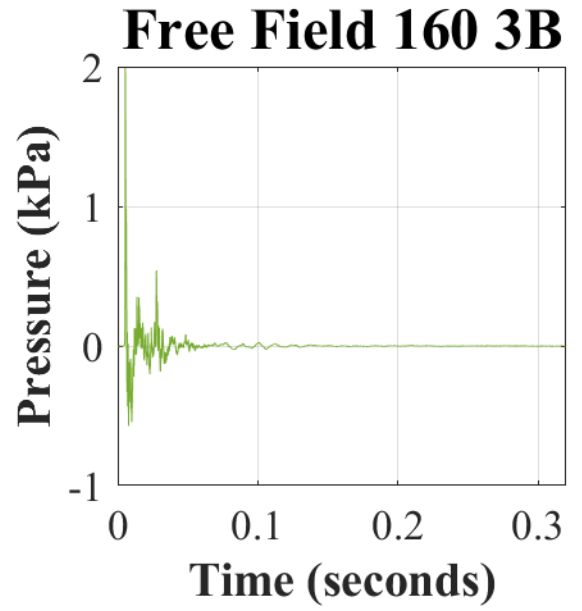
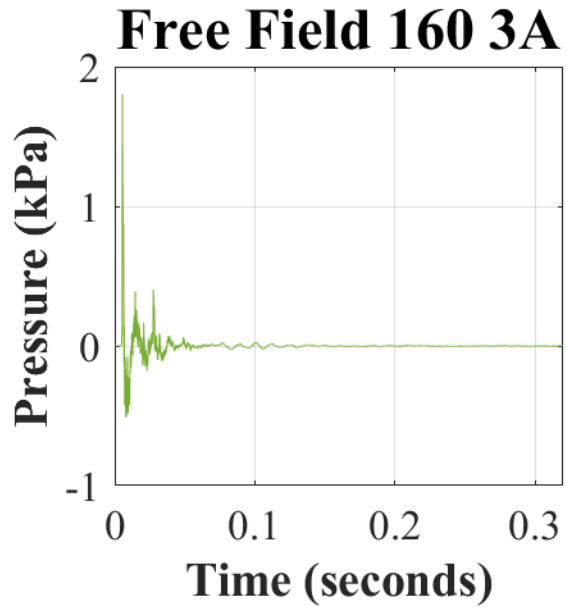
Free Field 150 5B

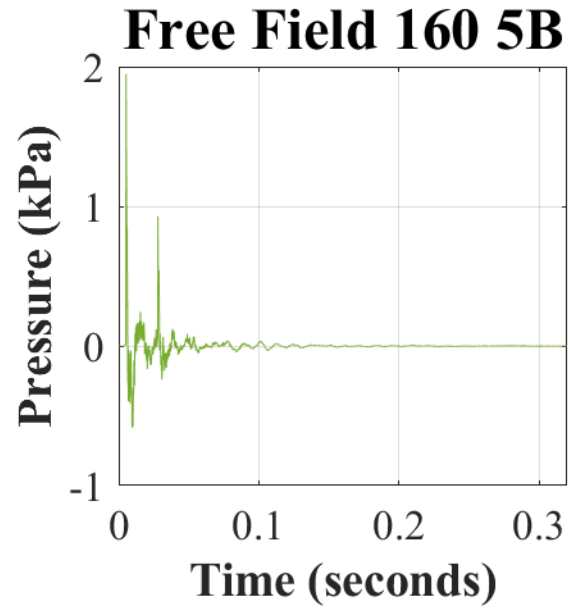
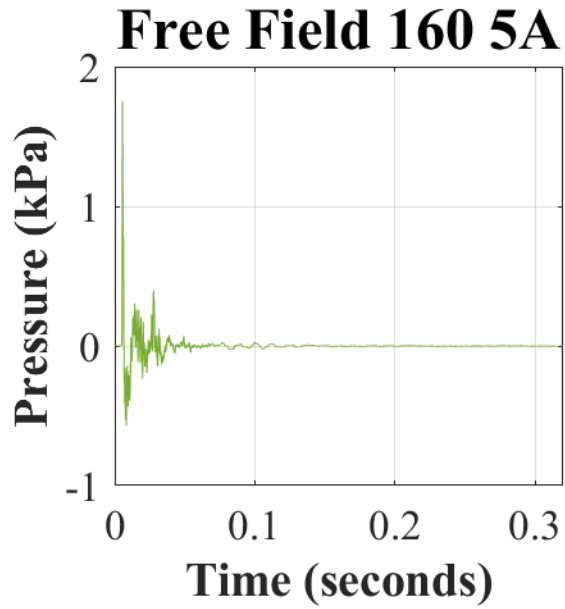


Note. The naming convention for all free-field waveforms is “Free Field LvL Nn”, where ‘Free Field’ indicates that the recording was obtained using the PCB reference microphone, ‘LvL’ is the nominal test level (150 dB), ‘N’ is the device sample number (1 to 5), and ‘n’ is the device trial (i.e., A or B).

Appendix H. Recorded waveform (in kilopascals [kPa]) over time (in seconds [s]) of the impulse measured with the free-field probe at 160 dB and the Camo Plugs[®] donned.

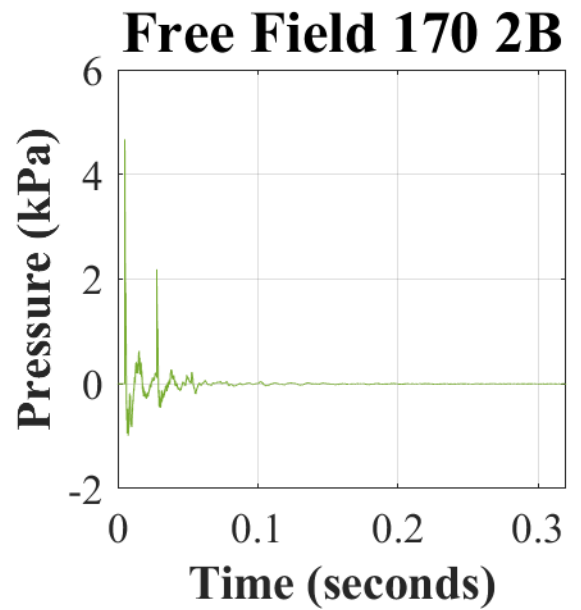
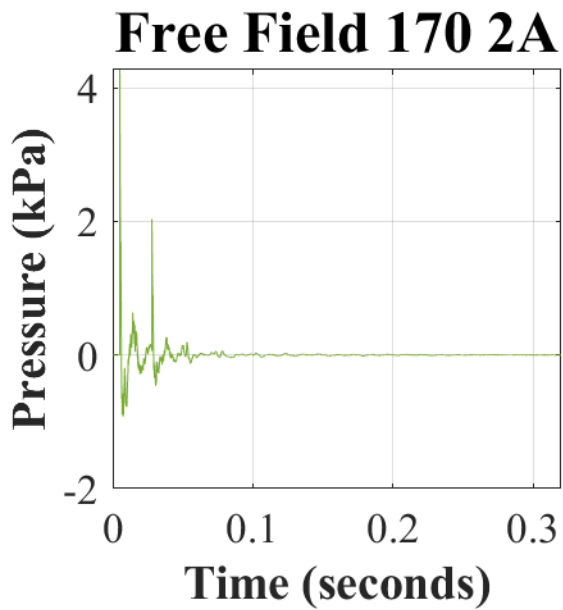
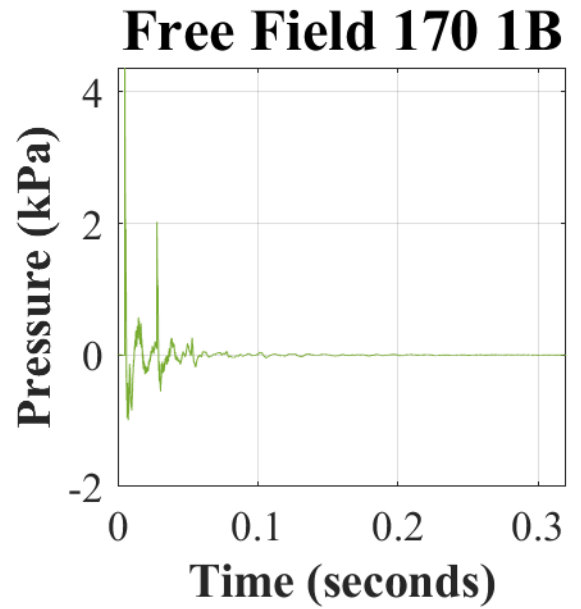
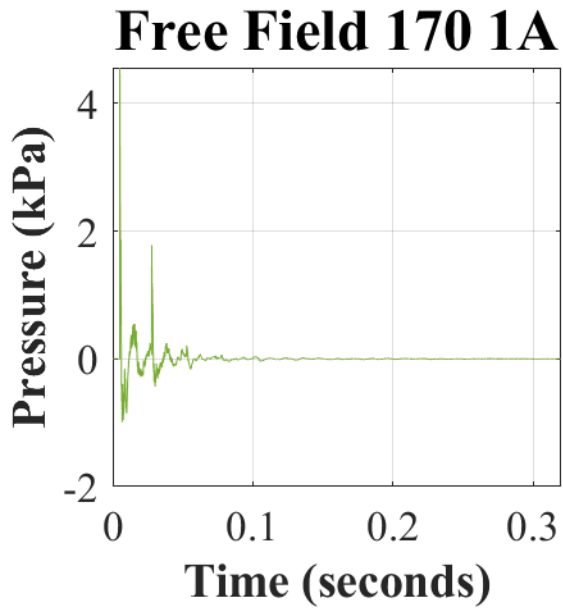




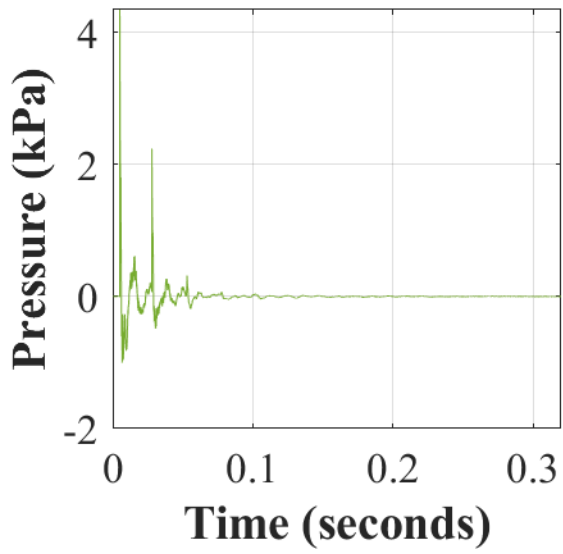


Note. The naming convention for all free-field waveforms is “Free Field LvL Nn”, where ‘Free Field’ indicates that the recording was obtained using the PCB reference microphone, ‘LvL’ is the nominal test level (160 dBp), ‘N’ is the device sample number (1 to 5), and ‘n’ is the device trial (i.e., A or B).

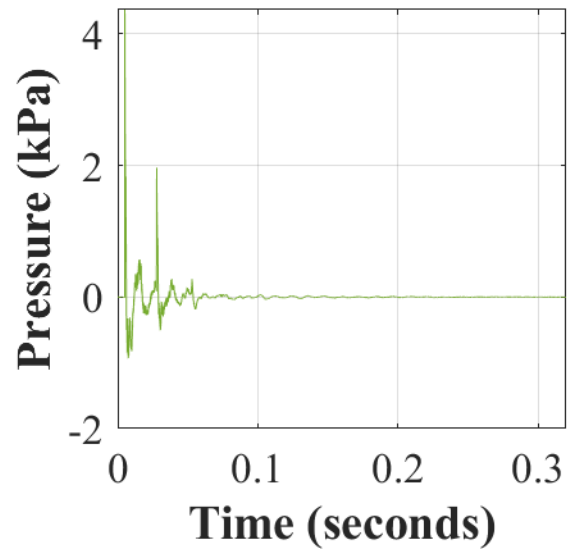
Appendix I. Recorded waveform (in kilopascals [kPa]) over time (in seconds [s]) of the impulse measured with the free-field probe at 170 dB_P and the Camo Plugs[®] donned.



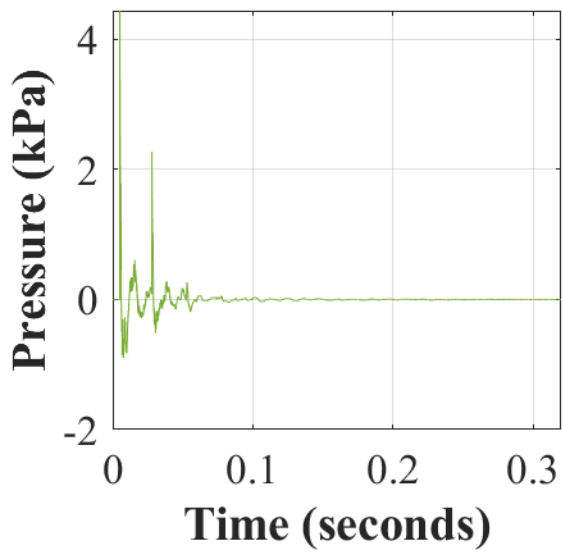
Free Field 170 3A



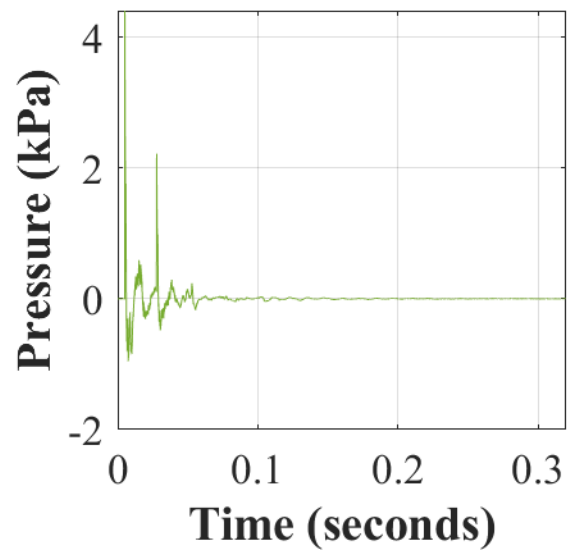
Free Field 170 3B

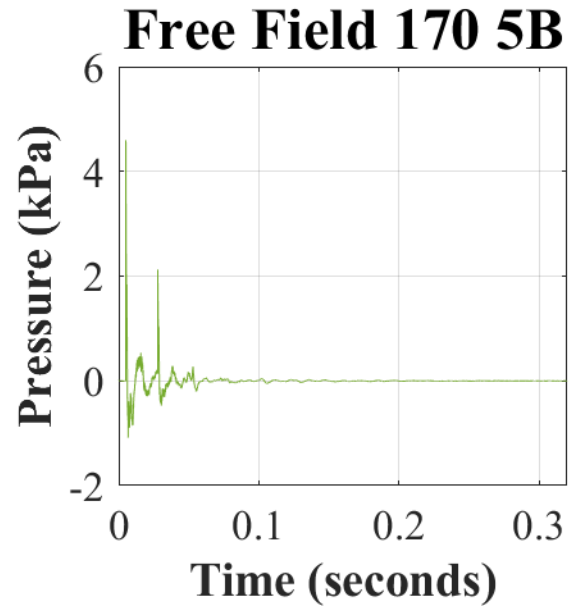
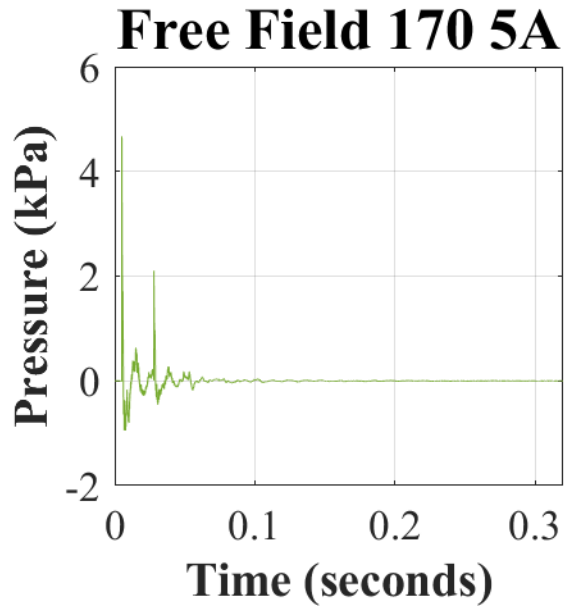


Free Field 170 4A



Free Field 170 4B





Note. The naming convention for all free-field waveforms is “Free Field LvL Nn”, where ‘Free Field’ indicates that the recording was obtained using the PCB reference microphone, ‘LvL’ is the nominal test level (170 dB), ‘N’ is the device sample number (1 to 5), and ‘n’ is the device trial (i.e., A or B).