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SOUND ATTENUATION OF FIBERGLASS LINED VENTILATION DUCTS

By

Jacob Albright

Bachelor of Science in Engineering – Mechanical Engineering

University of Nevada, Las Vegas

2012

A thesis submitted in partial fulfillment

of the requirements for the

Master of Science in Engineering – Mechanical Engineering

Department of Mechanical Engineering

Howard R. Hughes College of Engineering

The Graduate College

University of Nevada, Las Vegas

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Sound Attenuation of Fiberglass Lined Ventilation Ducts

is approved in partial fulfillment of the requirements for the degree of

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ABSTRACT

Sound Attenuation of Fiberglass Lined Ventilation Ducts

by

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Sound attenuation is a crucial part of designing any HVAC system. Most ventilation systems are designed to be in areas occupied by one or more persons. If these systems do not adequately attenuate the sound of the supply fan, compressor, or any other source of sound, the affected area could be subject to an array of problems ranging from an annoying hum to a deafening howl. The goals of this project are to quantify the sound attenuation properties of fiberglass duct liner and to perform a regression analysis to develop equations to predict insertion loss values for both rectangular and round duct liners.

The first goal was accomplished via insertion loss testing. The tests performed conformed to the ASTM E477 standard. Using the insertion loss test data, regression equations were developed to predict insertion loss values for rectangular ducts ranging in size from 12-in x 18-in to 48-in x 48-in in lengths ranging from 3ft to 30ft. Regression equations were also developed to predict insertion loss values for round ducts ranging in diameters from 12-in to 48-in in lengths ranging from 3ft to 30ft.

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CHAPTER 1 INTRODUCTION

1.1 Introduction

Modern buildings are quite analogous to the human body. They require a source of power to fuel their various systems, possess a processing unit to control their various systems, and have mechanisms for taking in air and regulating internal temperatures. The mechanisms for air intake and temperature regulation in buildings are usually fans and a heating, ventilation, and air-conditioning (HVAC) system respectively.

An unfortunate and unwanted byproduct of the fans and HVAC systems is acoustic noise. There are two main sources of noise from HVAC systems. The first is the operating equipment used to move and condition the air. The second is the turbulence in the air being moved within the ventilation ducts. When the level of noise gets too high, modifications to the HVAC system must be made.

On most systems, modifications to the sound source, fans, compressors, etc., will either be impractical or impossible. The alternative is to modify the path that the sound travels through, ventilation ducts. The two most common modifications are in-duct silencers and acoustical liner applied to the inside of the ducts. In order for a HVAC designer to select the right product for the system to achieve the desired sound levels the acoustic properties of silencers and liners must be known. Therefore, it is necessary to develop standards for and perform acoustic testing on these modifications.

The American Society for Testing and Materials (ASTM) has developed such a standard for testing sound attenuators in ventilation systems, ASTM E477: Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers. The standard requires a specific set of laboratory, equipment, and testing protocol guidelines. The Center for Mechanical & Environmental Systems Technology (CMEST) at the University of Nevada, Las Vegas has a testing facility that is in compliance with ASTM E477. The CMEST testing facility was recently upgraded to conform to the updated standards of ASTM E477. The upgrades include improving and relocating the sound source and reducing sound transmission through the inside walls of the duct in the supply and return duct systems. With the CMEST testing facility in compliance with ASTM E477, testing can now be performed to determine the acoustic characteristics of silencers and duct liners.

1.2 Test Method & Goals

Insertion loss testing was used to quantify the acoustic characteristics of the duct liners. Insertion loss is defined as "the reduction in sound power level, in decibels, due to the placement of a sound-attenuating device in the path of transmission." [9] To calculate insertion loss, two measurements must be made. First, an unlined duct must be tested. Then a duct with acoustic liner must be tested. The difference between these two measurements is the insertion loss.

The goal of this project is two-fold:

- To quantify the acoustic characteristics of the duct liners via insertion loss testing for various sizes and lengths of rectangular and round ducts
- To perform a regression analysis on the insertion loss data to predict insertion loss values based on the cross-section and length of the duct

CHAPTER 2 RELATED LITERATURE

2.1 HVAC Noise

There are two main sources from which sound can propagate in a ventilation system. The first is aerodynamically generated sound from system air handlers and sound from other equipment used to condition the air. The second is from turbulence associated with airflow through and around the duct fittings. These sources can transmit sound through the duct system into occupied spaces within a building. In some instances this transmitted sound can reach unpleasant or even dangerous levels. It would then be necessary to modify the HVAC system to reduce the sound to reasonable levels.

"For most HVAC and other mechanical systems, it is generally not possible for system designers to modify or change the source characteristics of occupied areas within a building. Thus, system designers most often are constrained to modifying the sound and vibration transmission paths to achieve desired background sound levels associated with HVAC and other mechanical systems." [8] The two most common methods for modifying the sound transmission path are installation of pre-fabricated duct silencers and installation of acoustical duct lining.

2.2 Acoustical Duct Lining

Acoustical duct lining is usually made from a porous material and is attached to the inside of the walls of the ducts through which the sound travels. The main purpose of acoustical duct lining is to attenuate the sound propagated through a sheet metal air duct system. Duct lining can also be used for thermal insulation. "The thickness of duct linings associated with thermal insulation usually vary from 0.5 in. (12.7mm) to 2.0 in. (50.8 mm). For fiberglass duct lining to be effective for attenuating sound, it must have a minimum thickness of 1.0 in (25 mm)." [8]

2.3 Previous Work

Extensive research has been done on the subject of acoustically lined sheet metal ducts. For rectangular ducts, various dimensions have been tested with both 1 in and 2 in liners. The only length tested, however, was 10 ft. "Attenuation for lengths greater than 10 ft is not well documented." [2]

The acoustically lined round sheet metal ducts underwent similar testing as the rectangular ducts. Various diameters were tested with both 1 in and 2 in liners. The round ducts were only tested at a length of 20 ft.

2.4 Third Octave Band

A third octave band is defined as "a frequency band whose cutoff frequencies have a ratio of 2 to the one-third power, which is approximately 1.26. The cutoff frequencies of 891 Hz and 1112 Hz define the 1000 Hz third-octave band in common use." [3] All data gathered and presented are using the third octave frequency bands from 50 Hz to 10,000 Hz.

2.5 Pink Noise

Pink noise is defined as "noise with constant energy per octave band width." [3] All data collected in this report were done so using pink noise as input at the sound source. The only exception is when ambient sound levels were measured to ensure the input sound levels were well above ambient levels.

CHAPTER 3 UPGRADES TO ASTM E477 FACILITY

In 2012 upgrades to the CMEST testing facility were completed that brought it into compliance with the updated standards of ASTM E477. The upgrades consisted of three main parts: integration of a measurement system, relocation of the sound source, and reduction of sound leakage.

3.1 Measurement System

The new measurement system can collect seven points of data: sound in the reverberation room, sound in the source room, air flow velocity, pressure in the source side of the duct, pressure in the reverberation side of the duct, temperature, and humidity. All of the data can be collected, recorded, and analyzed simultaneously with the help of National Instruments' LabView software.

3.2 Relocation of the Sound Source

Originally the speakers were attached to the sides of one of the upstream ducts. The speakers needed to be moved inside the sound chamber. "A significant amount of time was spent on how to position the speakers in the sound chamber so that its sound power input to the duct is high." [1] The microphone was tested in three locations to determine its optimal position: duct, center, and off-center. The recommended speaker position is shown in Figure 3.1. The center microphone position was found to be the best.

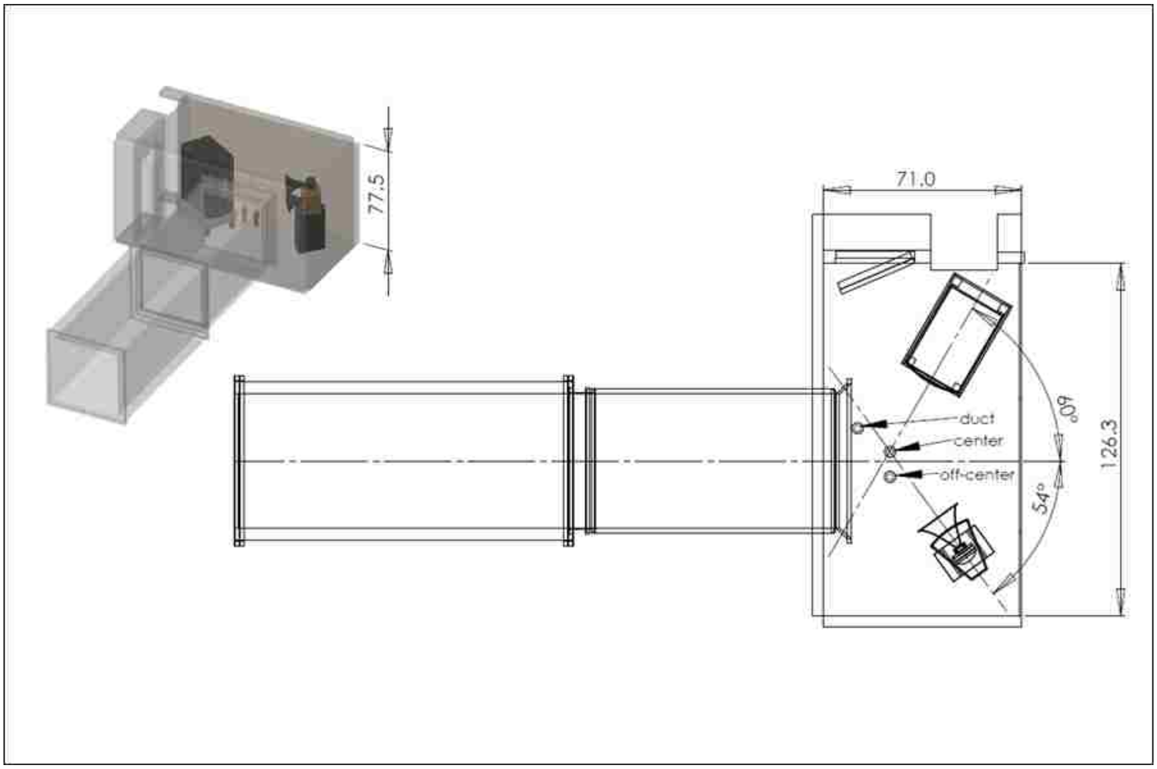

Figure 3.1: Recommended Speaker Position in Source Chamber

3.3 Reduction of Sound Leakage

Sound leakage from the duct system needed to be reduced to increase the sound attenuation that can be measured in the facility. Originally, both walls of the dual-walled duct were made of 18-gauge sheet metal. A layer of 12-gauge sheet metal was added to the inside walls of the duct to reduce the sound leakage from the system.

To determine the effectiveness of the 12-gauge sheet metal, insertion loss was measured using a plug that was inserted into the duct work both with and without the 12-gauge sheet metal. “Plug 1 is a sound barrier to be placed inside the duct. It is constructed of two 2-ft x 2-ft 0.75-

in.-thick plywood, four 54-in long L-shaped aluminum bars, and 1 lb/ft^3 loaded vinyl. Loaded vinyl is glued to both surfaces of the plywood pieces. With 54-in of space in between the two plywood pieces, they are connected on the corners using the 54-in long L-shaped aluminum. One side of the plug, which is the bottom, is totally covered with loaded vinyl. The other three sides are covered with loaded vinyl except for a 30-in space between the two plywood pieces. Also, the loaded vinyl extends about 4-in pass [sic] the length of the L-shaped aluminum to provide an effective surface for the edges of the plug to be taped on the inside surface of the duct to make a better seal. Finally, the entire cavities in the plug are filled with fiber glass." [1] Figure 3.2 through Figure 3.4 illustrate how the plug is constructed.

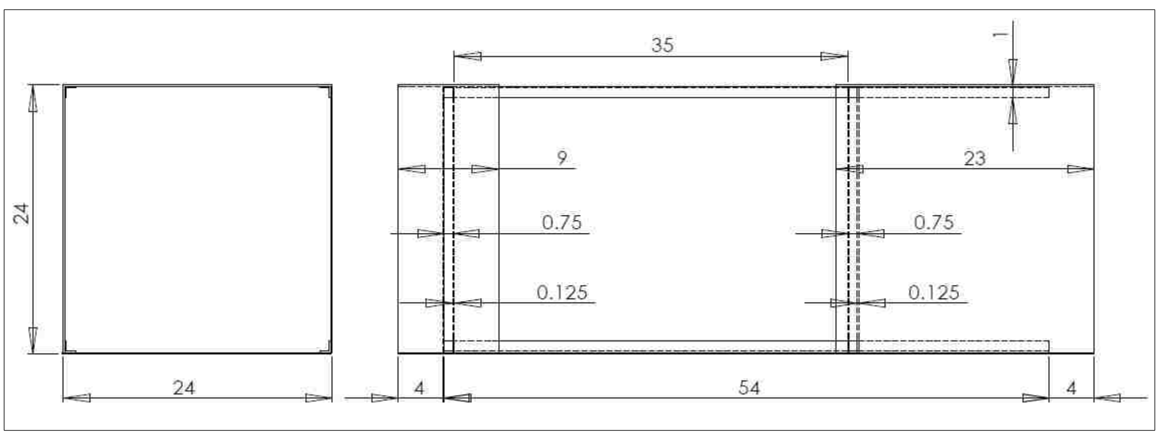

Figure 3.2: Schematic Drawing of Plug 1 (in inches) [1]

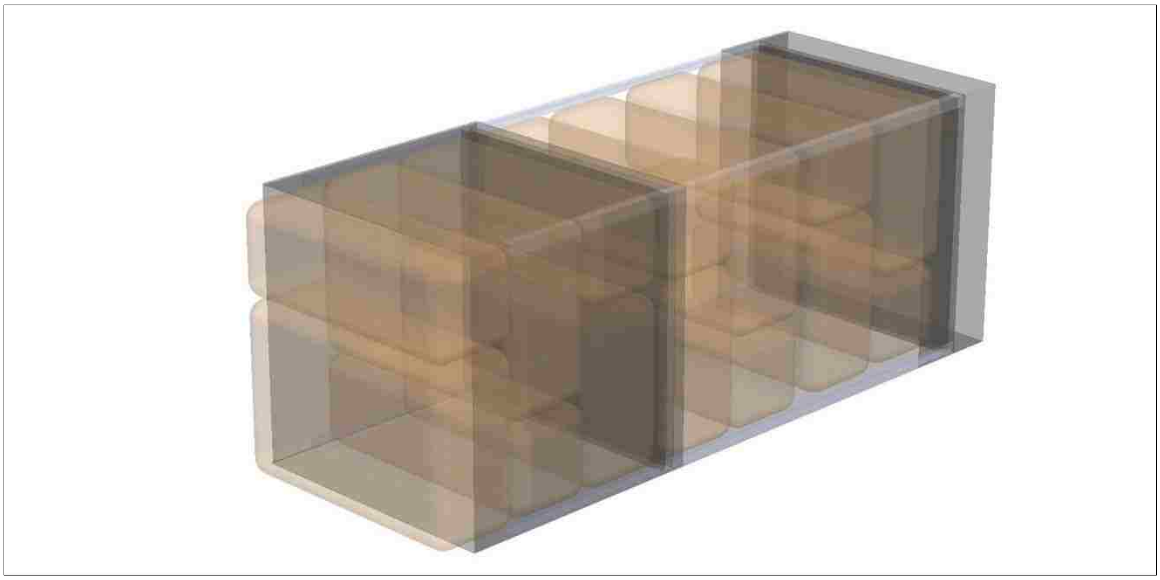

Figure 3.3: Drawing of Plug 1 [1]

Figure 3.4: Picture of Plug 1 [1]

There were three configurations tested using the recommended speaker position. 4A utilized a backboard in the source chamber and Plug 1. 4C utilized the same backboard and Plug 1 but also included the 12-gauge sheet metal on the inside of the ducts. 4D was exactly the same as 4C except with the backboard removed. The insertion loss data for these configurations is shown in Figure 3.5. The backboard did not have much of an effect on the insertion loss. However, an increase in insertion loss is clear between 4A and the other two configurations. This shows that the addition of the 12-gauge sheet metal made significant improvements to the breakout transmission loss.

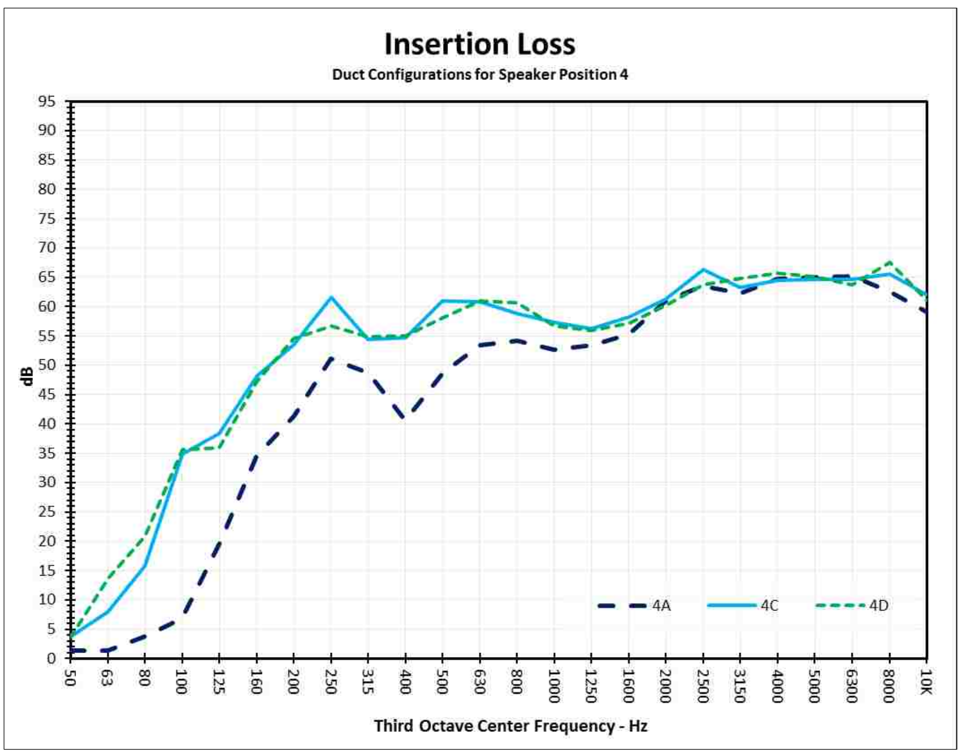

Figure 3.5: Insertion Loss for Speaker Position 4 [1]

CHAPTER 4 TEST & MEASUREMENT EQUIPMENT

4.1 Equalizers

The Behringer Ultra-Curve Pro DEQ2496 equalizer, shown in Figure 4.1, has two channels, a frequency range from 20 Hz to 20,000 Hz, and a gain setting range from -15 dB to +15 dB. The equalizer also has a built in function to produce continuous pink noise. There are a total of four channels through which the sound signals need to travel. Therefore, two equalizers were necessary to adequately produce and send the pink noise signal to the amplifiers. The first equalizer used channels 1 and 2 for the bass speaker. The second equalizer handled channels 3 and 4 which were set for the mid-range speaker and the high-frequency horn drivers respectively. The sound signals from the equalizers were sent to the amplifiers using XLR cables, shown in Figure 4.2. The gain settings for the 4 channels are shown in Figure 4.3 through Figure 4.5.

Figure 4.1: Behringer Ultra-Curve Pro DEQ2496

Figure 4.2: Male and Female end of XLR Cable

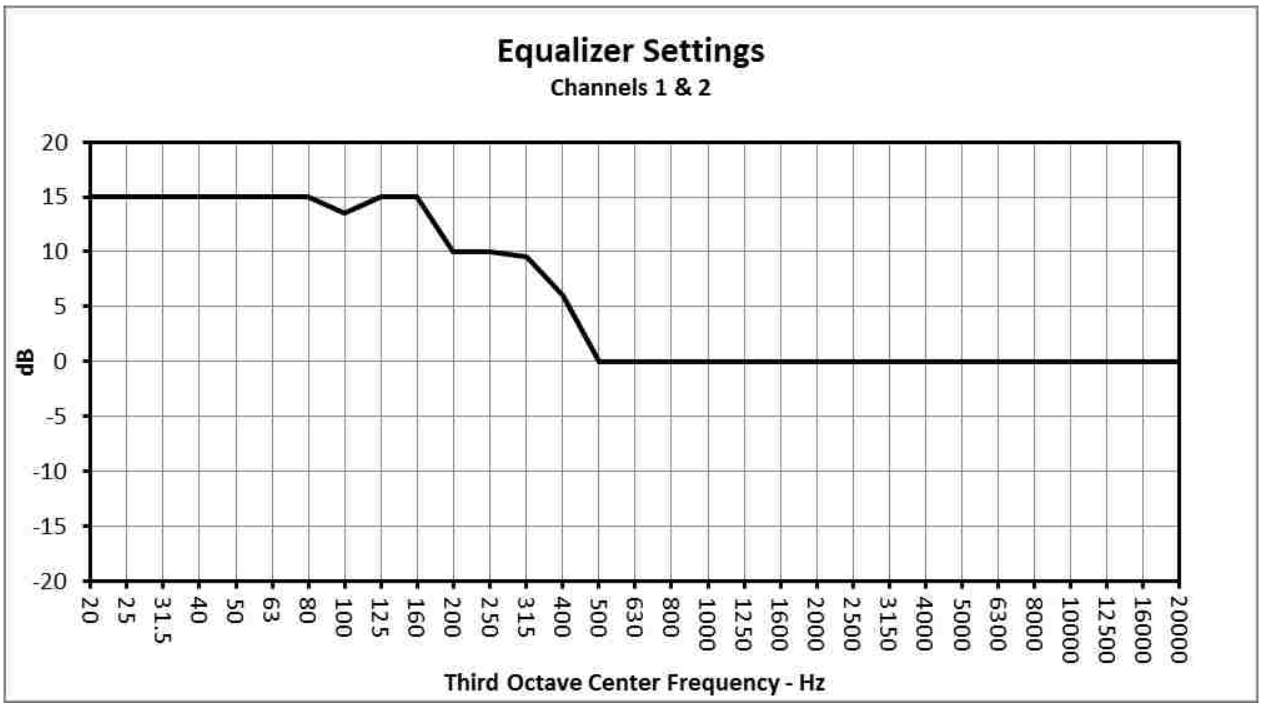

Figure 4.3: Equalizer Settings for Channels 1 & 2

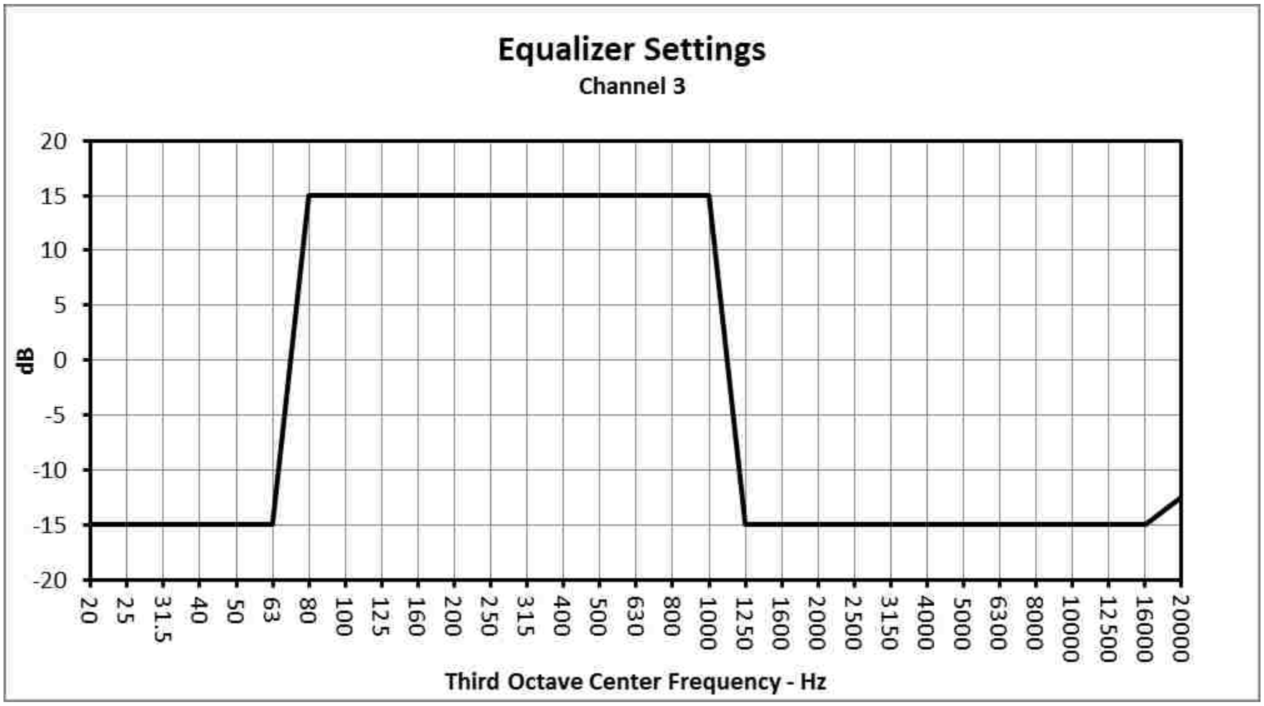

Figure 4.4: Equalizer Settings for Channel 3

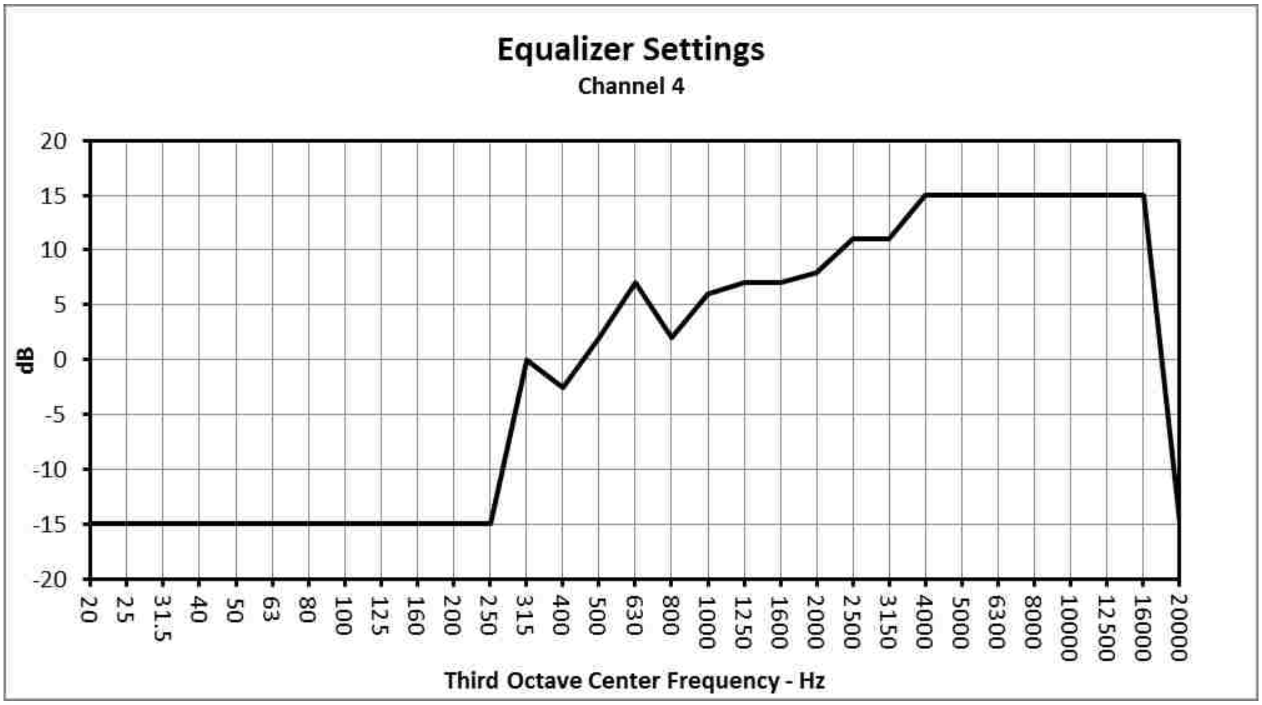

Figure 4.5: Equalizer Settings for Channel 4

4.2 Amplifiers

Two amplifiers were used to amplify the sound signals from the equalizers before they reach the speakers. Each amplifier is capable of handling two inputs. Channels 1 and 2 were connected to the QSC PowerLight PL380 amplifier, shown in Figure 4.6. It has a total maximum power output of 8,000 W. Because the signals that go through the amplifiers are separate, each channel has a maximum power output of 4,000 W.

Figure 4.6: QSC PowerLight PL380 8,000W Amplifier

Channels 3 and 4 were connected to the QSC PowerLight PL325 amplifier, shown in Figure 4.7. It has a total maximum power output of 2,500 W. Because the signals that go through the amplifiers are separate, each channel has a maximum power output of 1,250 W.

Figure 4.7: QSC PowerLight PL325 2,500W Amplifier

The gain settings were adjusted so that the sound signals were amplified to within the amplifiers' maximum wattage capacity while providing minimal clipping. The amplified sound signals were then passed to the speakers via 8-gauge speaker cables.

4.3 Speakers

One speaker alone cannot reproduce pink noise loud enough across all the frequencies being studied, i.e. 50 Hz to 10,000 Hz. Therefore, the amplified sound signals from the amplifiers were directed to three speakers: a bass speaker, a mid-range speaker, and two high-frequency horns.

4.3.1 Low Frequency Speaker

To reproduce the low frequency sound from channels 1 and 2 the JBL ASB7128 Speaker Unit, Figure 4.8, was used. The speaker unit has two individual speakers that can be controlled by two separate inputs. Both are 18-in.-dia. speakers with neodymium. The speaker unit is effective for frequencies from 20 Hz to 1,000 Hz, Figure 4.9. [5]

Figure 4.8: JBL ASB7128 Speaker Unit

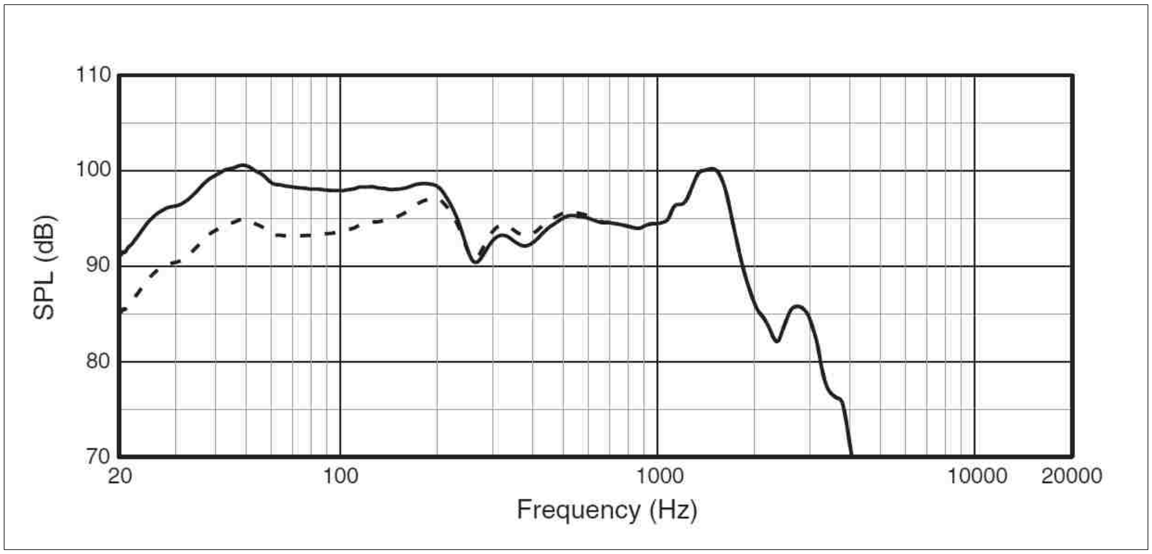

Figure 4.9: Frequency Response of JBL ASB7128 Speaker Unit [5]

4.3.2 Mid Frequency Speaker

The JBL AM7215 Speaker Unit was used to reproduce sound between 125 Hz and 1,600 Hz using the signal from channel 3. This speaker unit has one low frequency driver and one high frequency horn driver where both can be controlled by one input. The transducer for the low frequency has a capacity of 1,000 W while the high frequency has a capacity of 100 W. This speaker unit is effective on frequencies from 40 Hz to 20 kHz. [4]

Figure 4.10: JBL AM7215 Speaker Unit

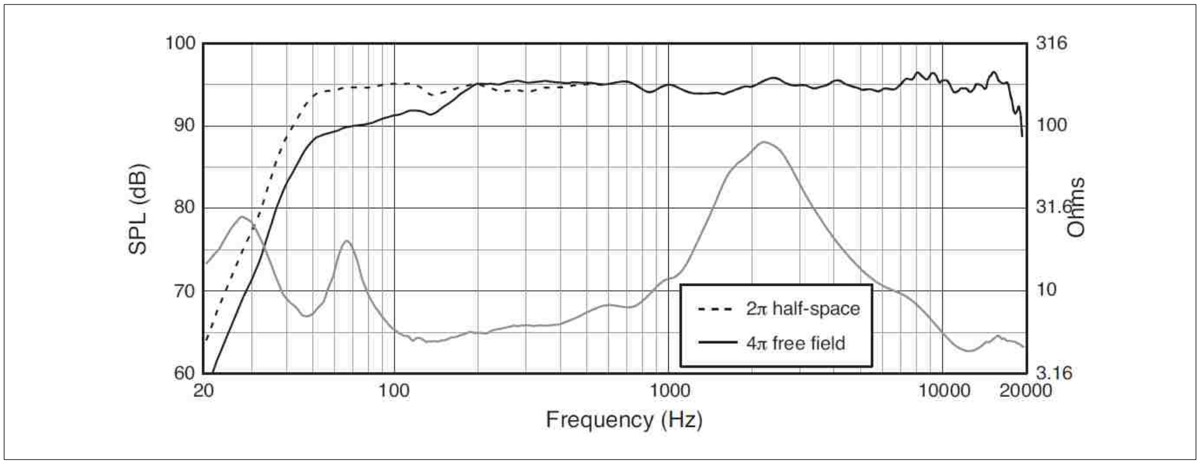

Figure 4.11: Frequency Response of JBL AM7215 Speaker Unit [4]

4.3.3 High Frequency Horn

Two JBL Selenium D4400Ti Drivers, Figure 4.12, coupled with two HL 4750SLF Horns, Figure 4.13, were used to reproduce sound between 1,000 Hz and 20,000 Hz using the signal from channel 4. The channel 4 cable from the amplifier branched into two so that the amplified signal could be passed to both units. Each drive has a capacity of 250 W. They are effective for frequencies from 400 Hz to 20,000 Hz. [6]

Figure 4.12: JBL Selenium D4400Ti Driver

Figure 4.13: JBL Selenium HL 4750SLF Horn

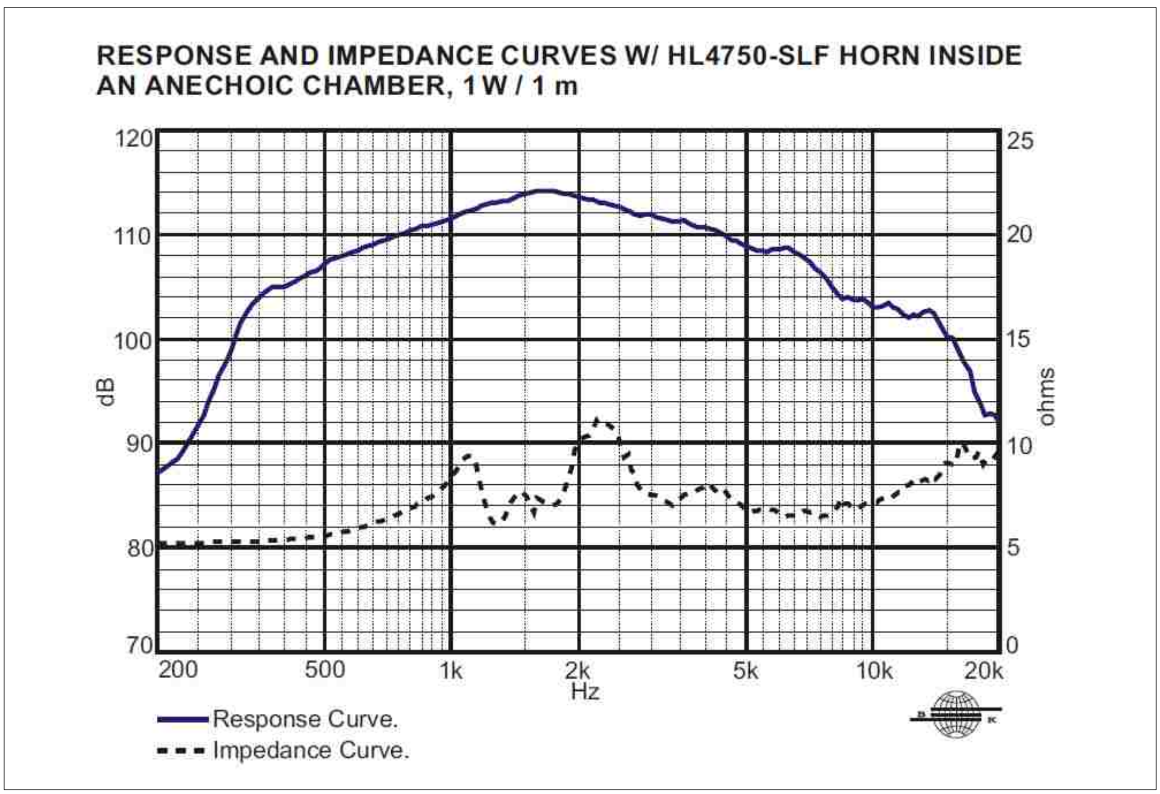

Figure 4.14: Frequency Response of JBL Selenium D4400Ti Horn Driver [6]

4.4 Microphones

Two Svantek SV 22 1/2" Pre-polarized Condenser Microphone, shown in Figure 4.15, were used for the insertion loss tests. The microphones contain a diaphragm that senses vibrations in the air and transforms them into electrical signals.

Figure 4.15: Svantek SV 22 Microphone

4.5 Microphone Preamplifiers

Two Svantek SV 12 Preamplifiers were used to amplify the signal from the microphone diaphragms. The SV 12 Preamplifier is pictured below in Figure 4.16.

Figure 4.16: Svantek SV 12 Microphone Preamplifier

4.6 Rotating Microphone Boom

The Norsonic Nor 265, Figure 4.17, is a sweeping microphone boom. It can be used for building acoustic measurements in accordance with ISO 140, reverberation time measurements in accordance with ISO 354, and sound power measurements in accordance with ISO 3740. It can sweep at ±90 degrees or ±180 degrees with variable sweep times. The inclination of the boom can also be adjusted.

Figure 4.17: Norsonic Nor 265 Microphone Boom

4.7 Sound Analyzer

The sound signal from the preamplifiers is transferred to the Svantek Svan 958 Four-channel Sound & Vibration Analyzer, Figure 4.18. The SVAN 958 is a digital, four channel 0.5 Hz to 20 kHz signal analyzer including a Type 1 sound level meter (meeting IEC 61672-1:2002) and vibration meter (meeting ISO 8041:2005). It can perform real time 1/1 or 1/3 octave analysis including statistical calculations, Fast Fourier Transform (FFT) analysis including cross spectra, and noise measurements with Type 1 accuracy in the frequency range of 10 Hz to 20,000 Hz among many other functions. Data stored on the analyzer can be transferred to a computer using the SvanPC++ software. [10]

Figure 4.18: Svantek Svan 958 Four-channel Sound & Vibration Analyzer

4.8 Calibrator

The Brüel & Kjær Type 4226 Acoustic Calibrator, Figure 4.19, was used to calibrate the microphones and the Svantek Svan 958 sound analyzer. It was used to calibrate at 94 dB at 1,000 Hz. The calibrator has an accuracy level of ±0.2 dB and conforms to IEC942 (1988) and ANSI S1.40–1984. [7]

Figure 4.19: Brüel & Kjær Type 4226 Acoustic Calibrator

4.9 Sheet Metal Ducts

The ducts that were tested were of two separate cross sections: rectangular and circular. Within each of these configurations were five distinct shapes and/or sizes of duct. Included with each test configuration were transition pieces to allow installation of the various shapes and sizes of ducts to the existing duct system in the CMEST testing facility.

4.9.1 Rectangular Ducts

The first of the duct configurations was rectangular. Instead of using the opening surface area as a defining characteristic, the value of the perimeter of the opening divided by the area is used. This value, P/A, has the units of 1/in. The five sizes of rectangular ducts were 12 in x 18 in, 24 in x 24 in, 18 in x 48 in, 32 in x 44 in, and 48 in x 48 in with P/A values of 0.278 1/in, 0.167 1/in, 0.153 1/in, 0.108 1/in, and 0.083 1/in respectively. All five sizes are pictured in Figure 4.20 in the same order listed above from left to right.

Each of these sizes had ducts of lengths 3, 7, and 10 ft. The 12 in x 18 in size also had a 5 ft length. Combinations of these lengths were required to test some of the longer test sections. Each length of duct was tested with a 1 in and a 2 in thick fiberglass liner.

Figure 4.20: All Sizes of Rectangular Duct

4.9.2 Round Ducts

The second configuration of ducts was circular in shape. The defining characteristic for the circular ducts is their diameter. The five sizes of circular ducts were 12 in, 24 in, 36 in, 42 in, and 48 in diameter. Figure 4.21 shows all five of these sizes.

Each of these sizes had ducts of lengths 3, 7, and 10 ft. The 12 in, 42 in, and 48 in diameter ducts also had a 5 ft length. Combinations of these lengths were required to test some of the longer test sections. Each length of duct was tested with a 1 in and a 2 in fiberglass liner.

Figure 4.21: All Sizes of Round Duct

4.9.3 Transitions

The rectangular transition ducts for each size start at 24 in x 24 in at one end and scale to the size of the test duct over the span of 5 ft and are shown in Figure 4.22. Because the duct system in the CMEST testing facility is rectangular, a coupler is needed to allow the round ducts to be connected to the existing rectangular ducts. This coupler is 24 in in diameter and has a 24 in x 24 in frame around it. The round duct transitions start at a 24 in diameter and scale to the appropriate diameter of the test duct over a span of 5 ft and are shown in Figure 4.23. One transition duct is placed upstream of the test section and another is placed downstream.

The reason these transition ducts are required is due to the fact that if these duct configurations were to be installed in an actual HVAC system, the air needs time to stabilize from going from one size duct to another. If the air is not allowed to do so, then turbulence will occur. This could cause unwanted noise generation within the duct system.

Figure 4.22: Rectangular Duct Transitions

Figure 4.23: Round Duct Transitions

CHAPTER 5 TEST SETUP & PROCEDURES

5.1 Test Setup

5.1.1 Testing Facility Layout

The layout of the testing facility is shown in Figure 5.1. The leftmost room is the reverberation room. In the center are the dual-wall ducts that can be removed and replaced with the ducts to be tested. The rooms on the right are the sound chambers. There is a supply and return side, each connected to the reverberation room via the dual-wall ducts. All the tests were performed with the speakers in the supply sound chamber.

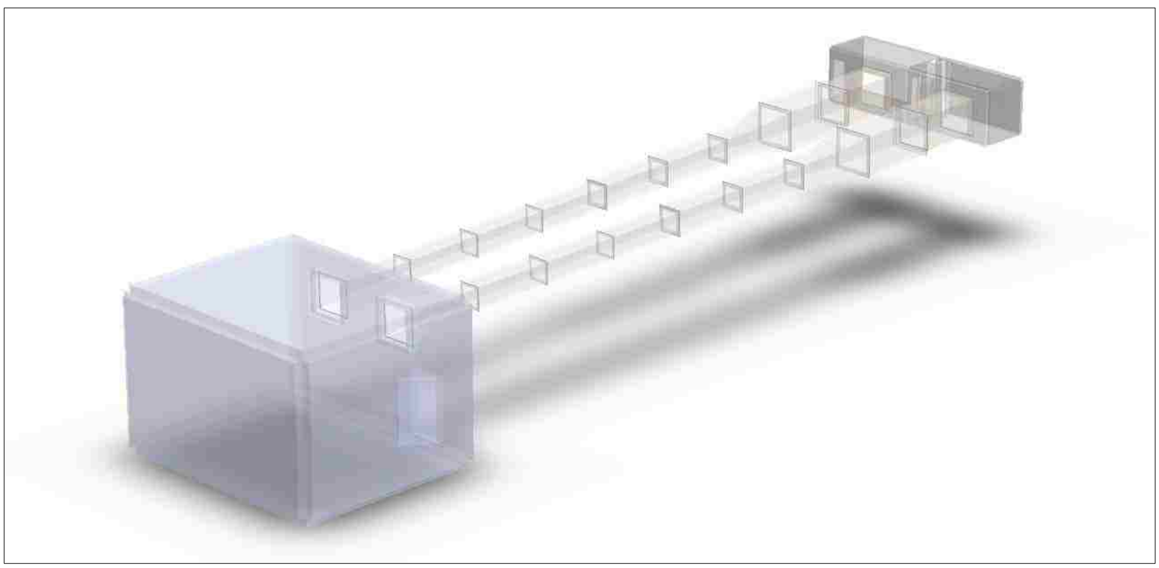

Figure 5.1: CMEST's ASTM E477 Compliant Test Facility

5.1.1.1 Reverberation Room

The reverberation room is pictured in Figure 5.2. It has a volume of 9,373 ft^3 and has been qualified for broad band sound testing per ANSI S12.31. Sound absorbers have been placed on the walls to smooth out the mid-frequency and lower the low-frequency reverberation times. There is also a half-cone turning vane installed in the center of the reverberation room. Its main purpose is to efficiently diffuse low-frequency room modes. The turning speed can be adjusted using a controller located just outside the reverberation room.

Figure 5.2: Reverberation Room

5.1.1.2 Dual-wall Ducts

The dual-wall ducts consist of nine sections each 10 ft long. Starting from the sound chamber, the first two sections measure 4 ft x 4 ft. The next section is a transition piece that starts at 4ft x 4 ft and goes down to 2 ft x 2ft. The next five sections are 2 ft x 2ft with the first two having a cavity of 4.25 in between the inside and outside walls and the last three having a cavity of 2.25 in. between the inside and outside walls. Another transition piece with similar dimensions as the previous transition piece finishes the dual-wall duct system. The walls of the ducts were originally 18-gauge sheet metal and the cavities between the walls are filled with fiber glass. 12-gauge sheet metal panels were attached to all four walls of all of the duct sections as part of the facility upgrade to bring it into compliance with the updated ASTM E477 standards.

5.1.1.3 Sound Chambers

The sound chambers are directly connected to the supply and return air dual-wall ducts. The insides of the walls of the sound chambers are filled with fiber glass with the inside surfaces of the walls and ceiling are perforated sheet metal. The sides of the sound chambers opposite the duct openings are silencers. The measurements for both chambers are about 12 ft x 6 ft x 6.5 ft in length, width, and height, respectively, totaling 460 ft^3 in volume.

5.1.2 Placement of Test & Measurement Equipment

The complete speaker assembly was placed into the supply air side sound chamber. A microphone and microphone preamplifier were also placed into the supply sound chamber. The speakers were then connected to amplifiers located just outside the sound chamber. The amplifiers were connected to the equalizers. The second microphone and microphone preamplifier were placed on the rotating boom in the center of the reverberation room.

The microphones were both connected to the Svantek Svan 958 Sound Analyzer. The sound chamber microphone was connected to channel 1. The reverberation room microphone was connected to channel 4.

5.1.3 Placement of Test Ducts

The dual-wall ducts were replaced by the test ducts only on the supply air side. The 2 ft x 2 ft dual-wall ducts closest to the sound chamber were replaced first, followed by the next closest 2 ft x 2 ft duct as needed to provide enough room for the test ducts and their transition ducts to fit into the test section. As previously stated, the transition pieces were placed upstream and downstream of the test ducts. The upstream transition piece always attached to the 4 ft x 4 ft to 2 ft x 2 ft dual-wall transition. The downstream transition piece usually connected to a 2 ft x 2 ft dual-wall duct. The lined test ducts were then placed into the test section starting at the upstream transition. If there were ever any open space between the lined test ducts and the downstream transition, a length of unlined duct of the same size was used to fill the gap. Figure 5.3shows an example of a rectangular duct test while Figure 5.4 shows an example of a round duct test.

Figure 5.3: 12x18 Duct Test Setup

Figure 5.4: 12-in Diameter Duct Test Setup

5.2 Test Procedure

5.2.1 Calibration

Before taking any measurements it was necessary to ensure the microphones and the sound analyzer were properly calibrated. The calibrator was set to produce a 94 dB tone at 1,000 Hz. To check the calibration of a microphone simply insert it into the calibrator and turn the calibrator on. Then turn on the sound analyzer and check to see if the 1,000 Hz 1/3 Octave Frequency Band shows 94 dB. If it does not, the sound analyzer has built in functions to assist with the calibration process and should be followed. If the signal is 94 dB then the microphone is ready for testing.

5.2.2 Data Acquisition

Once the microphones are calibrated and the test equipment is in place and all connected, the insertion loss test can be performed. To begin, the equalizers were turned on, set to the pink noise generator mode, and the gains were increased to 0 dB. The microphone boom was set to ±90 degrees every 30 seconds and the turning vane was turned on and set to speed 3. Next, the amplifiers and the sound analyzer were turned on. The sound analyzer was set to take a measurement every five seconds and stop after a minute. The test was then repeated with the equalizers and amplifiers turned off to acquire the ambient sound pressure levels. Once the data is recorded on the sound analyzer, everything else was turned off. This completed the data acquisition portion of the test procedure.

5.2.3 Data Transfer

After the data was collected, it needed to be transferred to a computer to be processed. This was done using a piece of software called SvanPC++. This software allowed the data stored in the sound analyzer to be transferred to a Microsoft Excel file to be processed. Two file types were transferred in this way. The first, called a buffer file, contained twelve measurements, each of which was taken every 5 seconds. The second file contains the overall measurement made over the course of 1 minute. The main purpose of the buffer file is to check that the main file is accurate and to make sure there are no anomalies during the test.

CHAPTER 6 SUMMARY OF RESULTS

The full suite of rectangular duct configurations was tested by a company called E.H. Price. Some of the rectangular duct tests were repeated at UNLV's CMEST testing facility to verify the data provided by E.H. Price. All of the round duct tests were performed at UNLV's CMEST testing facility.

There appears to be a linear relationship between insertion loss and the length of a lined duct. An example of this can be seen in Figure A.24. In order to develop an equation to accurately predict insertion loss, multiple regression analyses were performed. First, a linear regression was performed on insertion loss vs duct length. The slopes of these linear regressions were then plotted against the ducts' P/A values, which is the duct opening's perimeter divided by its area, and a regression analysis was performed. Finally, the Y-intercepts of the linear regressions were plotted against the P/A values and another regression analysis was performed. The type of regression analysis was different for each duct shape. The combination of these regression analyses make up the final equation used to approximate insertion loss values.

6.1 E.H. Price Rectangular

A second order polynomial regression was used on the plots of Slope vs P/A and Y-intercepts vs P/A. Because the plots of insertion loss vs duct length show a linear relationship, the final form of the regression equation is also linear. The following equation shows this final form.

$$IL = (a_1 * (P/A)^2 + a_2 * P/A + a_3) + L * (b_1 * (P/A)^2 + b_2 * P/A + b_3) \quad (1)$$

Where:

IL is Insertion Loss

L is Length

P/A is the perimeter of the opening of the duct divided by its area

a_1, a_2, a_3, b_1, b_2, and b_3 are coefficients determined by the second order polynomial regressions

Table 6.1 summarizes all the coefficients at each 1/3 Octave Frequency Band from 50Hz to 10kHz for the 1-in thick Fiberglass Lining. The coefficients for the 2-in thick Fiberglass Lining are shown in Table 6.3.

Table 6.2 and Table 6.4 show some of the statistical relationships between the measured insertion loss and the predicted insertion loss for 1-in and 2-in Fiberglass Lining respectively. AVG DIFF is the average of the difference between the measured value and the predicted value at each 1/3 Octave Frequency Band. Similarly, STD DEV is the standard deviation for each 1/3 Octave Frequency Band. MAX DIFF and MIN DIFF are the maximum and minimum difference between the measured insertion loss value and the predicted value. σ/μ is the standard deviation divided by the average of the measured values, also known as the coefficient of variance.

For both the 1-in and 2-in thicknesses the AVG DIFF is within ±1 dB for most of the 1/3 Octave Frequency Bands. The few outliers only exceed this to ±1.5 dB. The standard deviations are also quite reasonable. Most are within ±4 dB.

Table 6.1: Coefficients for Regression Analysis of 1-in Rectangular Ducts (E.H. Price Data)

Freq	a1	a2	a3	b1	b2	b3
50	52.347	-28.537	2.746	-10.858	3.913	-0.282
63	-0.852	-3.629	0.399	-28.482	9.118	-0.610
80	48.551	-23.663	1.687	24.963	-6.663	0.411
100	-89.565	22.024	-1.208	-4.969	1.326	-0.049
125	-15.703	6.347	-0.325	-6.106	3.064	-0.153
160	13.677	-1.820	0.056	7.137	-1.380	0.157
200	10.724	-2.058	0.084	3.148	0.369	0.104
250	-0.429	0.578	0.109	-5.251	3.636	-0.051
315	1.303	-1.612	0.641	0.904	1.663	0.238
400	25.123	-10.414	2.139	-7.016	5.644	0.179
500	58.126	-19.865	3.707	-7.800	7.357	0.392
630	65.849	-15.890	3.347	-23.292	13.290	0.522
800	324.947	-89.486	9.680	-98.146	42.828	-1.599
1000	251.197	-68.851	9.926	-136.583	66.371	-4.024
1250	209.030	-18.597	6.115	-94.823	49.848	-3.094
1600	-42.990	90.061	-2.477	23.175	6.551	-0.290
2000	-112.487	101.539	-3.929	32.052	-0.897	0.199
2500	-194.431	119.101	-4.910	33.261	-3.911	0.375
3150	-12.840	72.356	-2.785	3.287	2.666	0.019
4000	-131.936	96.279	-4.982	-7.160	4.980	-0.091
5000	-125.297	87.653	-4.308	2.534	2.441	0.016
6300	40.852	48.772	-2.523	-6.496	4.316	-0.084
8000	-22.459	59.678	-3.019	-7.103	4.346	-0.112
10000	-79.104	75.146	-3.976	-5.804	3.700	-0.069

Table 6.2: Statistics of Regression Analysis of 1-in Rectangular Ducts (E.H. Price Data)

Freq	MIN DIFF	MAX DIFF	AVG DIFF	STD Dev	σ/μ
50	-4.8	5.6	0.01	2.12	1440%
63	-4.1	6.8	-0.02	1.89	2653%
80	-3.7	4.2	0.00	1.67	441%
100	-2.1	2.9	0.00	0.84	-9371%
125	-3.6	3.2	-0.01	1.29	48%
160	-0.5	0.6	0.00	0.28	11%
200	-0.6	0.4	0.00	0.24	6%
250	-0.8	0.6	0.01	0.37	6%
315	-2.4	1.6	0.00	0.76	9%
400	-1.6	1.2	0.01	0.55	4%
500	-10.9	2.0	-0.28	2.03	9%
630	-5.2	2.8	-0.25	1.51	5%
800	-10.5	8.1	-1.20	3.58	10%
1000	-6.8	4.8	-0.62	2.68	8%
1250	-8.2	10.7	-0.67	3.86	11%
1600	-8.2	7.5	-0.39	3.65	13%
2000	-9.3	3.9	-0.62	2.61	12%
2500	-10.8	2.4	-0.28	2.38	13%
3150	-2.9	1.7	0.01	1.24	7%
4000	-5.3	2.6	-0.32	1.83	13%
5000	-8.9	2.8	-0.53	2.27	18%
6300	-9.6	1.7	-0.47	2.22	18%
8000	-8.4	2.4	-0.35	2.03	18%
10000	-6.5	2.8	-0.23	1.87	17%

Table 6.3: Coefficients for Regression Analysis of 2-in Rectangular Ducts (E.H. Price Data)

Freq	a1	a2	a3	b1	b2	b3
50	-172.567	47.504	-2.303	-14.066	5.387	-0.386
63	-32.924	14.939	-1.200	-5.220	0.724	0.020
80	45.900	-17.261	1.087	26.861	-7.495	0.515
100	-80.932	24.153	-1.540	-12.489	4.001	-0.159
125	30.134	-5.951	0.535	1.280	1.485	0.069
160	18.823	-1.013	0.093	9.289	-1.263	0.331
200	22.571	-7.055	0.950	-4.918	4.948	0.148
250	38.840	-12.589	1.868	-14.731	9.618	0.037
315	146.354	-52.155	6.085	-16.490	10.789	0.325
400	-67.478	14.027	1.622	-0.352	8.659	1.062
500	-69.339	56.996	-1.251	-18.578	9.598	1.601
630	-228.627	86.626	1.094	-64.132	37.216	-1.203
800	1011.467	-299.652	27.179	-327.433	132.197	-8.501
1000	370.631	-58.483	8.989	-87.352	52.176	-3.438
1250	-270.904	108.283	-1.065	111.275	-11.216	0.534
1600	-361.032	153.621	-6.015	81.671	-10.820	0.721
2000	-114.672	89.670	-3.201	11.534	4.113	-0.130
2500	-34.594	55.445	-0.654	4.855	4.985	-0.228
3150	104.151	26.894	0.337	-12.307	8.082	-0.357
4000	22.384	38.294	-0.776	-24.392	11.339	-0.518
5000	-30.762	54.831	-1.539	-8.564	6.933	-0.289
6300	273.833	-25.071	2.248	-30.050	12.635	-0.558
8000	118.457	15.361	0.166	-20.833	9.400	-0.408
10000	11.168	47.858	-2.566	-14.683	6.862	-0.197

Table 6.4: Statistics of Regression Analysis of 2-in Rectangular Ducts (E.H. Price Data)

Freq	MIN DIFF	MAX DIFF	AVG DIFF	STD Dev	σ/μ
50	-6.6	10.2	-0.14	3.21	353%
63	-2.1	2.6	0.11	0.95	554%
80	-2.8	4.4	0.18	1.35	96%
100	-4.0	1.9	-0.10	0.98	57%
125	-3.1	0.6	-0.22	0.76	13%
160	-4.3	1.1	-0.16	1.01	15%
200	-8.1	0.9	-0.56	1.87	15%
250	-13.5	0.7	-0.80	2.90	16%
315	-18.0	4.4	-0.49	3.40	13%
400	-1.9	5.2	0.43	1.43	4%
500	-3.8	5.7	0.04	2.15	6%
630	-9.7	13.1	-0.29	3.81	9%
800	-6.0	10.6	0.89	3.83	10%
1000	-5.4	7.7	0.38	3.13	9%
1250	-14.6	5.8	-0.06	3.43	12%
1600	-19.9	2.4	-0.83	4.37	18%
2000	-12.9	2.7	-1.03	3.14	16%
2500	-10.3	2.6	-0.78	2.63	15%
3150	-9.3	2.0	-0.71	2.44	15%
4000	-8.5	2.5	-0.96	2.71	19%
5000	-9.2	3.3	-0.99	2.88	21%
6300	-15.1	2.4	-1.54	3.91	28%
8000	-12.1	2.4	-0.96	2.92	23%
10000	-10.4	2.3	-0.97	2.69	23%

6.2 E.H. Price + UNLV Rectangular

Some of the rectangular duct configurations were tested at UNLV's CMEST testing facility to verify the data provided by E.H. Price. The configurations retested were the 3, 7, and 10ft lengths of the 12x18, 24x24, and 18x48 ducts with both 1-in and 2-in Fiberglass Lining. The 5ft and 20ft lengths were also retested for the 12x18 and 24x24 ducts respectively in both 1-in and 2-in Fiberglass Lining.

The data followed a similar pattern as the E.H. Price data. The exact same regressions were performed on the data, and the final equation took the same form as Equation 1. The coefficients and statistics associated with the retested configurations are shown from Table 6.5 to Table 6.8.

Table 6.5: Coefficients for Regression Analysis of 1-in Rectangular Ducts (E.H. Price + UNLV Data)

Freq	a1	a2	a3	b1	b2	b3
50	-10.166	22.471	-1.593	-11.078	2.854	-0.177
63	209.420	-69.467	4.688	-38.950	12.393	-0.824
80	62.443	-11.184	0.399	21.964	-6.460	0.418
100	-25.226	8.456	-0.515	-8.132	2.000	-0.084
125	22.169	-11.320	1.022	-6.222	3.256	-0.171
160	67.800	-19.862	1.298	5.421	-0.834	0.120
200	33.198	-10.298	0.658	2.552	0.588	0.089
250	2.748	-1.158	0.237	-5.317	3.680	-0.054
315	14.725	-2.828	0.629	-0.219	1.906	0.225
400	64.220	-16.404	2.325	-9.741	6.287	0.144
500	-21.635	14.015	1.270	-6.912	6.860	0.430
630	286.027	-61.939	5.721	-43.124	18.988	0.161
800	490.277	-148.674	13.688	-106.374	46.052	-1.825
1000	229.514	-62.632	9.543	-112.819	60.776	-3.714
1250	186.318	-29.995	7.395	-35.561	36.055	-2.332
1600	-193.580	97.705	-1.908	102.606	-12.189	0.757
2000	36.044	35.886	0.812	30.759	0.323	0.099
2500	-161.293	81.744	-1.805	37.011	-3.987	0.352
3150	20.469	31.667	0.526	4.687	3.465	-0.061
4000	136.344	3.970	1.085	-14.759	7.512	-0.253
5000	164.320	-23.448	3.311	-11.246	7.672	-0.342
6300	93.803	-0.168	1.391	-10.906	7.210	-0.306
8000	95.141	2.127	1.151	-15.444	7.978	-0.370
10000	63.709	15.855	0.171	-16.208	7.745	-0.349

Table 6.6: Statistics of Regression Analysis of 1-in Rectangular Ducts (E.H. Price + UNLV Data)

Freq	MIN DIFF	MAX DIFF	AVG DIFF	STD Dev	σ/μ
50	-7.8	4.7	-0.90	2.48	1683%
63	-4.9	6.0	-0.12	2.00	2813%
80	-4.3	3.9	-0.42	1.83	482%
100	-3.4	1.6	-0.17	0.95	-10534%
125	-3.5	3.4	0.20	1.31	49%
160	-0.5	0.7	0.02	0.32	13%
200	-0.6	0.5	0.04	0.25	6%
250	-0.7	0.6	0.04	0.37	6%
315	-2.5	1.5	-0.09	0.78	9%
400	-1.9	1.1	-0.21	0.65	4%
500	-11.1	1.8	-0.63	2.03	9%
630	-6.6	2.4	-1.21	1.97	6%
800	-10.5	8.1	-1.14	3.60	10%
1000	-8.0	4.4	-1.03	2.81	8%
1250	-6.6	11.2	-0.79	3.65	11%
1600	-14.2	8.5	-0.31	4.49	16%
2000	-10.0	4.5	-0.09	2.88	13%
2500	-12.2	4.0	0.50	2.88	15%
3150	-2.4	5.0	0.90	1.82	11%
4000	-5.4	3.7	0.05	2.06	15%
5000	-11.3	4.1	-0.18	2.97	23%
6300	-11.9	5.5	0.19	3.22	26%
8000	-10.6	4.0	-0.01	2.68	24%
10000	-8.7	2.8	-0.10	2.34	21%

Table 6.7: Coefficients for Regression Analysis of 2-in Rectangular Ducts (E.H. Price + UNLV Data)

Freq	a1	a2	a3	b1	b2	b3
50	-119.192	56.615	-3.633	-18.956	5.954	-0.396
63	18.325	-5.826	0.292	-10.272	2.720	-0.124
80	-111.811	39.479	-2.803	33.221	-9.811	0.675
100	-33.846	20.030	-1.599	-14.627	4.190	-0.156
125	68.726	-22.786	1.782	-1.664	2.708	-0.020
160	89.977	-21.606	1.421	4.297	0.367	0.221
200	96.754	-32.483	2.679	-8.628	6.267	0.056
250	74.684	-30.254	3.196	-16.797	10.578	-0.035
315	190.228	-64.758	6.861	-19.170	11.631	0.270
400	34.962	-14.042	3.296	-7.754	10.558	0.952
500	-210.204	116.938	-5.531	-14.222	7.473	1.757
630	-374.685	165.141	-4.958	-46.846	31.337	-0.807
800	722.980	-226.083	22.913	-266.136	116.621	-7.592
1000	347.541	-77.576	11.086	-25.873	38.297	-2.694
1250	-286.545	101.324	-0.294	163.725	-23.661	1.231
1600	-75.764	41.324	1.918	37.926	1.975	-0.086
2000	71.549	2.758	3.208	4.984	7.448	-0.382
2500	42.386	-0.537	3.819	2.648	7.047	-0.400
3150	98.585	-3.316	3.028	-8.344	8.095	-0.387
4000	251.051	-40.344	4.363	-31.858	13.859	-0.680
5000	167.214	-27.139	4.226	-14.914	9.612	-0.477
6300	331.406	-84.857	7.048	-37.735	17.104	-0.889
8000	141.181	-15.080	2.631	-21.567	10.539	-0.498
10000	88.527	8.473	0.281	-18.042	8.455	-0.308

Table 6.8: Statistics of Regression Analysis of 2-in Rectangular Ducts (E.H. Price + UNLV Data)

Freq	MIN DIFF	MAX DIFF	AVG DIFF	STD Dev	σ/μ
50	-6.8	10.0	-0.04	3.33	177%
63	-3.2	2.5	0.03	1.16	529%
80	-2.0	5.1	0.21	1.40	93%
100	-3.6	2.2	-0.03	0.92	44%
125	-4.0	2.2	-0.23	1.02	18%
160	-5.1	1.7	-0.18	1.22	18%
200	-8.7	1.2	-0.59	1.98	16%
250	-14.1	0.9	-0.84	2.98	16%
315	-18.2	4.4	-0.53	3.39	13%
400	-3.4	5.2	0.26	1.64	5%
500	-3.8	5.1	0.05	2.39	6%
630	-10.0	12.8	-0.16	4.15	10%
800	-5.2	11.7	1.11	3.78	10%
1000	-5.3	10.6	0.87	3.71	11%
1250	-14.6	13.7	-0.25	4.58	15%
1600	-21.5	2.1	-1.15	4.61	20%
2000	-14.9	3.5	-1.18	3.53	19%
2500	-12.0	3.4	-0.92	3.05	19%
3150	-10.1	3.0	-0.66	2.88	19%
4000	-8.9	3.9	-0.97	3.14	23%
5000	-10.1	4.2	-0.95	3.36	25%
6300	-19.0	4.3	-1.89	5.13	39%
8000	-13.1	3.2	-0.91	3.45	28%
10000	-11.1	3.6	-0.88	3.20	28%

Table 6.9 and Table 6.10 compare the statistics from the E.H. Price data, designated by P, and the added data from UNLV, designated by P+U, for the 1-in thick liner and 2-in thick liner respectively.

Table 6.9: Comparison of Statistics for 1-in Rectangular Ducts

Freq	AVG DIFF (P)	AVG DIFF (P+U)	Difference	STD DEV (P)	STD DEV(P+U)	Difference	σ/μ (P)	σ/μ (P+U)	Difference
50	0.01	-0.90	0.91	2.12	2.48	-0.36	1440%	1683%	-2.43
63	-0.02	-0.12	0.10	1.89	2.00	-0.11	2653%	2813%	-1.60
80	0.00	-0.42	0.43	1.67	1.83	-0.16	441%	482%	-0.41
100	0.00	-0.17	0.16	0.84	0.95	-0.10	-9371%	-10534%	11.63
125	-0.01	0.20	-0.21	1.29	1.31	-0.02	48%	49%	-0.01
160	0.00	0.02	-0.03	0.28	0.32	-0.04	11%	13%	-0.02
200	0.00	0.04	-0.04	0.24	0.25	-0.01	6%	6%	0.00
250	0.01	0.04	-0.03	0.37	0.37	0.00	6%	6%	0.00
315	0.00	-0.09	0.10	0.76	0.78	-0.01	9%	9%	0.00
400	0.01	-0.21	0.22	0.55	0.65	-0.10	4%	4%	-0.01
500	-0.28	-0.63	0.35	2.03	2.03	0.00	9%	9%	0.00
630	-0.25	-1.21	0.96	1.51	1.97	-0.47	5%	6%	-0.01
800	-1.20	-1.14	-0.06	3.58	3.60	-0.03	10%	10%	0.00
1000	-0.62	-1.03	0.41	2.68	2.81	-0.13	8%	8%	0.00
1250	-0.67	-0.79	0.12	3.86	3.65	0.20	11%	11%	0.01
1600	-0.39	-0.31	-0.08	3.65	4.49	-0.84	13%	16%	-0.03
2000	-0.62	-0.09	-0.54	2.61	2.88	-0.27	12%	13%	-0.01
2500	-0.28	0.50	-0.78	2.38	2.88	-0.50	13%	15%	-0.03
3150	0.01	0.90	-0.89	1.24	1.82	-0.58	7%	11%	-0.03
4000	-0.32	0.05	-0.37	1.83	2.06	-0.22	13%	15%	-0.02
5000	-0.53	-0.18	-0.35	2.27	2.97	-0.69	18%	23%	-0.05
6300	-0.47	0.19	-0.67	2.22	3.22	-1.00	18%	26%	-0.08
8000	-0.35	-0.01	-0.34	2.03	2.68	-0.66	18%	24%	-0.06
10000	-0.23	-0.10	-0.13	1.87	2.34	-0.47	17%	21%	-0.04

Table 6.10: Comparison of Statistics for 2-in Rectangular Ducts

Freq	AVG DIFF (P)	AVG DIFF (P+U)	Difference	STD DEV (P)	STD DEV(P+U)	Difference	σ/μ (P)	σ/μ (P+U)	Difference
50	-0.14	-0.04	-0.11	3.21	3.33	-0.13	353%	177%	1.75
63	0.11	0.03	0.07	0.95	1.16	-0.21	554%	529%	0.25
80	0.18	0.21	-0.03	1.35	1.40	-0.05	96%	93%	0.03
100	-0.10	-0.03	-0.07	0.98	0.92	0.06	57%	44%	0.13
125	-0.22	-0.23	0.01	0.76	1.02	-0.26	13%	18%	-0.05
160	-0.16	-0.18	0.03	1.01	1.22	-0.21	15%	18%	-0.02
200	-0.56	-0.59	0.03	1.87	1.98	-0.10	15%	16%	-0.01
250	-0.80	-0.84	0.04	2.90	2.98	-0.08	16%	16%	0.00
315	-0.49	-0.53	0.04	3.40	3.39	0.00	13%	13%	0.00
400	0.43	0.26	0.17	1.43	1.64	-0.21	4%	5%	-0.01
500	0.04	0.05	-0.02	2.15	2.39	-0.23	6%	6%	0.00
630	-0.29	-0.16	-0.13	3.81	4.15	-0.34	9%	10%	0.00
800	0.89	1.11	-0.22	3.83	3.78	0.05	10%	10%	0.00
1000	0.38	0.87	-0.49	3.13	3.71	-0.58	9%	11%	-0.01
1250	-0.06	-0.25	0.19	3.43	4.58	-1.16	12%	15%	-0.04
1600	-0.83	-1.15	0.32	4.37	4.61	-0.24	18%	20%	-0.02
2000	-1.03	-1.18	0.14	3.14	3.53	-0.39	16%	19%	-0.03
2500	-0.78	-0.92	0.14	2.63	3.05	-0.42	15%	19%	-0.03
3150	-0.71	-0.66	-0.05	2.44	2.88	-0.44	15%	19%	-0.04
4000	-0.96	-0.97	0.01	2.71	3.14	-0.44	19%	23%	-0.03
5000	-0.99	-0.95	-0.04	2.88	3.36	-0.49	21%	25%	-0.04
6300	-1.54	-1.89	0.35	3.91	5.13	-1.21	28%	39%	-0.11
8000	-0.96	-0.91	-0.06	2.92	3.45	-0.53	23%	28%	-0.05
10000	-0.97	-0.88	-0.09	2.69	3.20	-0.51	23%	28%	-0.05

6.3 UNLV Round

All of the round duct configurations were tested at UNLV's CMEST testing facility. The regression analyses that were performed were similar to the rectangular duct configurations. The main difference is that the data fit better into a third order polynomial regression rather than a second order. The other difference is instead of using the P/A value of the duct, the round duct analyses use the duct diameter as the defining characteristic of the ducts. Equation 2 was used to predict insertion loss values for the round ducts.

$$IL = (a_1 * D^3 + a_2 * D^2 + a_3 * D + a_4) + L * (b_1 * D^3 + b_2 * D^2 + b_3 * D + b_4) \qquad (2)$$

Where all the variables are the same as the previous equation with the exception of D being the duct diameter in inches.

Table 6.11 to Table 6.14 show the coefficients and statistics associated with the round duct tests for both 1-in and 2-in Fiberglass Lining. All of the statistics show a better fit for the round duct data compared to the rectangular duct data. The AVG DIFF as well as STD DEV are all much lower overall.

Table 6.11: Coefficients for Regression Analysis of 1-in Round Ducts

Freq	a1	a2	a3	a4	b1	b2	b3	b4
50	3.77E-04	-2.96E-02	6.58E-01	-3.20E+00	-3.07E-06	4.93E-04	-2.28E-02	3.19E-01
63	2.47E-04	-2.87E-02	1.02E+00	-9.98E+00	5.31E-06	-2.80E-04	3.62E-04	7.22E-02
80	3.87E-05	-3.97E-03	1.11E-01	-3.57E-01	1.19E-05	-1.12E-03	3.19E-02	-2.35E-01
100	1.14E-04	-1.15E-02	3.42E-01	-2.60E+00	-3.55E-06	4.85E-04	-2.14E-02	3.46E-01
125	-6.62E-06	7.89E-04	-4.71E-02	9.82E-01	-3.63E-06	5.44E-04	-2.59E-02	4.66E-01
160	7.39E-05	-8.33E-03	2.85E-01	-2.54E+00	-1.28E-05	1.52E-03	-5.92E-02	8.58E-01
200	-1.13E-05	6.08E-04	-3.08E-03	2.47E-01	-8.35E-06	1.16E-03	-5.44E-02	9.94E-01
250	8.08E-05	-8.07E-03	2.27E-01	-1.57E+00	-1.82E-05	2.24E-03	-9.24E-02	1.52E+00
315	1.00E-05	-1.98E-03	8.70E-02	-8.41E-01	-2.26E-05	2.87E-03	-1.25E-01	2.20E+00
400	-1.72E-04	1.63E-02	-4.93E-01	6.83E+00	3.03E-06	6.11E-04	-6.66E-02	2.01E+00
500	1.06E-04	-1.24E-02	4.00E-01	-1.08E+00	-2.36E-06	1.42E-03	-1.02E-01	2.87E+00
630	4.53E-04	-3.93E-02	9.34E-01	3.01E-01	-3.78E-05	3.89E-03	-1.42E-01	3.42E+00
800	-5.02E-04	5.11E-02	-1.48E+00	1.99E+01	1.17E-04	-1.06E-02	2.18E-01	1.72E+00
1000	3.75E-04	-1.09E-02	-7.71E-01	3.30E+01	9.69E-05	-9.81E-03	2.46E-01	2.71E-01
1250	-1.15E-03	1.44E-01	-5.81E+00	8.38E+01	1.17E-04	-1.20E-02	3.37E-01	-1.37E+00
1600	-1.49E-03	1.75E-01	-6.66E+00	8.81E+01	8.26E-05	-7.78E-03	1.88E-01	-5.15E-02
2000	-7.81E-04	1.01E-01	-4.31E+00	6.52E+01	7.95E-06	-2.29E-04	-3.32E-02	1.50E+00
2500	-3.19E-04	4.26E-02	-1.92E+00	3.51E+01	-5.17E-05	6.19E-03	-2.51E-01	3.63E+00
3150	6.47E-04	-5.30E-02	1.05E+00	5.53E+00	-8.42E-05	9.13E-03	-3.32E-01	4.37E+00
4000	1.06E-03	-9.88E-02	2.60E+00	-9.10E+00	-8.71E-05	9.28E-03	-3.22E-01	3.84E+00
5000	7.88E-04	-7.65E-02	2.03E+00	-3.26E+00	-4.29E-05	4.65E-03	-1.65E-01	2.11E+00
6300	8.54E-04	-8.16E-02	2.08E+00	-2.14E+00	-3.09E-05	3.50E-03	-1.29E-01	1.78E+00
8000	1.05E-03	-1.01E-01	2.64E+00	-6.74E+00	-3.67E-05	3.92E-03	-1.35E-01	1.71E+00
10000	1.73E-03	-1.73E-01	5.04E+00	-3.11E+01	-1.09E-04	1.14E-02	-3.77E-01	4.07E+00

Table 6.12: Statistics of Regression Analysis of 1-in Round Ducts

Freq	MIN DIFF	MAX DIFF	AVG DIFF	STD DEV	σ/μ
50	-1.2	1.5	3.83E-03	0.73	66%
63	-1.5	1.6	3.33E-03	0.77	184%
80	-1.5	1.0	-2.02E-04	0.53	73%
100	-0.5	0.7	-3.98E-04	0.33	35%
125	-0.6	0.5	-1.09E-03	0.26	18%
160	-0.4	0.3	1.15E-05	0.19	9%
200	-0.2	0.5	3.54E-04	0.17	5%
250	-0.3	0.3	-1.25E-05	0.16	4%
315	-0.4	0.3	4.99E-04	0.20	3%
400	-1.8	1.5	9.71E-05	0.73	6%
500	-2.6	3.4	-1.69E-03	1.17	7%
630	-3.8	6.7	1.37E-01	2.37	9%
800	-5.0	3.9	-8.97E-02	2.34	8%
1000	-3.7	2.8	-2.05E-01	2.06	8%
1250	-3.0	2.6	4.18E-02	1.50	6%
1600	-3.0	4.1	1.66E-02	1.24	6%
2000	-3.7	2.4	5.19E-03	1.32	8%
2500	-2.7	2.4	5.32E-04	1.11	7%
3150	-1.8	2.0	2.58E-03	0.94	7%
4000	-2.1	2.9	5.98E-03	1.00	8%
5000	-2.2	3.8	1.20E-02	1.35	11%
6300	-2.1	3.7	1.25E-02	1.36	11%
8000	-2.7	3.3	1.10E-02	1.29	11%
10000	-11.5	2.2	-7.15E-01	2.79	25%

Table 6.13: Coefficients for Regression Analysis of 2-in Round Ducts

Freq	a1	a2	a3	a4	b1	b2	b3	b4
50	1.31E-04	-5.71E-03	-8.70E-02	4.68E+00	-6.14E-06	7.25E-04	-2.53E-02	2.84E-01
63	3.60E-04	-3.64E-02	1.09E+00	-8.31E+00	-1.29E-05	1.37E-03	-4.57E-02	5.11E-01
80	7.10E-05	-2.75E-03	-7.77E-02	2.77E+00	-9.05E-06	9.23E-04	-3.35E-02	5.48E-01
100	1.08E-04	-8.72E-03	1.85E-01	-3.32E-01	-1.77E-05	1.93E-03	-7.14E-02	1.06E+00
125	2.41E-05	1.39E-03	-2.03E-01	4.13E+00	-1.27E-05	1.50E-03	-6.23E-02	1.13E+00
160	4.05E-05	-1.38E-03	-4.94E-02	1.61E+00	-1.97E-05	2.31E-03	-9.69E-02	1.76E+00
200	-7.23E-05	8.58E-03	-3.22E-01	3.95E+00	-1.89E-05	2.53E-03	-1.19E-01	2.37E+00
250	2.01E-05	-7.44E-04	-3.98E-02	1.69E+00	-3.21E-05	4.24E-03	-1.87E-01	3.41E+00
315	1.42E-04	-1.11E-02	2.47E-01	-1.04E+00	-7.49E-05	8.39E-03	-3.13E-01	5.18E+00
400	6.55E-04	-5.60E-02	1.34E+00	2.12E+00	-3.55E-05	3.86E-03	-1.44E-01	3.33E+00
500	6.22E-04	-5.25E-02	1.24E+00	8.67E+00	-1.66E-05	2.10E-03	-9.18E-02	2.67E+00
630	-5.78E-04	2.77E-02	-8.86E-02	1.59E+01	-1.25E-04	1.36E-02	-4.94E-01	7.36E+00
800	1.27E-03	-1.06E-01	1.92E+00	2.20E+01	4.61E-05	-6.04E-03	2.05E-01	-4.17E-01
1000	-1.10E-03	1.38E-01	-5.66E+00	8.60E+01	2.73E-04	-2.77E-02	8.15E-01	-5.23E+00
1250	-2.65E-03	2.89E-01	-1.03E+01	1.27E+02	1.74E-04	-1.75E-02	5.06E-01	-3.03E+00
1600	-1.78E-03	1.91E-01	-6.80E+00	8.63E+01	3.29E-05	-1.94E-03	-2.45E-02	2.26E+00
2000	-2.48E-04	2.09E-02	-7.92E-01	1.98E+01	-1.70E-04	2.03E-02	-7.85E-01	1.01E+01
2500	-8.57E-04	8.60E-02	-2.94E+00	4.20E+01	-4.07E-05	5.64E-03	-2.51E-01	3.78E+00
3150	-1.06E-06	-2.22E-03	-1.23E-01	1.42E+01	-6.31E-05	7.81E-03	-3.15E-01	4.44E+00
4000	3.21E-04	-4.09E-02	1.25E+00	1.83E+00	-5.86E-05	7.27E-03	-2.85E-01	3.70E+00
5000	4.88E-04	-5.81E-02	1.75E+00	-1.55E+00	-2.38E-05	3.49E-03	-1.50E-01	2.14E+00
6300	6.77E-04	-7.19E-02	1.94E+00	-1.27E-01	-1.22E-05	2.22E-03	-1.04E-01	1.60E+00
8000	1.03E-03	-1.02E-01	2.66E+00	-4.67E+00	-2.32E-05	2.97E-03	-1.12E-01	1.48E+00
10000	1.69E-03	-1.62E-01	4.31E+00	-1.82E+01	-5.45E-05	5.44E-03	-1.60E-01	1.51E+00

Table 6.14: Statistics of Regression Analysis of 2-in Round Ducts

Freq	MIN DIFF	MAX DIFF	AVG DIFF	STD Dev	σ/μ
50	-2.8	2.7	0.00	1.00	51%
63	-2.0	2.4	0.00	0.94	67%
80	-1.3	2.1	0.00	0.64	28%
100	-0.8	1.1	0.00	0.54	17%
125	-0.8	1.0	0.00	0.49	11%
160	-0.5	0.7	0.00	0.33	5%
200	-0.3	0.5	0.00	0.22	3%
250	-0.9	1.2	0.00	0.42	3%
315	-0.9	1.4	0.00	0.41	2%
400	-5.3	5.6	0.14	3.00	10%
500	-7.7	8.4	0.20	4.83	14%
630	-9.2	7.6	-0.10	4.43	12%
800	-6.1	4.9	0.26	3.08	9%
1000	-6.8	6.0	0.16	2.67	9%
1250	-4.4	3.8	0.10	1.67	7%
1600	-4.2	2.8	-0.04	1.58	8%
2000	-10.3	3.0	-0.71	2.81	16%
2500	-4.2	4.9	0.00	1.98	13%
3150	-2.5	3.9	0.01	1.44	9%
4000	-3.7	5.4	0.02	1.89	14%
5000	-4.1	3.6	0.02	1.72	13%
6300	-3.6	3.3	0.02	1.52	11%
8000	-2.6	2.9	0.01	1.25	10%
10000	-1.9	2.2	0.00	1.23	11%

CHAPTER 7 CONCLUSION

- Tests were conducted to quantify the sound attenuation of the fiberglass lining in both rectangular and round ducts in accordance with ASTM E477
- Regression equations were developed to predict insertion loss values of rectangular ducts with cross sectional areas from 12-in x 18-in to 48-in x 48-in for lengths from 3ft to 30ft and round ducts with diameters from 12-in to 48-in for lengths from 3ft to 30ft
- IL vs Length shows a linear relationship for every test configuration.
- A second order regression was necessary for the rectangular ducts.
- A third order regression was necessary for the round ducts.
- The average differences between the measured and predicted IL values were:
  - Between -1.2 and 0.01 for the 1-in, and -1.54 and 0.89 for the 2-in E.H. Price Rectangular Data
  - Between -1.21 and 0.90 for the 1-in, and -1.89 and 1.11 for the 2-in E.H. Price + UNLV Rectangular Data
  - Between -0.71 and 0.14 for the 1-in, and -0.71 and 0.26 for the 2-in Round Data
- The standard deviations were:
  - Between 0.24 and 3.86 for the 1-in, and 0.76 and 4.37 for the 2-in E.H. Price Rectangular Data
  - Between 0.25 and 4.49 for the 1-in, and 0.92 and 5.13 for the 2-in E.H. Price + UNLV Rectangular Data
  - Between -0.16 and 2.79 for the 1-in, and 0.22 and 4.83 for the 2-in Round Data
- The statistics of the E.H. Price data and the data added from UNLV differed by no more than 1dB in every field except σ/μ for a few of the low frequency bands.

APPENDIX A E.H. PRICE DATA FOR 1-IN RECTANGULAR DUCTS

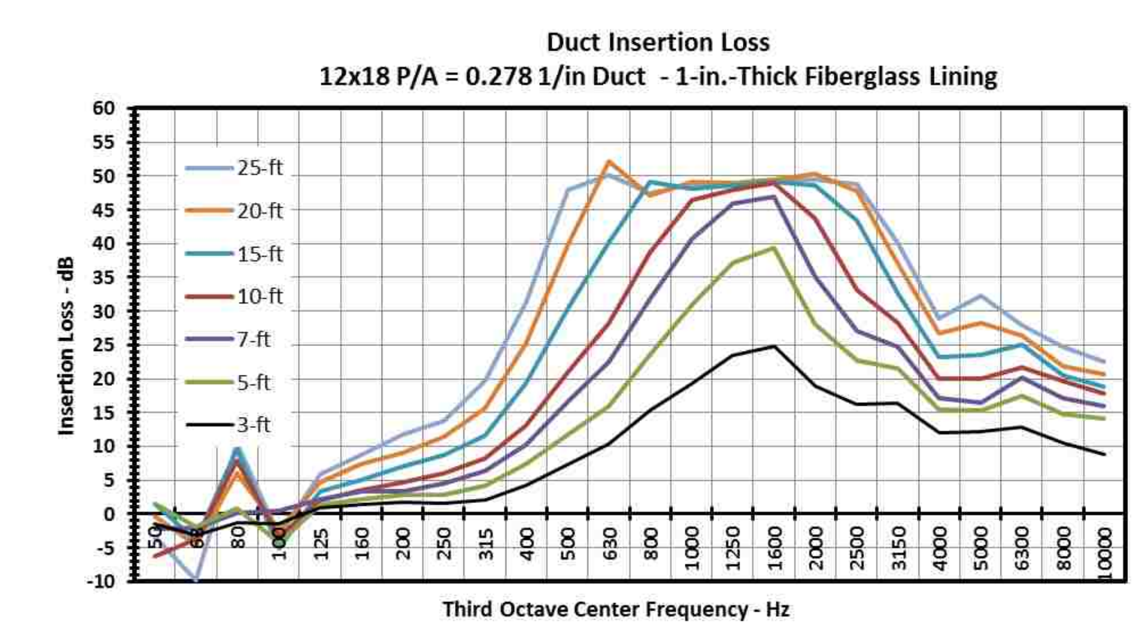

Figure A.1: Insertion Loss for 12x18 ducts with 1-in Fiberglass

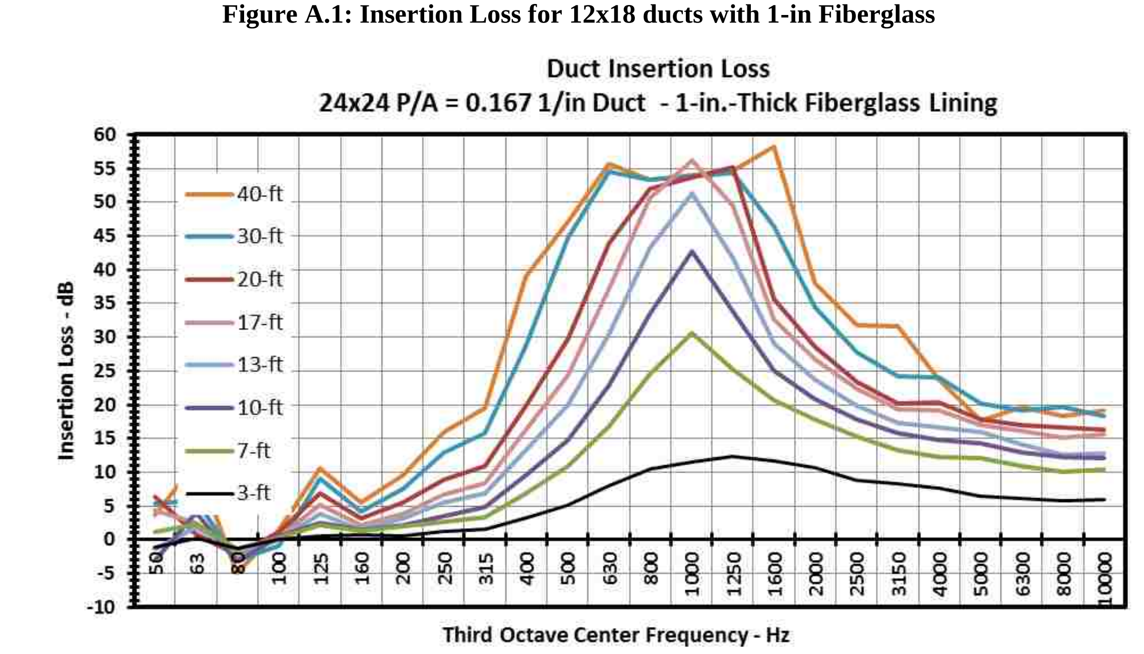

Figure A.2: Insertion Loss for 24x24 ducts with 1-in Fiberglass

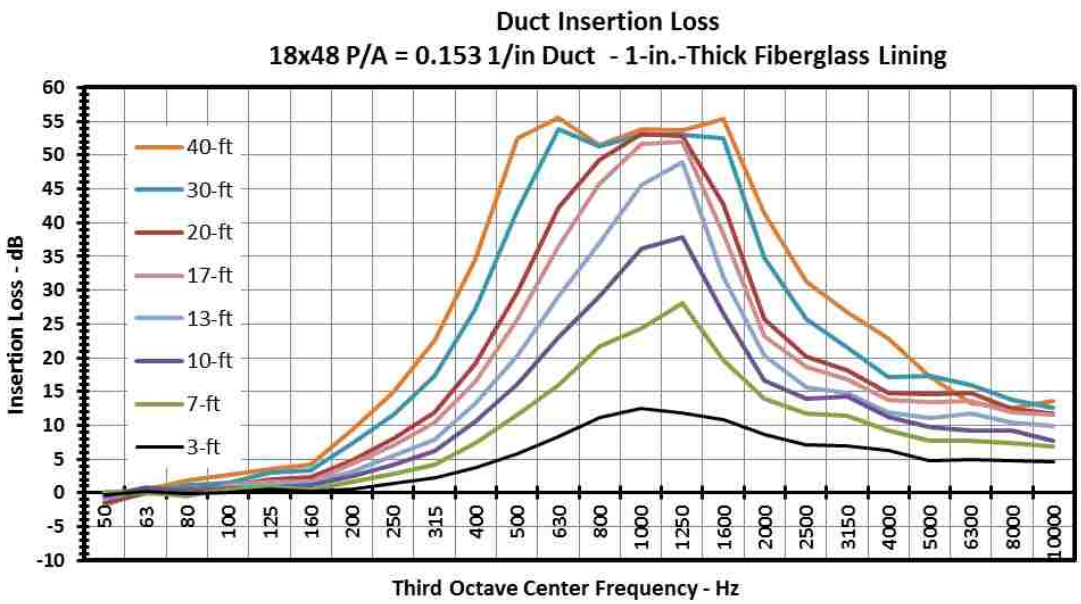

Figure A.3: Insertion Loss for 18x48 ducts with 1-in Fiberglass

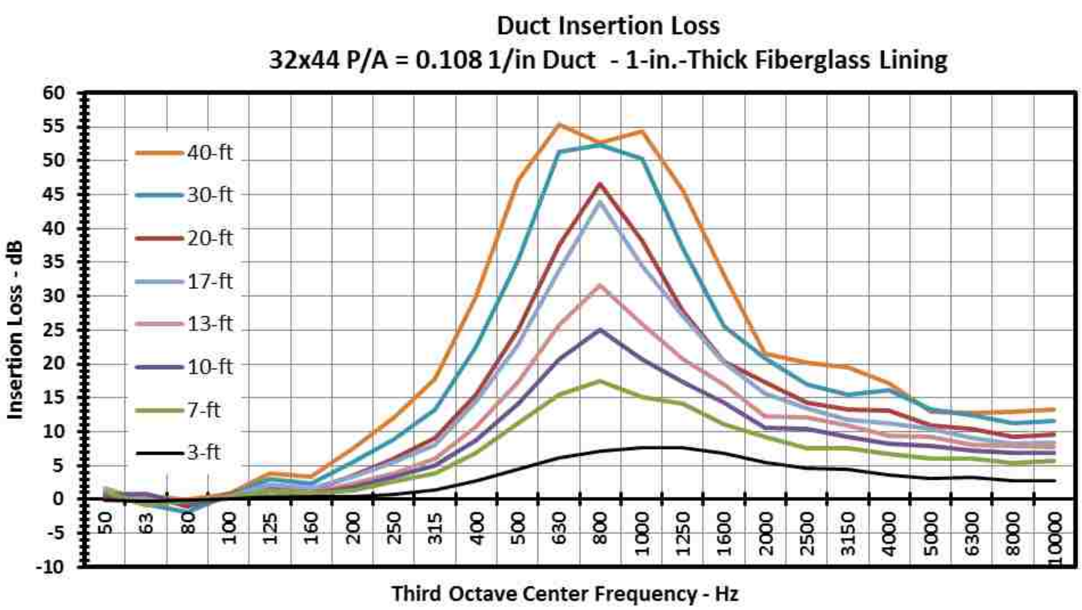

Figure A.4: Insertion Loss for 32x44 ducts with 1-in Fiberglass

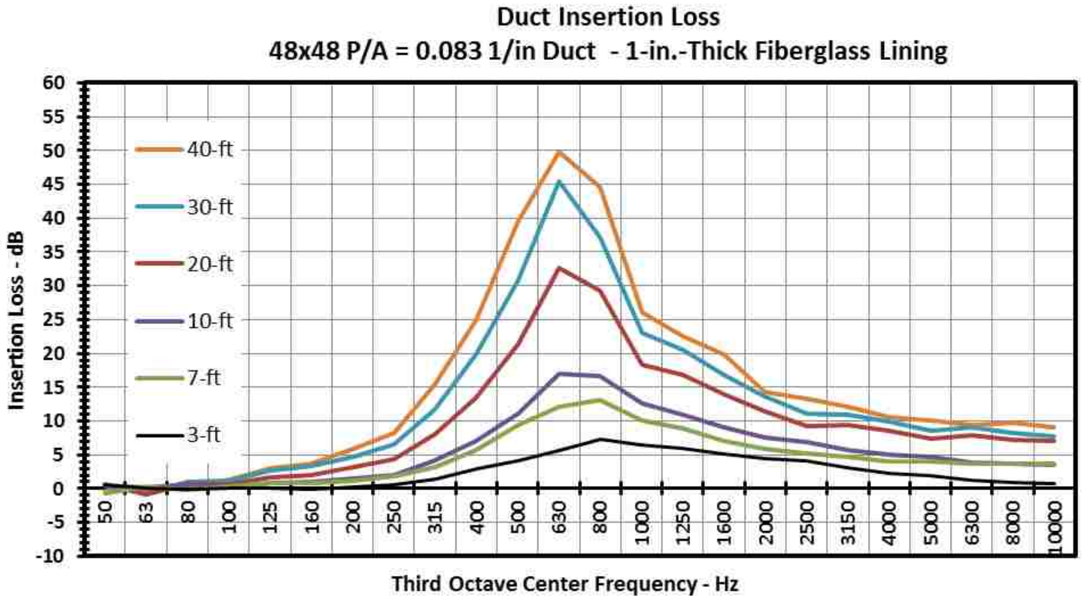

Figure A.5: Insertion Loss for 48x48 ducts with 1-in Fiberglass

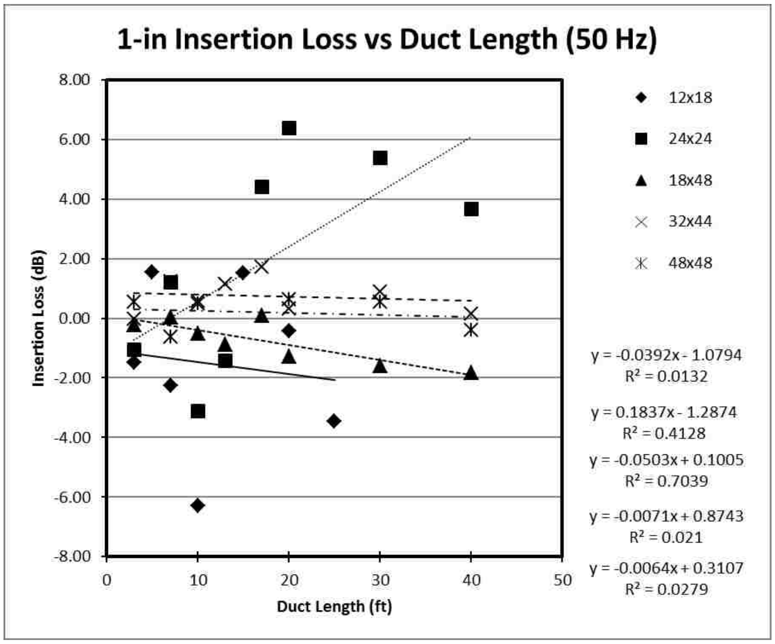

Figure A.6: 1-in Insertion Loss vs Duct Length at 50 Hz

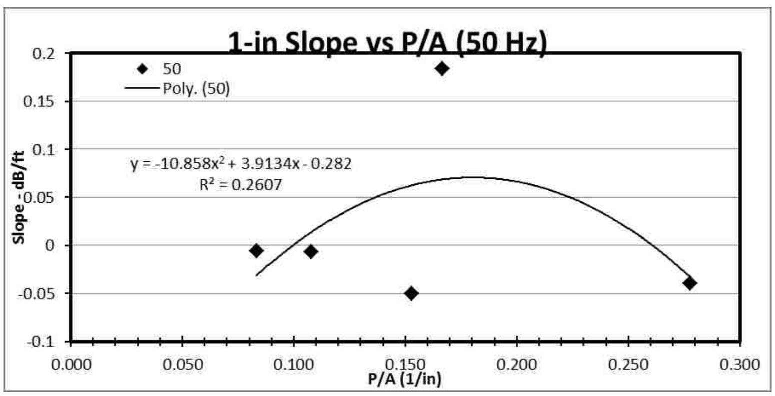

Figure A.7: 1-in Slope vs P/A at 50 Hz

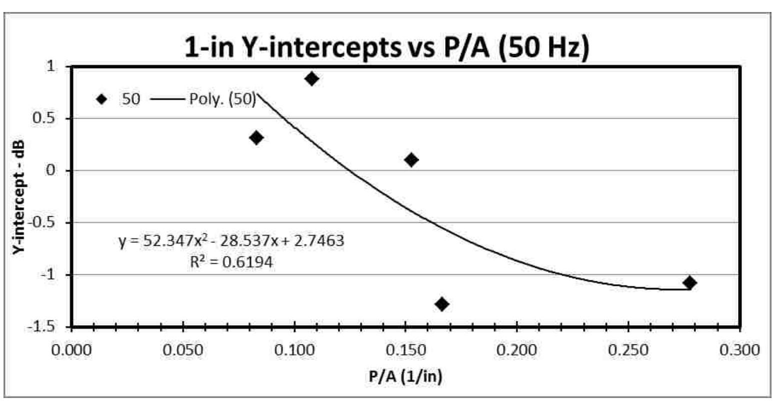

Figure A.8: 1-in Y-intercepts vs P/A at 50 Hz

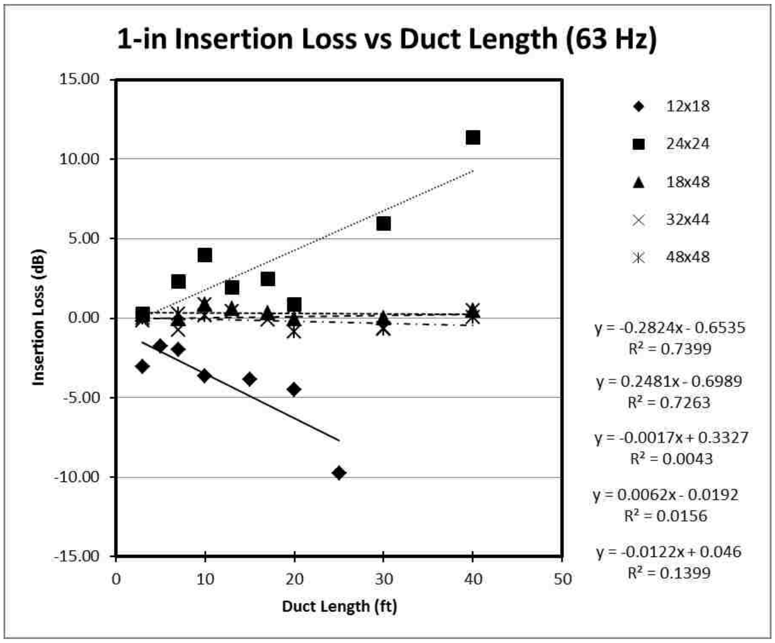

Figure A.9: 1-in Insertion Loss vs Duct Length at 63 Hz

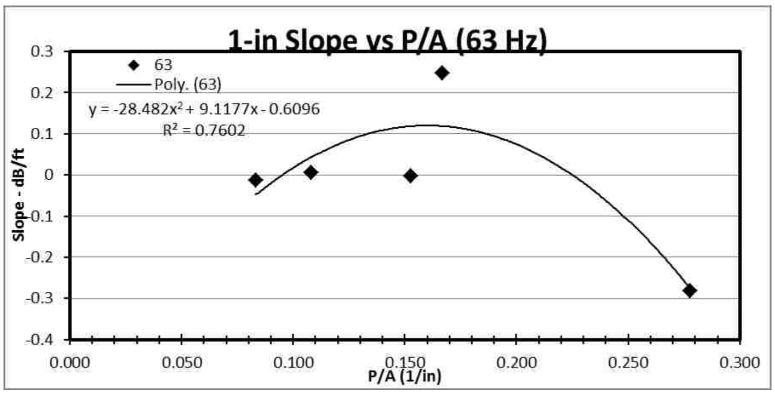

Figure A.10: 1-in Slope vs P/A at 63 Hz

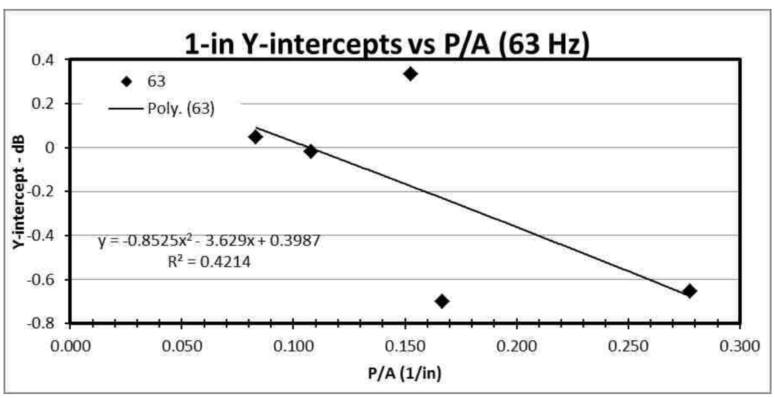

Figure A.11: 1-in Y-intercepts vs P/A at 63 Hz

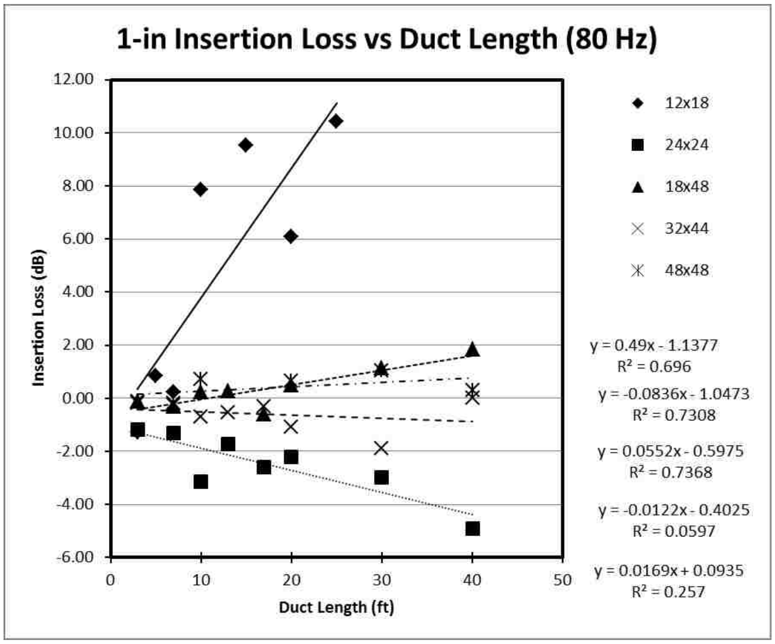

Figure A.12: 1-in Insertion Loss vs Duct Length at 80 Hz

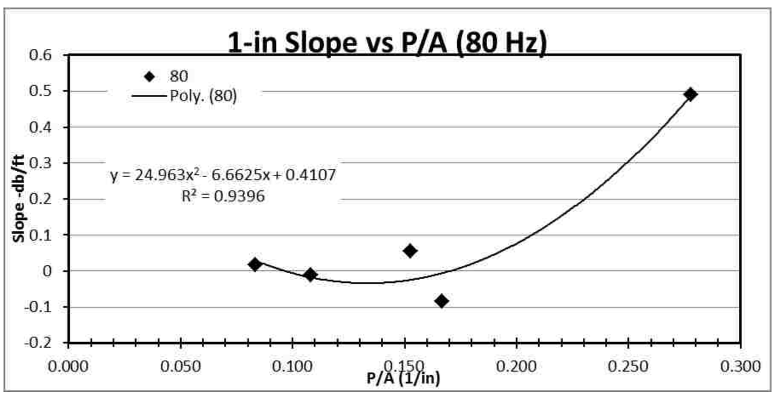

Figure A.13: 1-in Slope vs P/A at 80 Hz

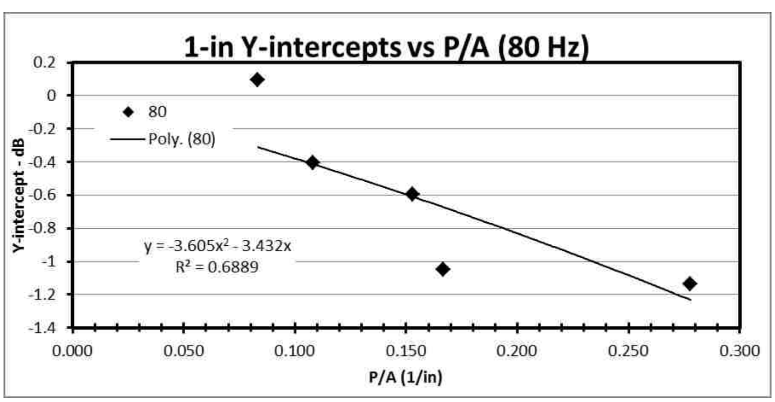

Figure A.14: 1-in Y-intercepts vs P/A at 80 Hz

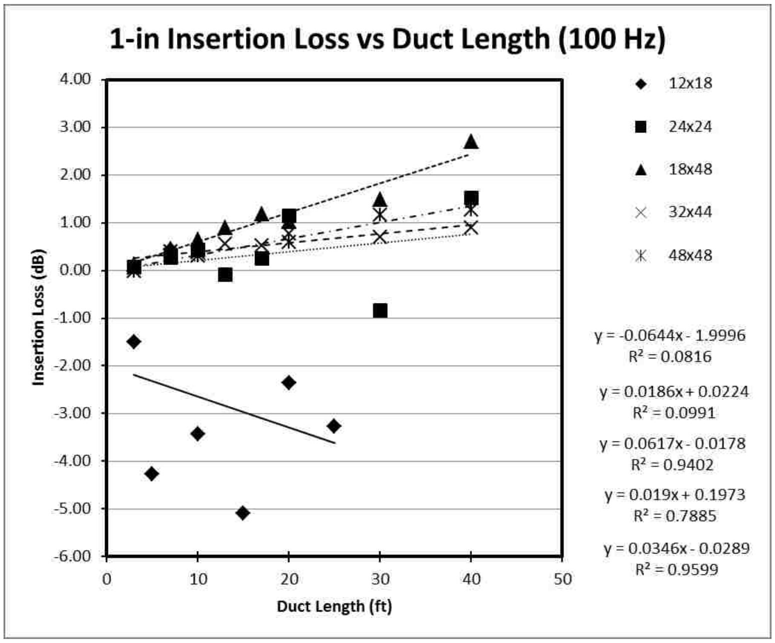

Figure A.15: 1-in Insertion Loss vs Duct Length at 100 Hz

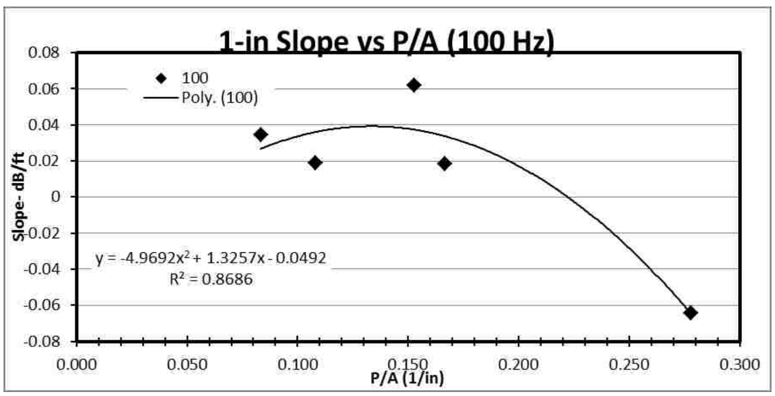

Figure A.16: 1-in Slope vs P/A at 100 Hz

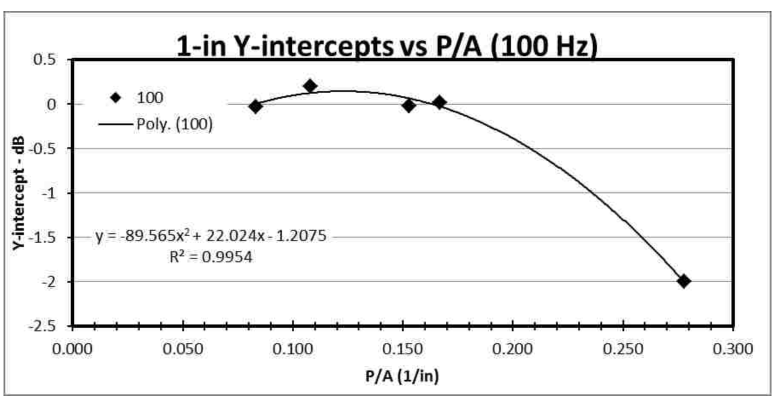

Figure A.17: 1-in Y-intercepts vs P/A at 100 Hz

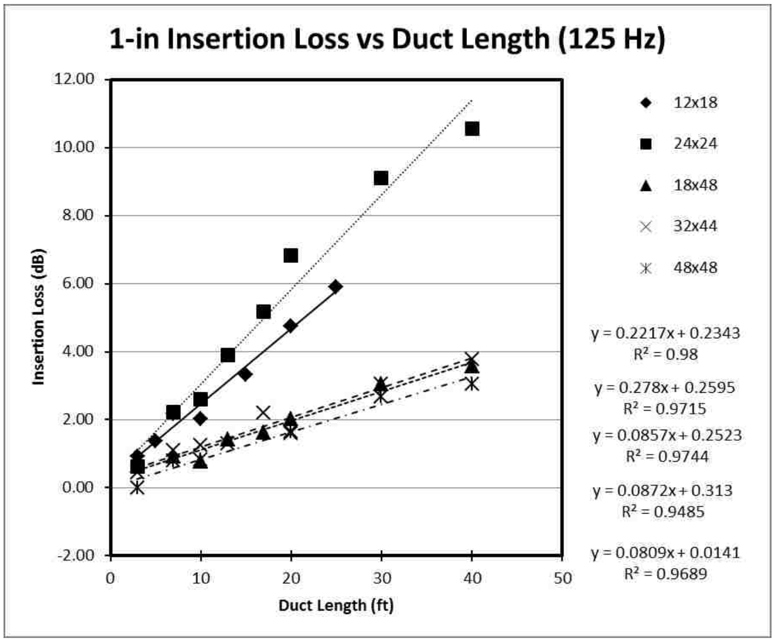

Figure A.18: 1-in Insertion Loss vs Duct Length at 125 Hz

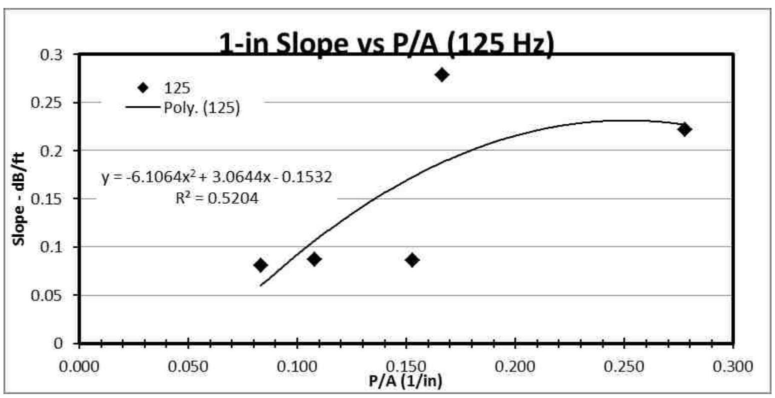

Figure A.19: 1-in Slope vs P/A at 125 Hz

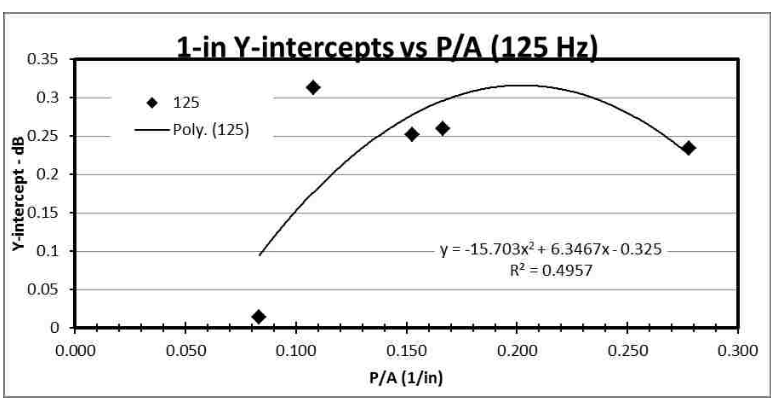

Figure A.20: 1-in Y-intercepts vs P/A at 125 Hz

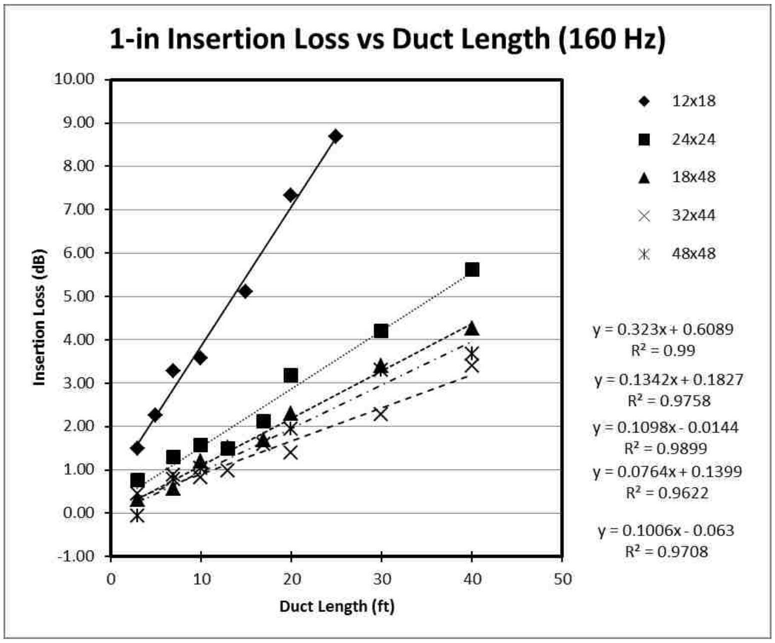

Figure A.21: 1-in Insertion Loss vs Duct Length at 160 Hz

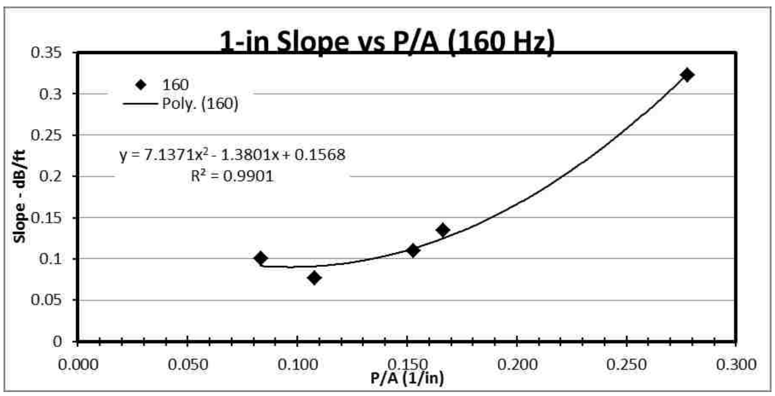

Figure A.22: 1-in Slope vs P/A at 160 Hz

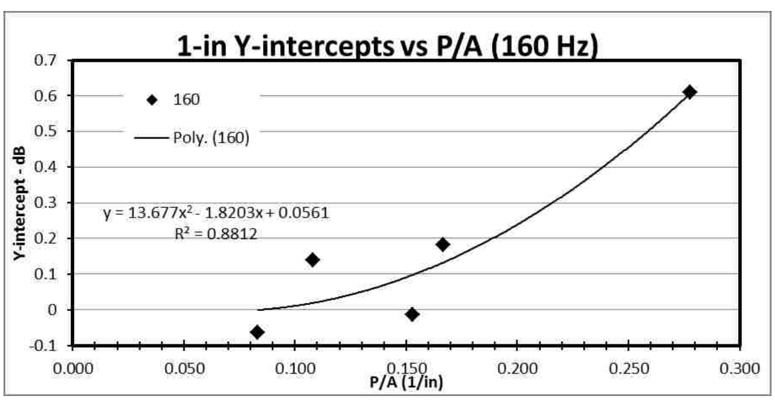

Figure A.23: 1-in Y-intercepts vs P/A at 160 Hz

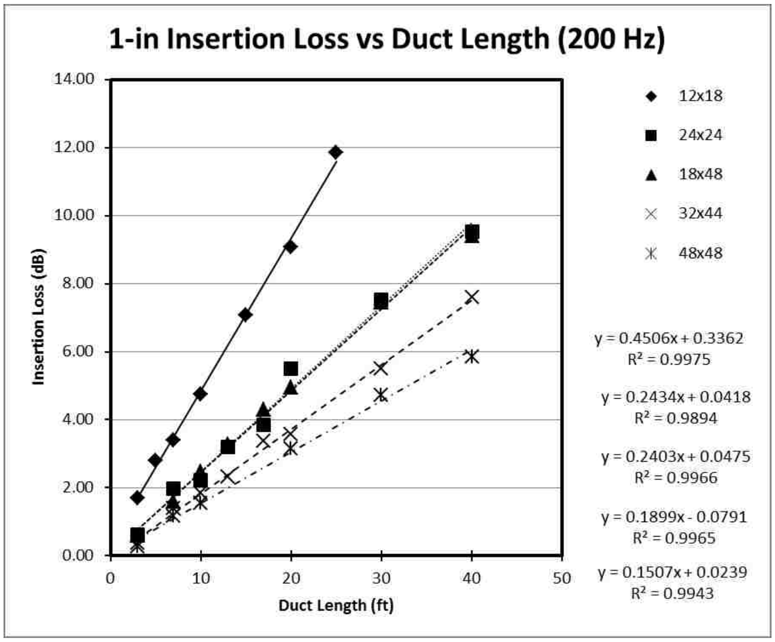

Figure A.24: 1-in Insertion Loss vs Duct Length at 200 Hz

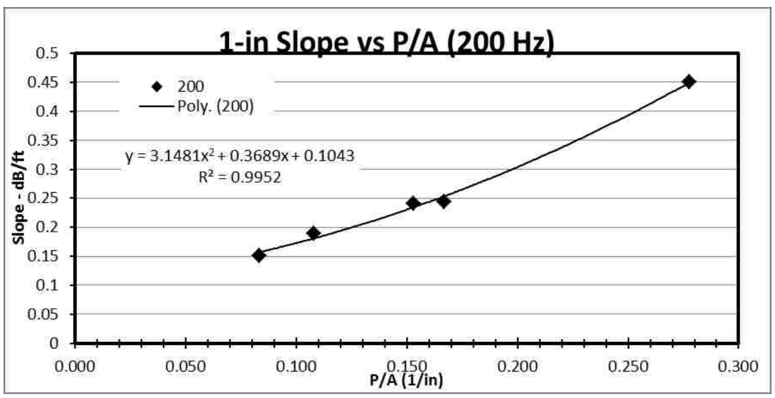

Figure A.25: 1-in Slope vs P/A at 200 Hz

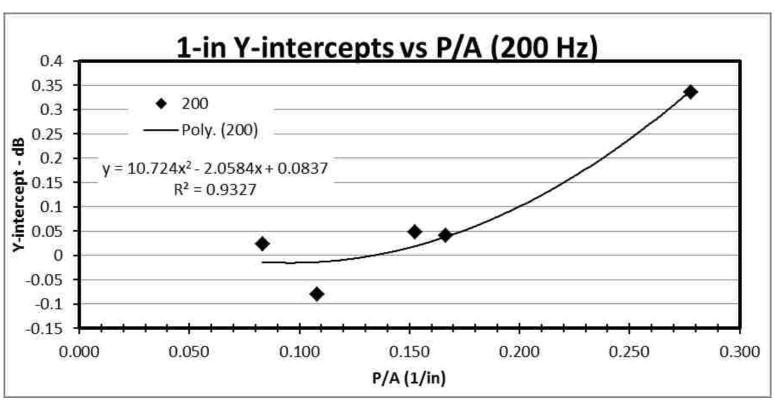

Figure A.26: 1-in Y-intercepts vs P/A at 200 Hz

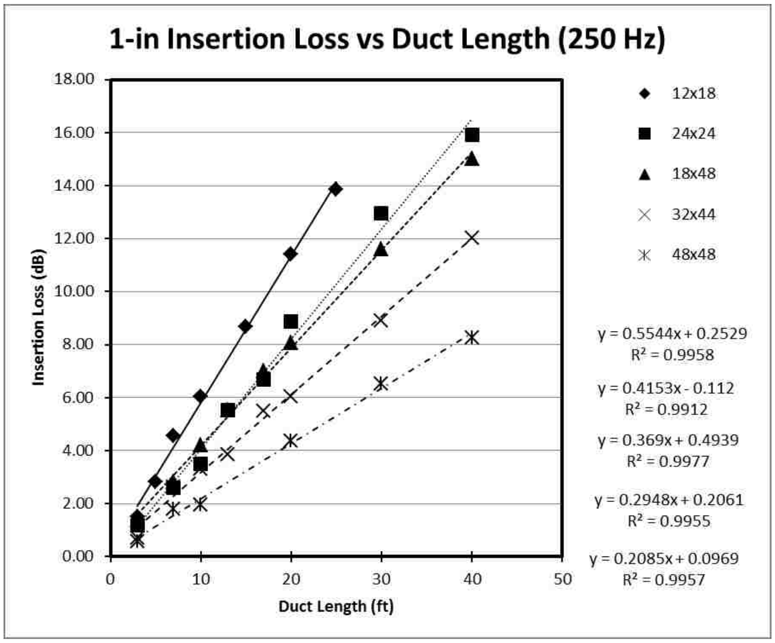

Figure A.27: 1-in Insertion Loss vs Duct Length at 250 Hz

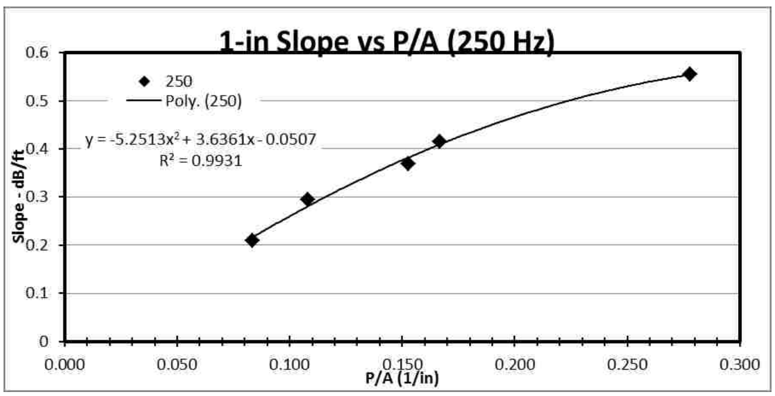

Figure A.28: 1-in Slope vs P/A at 250 Hz

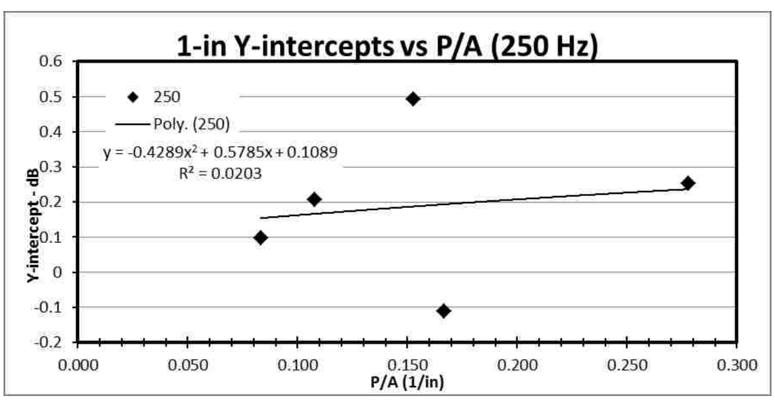

Figure A.29: 1-in Y-intercepts vs P/A at 250 Hz

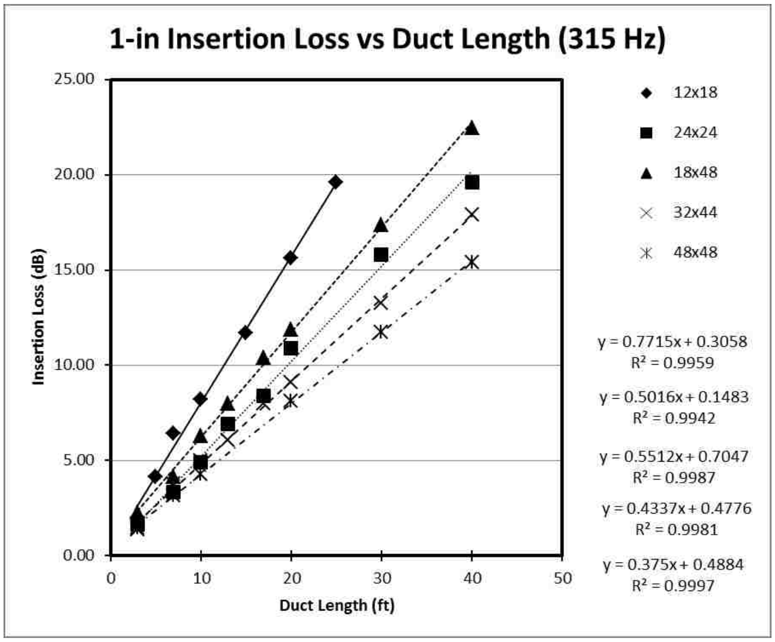

Figure A.30: 1-in Insertion Loss vs Duct Length at 315 Hz

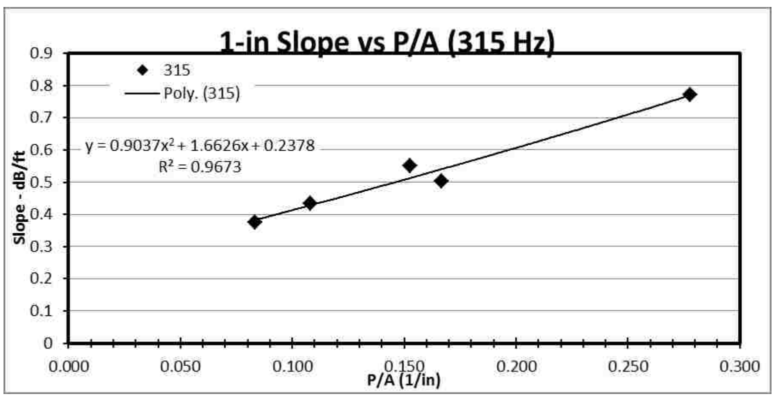

Figure A.31: 1-in Slope vs P/A at 315 Hz

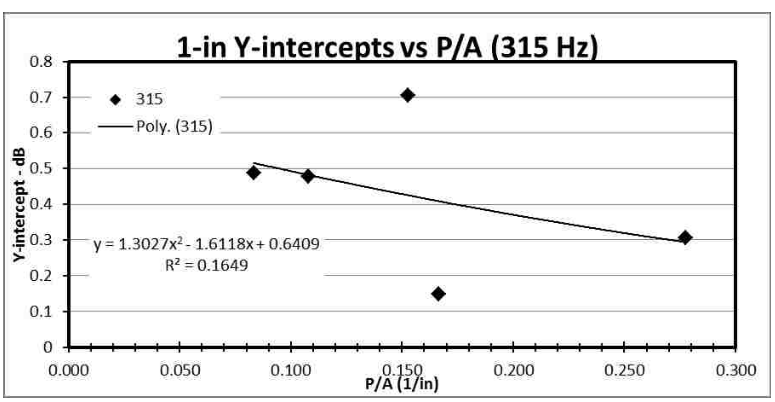

Figure A.32: 1-in Y-intercepts vs P/A at 315 Hz

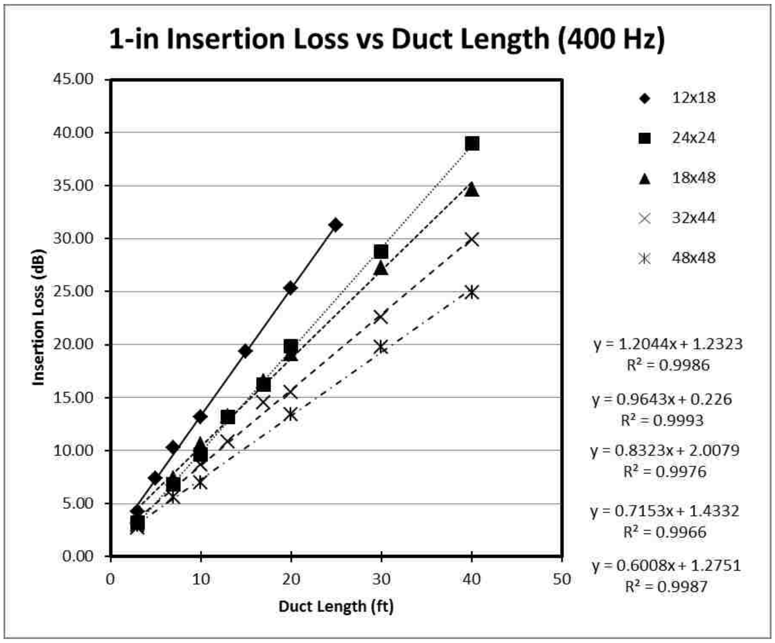

Figure A.33: 1-in Insertion Loss vs Duct Length at 400 Hz

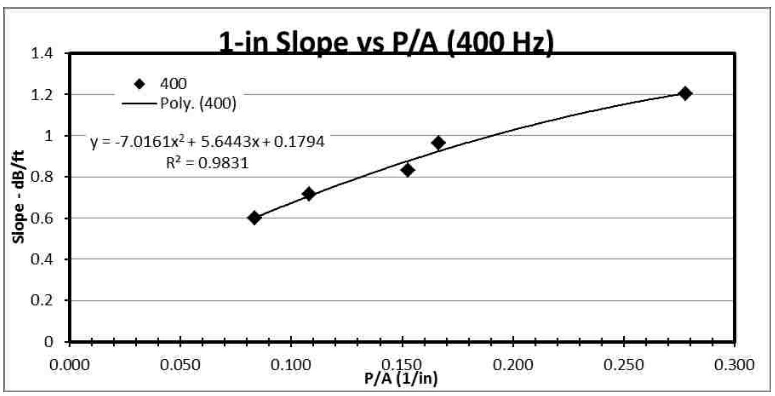

Figure A.34: 1-in Slope vs P/A at 400 Hz

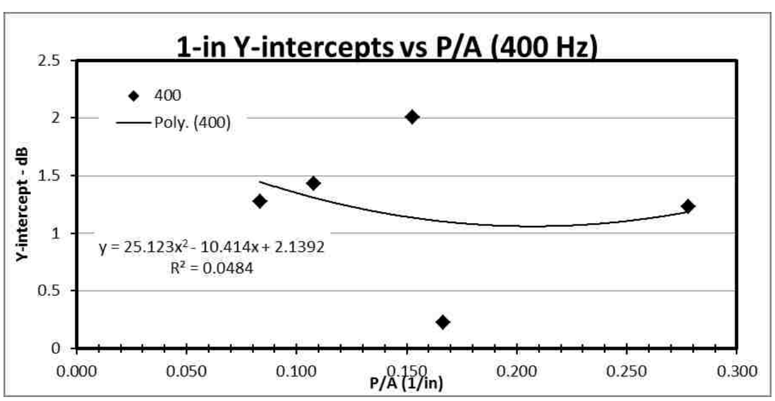

Figure A.35: 1-in Y-intercepts vs P/A at 400 Hz

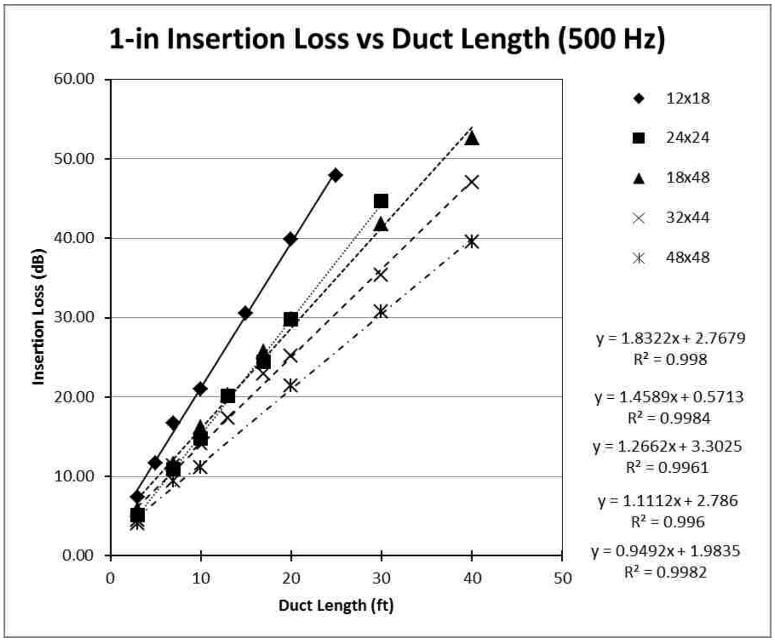

Figure A.36: 1-in Insertion Loss vs Duct Length at 500 Hz

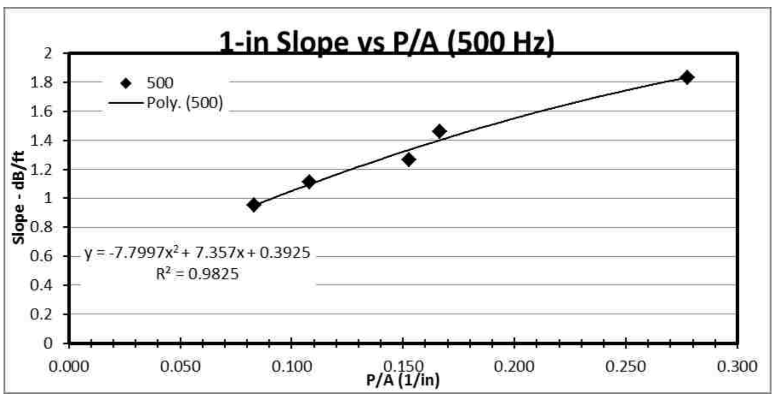

Figure A.37: 1-in Slope vs P/A at 500 Hz

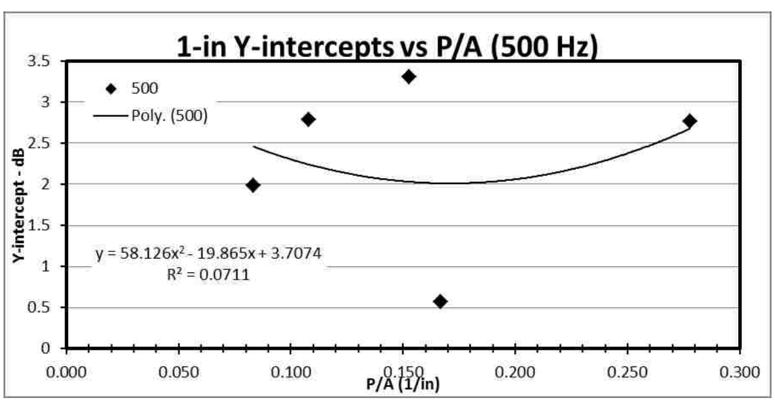

Figure A.38: 1-in Y-intercepts vs P/A at 500 Hz

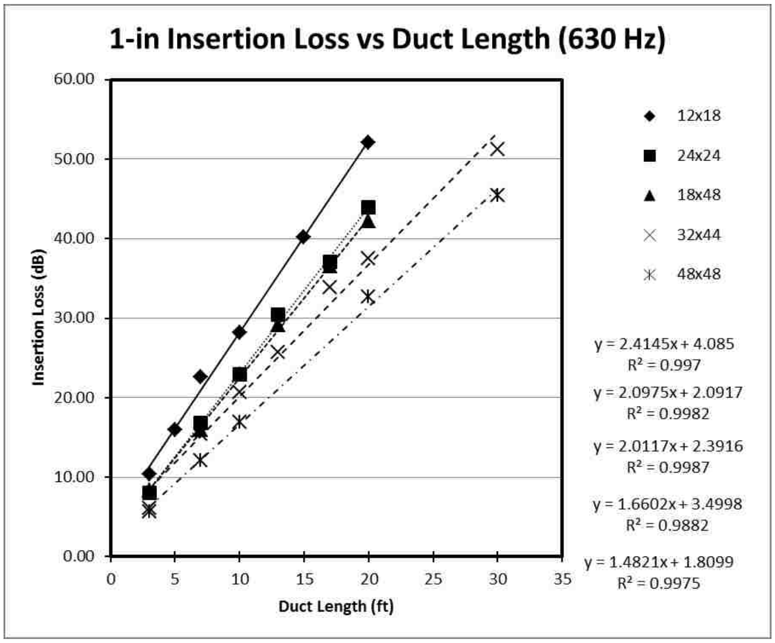

Figure A.39: 1-in Insertion Loss vs Duct Length at 630 Hz

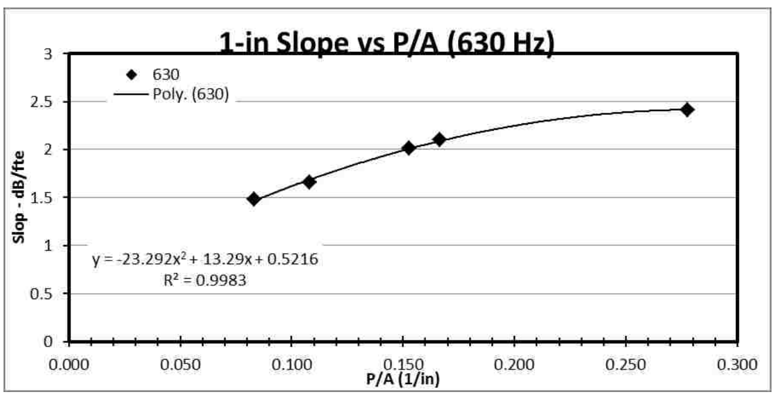

Figure A.40: 1-in Slope vs P/A at 630 Hz

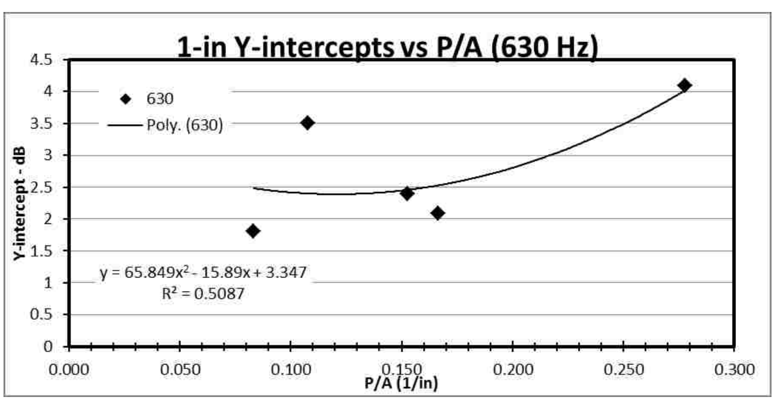

Figure A.41: 1-in Y-intercepts vs P/A at 630 Hz

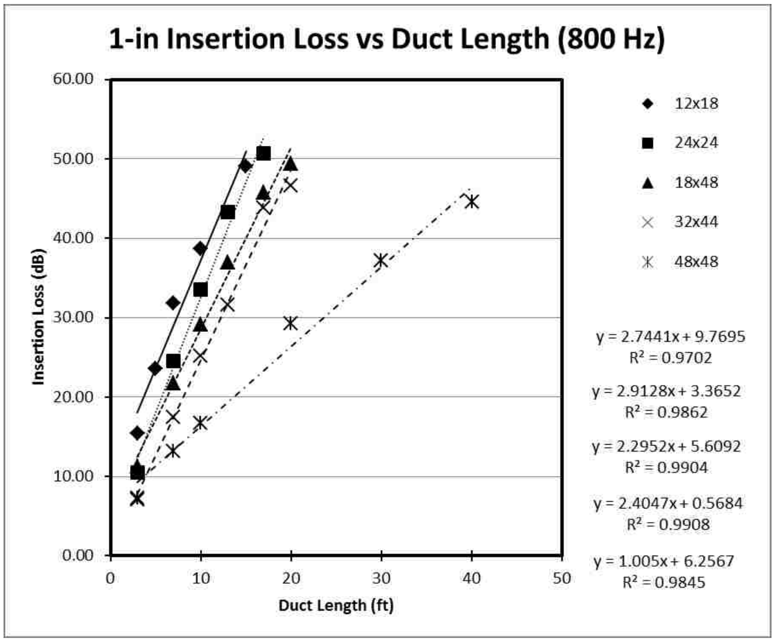

Figure A.42: 1-in Insertion Loss vs Duct Length at 800 Hz

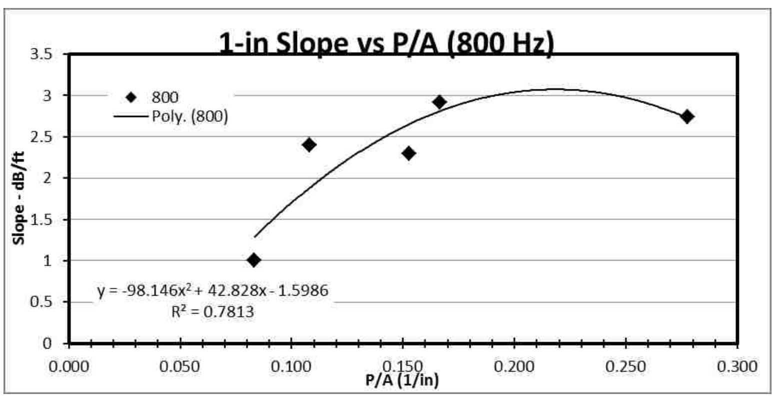

Figure A.43: 1-in Slope vs P/A at 800 Hz

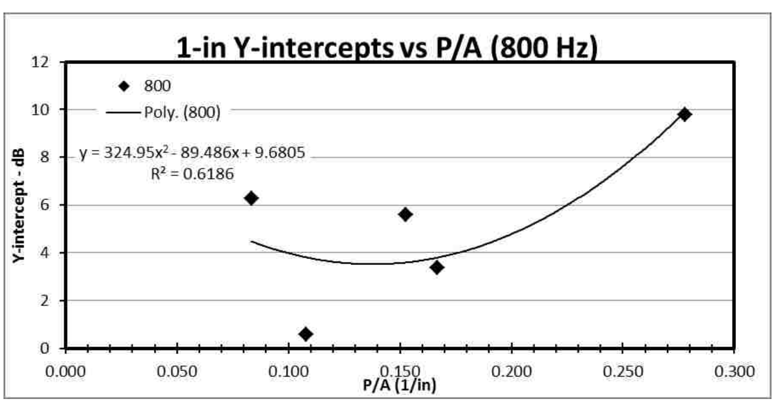

Figure A.44: 1-in Y-intercepts vs P/A at 800 Hz

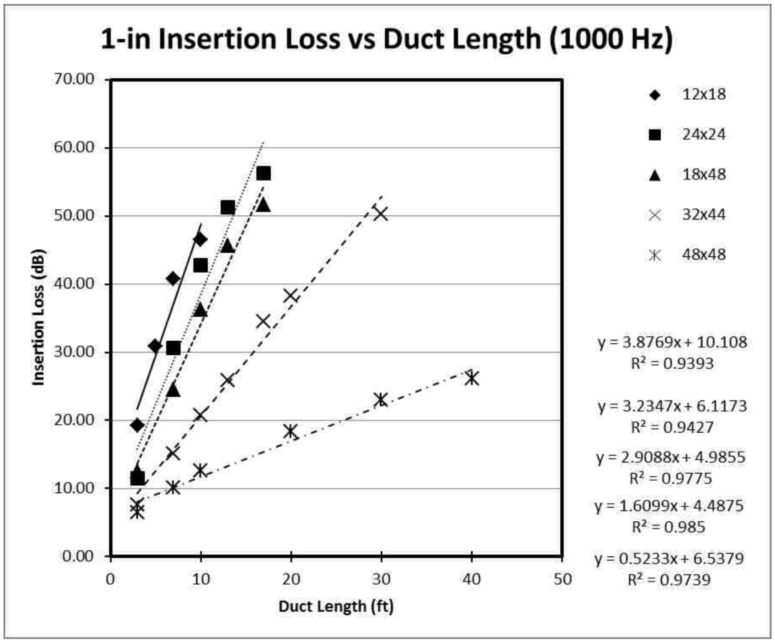

Figure A.45: 1-in Insertion Loss vs Duct Length at 1000 Hz

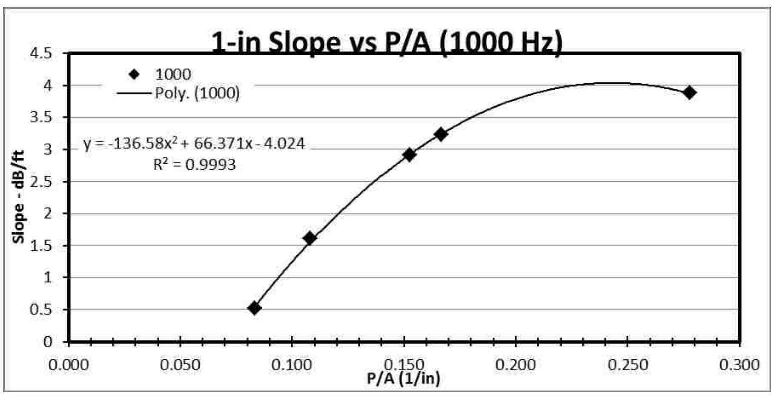

Figure A.46: 1-in Slope vs P/A at 1000 Hz

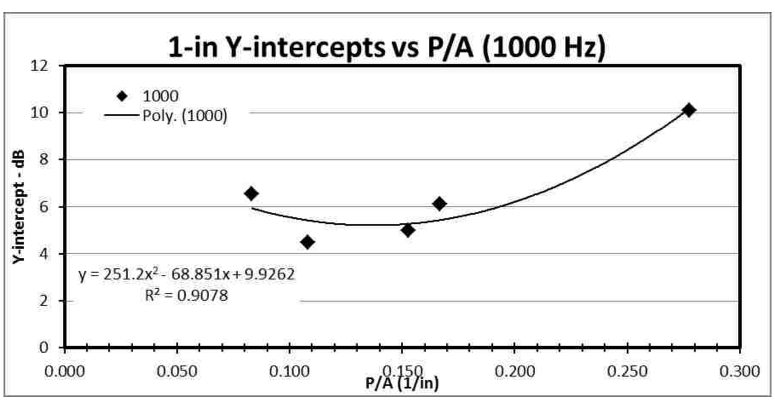

Figure A.47: 1-in Y-intercepts vs P/A at 1000 Hz

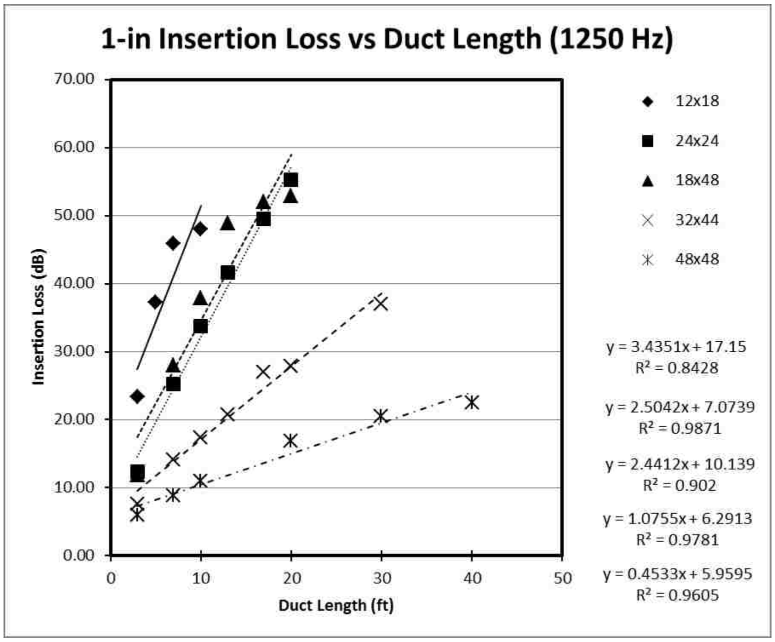

Figure A.48: 1-in Insertion Loss vs Duct Length at 1250 Hz

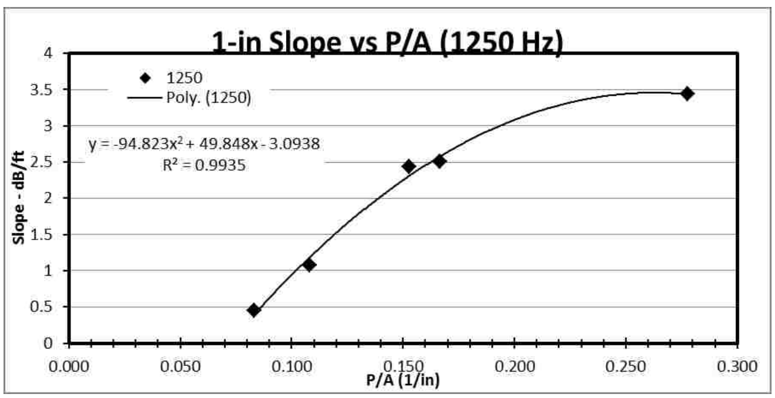

Figure A.49: 1-in Slope vs P/A at 1250 Hz

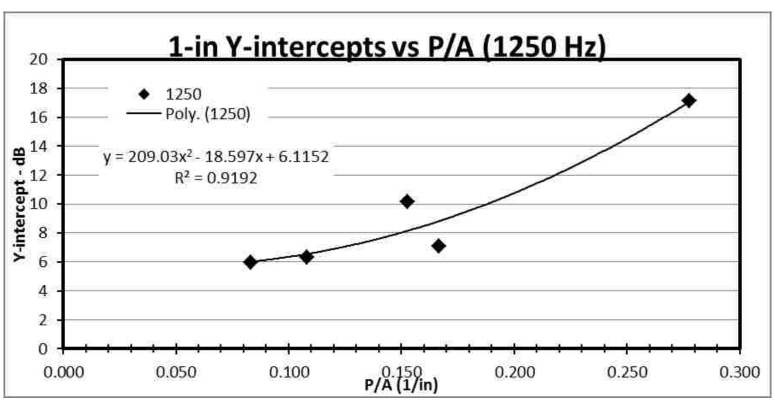

Figure A.50: 1-in Y-intercepts vs P/A at 1250 Hz

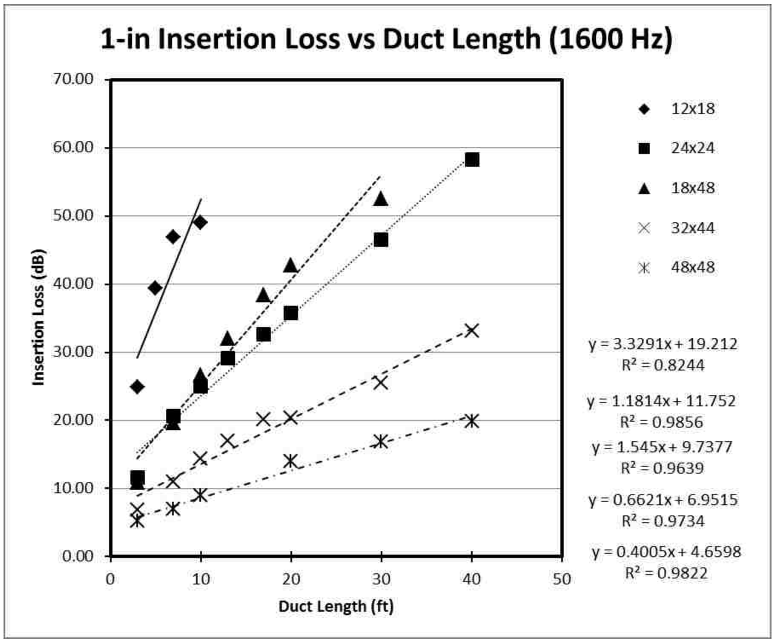

Figure A.51: 1-in Insertion Loss vs Duct Length at 1600 Hz

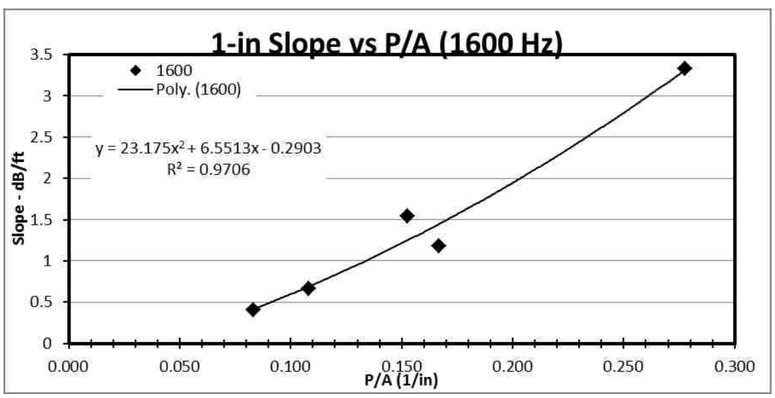

Figure A.52: 1-in Slope vs P/A at 1600 Hz

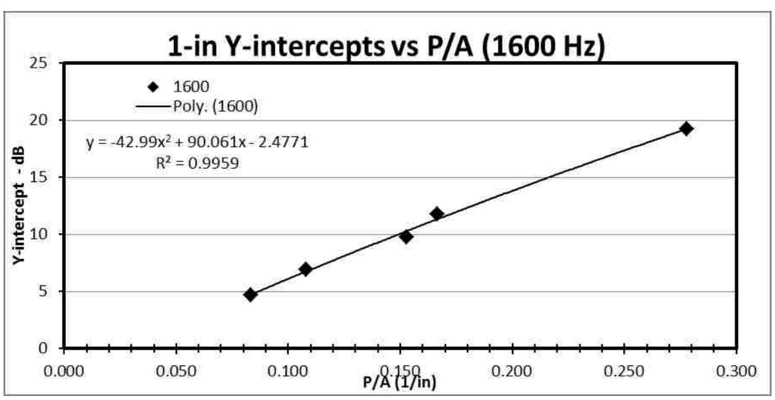

Figure A.53: 1-in Y-intercepts vs P/A at 1600 Hz

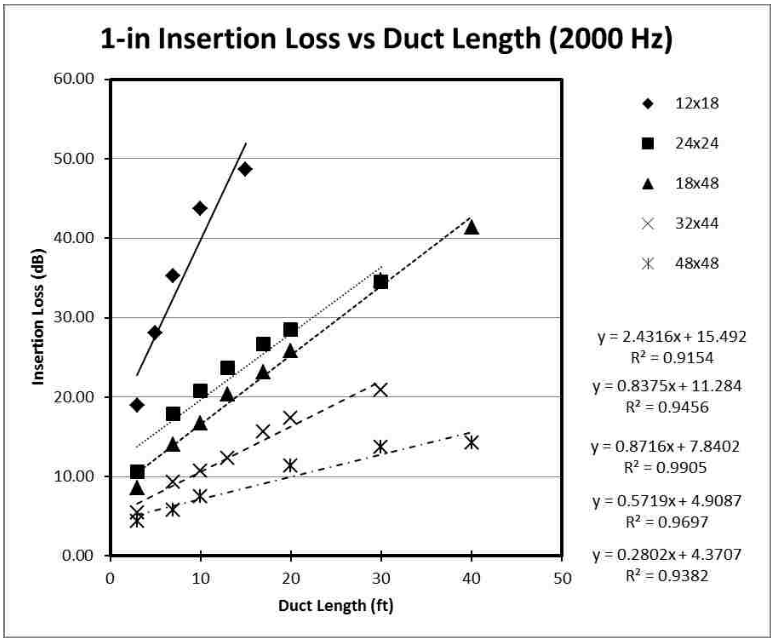

Figure A.54: 1-in Insertion Loss vs Duct Length at 2000 Hz

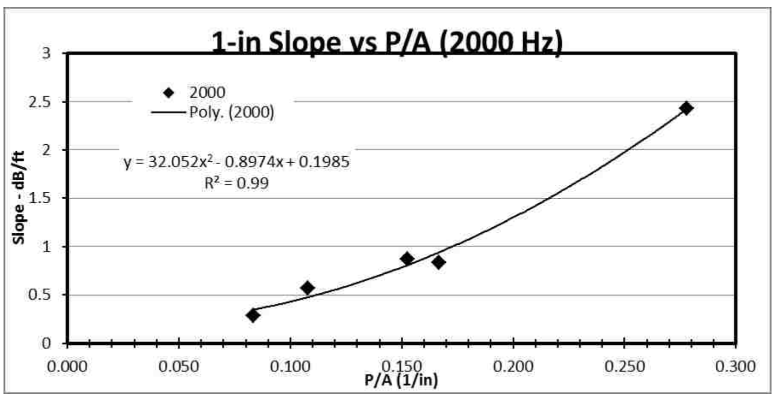

Figure A.55: 1-in Slope vs P/A at 2000 Hz

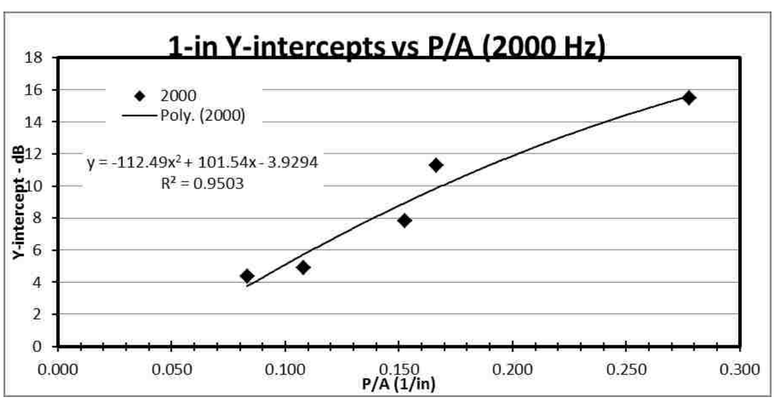

Figure A.56: 1-in Y-intercepts vs P/A at 2000 Hz

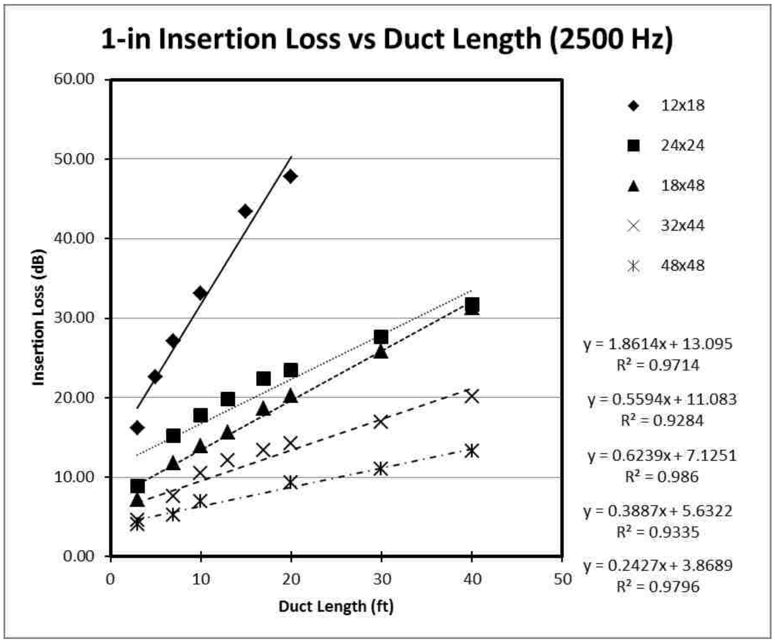

Figure A.57: 1-in Insertion Loss vs Duct Length at 2500 Hz

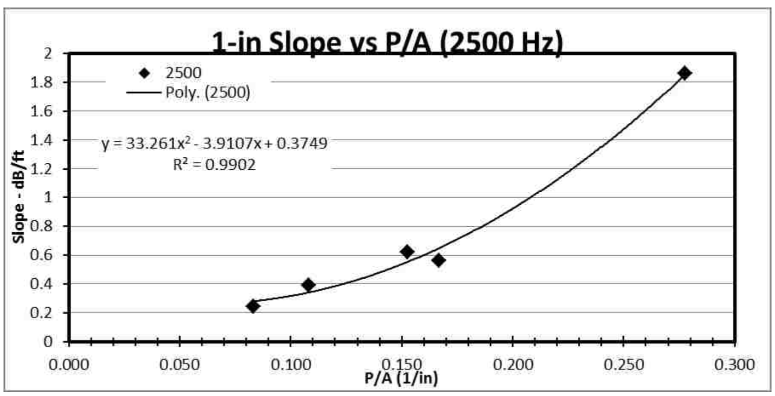

Figure A.58: 1-in Slope vs P/A at 2500 Hz

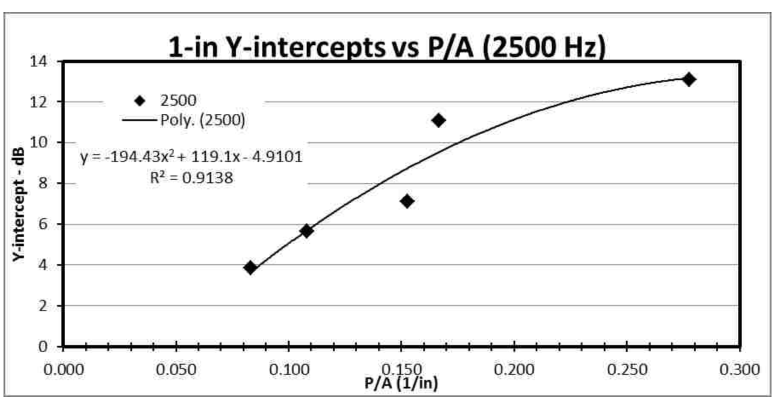

Figure A.59: 1-in Y-intercepts vs P/A at 2500 Hz

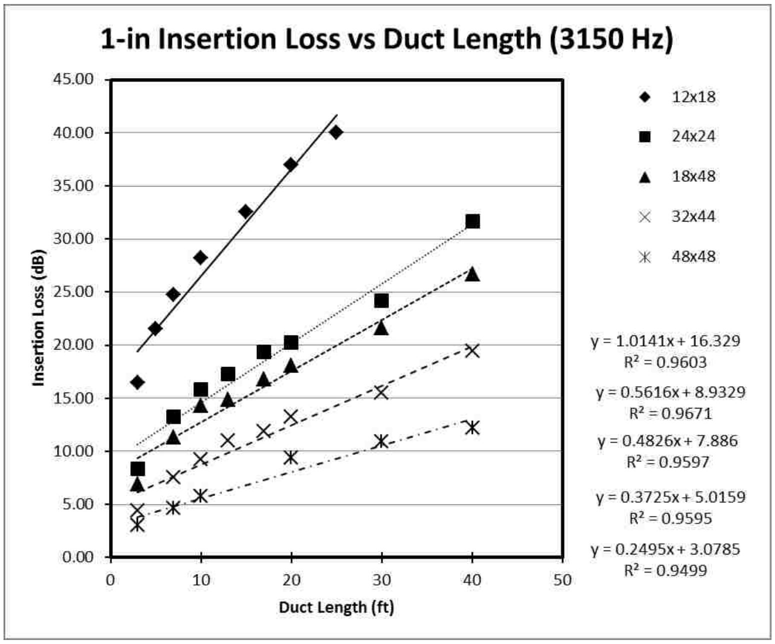

Figure A.60: 1-in Insertion Loss vs Duct Length at 3150 Hz

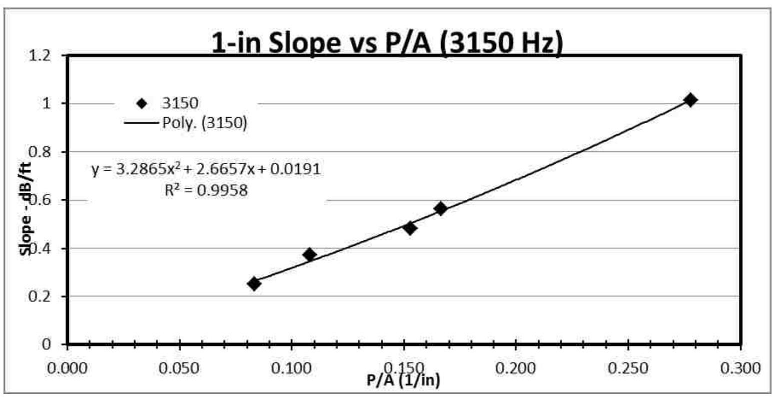

Figure A.61: 1-in Slope vs P/A at 3150 Hz

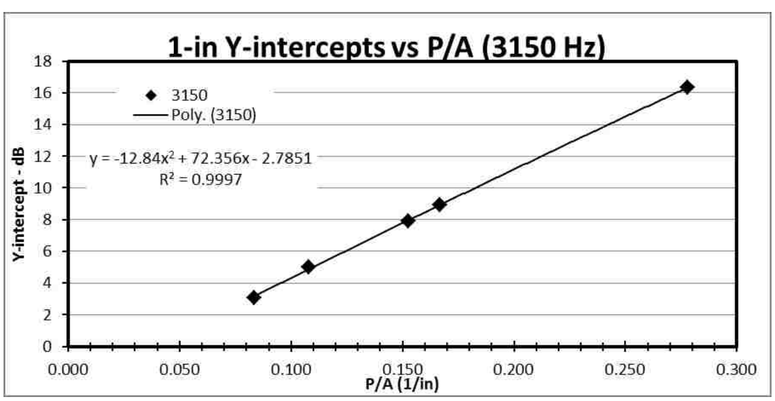

Figure A.62: 1-in Y-intercepts vs P/A at 3150 Hz

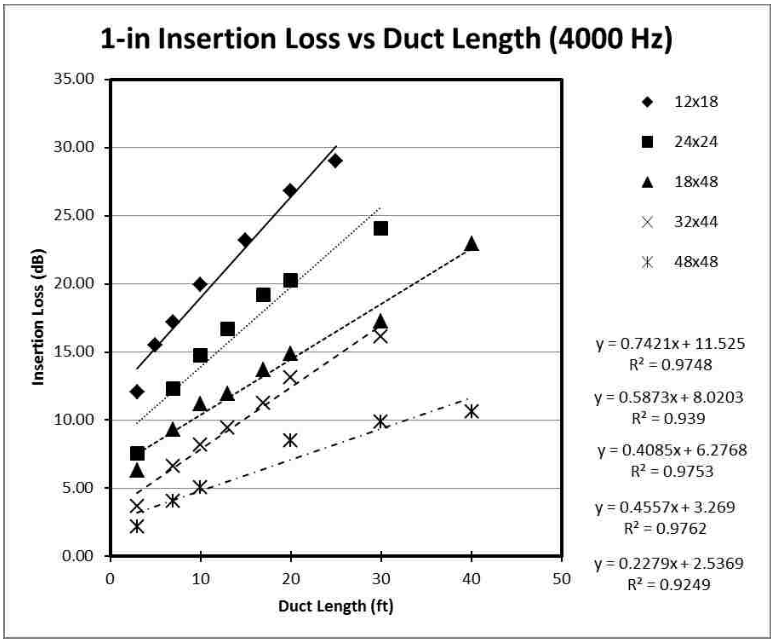

Figure A.63: 1-in Insertion Loss vs Duct Length at 4000 Hz

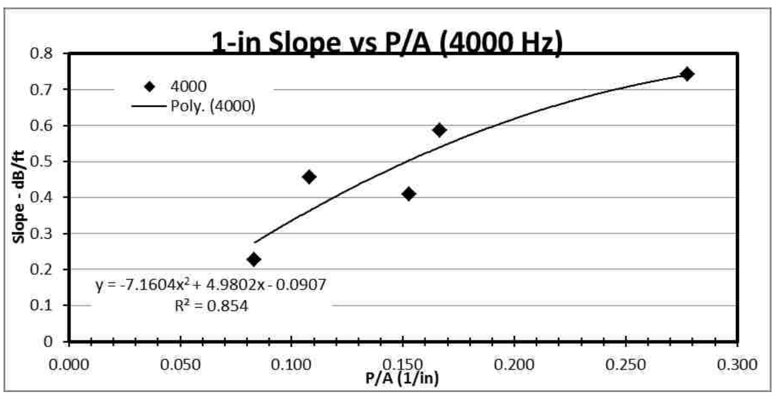

Figure A.64: 1-in Slope vs P/A at 4000 Hz

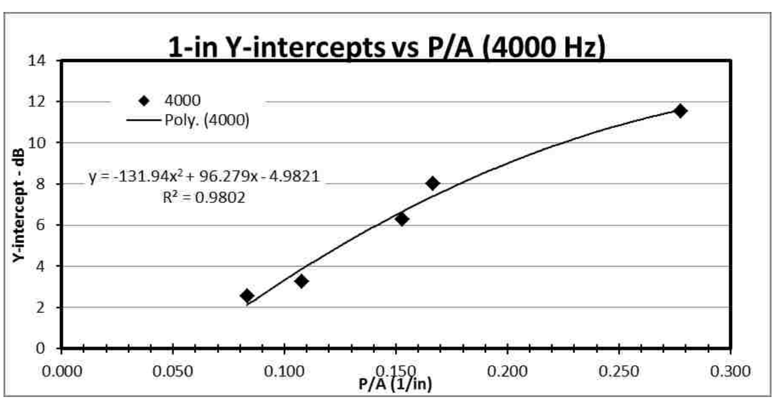

Figure A.65: 1-in Y-intercepts vs P/A at 4000 Hz

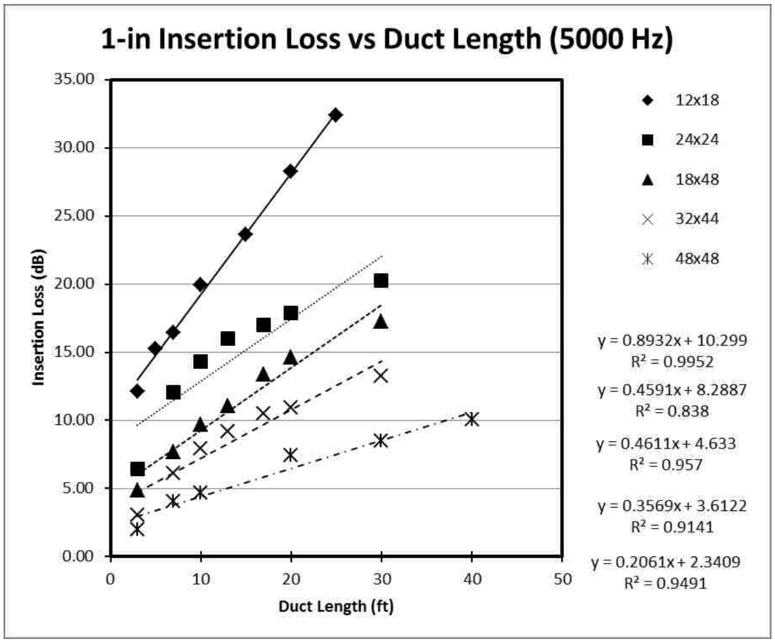

Figure A.66: 1-in Insertion Loss vs Duct Length at 5000 Hz

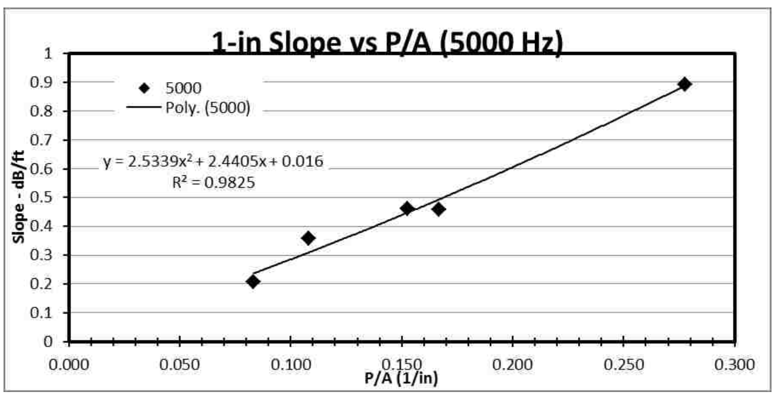

Figure A.67: 1-in Slope vs P/A at 5000 Hz

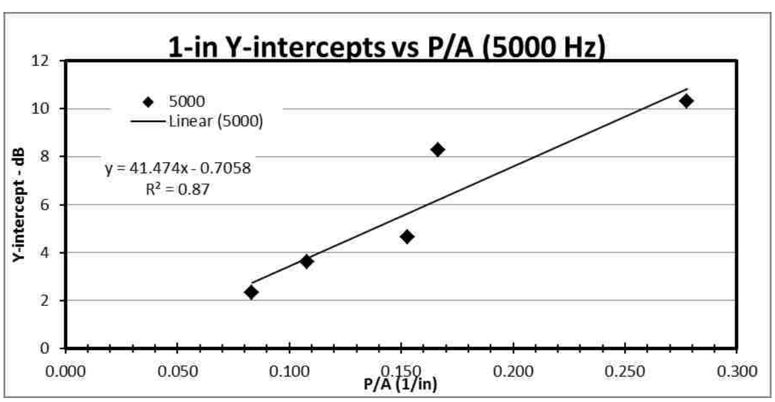

Figure A.68: 1-in Y-intercepts vs P/A at 5000 Hz

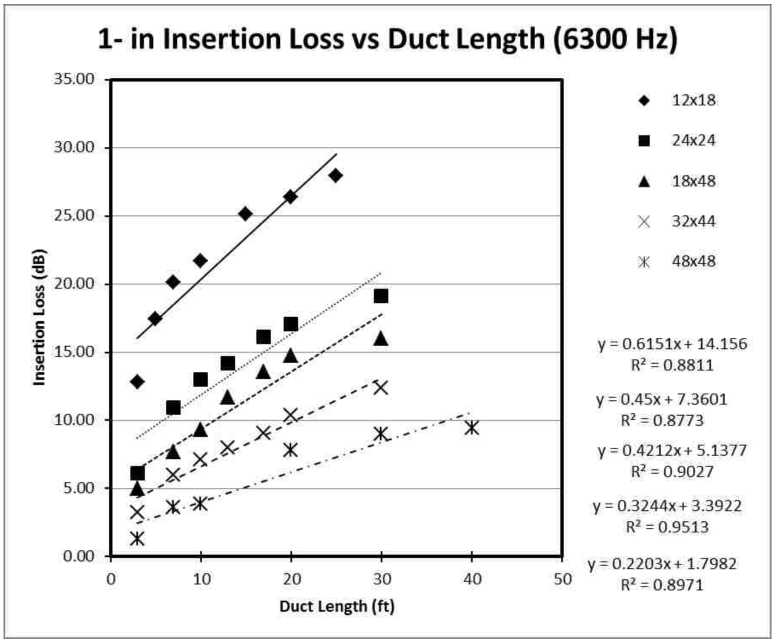

Figure A.69: 1-in Insertion Loss vs Duct Length at 6300 Hz

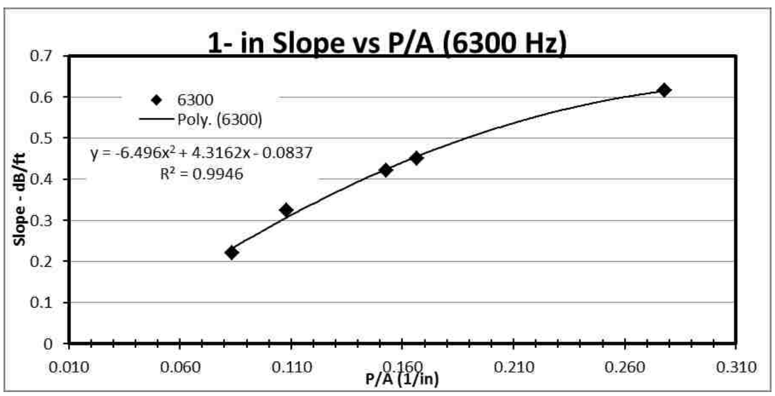

Figure A.70: 1-in Slope vs P/A at 6300 Hz

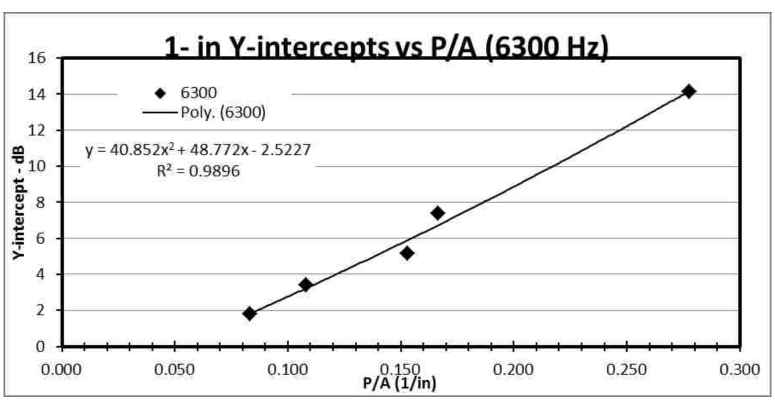

Figure A.71: 1-in Y-intercepts vs P/A at 6300 Hz

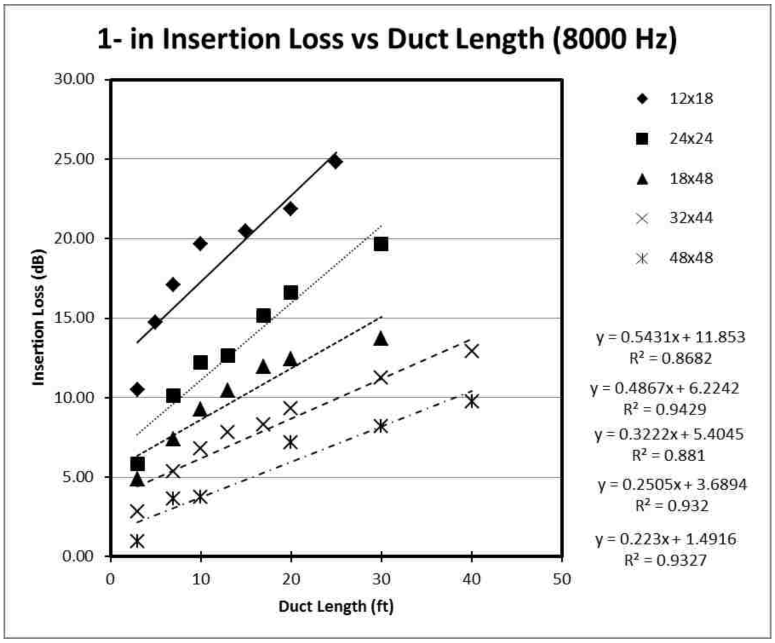

Figure A.72: 1-in Insertion Loss vs Duct Length at 8000 Hz

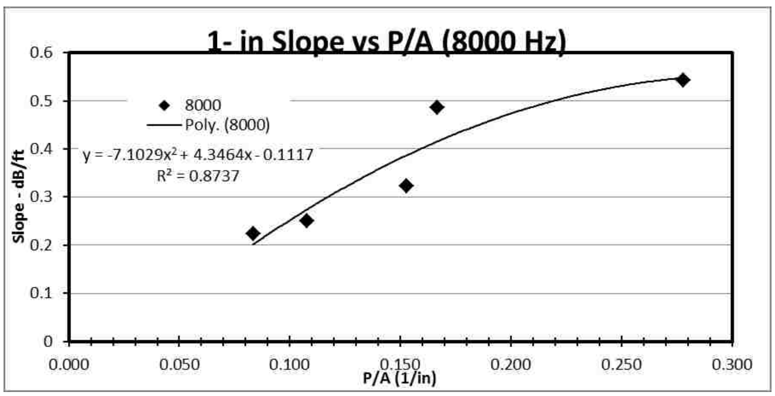

Figure A.73: 1-in Slope vs P/A at 8000 Hz

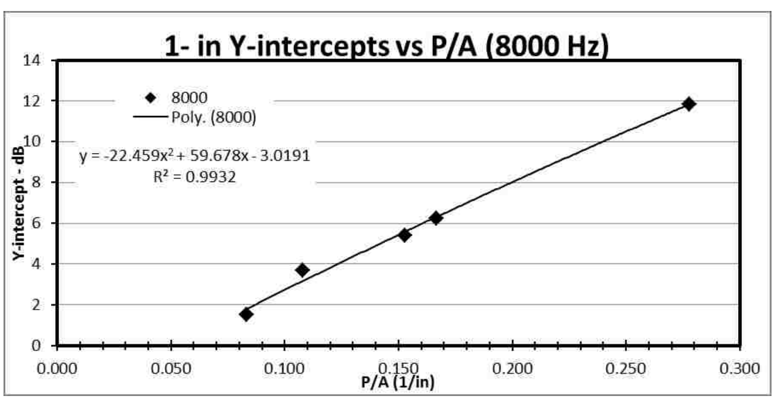

Figure A.74: 1-in Y-intercepts vs P/A at 8000 Hz

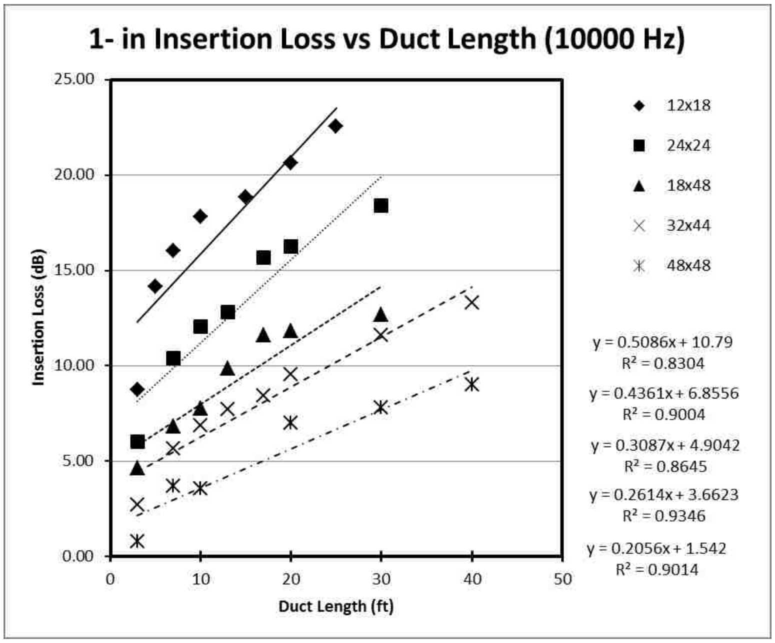

Figure A.75: 1-in Insertion Loss vs Duct Length at 10000 Hz

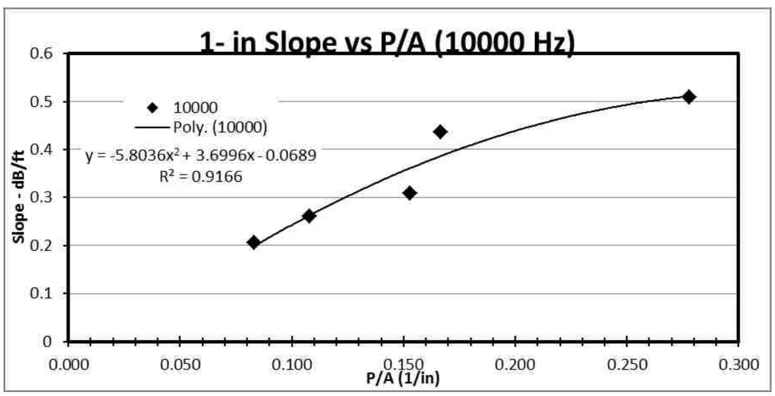

Figure A.76: 1-in Slope vs P/A at 10000 Hz

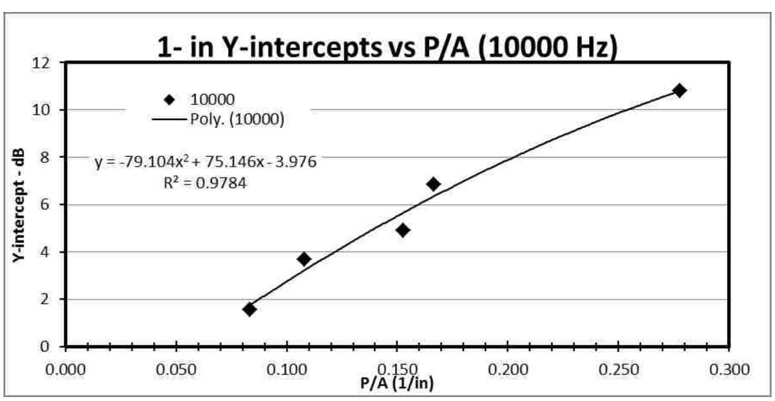

Figure A.77: 1-in Y-intercepts vs P/A at 10000 Hz

Duct Size - in x in		12x18	18x48	24x24	32x44	48x48	12x18	12x18	24x24	18x48	32x44	48x48	12x18	24x24	18x48	32x44	48x48	24x24	18x48	32x44	12x18	24x24	18x48	32x44	12x18	24x24	18x48	32x44	48x48	12x18	24x24	18x48	32x44	48x48	24x24	18x48	32x44	48x48			
Length -ft		3	3	3	3	3	5	7	7	7	7	7	10	10	10	10	10	13	13	13	15	17	17	17	20	20	20	20	20	25	30	30	30	30	40	40	40	40			
P/A - 1/in		0.278	0.153	0.167	0.108	0.083	0.278	0.278	0.167	0.153	0.108	0.083	0.278	0.167	0.153	0.108	0.083	0.167	0.153	0.108	0.278	0.167	0.153	0.108	0.278	0.167	0.153	0.108	0.083	0.278	0.167	0.153	0.108	0.083	0.167	0.153	0.108	0.083	AVG	STD	Freq
meas	50	-1.5	-0.2	-1.0	0.0	0.5	1.5	-2.3	1.2	0.0	1.2	-0.6	-6.3	-3.1	-0.5	0.6	0.5	-1.4	-0.9	1.1	1.5	4.4	0.1	1.7	-0.4	6.4	-1.3	0.3	0.6	-3.5	5.4	-1.6	0.9	0.5	3.7	-1.8	0.1	-0.4			50
regres	50	-1.2	-0.2	-0.3	0.3	0.6	-1.3	-1.4	-0.1	0.0	0.4	0.5	-1.5	0.1	0.2	0.4	0.4	0.3	0.4	0.5	-1.6	0.6	0.7	0.5	-1.8	0.8	0.9	0.6	0.1	-2.0	1.5	1.5	0.7	-0.2	2.2	2.1	0.8	-0.5			50
DIFF AVG		-0.3	0.0	-0.7	-0.4	-0.1	2.8	-0.9	1.3	0.0	0.8	-1.1	-4.8	-3.2	-0.7	0.2	0.1	-1.8	-1.3	0.7	3.1	3.8	-0.6	1.2	1.4	5.6	-2.2	-0.2	0.5	-1.5	3.9	-3.1	0.2	0.7	1.5	-3.9	-0.7	0.1	0.0	2.124	
meas	63	-3.0	0.2	0.3	-0.2	0.0	-1.8	-2.0	2.3	0.0	-0.8	0.3	-3.6	4.0	0.8	0.8	0.2	1.9	0.6	0.4	-3.9	2.5	0.3	-0.1	-4.5	0.9	0.0	0.7	-0.9	-9.7	5.9	0.0	-0.7	-0.7	11.4	0.5	0.5	0.0			63
regres	63	-1.5	0.2	0.1	0.1	-0.1	-2.0	-2.6	0.6	0.7	0.3	-0.2	-3.4	1.0	1.0	0.4	-0.4	1.3	1.4	0.6	-4.8	1.8	1.8	0.7	-6.2	2.1	2.2	0.9	-0.9	-7.5	3.3	3.4	1.3	-1.3	4.5	4.6	1.7	-1.8			63
DIFF AVG		-1.5	0.0	0.1	-0.3	0.1	0.3	0.6	1.7	-0.7	-1.1	0.5	-0.2	3.0	-0.2	0.4	0.5	0.6	-0.8	-0.1	0.9	0.7	-1.5	-0.8	1.6	-1.3	-2.2	-0.2	0.0	-2.2	2.6	-3.4	-1.9	0.7	6.8	-4.1	-1.2	1.9	0.0	1.886	
meas	80	-1.3	-0.1	-1.2	-0.2	-0.1	0.8	0.2	-1.3	-0.3	-0.3	-0.2	7.9	-3.2	0.2	-0.7	0.7	-1.7	0.3	-0.5	9.5	-2.6	-0.6	-0.3	6.1	-2.2	0.5	-1.1	0.7	10.4	-3.0	1.1	-1.9	1.0	-4.9	1.8	0.0	0.3			80
regres	80	0.3	-0.9	-0.9	-0.4	0.1	1.3	2.3	-1.0	-1.0	-0.4	0.3	3.7	-1.0	-1.0	-0.5	0.3	-1.0	-1.1	-0.5	6.2	-1.0	-1.2	-0.6	8.6	-1.0	-1.3	-0.7	0.6	11.0	-1.1	-1.5	-0.8	0.9	-1.2	-1.8	-1.0	1.2			80
DIFF AVG		-1.6	0.8	-0.3	0.2	-0.2	-0.4	-2.0	-0.4	0.7	0.2	-0.4	4.2	-2.2	1.3	-0.2	0.4	-0.7	1.4	0.0	3.4	-1.6	0.6	0.3	-2.5	-1.2	1.8	-0.4	0.0	-0.6	-1.9	2.7	-1.0	0.1	-3.7	3.6	1.0	-0.9	0.0	1.674	
meas	100	-1.5	0.1	0.1	0.0	0.0	-4.3	0.4	0.3	0.4	0.4	0.3	-3.4	0.4	0.6	0.4	0.3	-0.1	0.9	0.5	-5.1	0.3	1.2	0.5	-2.4	1.1	1.0	0.8	0.6	-3.3	-0.8	1.5	0.7	1.2	1.5	2.7	0.9	1.3			100
regres	100	-2.2	0.2	0.1	0.2	0.1	-2.3	-2.5	0.2	0.3	0.4	0.2	-2.6	0.3	0.4	0.5	0.3	0.4	0.6	0.6	-3.0	0.5	0.7	0.7	-3.3	0.6	0.8	0.8	0.5	-3.6	1.0	1.2	1.2	0.8	1.3	1.6	1.6	1.1			100
DIFF AVG		0.7	0.0	0.0	-0.2	-0.1	-1.9	2.9	0.1	0.1	0.0	0.1	-0.8	0.1	0.2	-0.1	0.0	-0.5	0.3	0.0	-2.1	-0.3	0.5	-0.2	0.9	0.5	0.2	-0.1	0.1	0.3	-1.8	0.3	-0.5	0.3	0.2	1.1	-0.7	0.2	0.0	0.842	
meas	125	0.9	0.7	0.6	0.4	0.0	1.4	2.2	2.2	0.9	1.1	0.8	2.0	2.6	0.8	1.2	0.8	3.9	1.4	1.3	3.3	5.2	1.6	2.2	4.7	6.8	2.0	1.6	1.7	5.9	9.1	3.0	3.0	2.7	10.6	3.6	3.8	3.0			125
regres	125	0.9	0.8	0.9	0.5	0.3	1.4	1.8	1.6	1.5	0.9	0.5	2.5	2.2	2.0	1.2	0.7	2.7	2.5	1.6	3.6	3.5	3.2	2.0	4.8	4.1	3.7	2.3	1.3	5.9	5.9	5.5	3.4	1.9	7.8	7.2	4.4	2.5			125
DIFF AVG		0.0	-0.1	-0.2	-0.1	-0.3	0.0	0.4	0.6	-0.6	0.2	0.3	-0.5	0.4	-1.2	0.0	0.1	1.2	-1.1	-0.3	-0.3	1.7	-1.6	0.2	0.0	2.8	-1.7	-0.7	0.4	0.0	3.2	-2.4	-0.3	0.8	2.7	-3.6	-0.7	0.6	0.0	1.293	
meas	160	1.5	0.3	0.8	0.4	-0.1	2.3	3.3	1.3	0.6	0.9	0.8	3.6	1.6	1.2	0.8	1.0	1.5	1.5	1.0	5.1	2.1	1.7	1.6	7.3	3.2	2.3	1.4	1.9	8.7	4.2	3.4	2.3	3.3	5.6	4.3	3.4	3.7			160
regres	160	1.6	0.4	0.5	0.3	0.3	2.2	2.9	1.0	0.9	0.7	0.6	3.8	1.4	1.2	0.9	0.9	1.8	1.6	1.2	5.5	2.3	2.0	1.6	7.1	2.6	2.3	1.8	1.8	8.7	3.9	3.5	2.7	2.7	5.1	4.6	3.7	3.7			160
DIFF AVG		-0.1	-0.1	0.3	0.2	-0.3	0.0	0.4	0.3	-0.3	0.2	0.1	-0.3	0.2	0.0	-0.1	0.1	-0.3	0.0	-0.2	-0.3	-0.1	-0.3	0.0	0.2	0.6	0.0	-0.4	0.1	0.0	0.3	-0.1	-0.5	0.6	0.5	-0.3	-0.3	0.0	0.0	0.278	
meas	200	1.7	0.6	0.6	0.4	0.3	2.8	3.4	2.0	1.6	1.4	1.2	4.8	2.2	2.5	1.9	1.5	3.2	3.3	2.3	7.1	3.8	4.3	3.4	9.1	5.5	4.9	3.6	3.2	11.9	7.5	7.5	5.5	4.7	9.5	9.4	7.6	5.9			200
regres	200	1.7	0.7	0.8	0.5	0.5	2.6	3.5	1.8	1.7	1.3	1.1	4.8	2.6	2.4	1.8	1.6	3.3	3.1	2.3	7.1	4.3	4.0	3.1	9.3	5.1	4.7	3.6	3.1	11.6	7.6	7.0	5.4	4.7	10.2	9.4	7.2	6.3			200
DIFF AVG		0.0	-0.1	-0.2	-0.2	-0.2	0.2	-0.1	0.2	-0.1	0.1	0.1	-0.1	-0.3	0.1	0.1	0.0	-0.1	0.2	0.0	0.0	-0.5	0.3	0.3	-0.3	0.4	0.2	0.0	0.0	0.3	-0.1	0.4	0.1	0.0	-0.6	0.0	0.4	-0.4	0.0	0.243	
meas	250	1.5	1.4	1.2	0.7	0.6	2.8	4.6	2.6	2.8	2.6	1.8	6.1	3.5	4.2	3.3	2.0	5.5	5.5	3.9	8.7	6.7	7.0	5.5	11.4	8.9	8.1	6.0	4.4	13.9	12.9	11.6	8.9	6.5	15.9	15.0	12.0	8.3			250
regres	250	1.9	1.3	1.4	1.0	0.8	3.0	4.1	3.1	2.9	2.1	1.7	5.8	4.3	4.0	3.0	2.3	5.5	5.2	3.8	8.5	7.2	6.7	4.9	11.3	8.4	7.8	5.8	4.5	14.1	12.5	11.7	8.6	6.6	16.6	15.5	11.4	8.8			250
DIFF AVG		-0.4	0.0	-0.2	-0.3	-0.2	-0.2	0.4	-0.5	0.0	0.5	0.1	0.3	-0.8	0.2	0.3	-0.4	0.0	0.4	0.1	0.1	-0.5	0.3	0.5	0.1	0.5	0.2	0.3	-0.1	-0.2	0.5	-0.1	0.3	-0.1	-0.7	-0.5	0.6	-0.5	0.0	0.368	
meas	315	2.0	2.3	1.6	1.4	1.5	4.1	6.4	3.3	4.1	3.8	3.1	8.2	4.9	6.3	5.0	4.3	6.9	8.0	6.1	11.7	8.4	10.4	8.0	15.6	10.9	11.9	9.1	8.1	19.6	15.8	17.4	13.3	11.8	19.6	22.5	17.9	15.4			315
regres	315	2.6	2.0	2.0	1.8	1.7	4.1	5.7	4.2	4.0	3.5	3.2	8.0	5.8	5.6	4.8	4.3	7.4	7.1	6.0	11.8	9.6	9.1	7.8	15.7	11.2	10.7	9.0	8.2	19.5	16.6	15.8	13.3	12.0	22.0	20.9	17.6	15.8			315
DIFF AVG		-0.6	0.3	-0.4	-0.4	-0.2	0.0	0.7	-0.8	0.1	0.3	0.0	0.2	-0.9	0.7	0.3	-0.1	-0.5	0.9	0.0	-0.2	-1.2	1.3	0.3	-0.1	-0.3	1.2	0.1	0.0	0.1	-0.8	1.6	-0.1	-0.2	-2.4	1.5	0.3	-0.4	0.0	0.764	
meas	400	4.2	3.8	3.2	2.7	3.0	7.4	10.3	6.9	7.4	6.8	5.6	13.2	9.6	10.6	8.7	7.0	13.2	13.3	10.8	19.3	16.3	16.5	14.5	25.3	19.9	19.1	15.5	13.4	31.2	28.8	27.2	22.6	19.8	39.0	34.6	29.9	24.9			400
regres	400	4.8	3.8	3.9	3.4	3.2	7.2	9.6	7.6	7.3	6.3	5.7	13.2	10.4	9.9	8.4	7.5	13.1	12.5	10.5	19.3	16.8	16.1	13.3	25.3	19.6	18.7	15.4	13.5	31.3	28.9	27.5	22.5	19.5	38.1	36.3	29.6	25.5			400
DIFF AVG		-0.6	0.0	-0.6	-0.7	-0.3	0.2	0.7	-0.7	0.1	0.5	0.0	0.0	-0.8	0.7	0.3	-0.4	0.1	0.7	0.3	0.1	-0.6	0.5	1.2	0.0	0.3	0.4	0.1	-0.1	-0.1	0.0	-0.3	0.1	0.3	0.9	-1.6	0.3	-0.6	0.0	0.546	
meas	500	7.4	5.8	5.2	4.5	4.1	11.7	16.7	11.0	11.6	11.3	9.4	21.0	14.8	16.2	14.2	11.2	20.1	20.3	17.4	30.5	24.4	25.7	22.9	39.8	29.8	29.8	25.1	21.4	48.0	44.7	41.8	35.4	30.8	47.2	52.6	47.1	39.5			500
regres	500	8.2	6.0	6.2	5.5	5.3	11.8	15.5	11.8	11.4	9.9	9.1	21.0	16.0	15.4	13.2	12.0	20.2	19.4	16.5	30.2	25.8	24.7	20.9	39.4	30.1	28.7	24.2	21.5	48.5	44.1	42.1	35.1	31.0	58.1	55.0	46.1	40.5			500
DIFF AVG		-0.8	-0.3	-1.0	-1.0	-1.2	-0.1	1.2	-0.9	0.2	1.4	0.3	0.0	-1.2	0.8	1.0	-0.8	-0.1	0.9	0.9	0.3	-1.5	1.0	2.0	0.5	-0.3	1.0	1.0	-0.1	-0.6	0.6	-0.2	0.3	-0.2	-10.9	-2.4	1.0	-1.0	-0.3	2.033	
meas	630	10.3	8.3	8.1	6.0	5.7	16.0	22.6	16.9	15.9	15.5	12.1	28.2	23.0	23.0	20.6	16.9	30.4	29.2	25.8	40.2	37.1	36.5	33.8	52.1	44.0	42.3	37.5	32.7	50.1	54.6	53.8	51.3	45.4	55.6	55.5	55.3	49.8			630
regres	630	11.3	8.5	8.8	7.5	6.9	16.1	20.9	17.2	16.5	14.2	12.8	28.2	23.4	22.5	19.2	17.2	29.7	28.6	24.3	40.3	38.1	36.6	31.0	52.3	44.3	42.6	36.1	31.8	55.0	55.0	55.0	52.9	46.5	55.0	55.0	55.0	55.0			630
DIFF AVG		-0.9	-0.1	-0.7	-1.4	-1.2	-0.1	1.6	-0.3	-0.6	1.3	-0.6	0.0	-0.5	0.4	1.4	-0.2	0.7	0.6	1.5	-0.1	-0.9	-0.1	2.8	-0.2	-0.4	-0.4	1.4	0.9	-4.9	-0.4	-1.2	-1.7	-1.1	0.6	0.5	0.3	-5.2	-0.2	1.505	
meas	800	15.4	11.2	10.4	7.1	7.3	23.6	31.8	24.5	21.8	17.4	13.2	38.7	33.6	29.2	25.1	16.7	43.3	37.0	31.6	49.1	50.6	45.8	43.8	47.1	52.0	49.4	46.6	29.3	47.4	53.3	51.3	52.4	37.1	53.4	51.6	52.7	44.5			800
REGRESS	800	18.1	11.6	12.2	9.5	8.3	23.5	29.0	23.5	22.2	17.0	13.5	37.1	31.9	30.1	22.6	17.4	40.4	38.1	28.3	50.8	51.6	48.7	35.8	55.0	55.0	55.0	41.4	30.3	55.0	55.0	55.0	55.0	43.1	55.0	55.0	55.0	55.0			800
DIFF AVG		-2.7	-0.3	-1.8	-2.3	-1.0	0.1	2.8	1.0	-0.4	0.5	-0.3	1.5	1.6	-1.0	2.5	-0.7	3.0	-1.1	3.4	-1.7	-1.0	-2.9	8.1	-7.9	-3.0	-5.6	5.2	-1.0	-7.6	-1.7	-3.7	-2.6	-6.0	-1.6	-3.4	-2.3	-10.5	-1.2	3.575	
meas	1000	19.2	12.5	11.5	7.6	6.5	30.9	40.7	30.6	24.5	15.1	10.1	46.5	42.7	36.2	20.7	12.7	51.3	45.6	25.9	48.2	56.2	51.6	34.5	49.1	53.7	53.1	38.2	18.4	48.7	53.9	53.1	50.3	23.0	53.9	53.8	54.3	26.1			1000
regres	1000	21.8	14.1	15.2	10.1	7.6	29.6	37.3	28.1	25.8	16.3	9.8	48.9	37.9	34.6	20.9	11.5	47.6	43.3	25.6	55.0	55.0	55.0	31.8	55.0	55.0	55.0	36.4	17.1	55.0	55.0	55.0	51.9	22.7	55.0	55.0	55.0	28.3			1000
DIFF AVG		-2.6	-1.6	-3.7	-2.5	-1.1	1.3	3.4	2.4	-1.3	-1.2	0.3	-2.4	4.8	1.7	-0.2	1.2	3.7	2.2	0.4	-6.8	1.2	-3.4	2.8	-5.9	-1.3	-1.9	1.8	1.3	-6.3	-1.1	-1.9	-1.6	0.3	-1.1	-1.2	-0.7	-2.1	-0.6	2.676	
meas	1250	23.4	11.9	12.3	7.6	6.0	37.2	45.9	25.2	28.1	14.1	8.9	48.0	33.8	37.9	17.4	10.9	41.7	48.9	20.8	48.6	49.5	52.1	27.0	48.9	55.2	52.9	27.8	16.9	48.6	54.4	53.0	37.0	20.4	54.7	53.8	45.6	22.5			1250
regres	1200	27.4	15.1	16.6	10.1	7.2	34.3	41.1	26.9	24.3	14.8	8.8	51.4	34.6	31.2	18.4	10.0	42.4	38.2	21.9	55.0	52.7	47.4	26.6	55.0	55.0	54.3	30.2	14.1	55.0	55.0	55.0	42.0	18.1	55.0	55.0	53.8	22.1			1200
DIFF AVG		-4.0	-3.2	-4.3	-2.5	-1.3	2.9	4.7	-1.7	3.7	-0.7	0.0		-0.8	6.6	-1.0	0.9	-0.7	10.7	-1.2	-6.4	-3.2	4.7	0.4	-6.1	0.2	-1.4	-2.4	2.8	-6.4	-0.6	-2.0	-5.0	2.4	-0.3	-1.2	-8.2	0.5	-0.7	3.858	
meas	1600	24.8	10.8	11.6	6.8	5.2	39.3	46.9	20.6	19.6	11.0	7.0	49.0	25.0	26.6	14.3	9.0	29.1	32.0	17.0	49.1	32.6	38.4	20.1	49.4	35.7	42.8	20.3	14.0	49.4	46.5	52.5	25.6	16.9	58.2	55.4	33.1	19.9			1600
regres	1600	29.2	14.0	15.7	8.8	6.0	35.8	42.4	21.5	19.0	11.6	7.6	52.4	25.8	22.8	13.6	8.9	30.1	26.5	15.7	55.0	35.9	31.6	18.4	55.0	40.2	35.3	20.5	13.1	55.0	54.7	47.8	27.4	17.2	55.0	55.0	34.2	21.4			1600
DIFF AVG		-4.4	-3.2	-4.0	-2.0	-0.8	3.5	4.5	-0.8	0.6	-0.5	-0.6	-3.4	-0.8	3.8	0.7	0.1	-1.0	5.5	1.3	-5.9	-3.3	6.8	1.7	-5.6	-4.5	7.5	-0.2	0.9	-5.6	-8.2	4.6	-1.8	-0.3	3.2	0.4	-1.1	-1.5	-0.4	3.651	
meas	2000	19.0	8.6	10.6	5.5	4.4	28.1	35.2	17.9	14.0	9.3	5.8	43.7	20.8	16.7	10.7	7.5	23.7	20.3	12.3	48.7	26.7	23.2	15.6	50.3	28.5	25.8	17.4	11.4	49.5	34.5	34.8	20.9	13.7	38.1	41.4	21.5	14.3			2000
regres	2000	22.9	11.4	12.7	7.1	4.8	27.7	32.6	16.4	14.6	9.0	6.2	39.8	19.3	17.1	10.5	7.2	22.1	19.5	11.9	51.9	25.8	22.7	13.8	55.0	28.7	25.1	15.2	10.7	55.0	38.0	33.2	20.0	14.1	47.4	41.3	24.7	17.6			2000
DIFF AVG		-3.9	-2.8	-2.1	-1.7	-0.4	0.3	2.7	1.4	-0.6	0.3	-0.4	3.9	1.5	-0.3	0.2	0.3	1.6	0.8	0.4	-3.2	0.9	0.5	1.8	-4.7	-0.1	0.6	2.2	0.7	-5.5	-3.5	1.5	0.9	-0.5	-9.3	0.0	-3.2	-3.3	-0.6	2.606	
meas	2500	16.2	7.1	8.9	4.6	4.0	22.7	27.1	15.3	11.8	7.6	5.3	33.1	17.8	13.9	10.5	6.9	19.9	15.7	12.0	43.4	22.4	18.6	13.4	47.8	23.4	20.2	14.3	9.3	48.8	27.7	25.8	17.0	11.1	31.8	31.3	20.1	13.3			2500
regres	2500	18.7	10.4	11.5	6.7	4.5	22.4	26.2	14.1	12.6	8.1	5.6	31.7	16.0	14.3	9.1	6.5	18.0	15.9	10.1	41.0	20.5	18.2	11.5	50.3	22.5	19.8	12.5	9.3	59.5	28.9	25.4	15.9	12.1	35.4	30.9	19.3	14.9			2500
DIFF AVG		-2.5	-3.3	-2.6	-2.1	-0.5	0.2	1.0	1.2	-0.9	-0.5	-0.3	1.3	1.7	-0.4	1.4	0.5	1.9	-0.3	1.9	2.4	1.8	0.5	2.0	-2.5	0.9	0.4	1.8	0.1	-10.8	-1.3	0.4	1.1	-1.0	-3.7	0.4	0.8	-1.6	-0.3	2.377	
meas	3150	16.5	6.9	8.3	4.4	3.0	21.5	24.7	13.3	11.4	7.6	4.6	28.2	15.8	14.3	9.3	5.8	17.2	14.9	11.0	32.6	19.4	16.8	11.9	37.0	20.2	18.1	13.3	9.4	40.0	24.2	21.6	15.5	10.9	31.6	26.7	19.5	12.2			3150
regres	3150	19.4	9.5	10.6	5.9	3.9	21.4	23.4	12.8	11.5	7.3	5.0	26.5	14.5	13.0	8.3	5.8	16.1	14.5	9.4	31.5	18.3	16.5	10.7	36.6	20.0	18.0	11.8	8.4	41.7	25.6	23.1	15.2	11.1	31.1	28.1	18.7	13.7			3150
DIFF AVG		-2.9	-2.6	-2.2	-1.5	-0.9	0.1	1.3	0.5	-0.1	0.3	-0.4	1.7	1.3	1.3	0.9	0.0	1.1	0.4	1.6	1.1	1.0	0.3	1.1	0.4	0.2	0.1	1.5	1.0	-1.6	-1.4	-1.5	0.2	-0.2	0.5	-1.4	0.8	-1.5	0.0	1.242	
meas	4000	12.1	6.3	7.6	3.7	2.2	15.5	17.2	12.3	9.3	6.6	4.1	20.0	14.8	11.2	8.2	5.0	16.7	11.9	9.5	23.2	19.2	13.7	11.2	26.8	20.3	14.9	13.1	8.5	29.0	24.1	17.2	16.1	9.8	23.7	22.9	17.1	10.6			4000
regres	4000	13.8	8.2	9.0	5.0	2.9	15.3	16.8	11.2	10.2	6.4	4.0	19.0	12.8	11.7	7.5	4.9	14.4	13.2	8.6	22.7	16.6	15.2	10.1	26.4	18.2	16.7	11.1	7.6	30.1	23.6	21.7	14.8	10.4	29.0	26.8	18.4	13.1			4000
DIFF AVG		-1.7	-1.9	-1.4	-1.3	-0.7	0.2	0.4	1.1	-0.9	0.2	0.0	1.0	2.0	-0.5	0.7	0.2	2.2	-1.3	0.9	0.5	2.6	-1.5	1.2	0.4	2.1	-1.8	2.0	0.9	-1.1	0.5	-4.5	1.4	-0.5	-5.3	-3.8	-1.3	-2.5	-0.3	1.832	
meas	5000	12.2	4.8	6.5	3.1	2.0	15.3	16.4	12.1	7.7	6.1	4.1	20.0	14.3	9.7	7.9	4.7	16.0	11.1	9.2	23.6	17.0	13.4	10.5	28.2	17.9	14.6	11.0	7.4	32.4	20.3	17.3	13.2	8.5	17.6	17.2	12.9	10.1			5000
regres	5000	13.0	7.5	8.3	4.6	2.8	14.8	16.6	10.3	9.3	5.9	3.8	19.3	11.8	10.6	6.8	4.5	13.2	12.0	7.7	23.7	15.2	13.8	8.9	28.2	16.7	15.1	9.9	6.9	32.6	21.6	19.6	13.0	9.2	26.5	24.1	16.1	11.6			5000
DIFF AVG		-0.9	-2.7	-1.8	-1.5	-0.9	0.4	-0.2	1.8	-1.6	0.3	0.3	0.7	2.5	-1.0	1.1	0.2	2.8	-0.9	1.4	-0.1	1.8	-0.4	1.5	0.1	1.2	-0.5	1.1	0.6	-0.2	-1.4	-2.3	0.3	-0.7	-8.9	-6.9	-3.1	-1.5	-0.5	2.273	
meas	6300	12.8	5.0	6.1	3.2	1.3	17.4	20.1	10.9	7.7	6.0	3.6	21.7	13.0	9.3	7.1	3.8	14.2	11.7	8.0	25.1	16.1	13.6	9.1	26.4	17.0	14.8	10.4	7.8	27.9	19.1	16.0	12.4	9.0	19.8	13.3	12.8	9.4			6300
regres	6300	16.0	7.2	8.1	4.1	2.5	17.2	18.5	9.9	8.9	5.4	3.4	20.3	11.3	10.1	6.3	4.1	12.7	11.4	7.2	23.4	14.5	13.1	8.4	26.5	15.8	14.4	9.4	6.4	29.5	20.4	18.6	12.4	8.8	25.0	22.8	15.5	11.1			6300
DIFF AVG		-3.2	-2.1	-2.0	-0.9	-1.2	0.2	1.6	1.0	-1.2	0.6	0.2	1.3	1.7	-0.8	0.9	-0.3	1.5	0.3	0.8	1.7	1.6	0.5	0.6	-0.1	1.2	0.4	1.0	1.4	-1.6	-1.3	-2.6	0.0	0.3	-5.2	-9.6	-2.7	-1.6	-0.5	2.221	
meas	8000	10.5	4.8	5.8	2.8	1.0	14.8	17.1	10.1	7.4	5.3	3.6	19.7	12.2	9.3	6.8	3.7	12.6	10.5	7.8	20.5	15.2	11.9	8.3	21.9	16.6	12.4	9.3	7.2	24.8	19.7	13.7	11.3	8.2	18.4	12.6	12.9	9.8			8000
regres	8000	13.5	6.7	7.5	4.0	2.4	14.6	15.7	9.2	8.3	5.1	3.2	17.3	10.5	9.4	5.9	3.8	11.7	10.6	6.7	20.0	13.4	12.1	7.8	22.8	14.6	13.3	8.7	5.8	25.5	18.8	17.2	11.4	7.8	22.9	21.0	14.2	9.8			8000
DIFF AVG		-3.0	-1.9	-1.7	-1.2	-1.4	0.2	1.4	0.9	-0.9	0.2	0.4	2.4	1.7	-0.2	0.9	-0.1	0.9	-0.1	1.1	0.4	1.8	-0.2	0.5	-0.9	2.0	-0.9	0.6	1.4	-0.7	0.9	-3.5	-0.1	0.4	-4.5	-8.4	-1.2	-0.1	-0.3	2.027	
meas	10000	8.8	4.6	6.0	2.7	0.8	14.1	16.0	10.4	6.8	5.7	3.7	17.8	12.0	7.7	6.9	3.6	12.8	9.9	7.7	18.8	15.7	11.6	8.4	20.6	16.2	11.8	9.6	7.0	22.5	18.4	12.7	11.6	7.8	19.2	13.6	13.3	9.0			10000
regres	10000	12.3	6.7	7.5	4.0	2.3	13.3	14.4	9.1	8.2	5.1	3.1	15.9	10.2	9.3	5.8	3.7	11.4	10.3	6.6	18.5	12.9	11.8	7.7	21.0	14.1	12.9	8.5	5.7	23.6	17.9	16.5	11.1	7.7	21.8	20.1	13.7	9.7			10000
DIFF AVG		-3.6	-2.1	-1.5	-1.3	-1.6	0.8	1.7	1.3	-1.4	0.6	0.6	1.9	1.8	-1.5	1.0	-0.1	1.4	-0.5	1.1	0.4	2.8	-0.2	0.7	-0.4	2.2	-1.1	1.1	1.3	-1.0	0.5	-3.8	0.5	0.1	-2.6	-6.5	-0.4	-0.7	-0.2	1.872	

(shaded cell) Flanking Insertion Loss Reached

meas - Measured IL Values

Regress - Calculated IL Values from Regression Equat

DIF AVG - Calculation of the average of the differneces between measured and calculated IL values

STD - Calculation of the standard deviation relative to the DIFF AVG

Figure A.78: Data Comparison for 1-in Rectangular Ducts

APPENDIX B E.H. PRICE DATA FOR 2-IN RECTANGULAR DUCTS

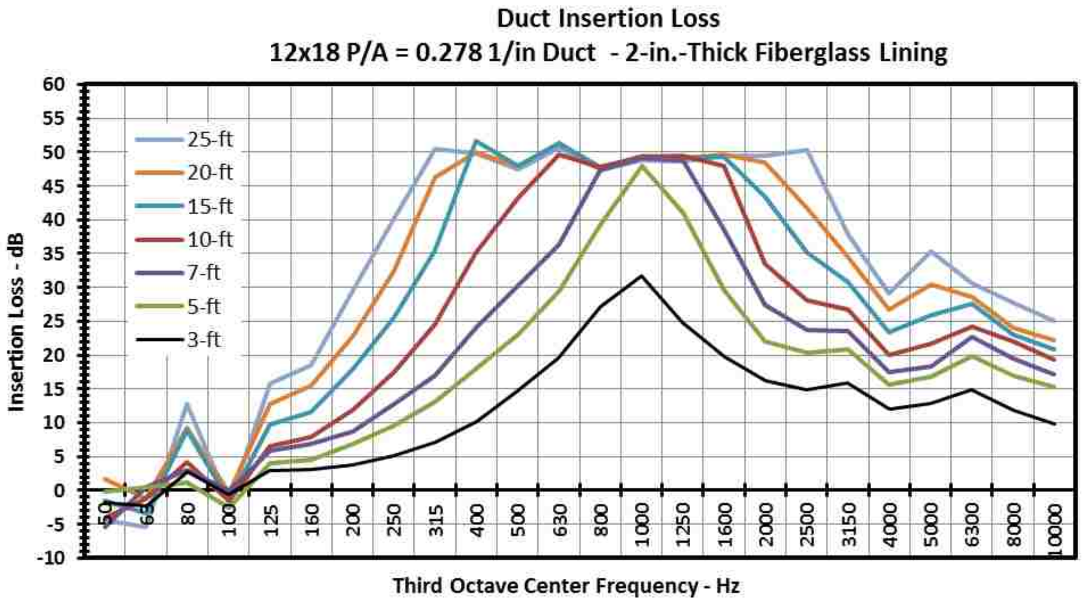

Figure B.1: Insertion Loss for 12x18 ducts with 2-in Fiberglass

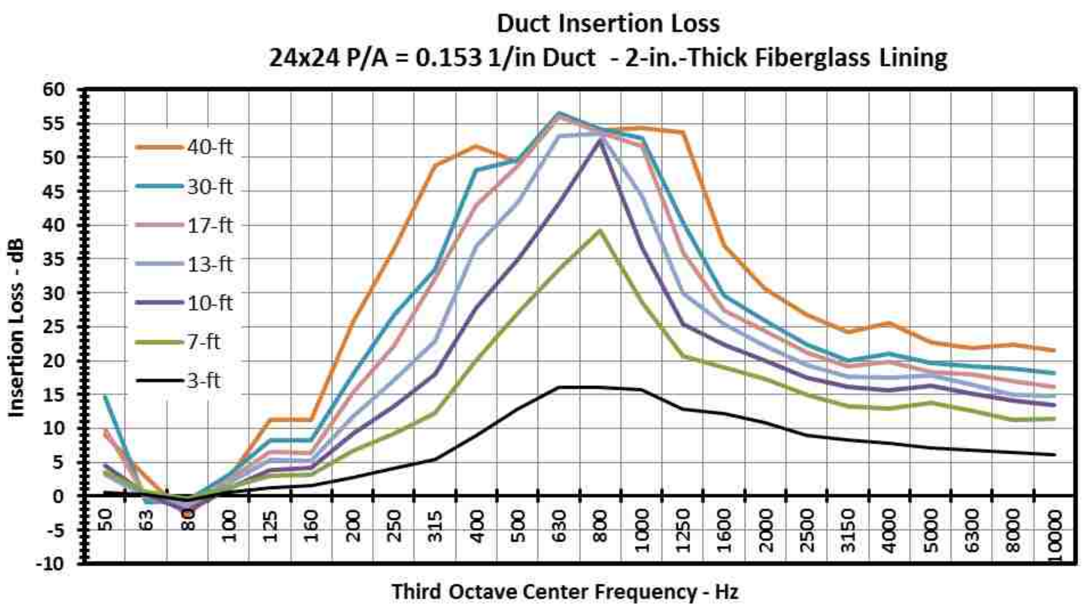

Figure B.2: Insertion Loss for 24x24 ducts with 2-in Fiberglass

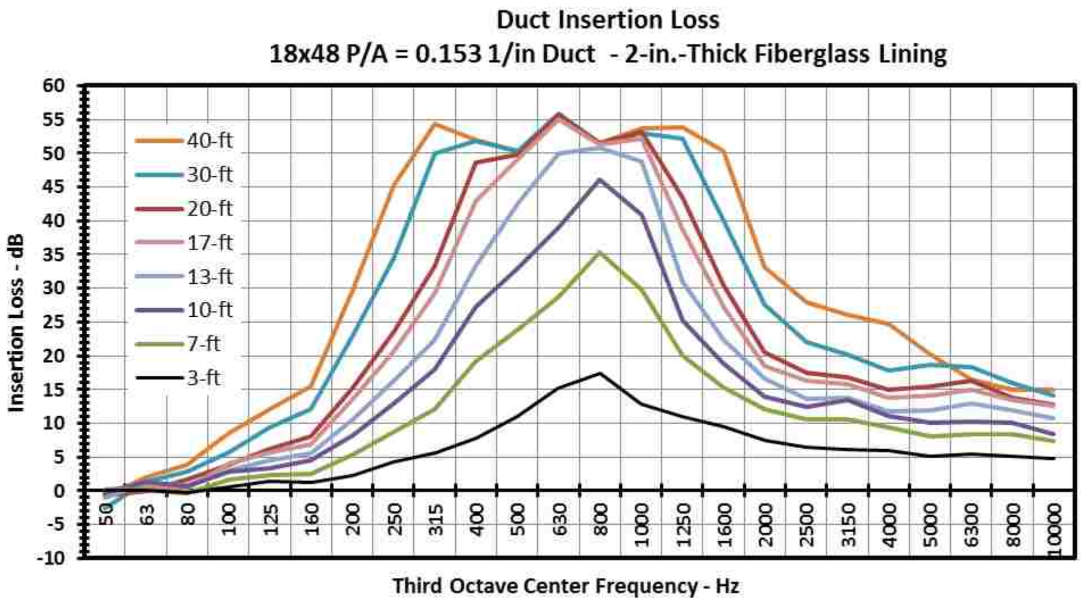

Figure B.3: Insertion Loss for 18x48 ducts with 2-in Fiberglass

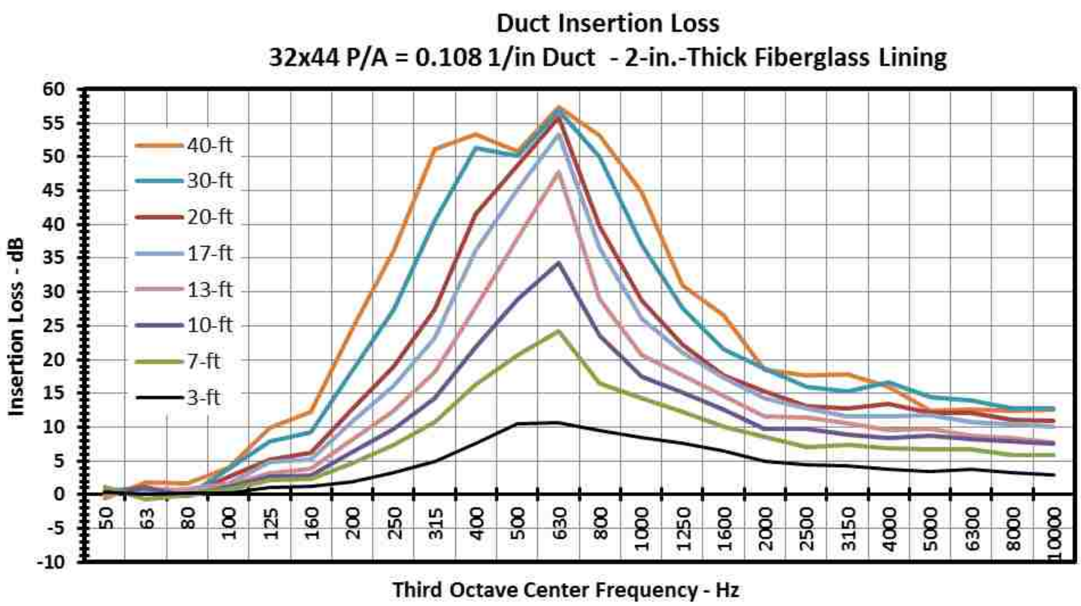

Figure B.4: Insertion Loss for 32x44 ducts with 2-in Fiberglass

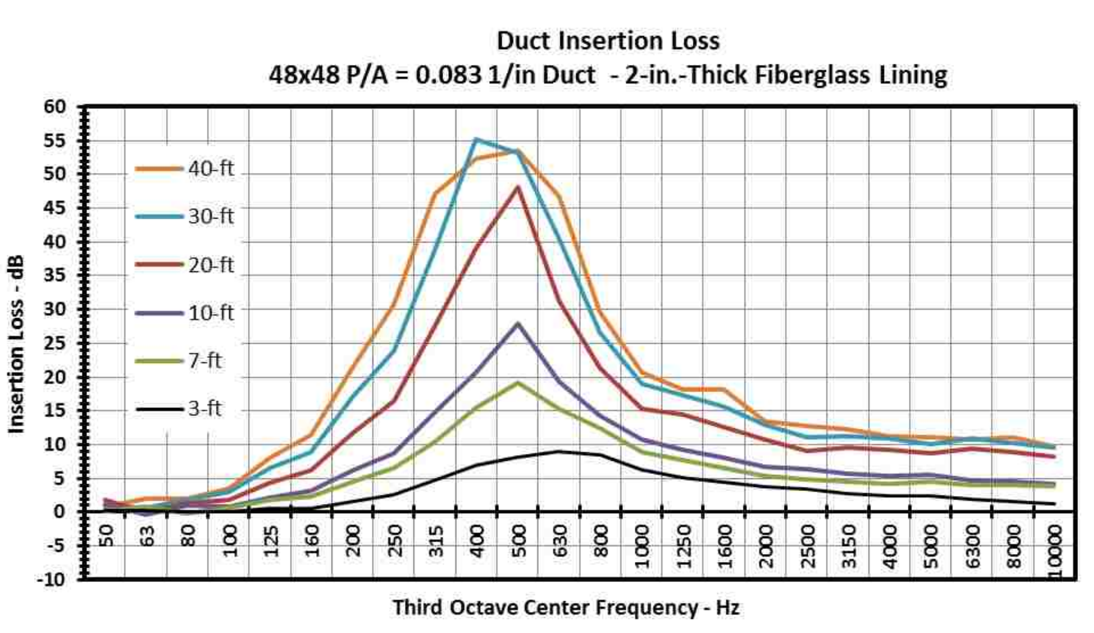

Figure B.5: Insertion Loss for 48x48 ducts with 2-in Fiberglass

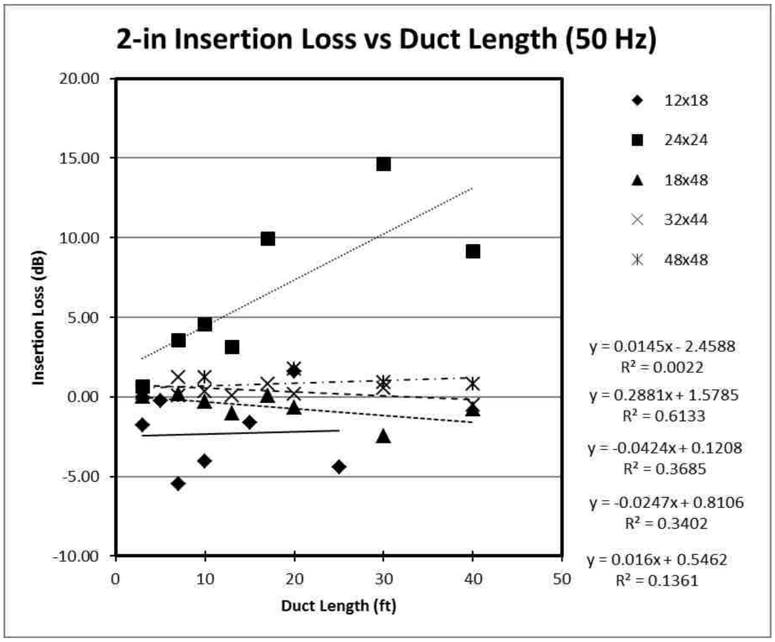

Figure B.6: 2-in Insertion Loss vs Duct Length at 50 Hz

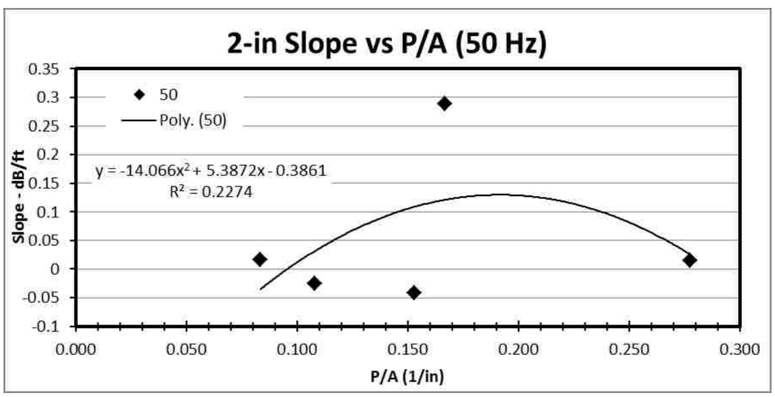

Figure B.7: 2-in Slope vs P/A at 50 Hz

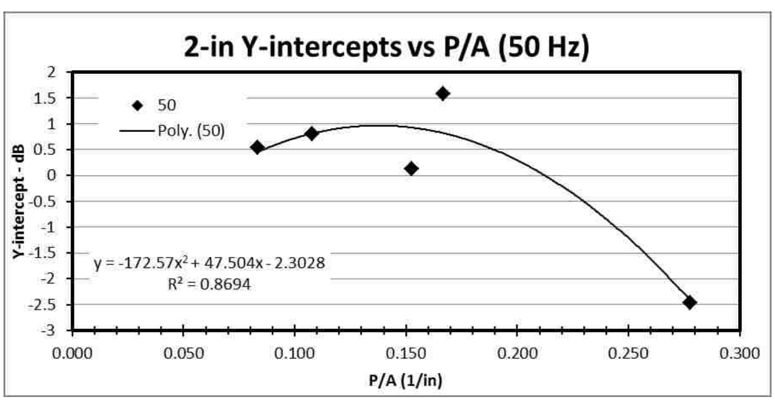

Figure B.8: 2-in Y-intercepts vs P/A at 50 Hz

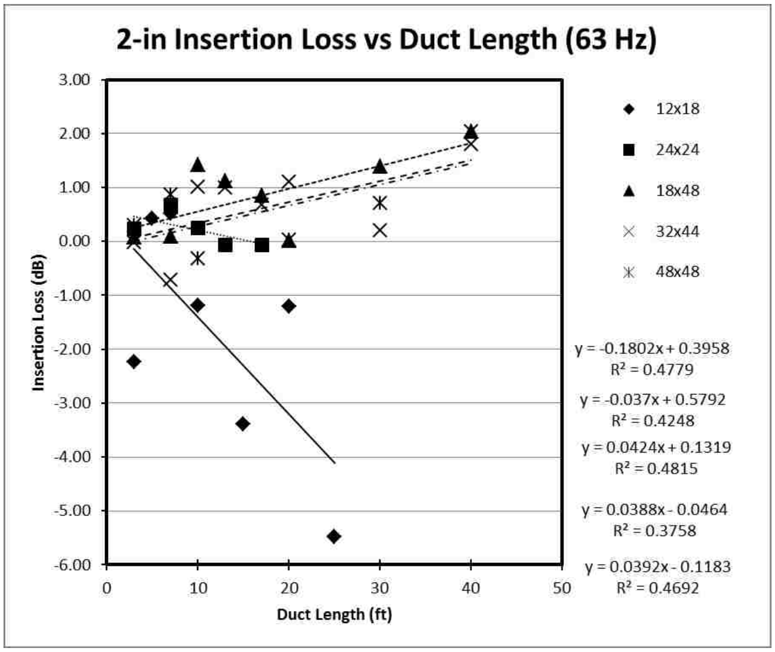

Figure B.9: 2-in Insertion Loss vs Duct Length at 63 Hz

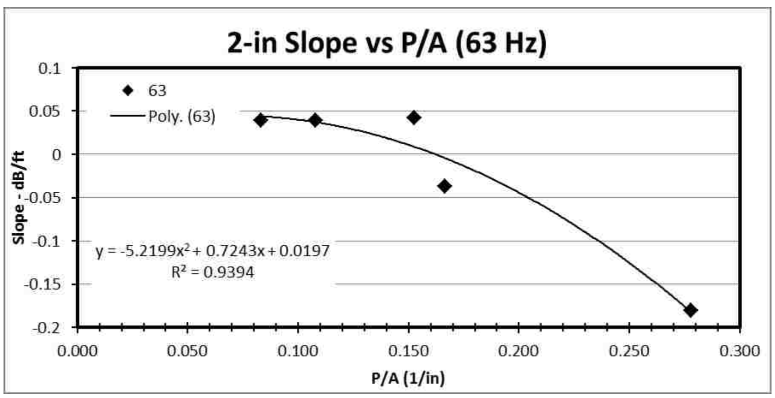

Figure B.10: 2-in Slope vs P/A at 63 Hz

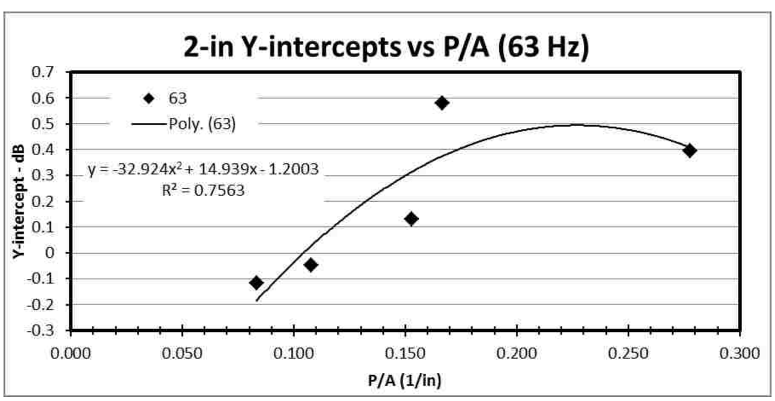

Figure B.11: 2-in Y-intercepts vs P/A at 63 Hz

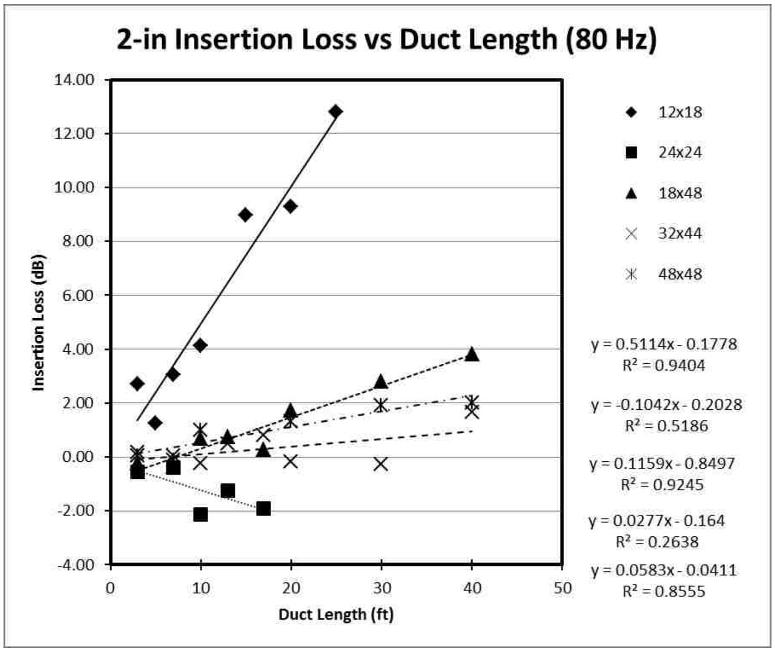

Figure B.12: 2-in Insertion Loss vs Duct Length at 80 Hz

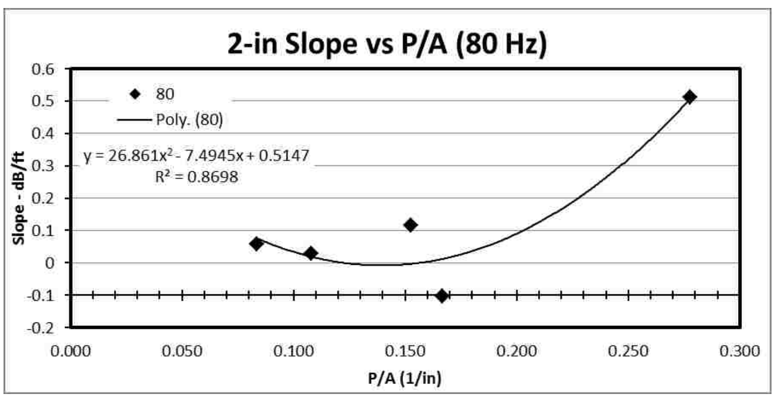

Figure B.13: 2-in Slope vs P/A at 80 Hz

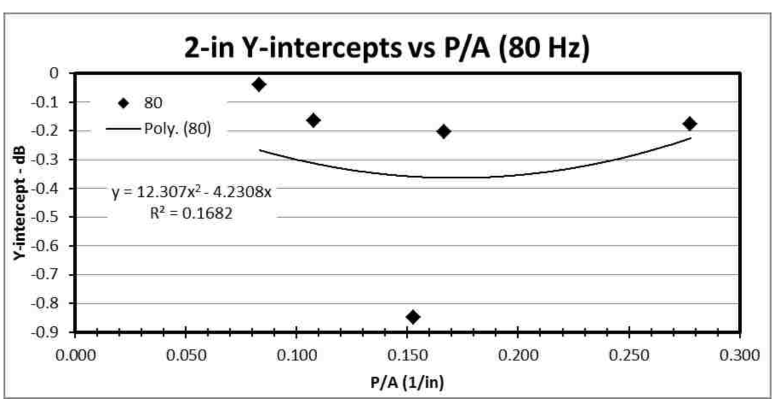

Figure B.14: 2-in Y-intercepts vs P/A at 80 Hz

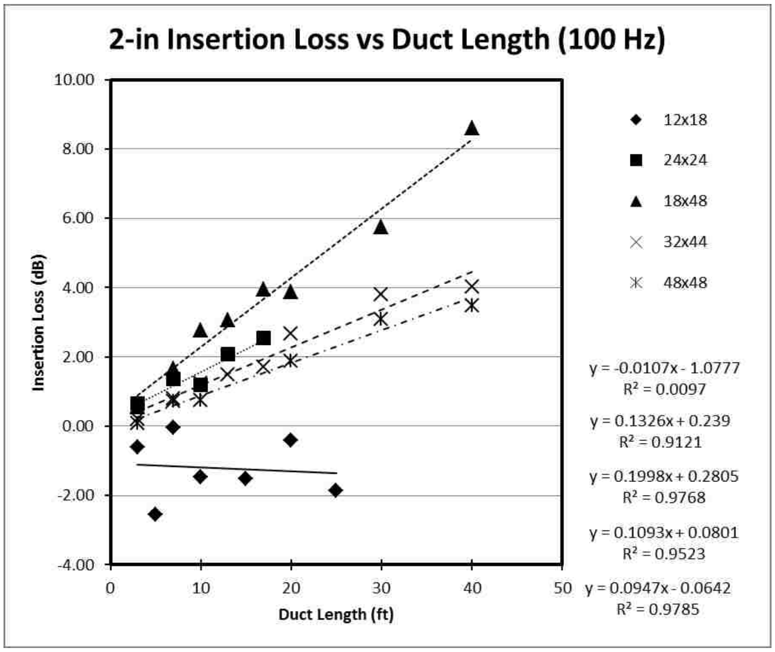

Figure B.15: 2-in Insertion Loss vs Duct Length at 100 Hz

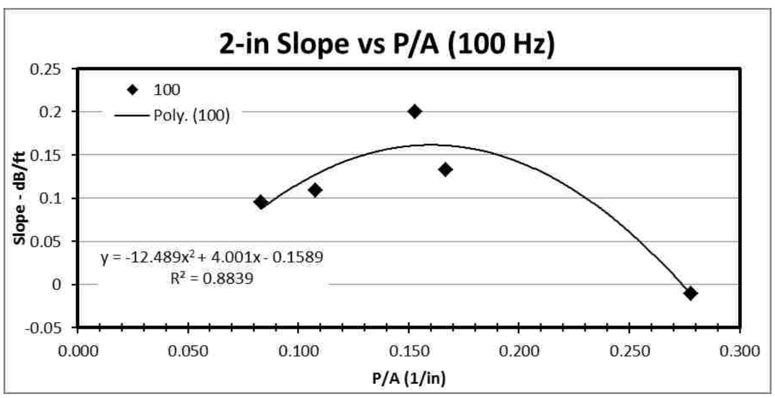

Figure B.16: 2-in Slope vs P/A at 100 Hz

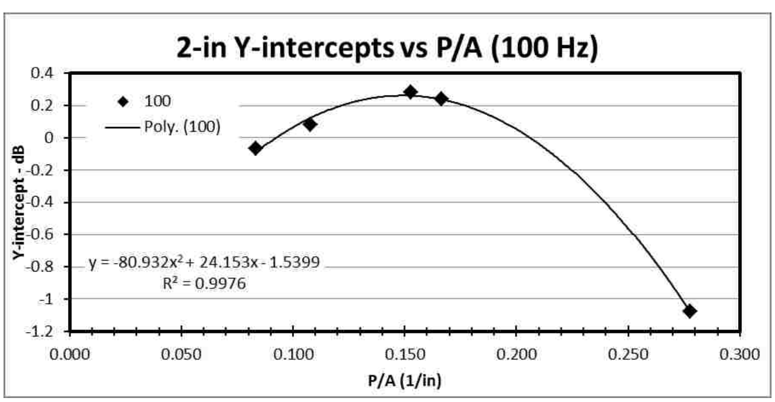

Figure B.17: 2-in Y-intercepts vs P/A at 100 Hz

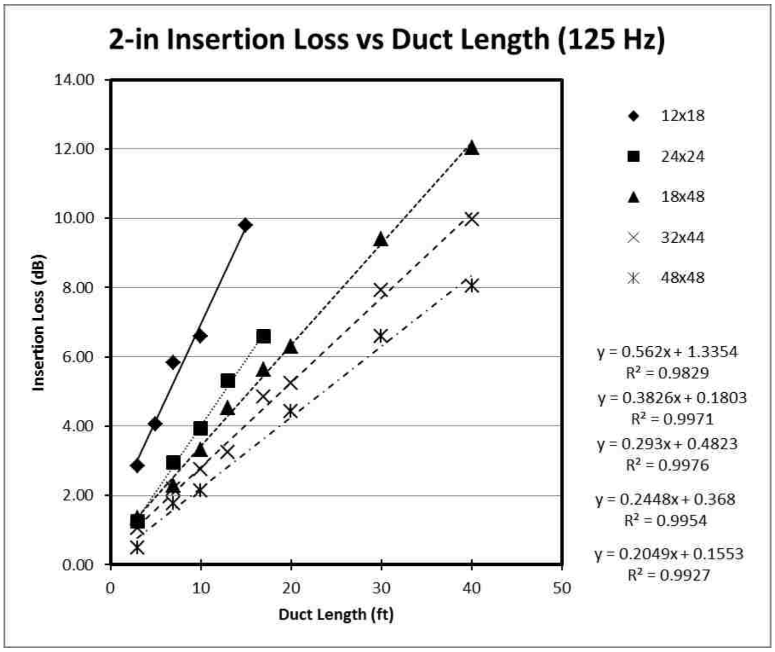

Figure B.18: 2-in Insertion Loss vs Duct Length at 125 Hz

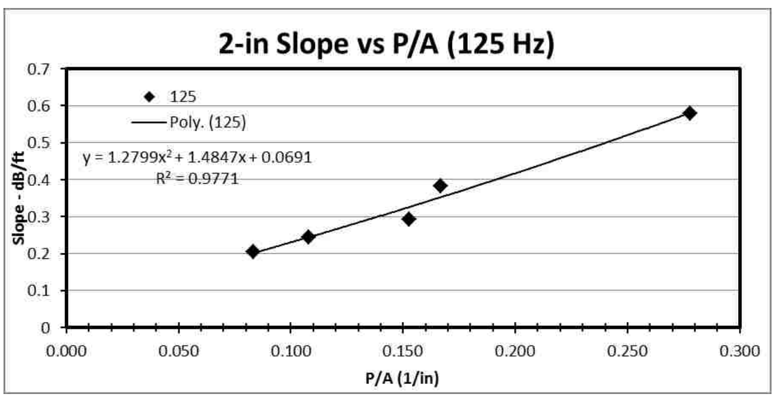

Figure B.19: 2-in Slope vs P/A at 125 Hz

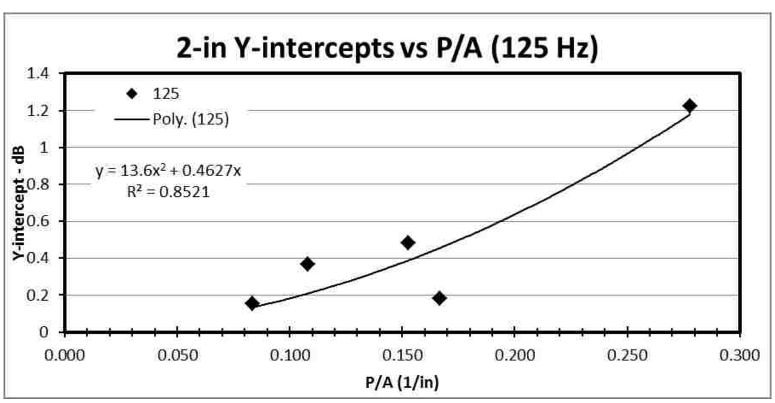

Figure B.20: 2-in Y-intercepts vs P/A at 125 Hz

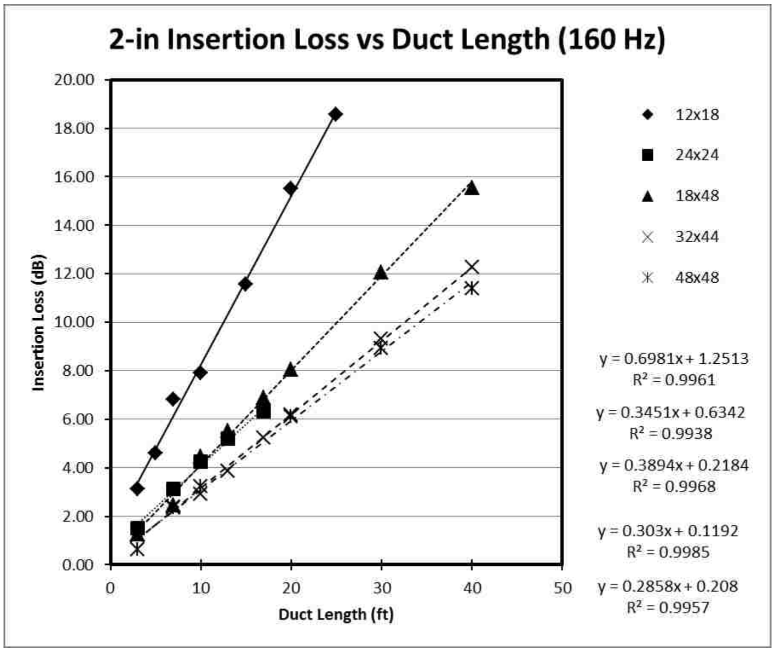

Figure B.21: 2-in Insertion Loss vs Duct Length at 160 Hz

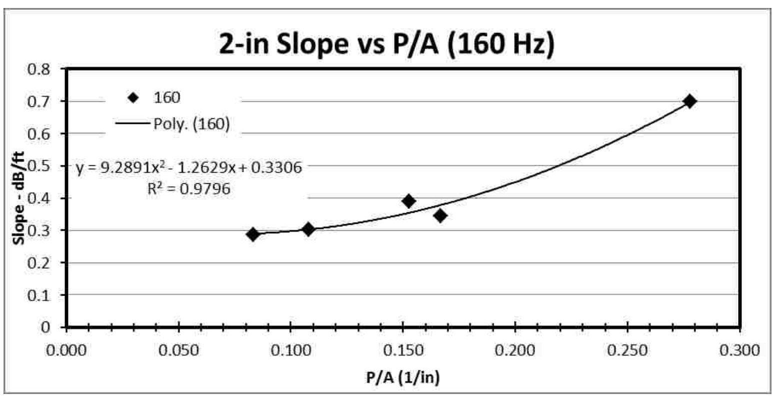

Figure B.22: 2-in Slope vs P/A at 160 Hz

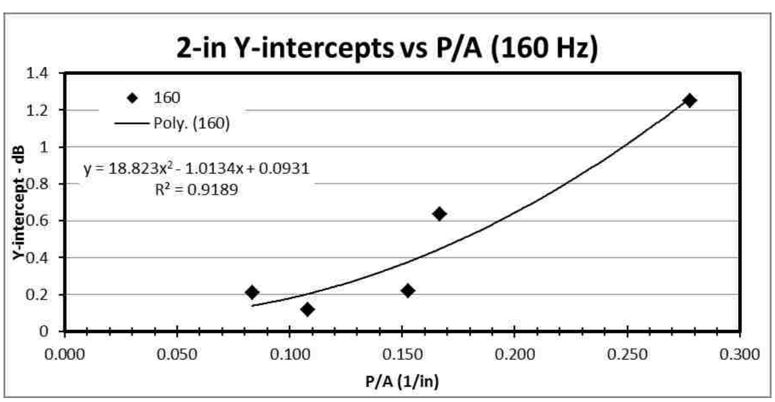

Figure B.23: 2-in Y-intercepts vs P/A at 160 Hz

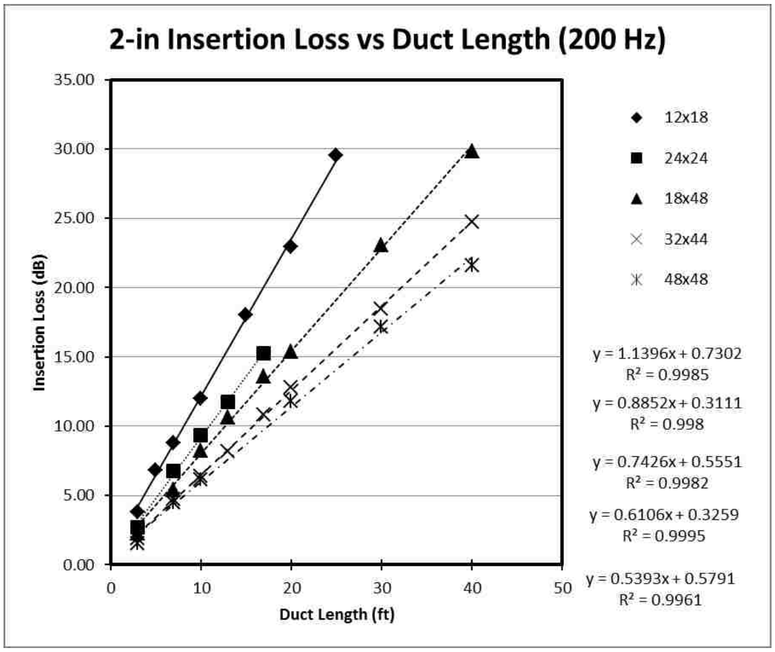

Figure B.24: 2-in Insertion Loss vs Duct Length at 200 Hz

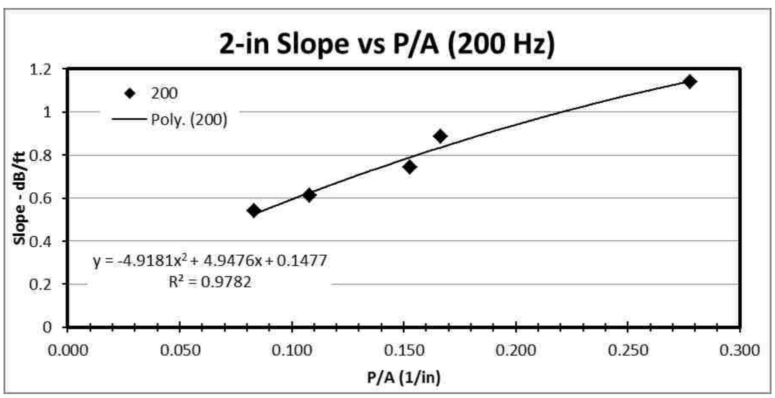

Figure B.25: 2-in Slope vs P/A at 200 Hz

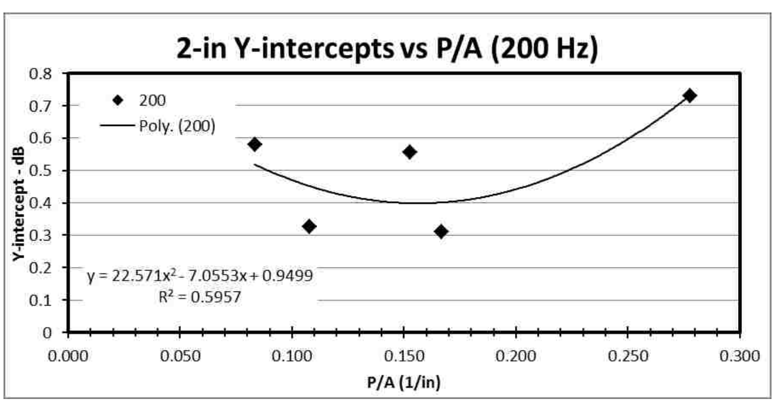

Figure B.26: 2-in Y-intercepts vs P/A at 200 Hz

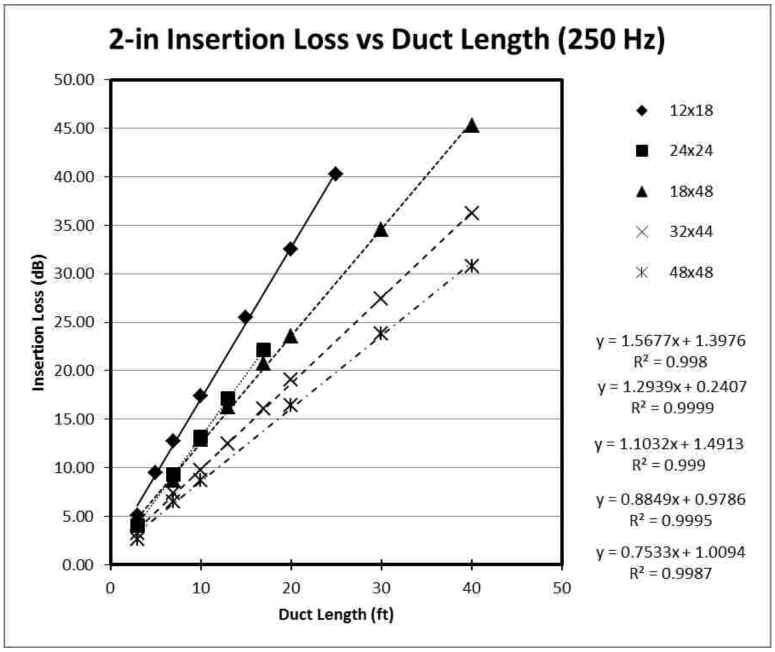

Figure B.27: 2-in Insertion Loss vs Duct Length at 250 Hz

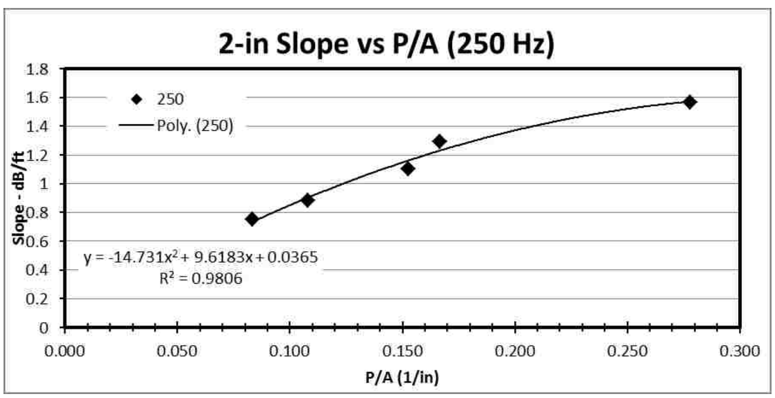

Figure B.28: 2-in Slope vs P/A at 250 Hz

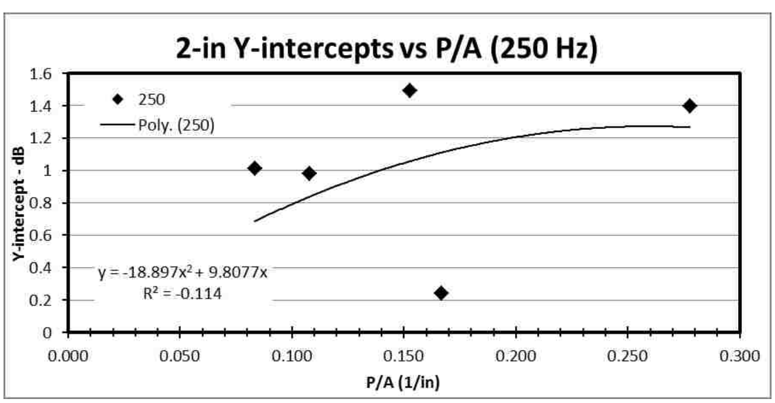

Figure B.29: 2-in Y-intercepts vs P/A at 250 Hz

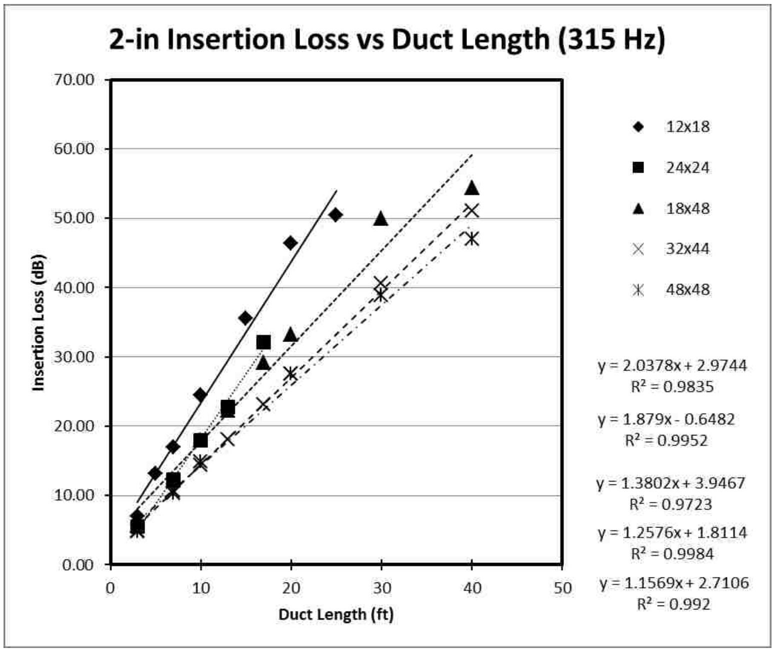

Figure B.30: 2-in Insertion Loss vs Duct Length at 315 Hz

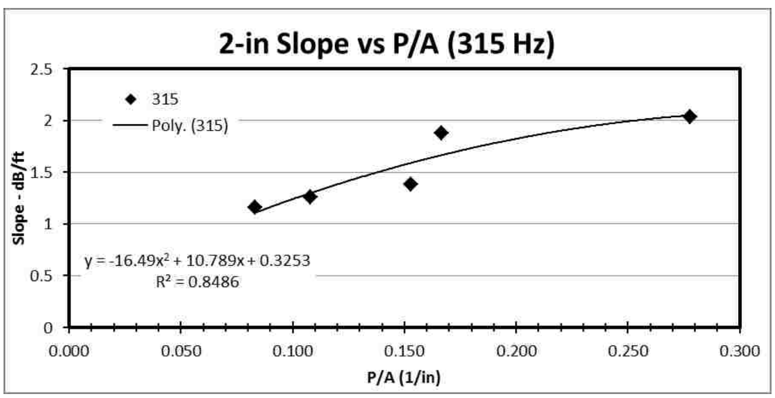

Figure B.31: 2-in Slope vs P/A at 315 Hz

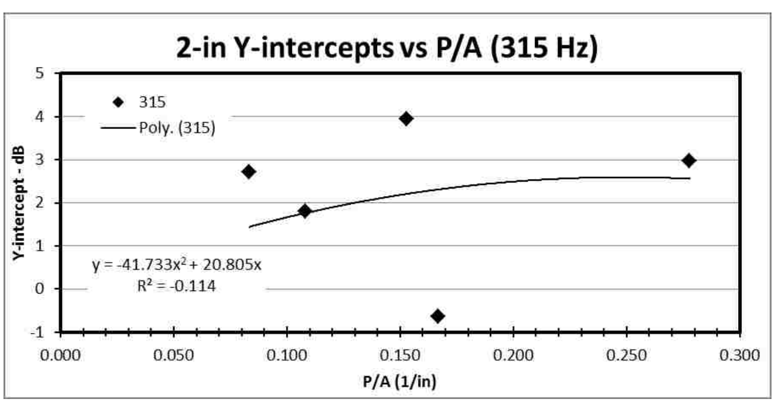

Figure B.32: 2-in Y-intercepts vs P/A at 315 Hz

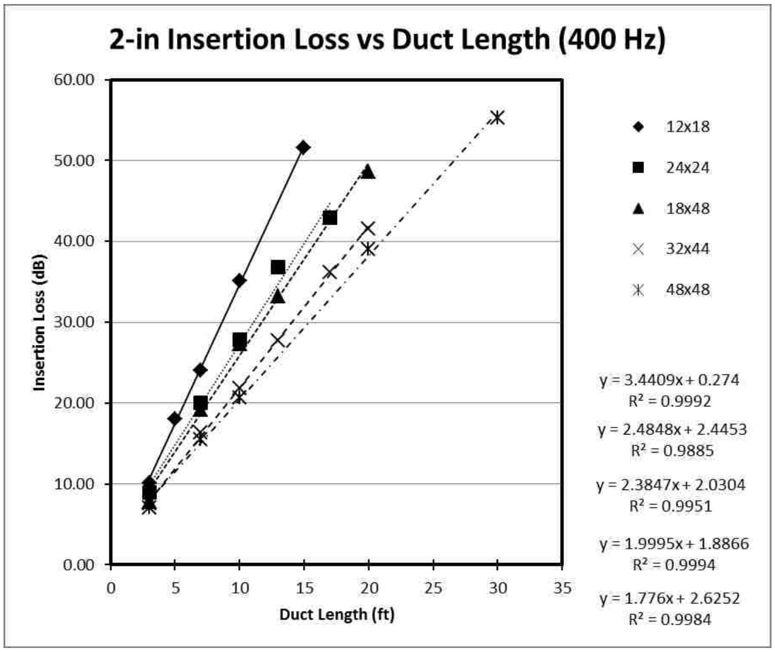

Figure B.33: 2-in Insertion Loss vs Duct Length at 400 Hz

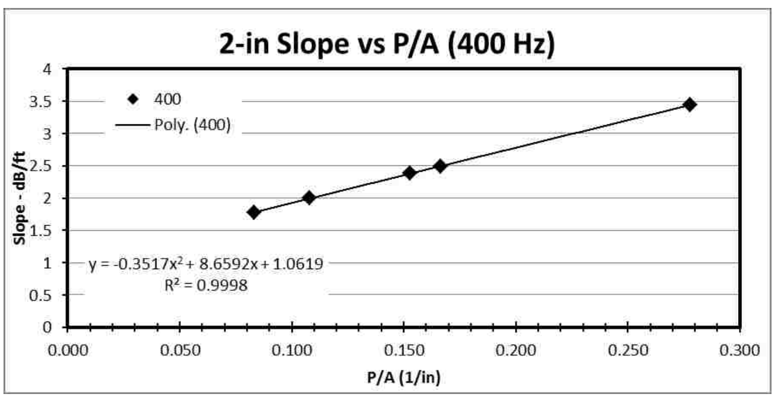

Figure B.34: 2-in Slope vs P/A at 400 Hz

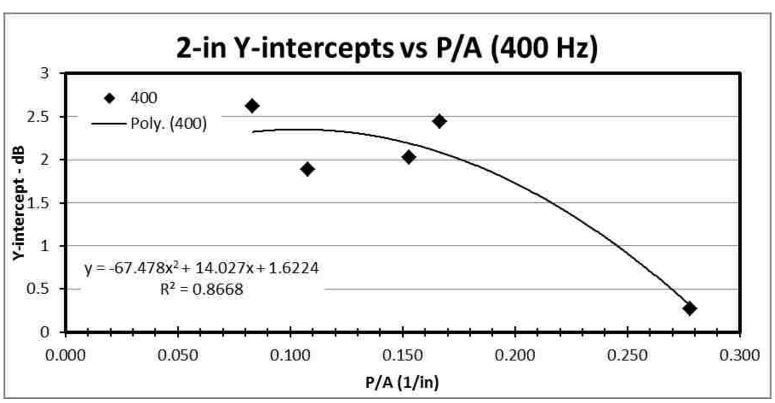

Figure B.35: 2-in Y-intercepts vs P/A at 400 Hz

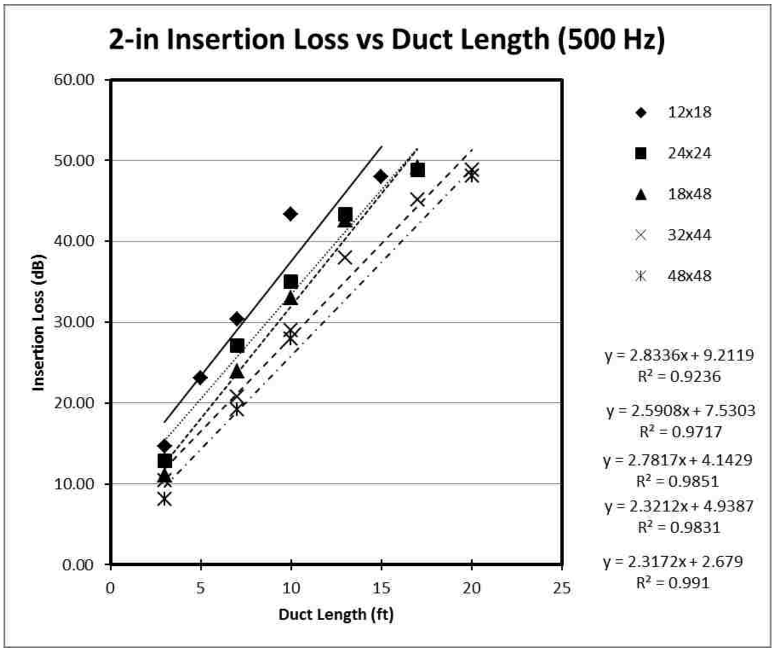

Figure B.36: 2-in Insertion Loss vs Duct Length at 500 Hz

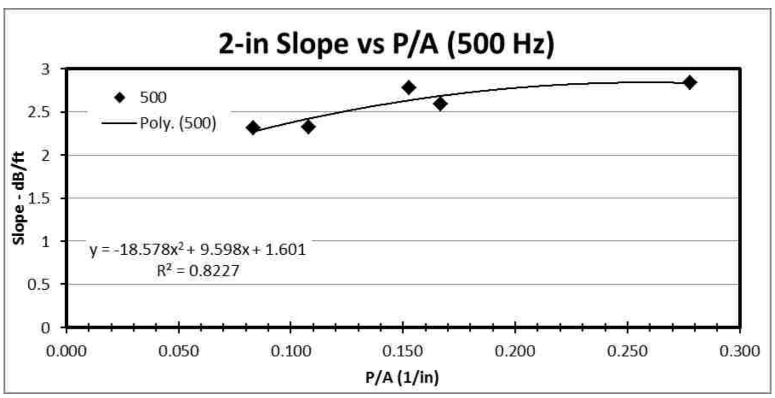

Figure B.37: 2-in Slope vs P/A at 500 Hz

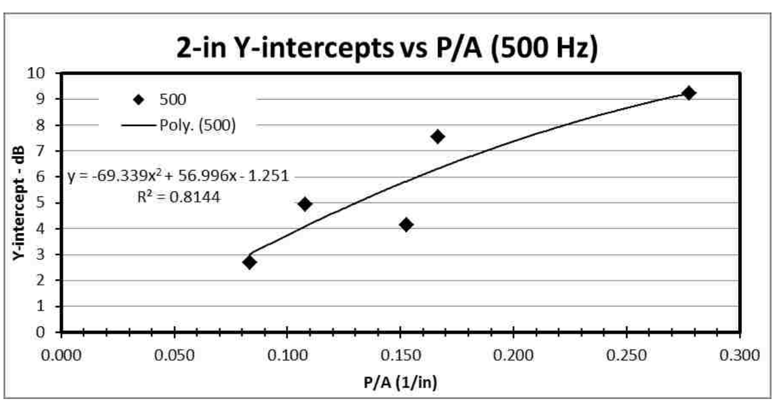

Figure B.38: 2-in Y-intercepts vs P/A at 500 Hz

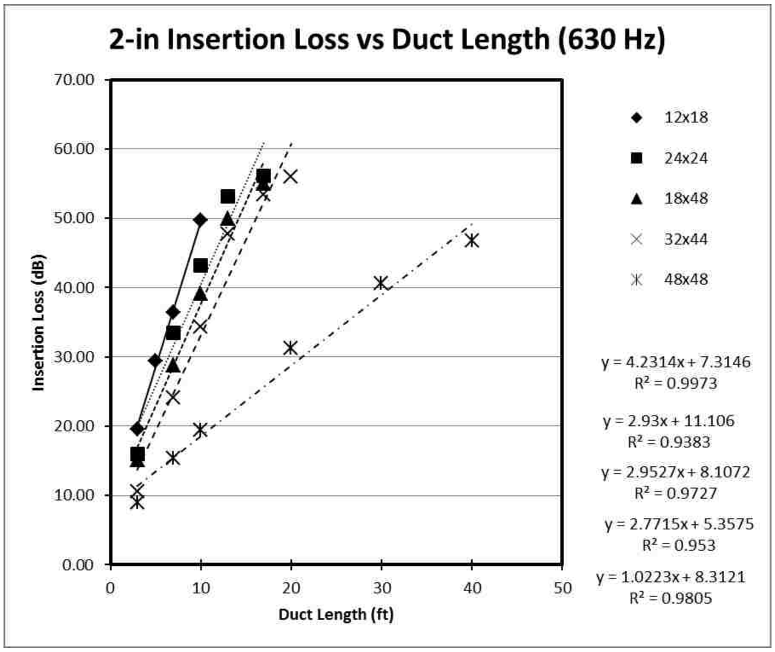

Figure B.39: 2-in Insertion Loss vs Duct Length at 630 Hz

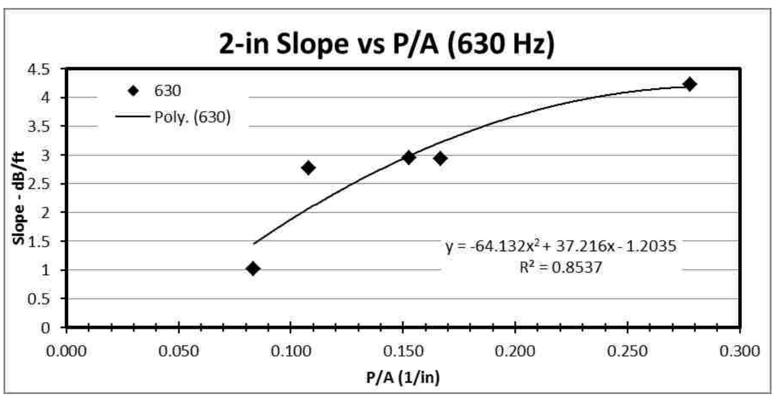

Figure B.40: 2-in Slope vs P/A at 630 Hz

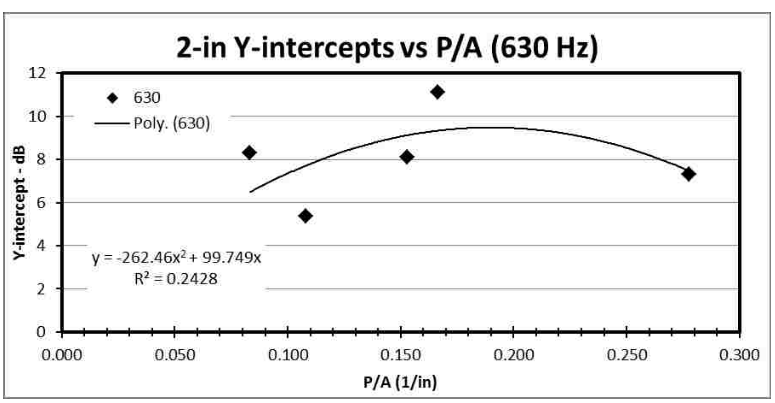

Figure B.41: 2-in Y-intercepts vs P/A at 630 Hz

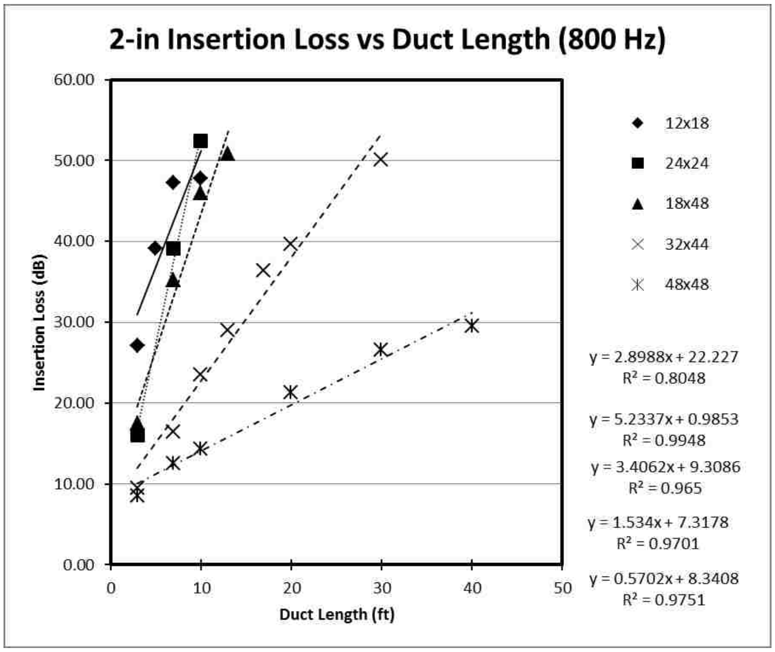

Figure B.42: 2-in Insertion Loss vs Duct Length at 800 Hz

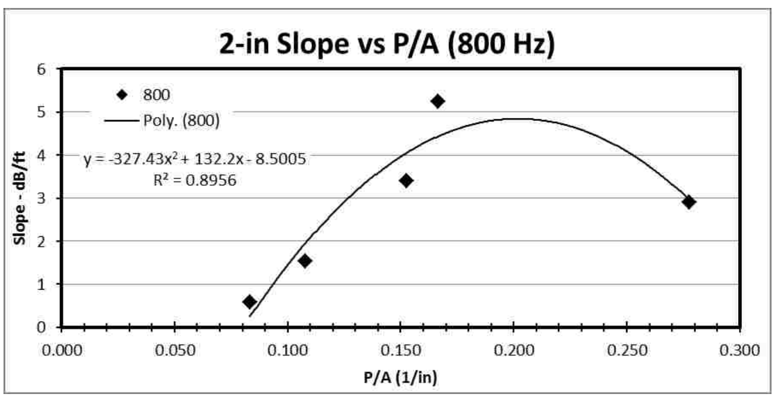

Figure B.43: 2-in Slope vs P/A at 800 Hz

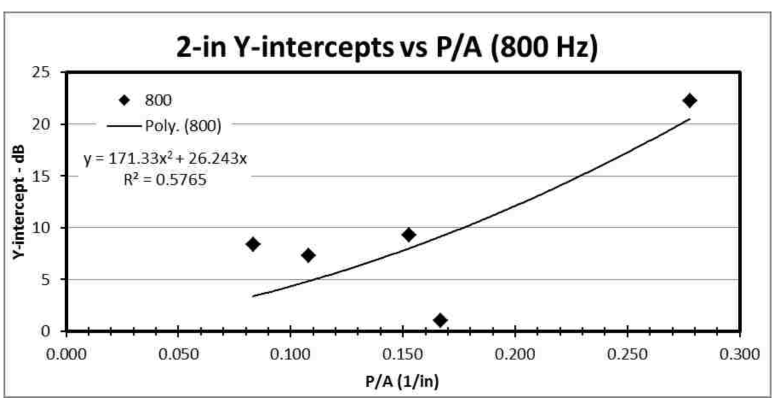

Figure B.44: 2-in Y-intercepts vs P/A at 800 Hz

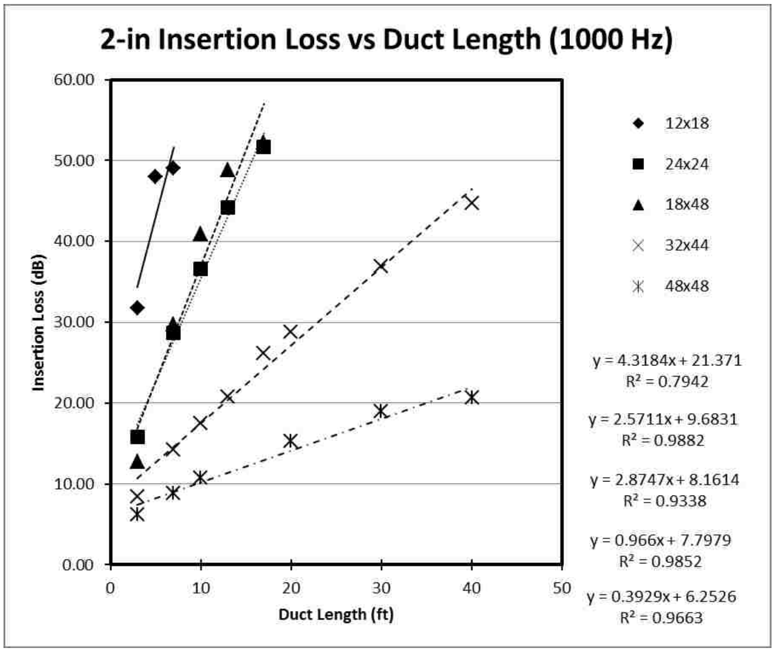

Figure B.45: 2-in Insertion Loss vs Duct Length at 1000 Hz

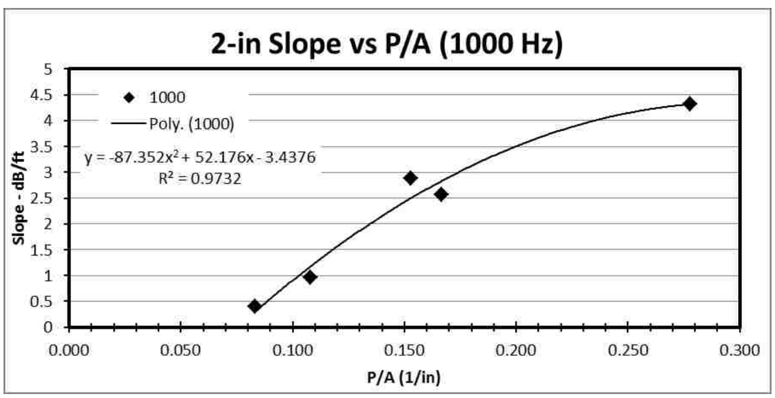

Figure B.46: 2-in Slope vs P/A at 1000 Hz

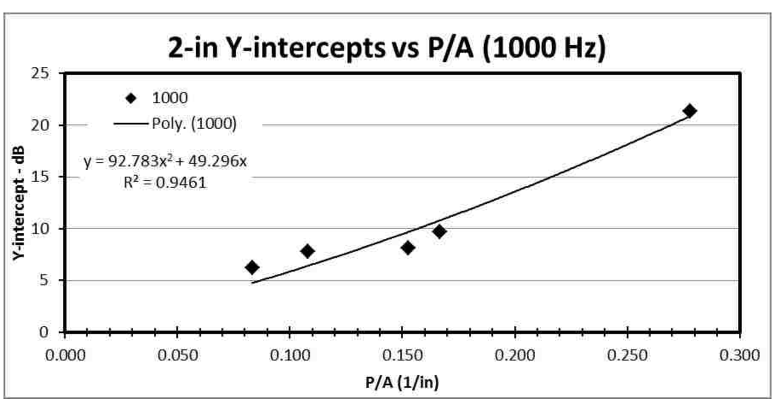

Figure B.47: 2-in Y-intercepts vs P/A at 1000 Hz

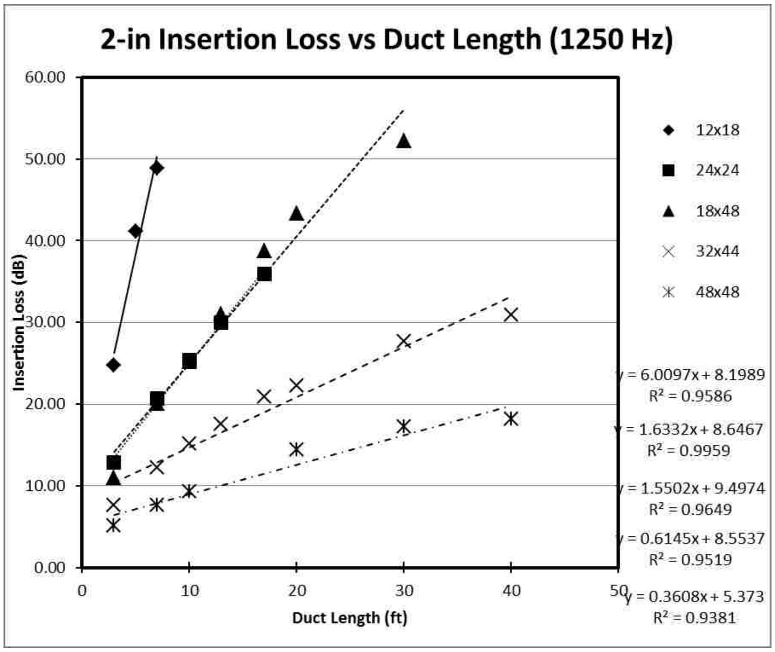

Figure B.48: 2-in Insertion Loss vs Duct Length at 1250 Hz

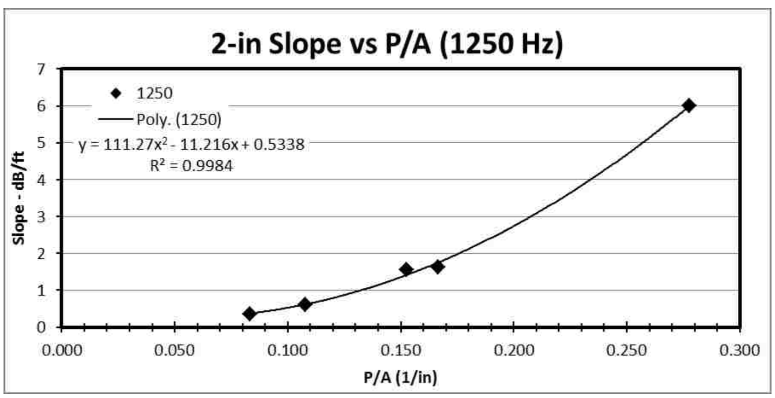

Figure B.49: 2-in Slope vs P/A at 1250 Hz

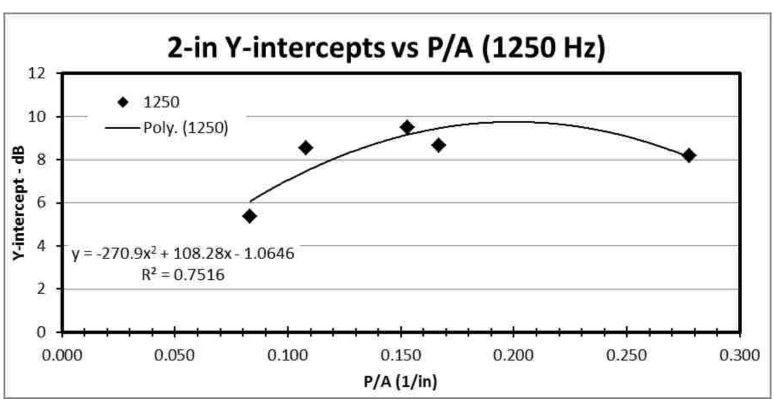

Figure B.50: 2-in Y-intercepts vs P/A at 1250 Hz

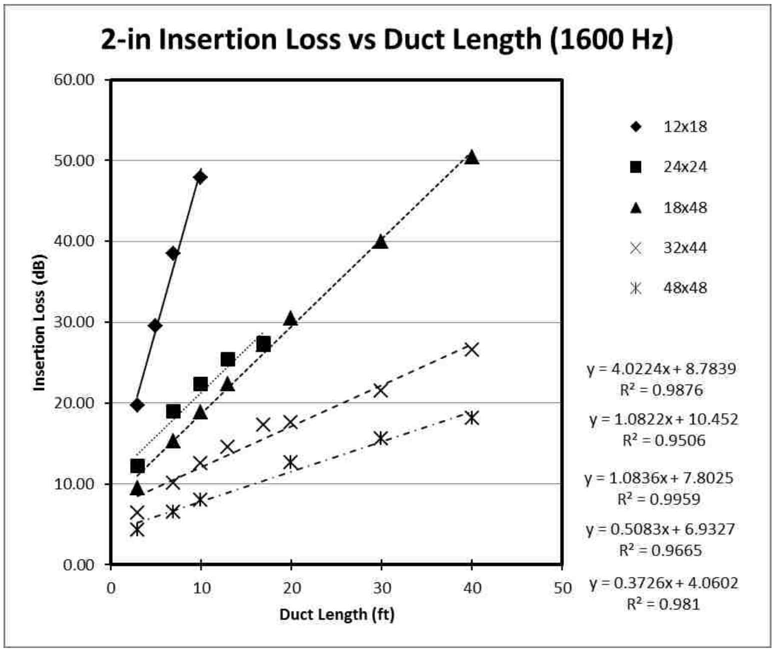

Figure B.51: 2-in Insertion Loss vs Duct Length at 1600 Hz

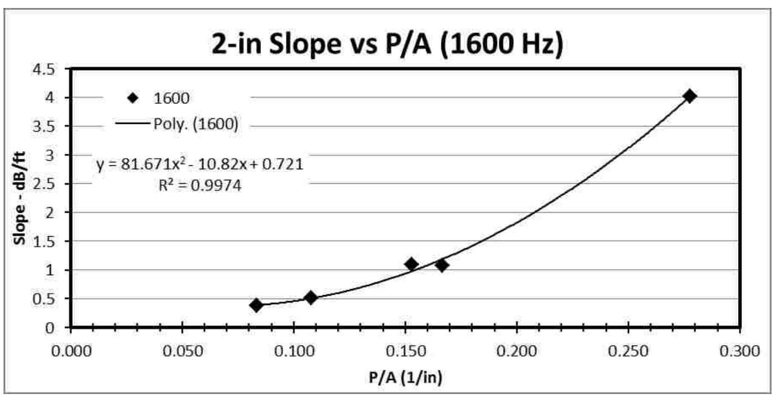

Figure B.52: 2-in Slope vs P/A at 1600 Hz

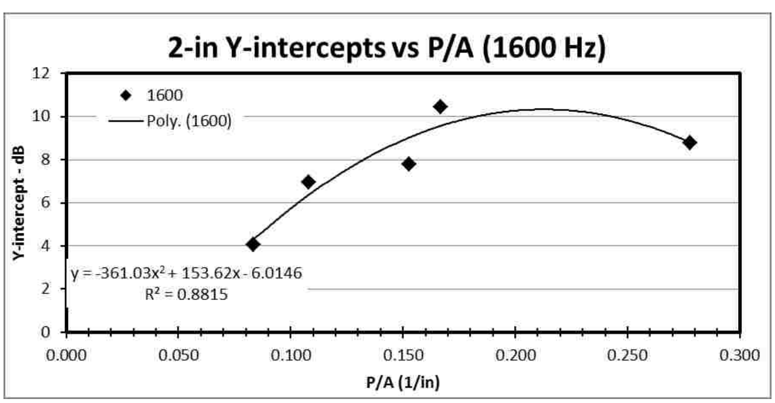

Figure B.53: 2-in Y-intercepts vs P/A at 1600 Hz

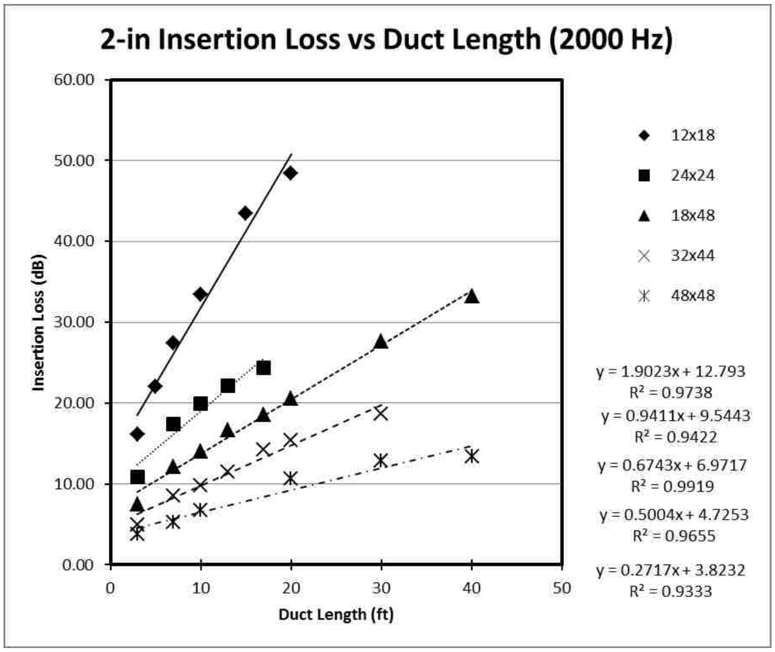

Figure B.54: 2-in Insertion Loss vs Duct Length at 2000 Hz

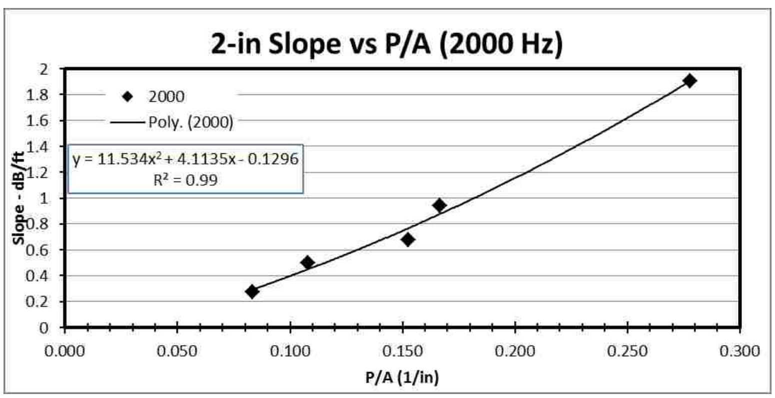

Figure B.55: 2-in Slope vs P/A at 2000 Hz

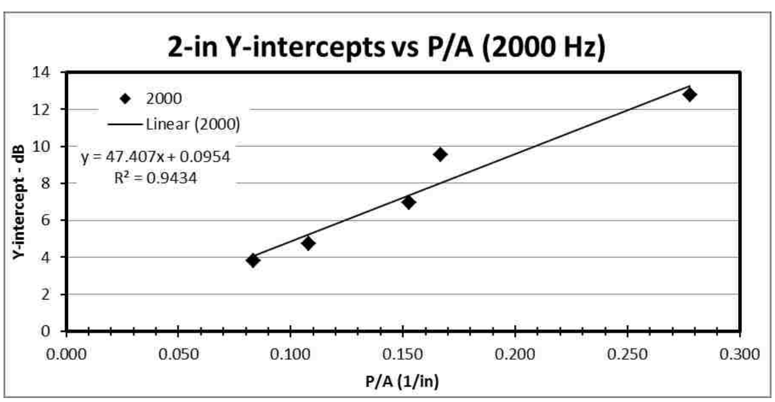

Figure B.56: 2-in Y-intercepts vs P/A at 2000 Hz

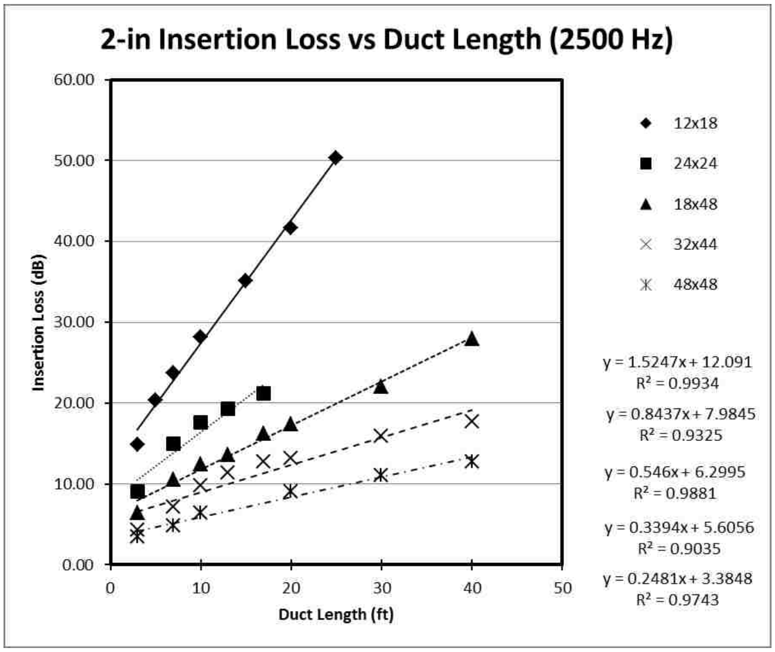

Figure B.57: 2-in Insertion Loss vs Duct Length at 2500 Hz

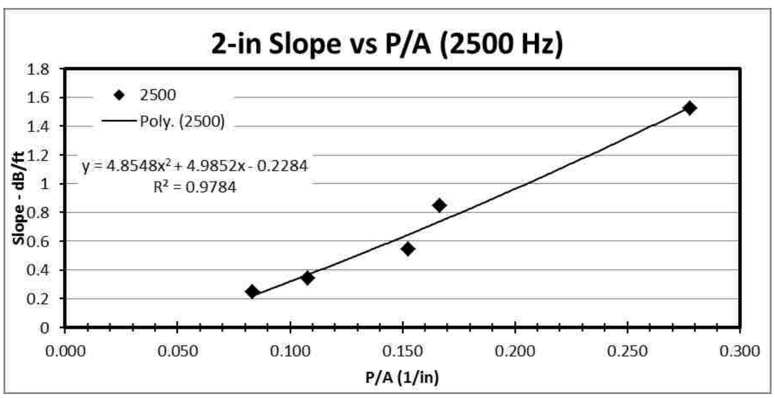

Figure B.58: 2-in Slope vs P/A at 2500 Hz

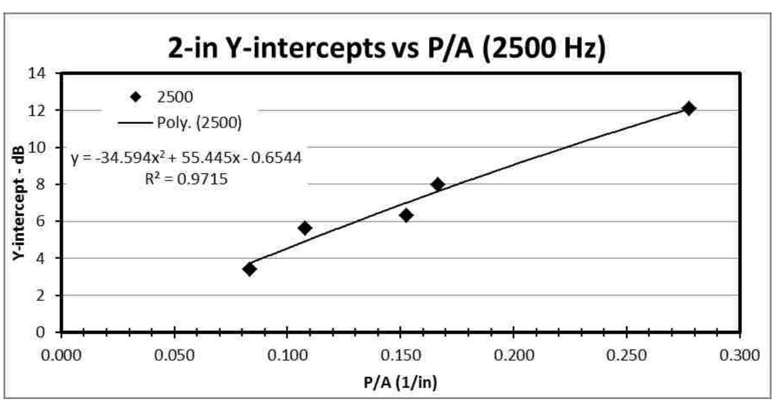

Figure B.59: 2-in Y-intercepts vs P/A at 2500 Hz

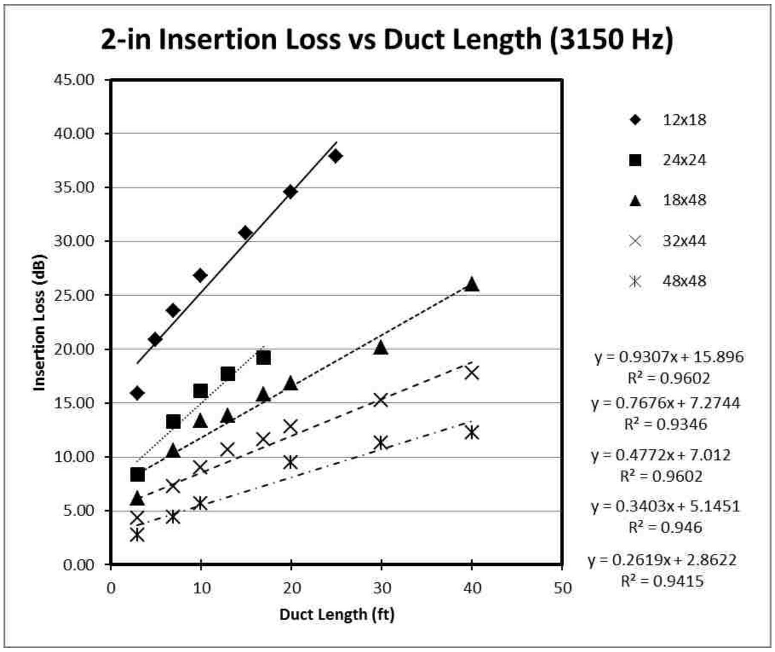

Figure B.60: 2-in Insertion Loss vs Duct Length at 3150 Hz

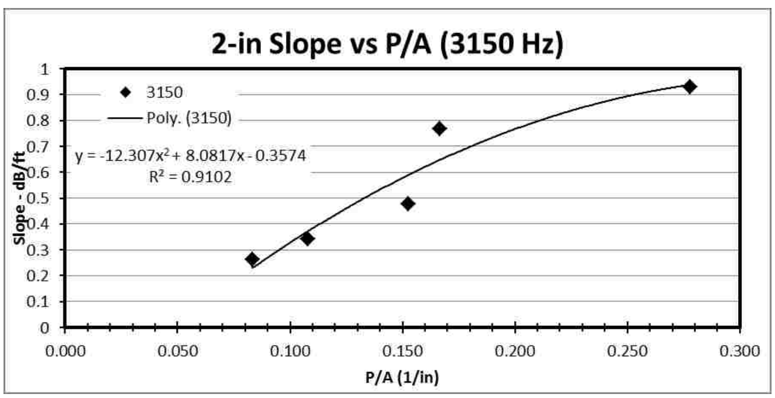

Figure B.61: 2-in Slope vs P/A at 3150 Hz

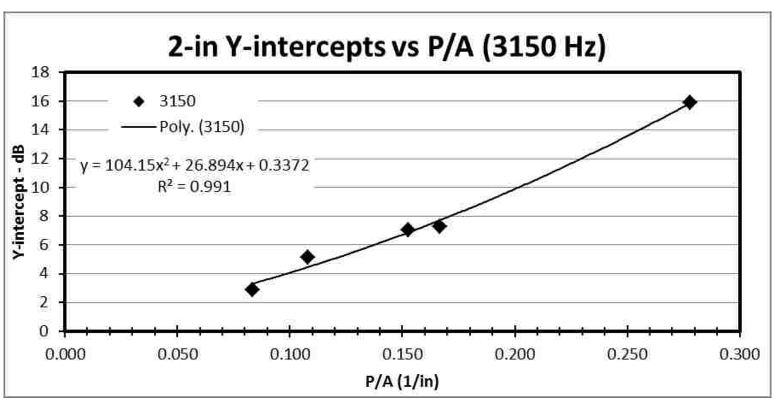

Figure B.62: 2-in Y-intercepts vs P/A at 3150 Hz

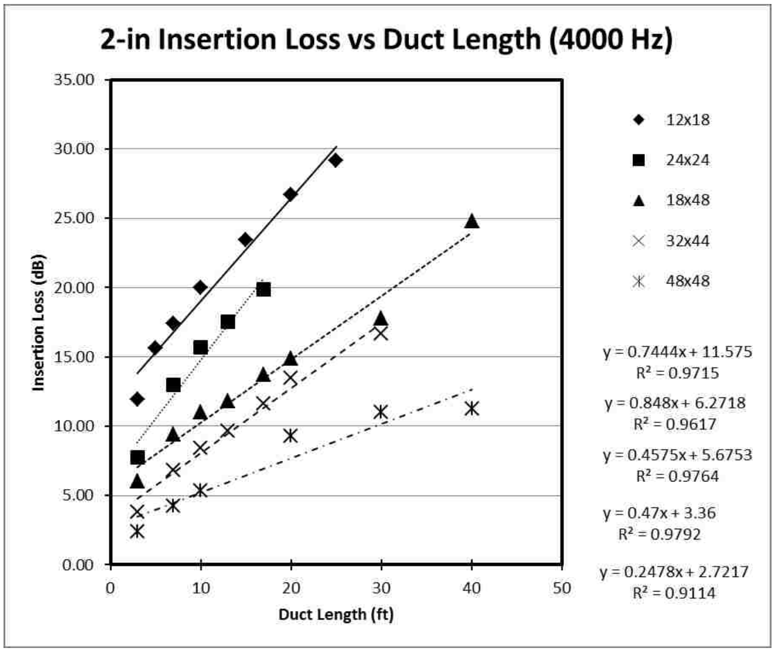

Figure B.63: 2-in Insertion Loss vs Duct Length at 4000 Hz

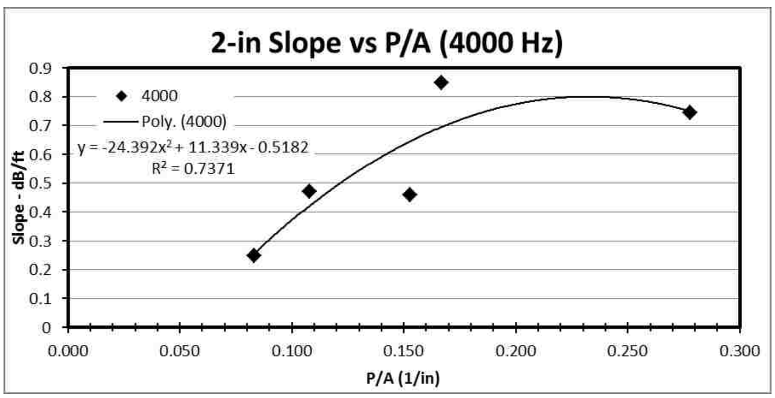

Figure B.64: 2-in Slope vs P/A at 4000 Hz

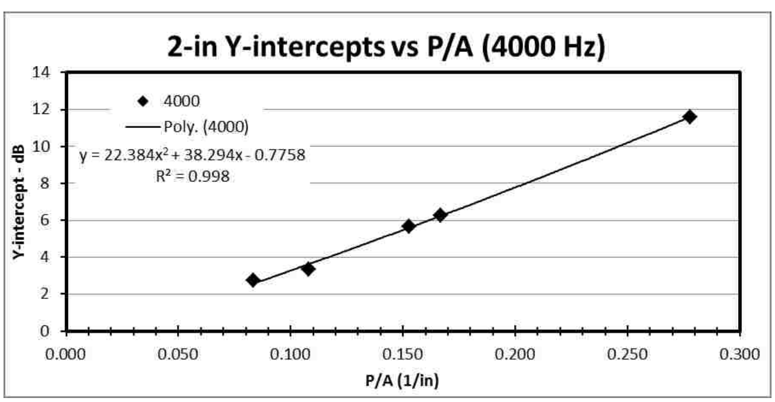

Figure B.65: 2-in Y-intercepts vs P/A at 4000 Hz

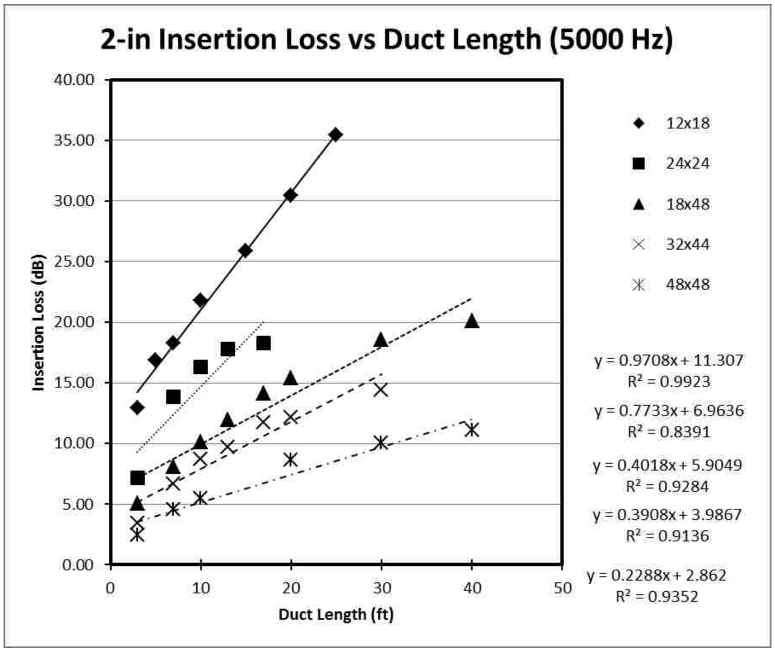

Figure B.66: 2-in Insertion Loss vs Duct Length at 5000 Hz

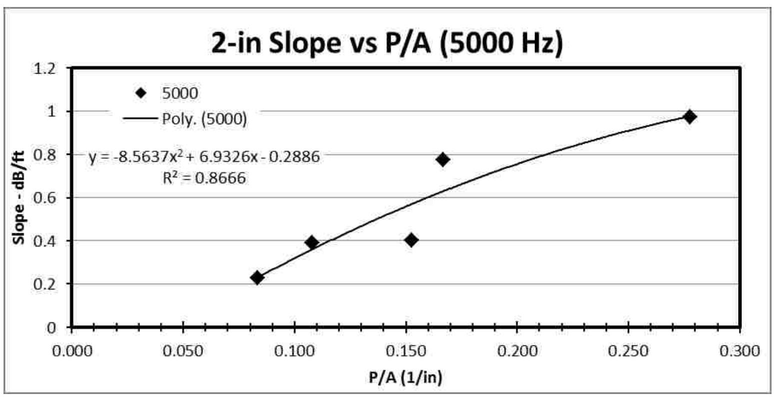

Figure B.67: 2-in Slope vs P/A at 5000 Hz

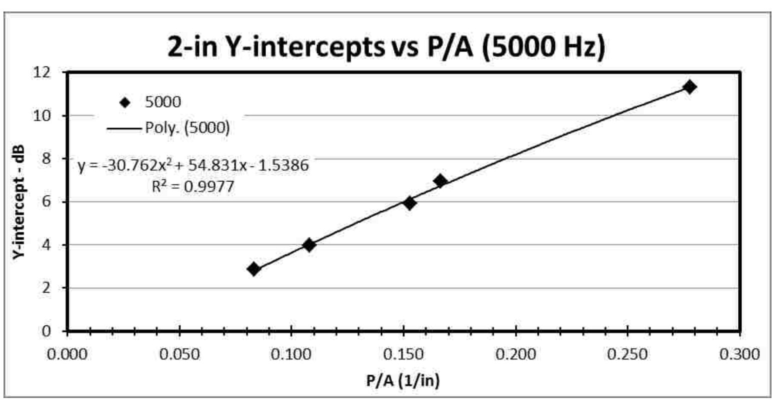

Figure B.68: 2-in Y-intercepts vs P/A at 5000 Hz

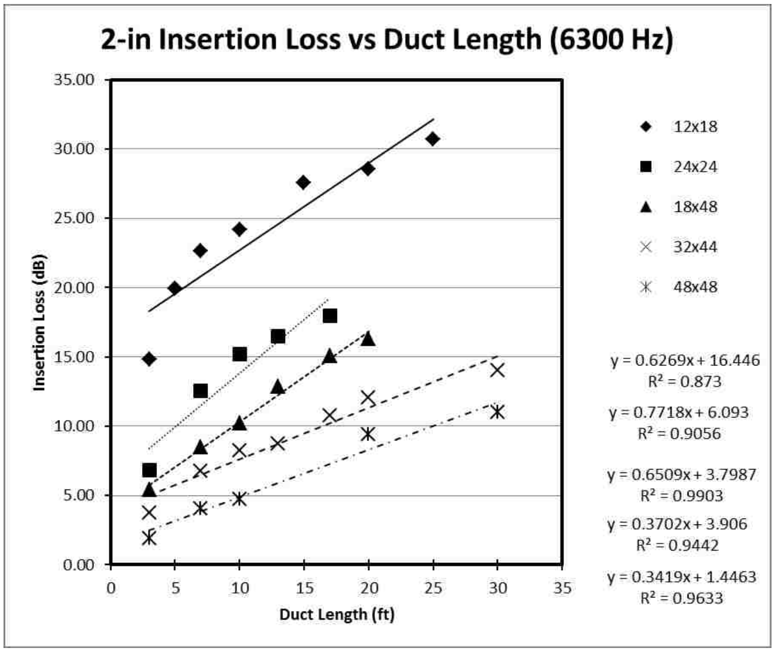

Figure B.69: 2-in Insertion Loss vs Duct Length at 6300 Hz

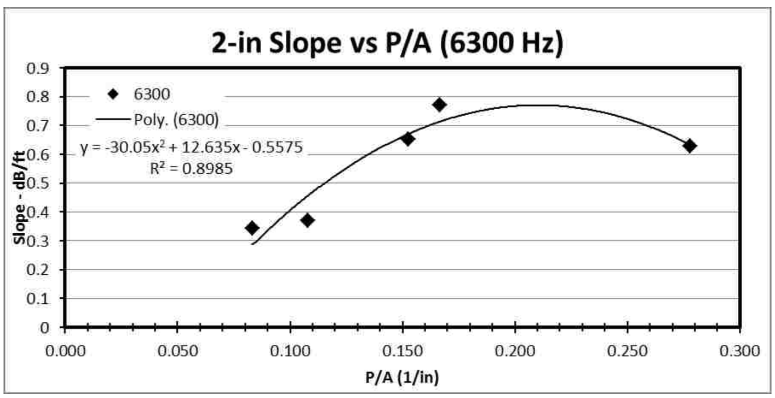

Figure B.70: 2-in Slope vs P/A at 6300 Hz

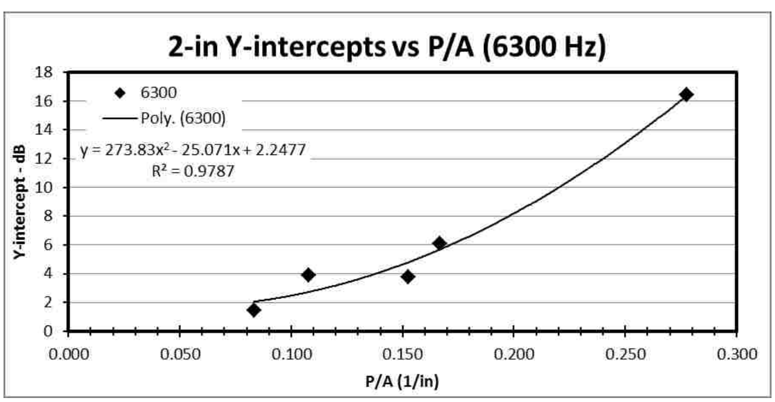

Figure B.71: 2-in Y-intercepts vs P/A at 6300 Hz

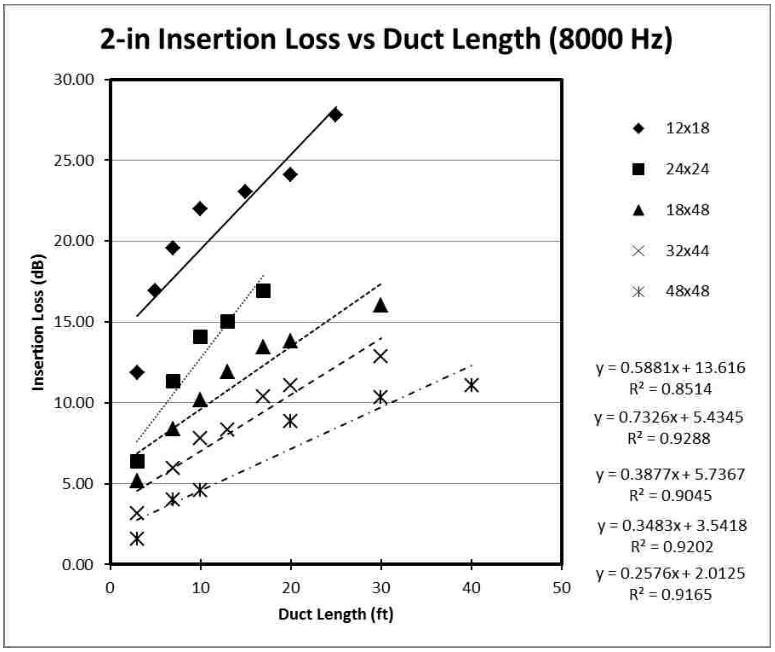

Figure B.72: 2-in Insertion Loss vs Duct Length at 8000 Hz

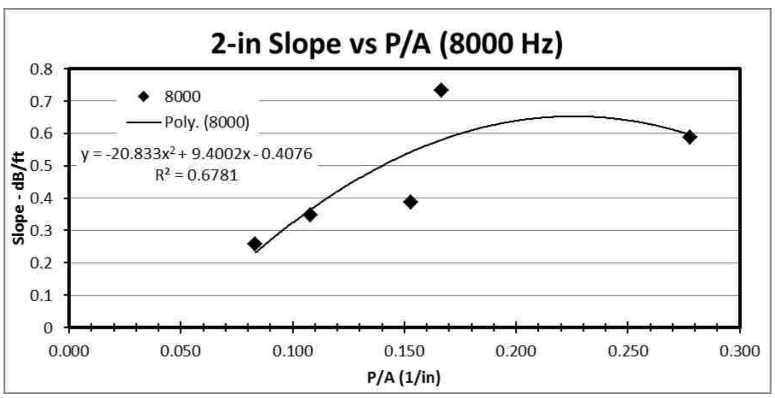

Figure B.73: 2-in Slope vs P/A at 8000 Hz

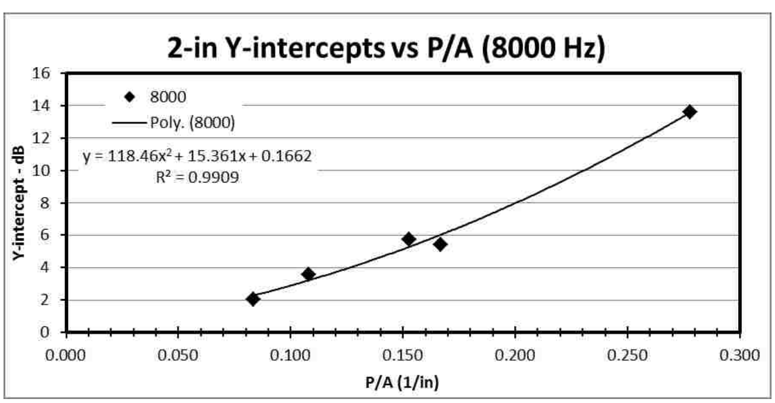

Figure B.74: 2-in Y-intercepts vs P/A at 8000 Hz

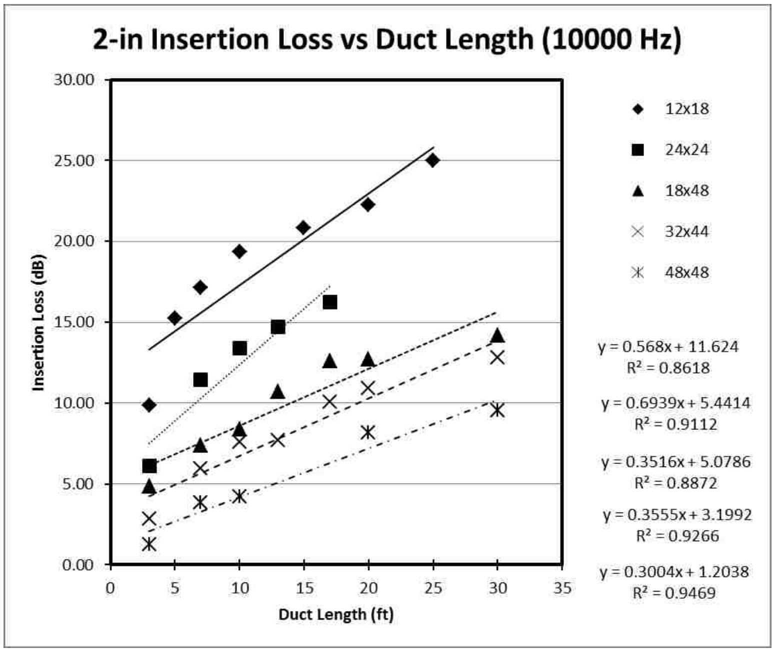

Figure B.75: 2-in Insertion Loss vs Duct Length at 10000 Hz

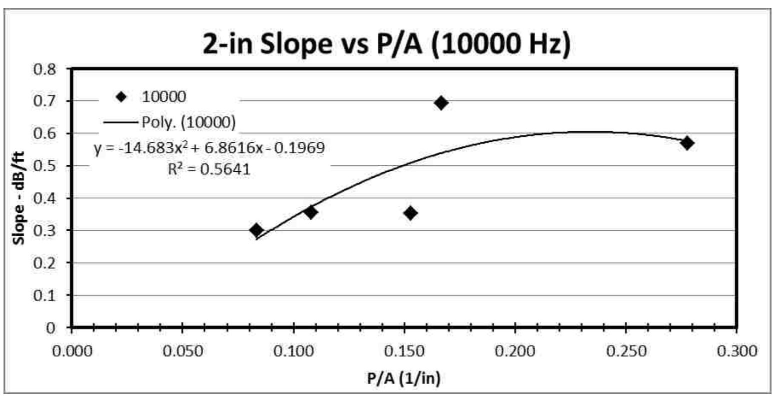

Figure B.76: 2-in Slope vs P/A at 10000 Hz

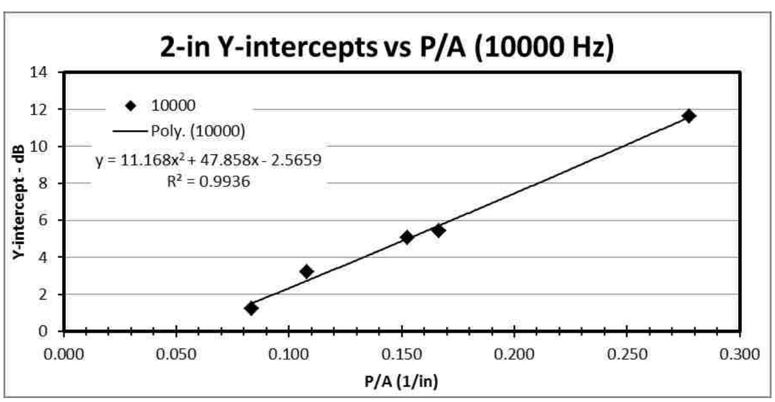

Figure B.77: 2-in Y-intercepts vs P/A at 10000 Hz

Duct Size - in x in		12x18	24x24	18x48	32x44	48x48	12x18	12x18	24x24	18x48	32x44	48x48	12x18	24x24	18x48	32x44	48x48	24x24	18x48	32x44	12x18	24x24	18x48	32x44	12x18	18x48	32x44	48x48	12x18	24x24	18x48	32x44	48x48	24x24	18x48	32x44	48x48			
Length -ft		3	3	3	3	3	5	7	7	7	7	7	10	10	10	10	10	13	13	13	15	17	17	17	20	20	20	20	25	30	30	30	30	40	40	40	40			
P/A - 1/in		0.278	0.167	0.153	0.108	0.083	0.278	0.278	0.167	0.153	0.108	0.083	0.278	0.167	0.153	0.108	0.083	0.167	0.153	0.108	0.278	0.167	0.153	0.108	0.278	0.153	0.108	0.083	0.278	0.167	0.153	0.108	0.083	0.167	0.153	0.108	0.083	AVG	STD	Freq
meas	50	-1.8	0.6	0.0	0.4	0.2	-0.3	-5.5	3.6	0.2	1.2	0.1	-4.0	4.5	-0.3	0.3	1.2	3.1	-1.0	0.1	-1.6	10.0	0.1	0.8	1.6	-0.7	0.2	1.8	-4.4	14.6	-2.5	0.5	0.9	9.1	-0.8	-0.5	0.8			50
regres	50	-2.3	1.2	1.3	0.9	0.4	-2.3	-2.2	1.7	1.7	1.0	0.2	-2.2	2.0	2.0	1.1	0.1	2.4	2.3	1.2	-2.0	2.9	2.8	1.4	-1.9	3.1	1.4	-0.2	-1.8	4.5	4.2	1.8	-0.6	5.7	5.3	2.1	-0.9			50
DIFF AVG		0.6	-0.5	-1.2	-0.5	-0.1	2.0	-3.2	1.9	-1.5	0.2	-0.1	-1.9	2.5	-2.3	-0.8	1.1	0.7	-3.4	-1.2	0.5	7.1	-2.7	-0.5	3.5	-3.8	-1.3	2.0	-2.6	10.2	-6.6	-1.2	1.5	3.5	-6.1	-2.6	1.7	-0.1	3.206	
meas	63	-2.2	0.2	0.1	0.0	0.3	0.4	0.5	0.7	0.1	-0.7	0.9	-1.2	0.3	1.4	1.0	-0.3	-0.1	1.1	1.0	-3.4	-0.1	0.8	0.7	-1.2	0.0	1.1	0.0	-5.5	-0.8	1.4	0.2	0.7	2.8	2.0	1.8	2.0			63
regres	63	-0.1	0.4	0.3	0.1	-0.1	-0.5	-0.9	0.3	0.4	0.3	0.1	-1.4	0.3	0.4	0.4	0.3	0.3	0.4	0.5	-2.3	0.3	0.5	0.7	-3.2	0.5	0.8	0.7	-4.1	0.2	0.6	1.1	1.1	0.2	0.7	1.5	1.6			63
DIFF AVG		-2.1	-0.1	-0.3	-0.2	0.3	0.9	1.4	0.3	-0.3	-1.0	0.7	0.2	-0.1	1.0	0.6	-0.6	-0.4	0.7	0.5	-1.1	-0.4	0.4	0.0	2.0	-0.5	0.3	-0.7	-1.3	-1.1	0.8	-0.9	-0.4	2.6	1.4	0.3	0.5	0.1	0.949	
meas	80	2.7	-0.6	-0.2	0.2	0.0	1.2	3.1	-0.4	-0.4	0.1	-0.1	4.1	-2.1	0.7	-0.2	1.0	-1.3	0.8	0.5	9.0	-1.9	0.3	0.8	9.3	1.7	-0.2	1.3	12.8	-0.6	2.8	-0.3	1.9	-2.8	3.8	1.7	2.0			80
regres	80	1.3	-0.5	-0.5	-0.2	0.2	2.4	3.4	-0.4	-0.5	-0.1	0.5	4.9	-0.4	-0.5	-0.1	0.7	-0.4	-0.5	0.0	7.4	-0.3	-0.5	0.1	9.9	-0.5	0.1	1.5	12.5	-0.2	-0.6	0.3	2.3	0.0	-0.6	0.5	3.0			80
DIFF AVG		1.4	-0.1	0.3	0.4	-0.2	-1.1	-0.3	0.0	0.1	0.2	-0.6	-0.7	-1.7	1.2	-0.2	0.3	-0.9	1.3	0.5	1.6	-1.6	0.8	0.7	-0.6	2.3	-0.3	-0.2	0.3	-0.5	3.4	-0.6	-0.3	-2.8	4.4	1.2	-1.0	0.2	1.355	
meas	100	-0.6	0.7	0.6	0.2	0.1	-2.5	0.0	1.4	1.7	0.8	0.7	-1.5	1.2	2.8	1.2	0.8	2.1	3.1	1.5	-1.5	2.6	4.0	1.7	-0.4	3.9	2.7	1.9	-1.9	3.3	5.7	3.8	3.1	2.6	8.6	4.0	3.5			100
regres	100	-1.1	0.7	0.7	0.5	0.2	-1.1	-1.2	1.4	1.4	1.0	0.5	-1.2	1.8	1.9	1.4	0.8	2.3	2.4	1.8	-1.2	3.0	3.0	2.3	-1.3	3.5	2.7	1.7	-1.4	5.1	5.1	3.9	2.5	6.7	6.7	5.2	3.4			100
DIFF AVG		0.5	-0.1	-0.2	-0.3	-0.1	-1.4	1.1	0.0	0.3	-0.2	0.2	-0.3	-0.7	0.9	-0.2	0.0	-0.3	0.7	-0.3	-0.3	-0.4	1.0	-0.6	0.9	0.4	0.0	0.2	-0.5	-1.8	0.7	-0.2	0.5	-4.0	1.9	-1.2	0.1	-0.1	0.978	
meas	125	2.9	1.3	1.4	1.0	0.5	4.1	5.8	2.9	2.3	2.2	1.8	6.6	3.9	3.3	2.7	2.1	5.3	4.5	3.2	9.8	6.6	5.6	4.8	12.9	6.3	5.2	4.4	15.7	8.2	9.4	7.9	6.6	11.3	12.0	10.0	8.0			125
regres	125	2.9	1.4	1.3	1.0	0.9	4.1	5.3	2.8	2.6	2.0	1.7	7.0	3.9	3.6	2.7	2.3	5.0	4.6	3.4	9.9	6.4	5.9	4.4	12.8	6.8	5.1	4.3	15.7	10.9	10.1	7.6	6.3	14.5	13.4	10.0	8.3			125
DIFF AVG		-0.1	-0.2	0.1	0.1	-0.4	0.0	0.6	0.1	-0.3	0.2	0.1	-0.4	0.0	-0.3	0.1	-0.1	0.3	0.0	-0.2	-0.1	0.2	-0.2	0.5	0.0	-0.6	0.1	0.1	0.0	-2.8	-0.7	0.4	0.3	-3.1	-1.3	0.0	-0.3	-0.2	0.756	
meas	160	3.1	1.5	1.3	1.2	0.6	4.6	6.8	3.1	2.5	2.4	2.4	7.9	4.3	4.5	2.9	3.3	5.2	5.5	3.9	11.6	6.3	6.9	5.2	15.5	8.0	6.2	6.1	18.6	8.2	12.1	9.3	8.9	11.3	15.6	12.3	11.4			160
regres	160	3.4	1.6	1.4	1.1	1.0	4.7	6.1	3.1	2.9	2.3	2.2	8.2	4.2	3.9	3.2	3.0	5.4	5.0	4.1	11.7	6.9	6.4	5.3	15.2	7.5	6.3	5.9	18.7	11.8	11.0	9.3	8.8	15.6	14.6	12.3	11.7			160
DIFF AVG		-0.2	-0.1	-0.2	0.1	-0.4	-0.2	0.7	0.0	-0.4	0.1	0.2	-0.3	0.0	0.5	-0.3	0.2	-0.2	0.5	-0.3	-0.2	-0.5	0.5	-0.1	0.3	0.6	-0.1	0.2	-0.1	-3.6	1.1	0.0	0.1	-4.3	1.0	0.0	-0.3	-0.2	1.011	
meas	200	3.8	2.7	2.3	1.9	1.5	6.8	8.8	6.8	5.4	4.7	4.5	12.0	9.3	8.3	6.4	6.2	11.8	10.6	8.2	18.0	15.2	13.6	10.9	22.9	15.4	12.8	11.8	29.5	18.0	23.1	18.5	17.2	25.7	29.8	24.7	21.6			200
regres	200	4.2	2.9	2.8	2.3	2.1	6.4	8.7	6.3	5.9	4.8	4.2	12.2	8.8	8.3	6.7	5.8	11.3	10.7	8.6	17.9	14.6	13.8	11.1	23.6	16.2	12.9	11.0	29.3	25.5	24.1	19.2	16.3	33.8	32.0	25.4	21.6			200
DIFF AVG		-0.3	-0.2	-0.5	-0.4	-0.6	0.4	0.1	0.5	-0.5	-0.1	0.3	-0.1	0.6	0.0	-0.3	0.4	0.5	0.0	-0.4	0.2	0.6	-0.2	-0.2	-0.6	-0.8	-0.1	0.8	0.2	-7.5	-1.0	-0.7	0.9	-8.1	-2.1	-0.7	0.0	-0.6	1.873	
meas	250	5.1	4.1	4.3	3.2	2.7	9.5	12.7	9.3	8.7	7.4	6.5	17.4	13.2	12.9	9.8	8.7	17.2	16.3	12.5	25.5	22.1	20.8	16.1	32.5	23.6	19.1	16.4	40.2	26.7	34.6	27.4	23.9	36.6	45.3	36.2	30.7			250
regres	250	6.1	4.5	4.3	3.7	3.3	9.2	12.4	9.5	9.0	7.3	6.2	17.1	13.2	12.5	10.0	8.4	16.8	16.0	12.7	24.9	21.8	20.6	16.3	32.8	24.1	19.0	15.8	40.7	37.8	35.7	28.1	23.2	50.1	47.3	37.1	30.5			250
DIFF AVG		-1.0	-0.5	-0.1	-0.4	-0.6	0.3	0.4	-0.1	-0.3	0.1	0.2	0.4	0.1	0.5	-0.2	0.3	0.3	0.3	-0.2	0.6	0.4	0.2	-0.2	-0.3	-0.5	0.1	0.6	-0.4	-11.1	-1.1	-0.6	0.7	-13.5	-2.1	-0.9	0.2	-0.8	2.899	
meas	315	7.1	5.5	5.7	5.0	4.8	13.1	17.0	12.3	12.1	10.7	10.4	24.5	17.9	17.9	14.3	14.8	22.8	22.3	18.1	35.5	32.1	29.2	23.2	46.4	33.2	27.5	27.5	50.5	33.4	49.9	40.6	38.9	48.8	54.4	51.1	47.1			315
regres	315	9.0	6.5	6.3	6.1	6.1	13.1	17.2	13.1	12.7	11.2	10.5	23.4	18.1	17.4	15.1	13.9	23.1	22.2	19.0	33.6	29.8	28.5	24.2	43.9	33.3	28.1	25.0	54.1	51.4	49.2	41.1	36.0	50.0	50.0	54.1	47.1			315
DIFF AVG		-2.0	-1.0	-0.6	-1.1	-1.3	0.0	-0.3	-0.8	-0.5	-0.5	-0.1	1.1	-0.2	0.5	-0.8	1.0	-0.3	0.1	-0.9	1.9	2.4	0.7	-1.0	2.5	-0.1	-0.6	2.6	-3.6	-18.0	0.7	-0.5	2.9	-1.2	4.4	-3.0	-0.1	-0.5	3.395	
meas	400	10.2	8.9	7.8	7.6	7.0	18.0	24.1	20.0	19.2	16.3	15.5	35.2	27.8	27.3	21.9	20.7	36.8	33.2	27.7	51.6	42.9	43.0	36.2	49.9	48.6	41.6	39.0	49.7	48.1	51.8	51.3	55.2	51.7	52.0	53.3	52.3			400
regres	400	10.6	9.6	9.3	8.3	7.7	17.5	24.4	19.6	18.8	16.3	14.8	34.7	27.0	26.0	22.3	20.1	34.5	33.1	28.3	51.9	44.5	42.6	36.2	50.0	49.7	42.2	37.9	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			400
DIFF AVG		-0.5	-0.6	-1.5	-0.8	-0.6	0.5	-0.3	0.5	0.4	0.0	0.7	0.5	0.8	1.3	-0.4	0.6	2.2	0.2	-0.5	-0.3	-1.6	0.4	0.0	-0.1	-1.1	-0.6	1.1	-0.3	-1.9	1.8	1.3	5.2	1.7	2.0	3.3	2.3	0.4	1.427	
meas	500	14.7	12.9	11.1	10.4	8.2	23.1	30.4	27.1	23.9	20.8	19.2	43.3	35.0	33.0	29.0	28.0	43.3	42.6	38.0	48.0	48.8	49.2	45.2	47.9	49.8	48.8	48.1	47.5	49.7	50.4	50.2	53.1	49.3	50.4	50.8	53.4			500
regres	500	17.7	14.4	13.7	11.4	9.8	23.4	29.1	25.1	24.3	21.0	18.9	37.6	33.2	32.2	28.3	25.7	41.2	40.1	35.6	51.7	52.0	50.6	45.2	50.0	50.0	52.5	48.5	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			500
DIFF AVG		-3.1	-1.5	-2.7	-0.9	-1.7	-0.3	1.3	2.0	-0.3	-0.3	0.2	5.7	1.9	0.8	0.7	2.3	2.1	2.6	2.4	-3.8	-3.1	-1.4	-0.1	-2.1	-0.2	-3.7	-0.4	-2.5	-0.3	0.4	0.2	3.1	-0.7	0.4	0.8	3.4	0.0	2.152	
meas	630	19.6	16.0	15.2	10.6	9.0	29.4	36.4	33.4	28.8	24.2	15.3	49.7	43.3	39.1	34.3	19.4	53.2	50.0	47.7	51.3	56.1	55.0	53.4	51.3	55.7	55.9	31.3	50.7	56.5	55.9	56.9	40.6	56.3	55.7	57.3	46.7			630
regres	630	20.1	18.8	17.9	14.0	11.1	28.4	36.8	31.7	29.9	22.2	16.9	49.4	41.4	38.8	28.4	21.3	51.0	47.8	34.6	55.0	55.0	55.0	55.0	55.0	55.0	55.0	35.8	55.0	55.0	55.0	55.0	50.3	55.0	55.0	55.0	55.0			630
DIFF AVG		-0.5	-2.8	-2.8	-3.4	-2.1	0.9	-0.5	1.7	-1.0	1.9	-1.6	0.3	1.9	0.3	5.8	-1.9	2.2	2.2	13.1	-3.7	1.1	0.0	-1.6	-3.7	0.7	0.9	-4.5	-4.3	1.5	0.9	1.9	-9.7	1.3	0.7	2.3	-8.3	-0.3	3.815	
meas	800	27.1	16.0	17.5	9.4	8.5	39.2	47.3	39.2	35.3	16.5	12.5	47.8	52.4	46.0	23.5	14.3	53.5	50.9	29.0	47.7	53.7	51.4	36.4	47.7	51.6	39.7	21.3	47.5	54.1	51.4	50.1	26.6	53.9	51.5	53.2	29.5			800
REGRESS	800	30.9	18.6	17.2	12.5	10.0	36.8	42.7	36.4	33.4	20.3	10.9	51.5	49.7	45.5	26.2	11.7	50.0	50.0	32.0	50.0	50.0	50.0	39.8	50.0	50.0	45.7	14.1	50.0	50.0	50.0	50.0	16.5	50.0	50.0	50.0	18.9			800
DIFF AVG		-3.7	-2.6	0.3	-3.0	-1.4	2.4	4.6	2.8	1.9	-3.8	1.6	-3.7	2.7	0.5	-2.6	2.7	3.5	0.9	-3.0	-2.3	3.7	1.4	-3.4	-2.3	1.6	-6.0	7.2	-2.5	4.1	1.4	0.1	10.1	3.9	1.5	3.2	10.6	0.9	3.829	
meas	1000	31.8	15.8	12.8	8.5	6.2	48.0	49.1	28.6	29.7	14.2	8.9	49.3	36.6	40.9	17.5	10.7	44.2	48.9	20.8	49.1	51.7	52.2	26.2	49.4	53.2	28.8	15.3	48.8	52.9	53.1	36.9	19.0	54.4	53.7	44.7	20.7			1000
regres	1000	34.3	18.0	16.2	10.5	7.6	42.9	51.6	29.4	26.2	15.2	8.8	50.0	37.9	33.7	18.8	9.7	46.4	41.1	22.3	50.0	50.0	51.1	27.0	50.0	50.0	30.5	12.8	50.0	50.0	50.0	42.3	15.8	50.0	50.0	50.0	18.8			1000
DIFF AVG		-2.5	-2.3	-3.4	-2.0	-1.4	5.1	-2.5	-0.7	3.5	-1.0	0.1	-0.7	-1.2	7.2	-1.3	1.0	-2.1	7.7	-1.5	-0.9	1.7	1.1	-0.8	-0.6	3.2	-1.7	2.5	-1.2	2.9	3.1	-5.4	3.1	4.4	3.7	-5.3	1.8	0.4	3.126	
meas	1250	24.8	12.9	11.0	7.6	5.1	41.1	48.8	20.7	20.0	12.3	7.7	49.4	25.4	25.2	15.2	9.3	30.0	31.0	17.6	49.1	35.9	38.7	20.9	49.2	43.4	22.2	14.4	48.6	40.4	52.2	27.7	17.2	53.8	53.9	31.0	18.2			1250
regres	1250	26.1	14.7	13.4	9.3	7.2	38.1	50.1	21.7	19.1	11.8	8.7	50.0	27.0	23.3	13.7	9.8	32.3	27.6	15.5	50.0	39.3	33.3	18.0	50.0	37.5	19.9	13.5	50.0	55.0	51.7	26.1	17.2	50.0	50.0	32.3	21.0			1250
DIFF AVG	27.1	-1.3	-1.9	-2.4	-1.7	-2.1	3.0	-1.3	-1.0	0.9	0.5	-1.0	-0.6	-1.6	1.8	1.5	-0.5	-2.3	3.4	2.1	-0.9	-3.4	5.5	2.9	-0.8	5.8	2.4	0.9	-1.4	-14.6	0.5	1.6	0.0	3.8	3.9	-1.3	-2.8	-0.1	3.426	
meas	1600	19.7	12.2	9.5	6.5	4.4	29.6	38.5	19.0	15.3	10.1	6.5	47.9	22.3	18.9	12.6	8.1	25.4	22.4	14.6	49.3	27.4	27.2	17.3	49.7	30.4	17.6	12.6	49.5	29.6	40.0	21.5	15.6	37.1	50.4	26.5	18.2			1600
regres	1600	20.9	13.1	12.0	7.9	5.4	28.9	36.9	17.9	15.8	9.9	7.0	49.0	21.4	18.8	11.4	8.1	25.0	21.7	12.9	50.0	29.7	25.6	14.9	50.0	28.5	16.5	12.0	50.0	45.1	38.3	21.5	15.9	57.0	48.0	26.6	19.7			1600
DIFF AVG		-1.2	-0.9	-2.4	-1.4	-1.1	0.7	1.6	1.2	-0.5	0.2	-0.4	-1.1	0.9	0.1	1.1	-0.1	0.4	0.7	1.6	-0.7	-2.3	1.6	2.3	-0.3	1.9	1.1	0.6	-0.5	-15.6	1.7	0.0	-0.3	-19.9	2.4	0.0	-1.6	-0.8	4.369	
meas	2000	16.2	10.9	7.5	5.0	3.8	22.0	27.4	17.4	12.1	8.6	5.3	33.5	20.0	14.0	9.8	6.7	22.2	16.6	11.5	43.4	24.4	18.6	14.2	48.4	20.5	15.4	10.7	49.4	25.9	27.6	18.6	12.9	30.7	33.2	18.5	13.4			2000
regres	2000	18.6	11.2	10.1	6.5	4.4	22.4	26.2	14.7	13.2	8.3	5.5	31.9	17.3	15.5	9.6	6.4	20.0	17.8	11.0	41.4	23.5	20.9	12.8	50.9	23.2	14.1	9.3	50.0	34.9	30.9	18.6	12.3	43.6	38.5	23.1	15.2			2000
DIFF AVG		-2.4	-0.3	-2.6	-1.5	-0.5	-0.3	1.2	2.7	-1.1	0.3	-0.2	1.6	2.6	-1.5	0.2	0.3	2.2	-1.2	0.5	2.0	1.0	-2.3	1.5	-2.5	-2.7	1.3	1.4	-0.6	-8.9	-3.2	0.0	0.6	-12.9	-5.3	-4.6	-1.8	-1.0	3.141	
meas	2500	14.8	9.1	6.5	4.4	3.5	20.4	23.7	15.0	10.6	7.1	4.9	28.2	17.6	12.4	9.8	6.4	19.3	13.6	11.4	35.2	21.2	16.3	12.8	41.7	17.4	13.2	9.0	50.3	22.3	22.1	16.0	11.1	26.8	28.0	17.7	12.7			2500
regres	2500	16.7	9.8	8.9	6.0	4.4	19.7	22.8	12.8	11.5	7.5	5.3	27.4	15.0	13.5	8.6	5.9	17.2	15.4	9.7	35.0	20.2	18.0	11.2	42.7	19.9	12.3	8.1	50.4	29.7	26.4	15.9	10.3	37.1	32.9	19.6	12.6			2500
DIFF AVG		-1.8	-0.8	-2.5	-1.7	-0.9	0.6	1.0	2.2	-0.9	-0.4	-0.4	0.8	2.6	-1.0	1.2	0.5	2.1	-1.9	1.7	0.1	1.0	-1.7	1.6	-1.0	-2.5	0.9	0.9	-0.1	-7.4	-4.3	0.0	0.8	-10.3	-4.9	-1.8	0.2	-0.8	2.632	
meas	3150	15.9	8.4	6.2	4.3	2.8	20.8	23.6	13.3	10.6	7.3	4.5	26.8	16.2	13.4	9.0	5.7	17.7	13.9	10.7	30.8	19.2	15.8	11.6	34.6	16.8	12.9	9.5	37.9	20.0	20.1	15.3	11.3	24.3	26.1	17.8	12.2			3150
regres	3150	18.7	9.7	8.6	5.6	4.0	20.5	22.4	12.2	11.0	7.1	4.9	25.2	14.2	12.8	8.2	5.6	16.1	14.5	9.3	29.9	18.7	16.9	10.8	34.6	18.7	11.9	7.9	39.3	27.1	24.6	15.6	10.2	33.6	30.5	19.3	12.5			3150
DIFF AVG		-2.7	-1.3	-2.4	-1.2	-1.2	0.3	1.2	1.0	-0.4	0.3	-0.5	1.6	2.0	0.6	0.8	0.1	1.6	-0.7	1.4	0.9	0.5	-1.1	0.8	0.0	-1.8	1.0	1.6	-1.4	-7.2	-4.4	-0.3	1.1	-9.3	-4.4	-1.5	-0.3	-0.7	2.44	
meas	4000	12.0	7.7	6.0	3.8	2.4	15.6	17.4	13.0	9.4	6.8	4.3	20.0	15.7	11.0	8.4	5.4	17.5	11.8	9.6	23.4	19.8	13.7	11.7	26.7	14.9	13.5	9.3	29.2	21.0	17.8	16.7	11.0	25.5	24.8	16.0	11.3			4000
regres	4000	13.8	8.3	7.5	4.9	3.3	15.3	16.8	11.1	10.1	6.6	4.4	19.1	13.2	12.0	7.8	5.1	15.3	14.0	9.1	22.8	18.0	16.6	10.8	26.6	18.5	12.1	7.7	30.3	27.1	24.9	16.3	10.3	34.0	31.4	20.5	12.9			4000
DIFF AVG		-1.9	-0.6	-1.5	-1.1	-0.9	0.3	0.6	1.9	-0.7	0.3	-0.1	0.9	2.5	-1.0	0.6	0.2	2.3	-2.2	0.5	0.6	1.8	-2.8	0.9	0.1	-3.6	1.4	1.5	-1.2	-6.1	-7.2	0.4	0.7	-8.5	-6.6	-4.5	-1.6	-1.0	2.709	
meas	5000	12.9	7.2	5.1	3.5	2.4	16.9	18.3	13.9	8.1	6.7	4.6	21.8	16.3	10.1	8.7	5.5	17.8	11.9	9.7	25.9	18.3	14.1	11.8	30.5	15.4	12.2	8.7	35.4	19.7	18.6	14.4	10.1	22.7	20.1	12.4	11.1			5000
regres	5000	14.2	8.6	7.8	5.1	3.5	16.2	18.2	11.1	10.1	6.5	4.4	21.1	13.0	11.8	7.6	5.1	14.9	13.5	8.7	26.0	17.4	15.8	10.1	30.8	17.5	11.2	7.4	35.7	25.6	23.2	14.8	9.7	31.9	28.9	18.4	12.0			5000
DIFF AVG		-1.3	-1.5	-2.8	-1.6	-1.1	0.7	0.1	2.7	-2.0	0.2	0.2	0.7	3.3	-1.7	1.1	0.4	2.9	-1.6	1.0	-0.1	0.9	-1.7	1.6	-0.4	-2.1	0.9	1.2	-0.3	-5.9	-4.6	-0.4	0.4	-9.2	-8.8	-6.0	-0.9	-1.0	2.875	
meas	6300	14.8	6.9	5.4	3.8	1.9	19.9	22.7	12.5	8.5	6.8	4.1	24.2	15.2	10.2	8.3	4.8	16.5	12.9	8.7	27.6	17.9	15.0	10.8	28.6	16.3	12.0	9.4	30.7	19.1	18.4	14.0	11.0	21.9	16.6	12.7	10.8			6300
regres	6300	18.3	7.8	6.8	4.1	2.9	19.6	20.8	10.7	9.5	5.9	4.1	22.7	12.8	11.5	7.3	4.9	15.0	13.5	8.7	25.9	17.8	16.2	10.5	29.1	18.2	11.9	7.8	32.3	27.1	25.0	16.4	10.7	34.2	31.7	21.0	13.5			6300
DIFF AVG		-3.5	-1.0	-1.4	-0.4	-1.0	0.3	1.8	1.9	-1.0	0.8	0.0	1.4	2.4	-1.3	1.0	-0.2	1.6	-0.7	0.1	1.7	0.1	-1.2	0.3	-0.5	-1.9	0.2	1.6	-1.6	-8.0	-6.5	-2.4	0.3	-12.4	-15.1	-8.3	-2.8	-1.5	3.912	
meas	8000	11.9	6.4	5.2	3.2	1.6	16.9	19.6	11.3	8.4	6.0	4.0	22.0	14.1	10.2	7.8	4.6	15.1	11.9	8.4	23.1	16.9	13.5	10.4	24.1	13.8	11.1	8.9	27.8	18.9	16.0	12.8	10.3	22.3	14.9	12.5	11.1			8000
regres	8000	15.4	7.8	6.9	4.3	3.0	16.6	17.7	10.1	9.1	5.8	3.9	19.5	11.8	10.7	6.8	4.6	13.6	12.3	7.9	22.5	15.9	14.5	9.4	25.5	16.1	10.5	6.9	28.5	23.4	21.5	14.1	9.2	29.2	27.0	17.8	11.5			8000
DIFF AVG		-3.5	-1.4	-1.7	-1.1	-1.4	0.4	1.8	1.2	-0.7	0.2	0.1	2.4	2.3	-0.5	1.0	0.0	1.5	-0.4	0.4	0.5	1.1	-1.0	1.0	-1.4	-2.3	0.6	2.0	-0.7	-4.5	-5.5	-1.3	1.1	-6.9	-12.1	-5.3	-0.4	-1.0	2.919	
meas	10000	9.9	6.1	4.8	2.9	1.3	15.2	17.1	11.5	7.4	6.0	3.9	19.3	13.4	8.4	7.6	4.2	14.7	10.7	7.7	20.8	16.2	12.6	10.0	22.3	12.7	10.9	8.2	25.0	18.1	14.2	12.8	9.5	21.5	15.0	12.6	9.7			10000
regres	10000	13.3	7.3	6.5	3.8	2.3	14.5	15.6	9.5	8.6	5.3	3.4	17.4	11.1	10.1	6.5	4.2	12.7	11.6	7.6	20.2	14.9	13.7	9.1	23.1	15.2	10.2	7.0	26.0	21.9	20.3	13.9	9.7	27.3	25.4	17.6	12.4			10000
DIFF AVG		-3.5	-1.2	-1.7	-1.0	-1.1	0.8	1.5	2.0	-1.2	0.6	0.5	2.0	2.3	-1.7	1.2	0.0	2.0	-0.9	0.1	0.6	1.3	-1.1	1.0	-0.8	-2.5	0.8	1.2	-1.0	-3.8	-6.1	-1.1	-0.2	-5.8	-10.4	-5.1	-2.7	-1.0	2.687	

meas - Measured IL Values

DIF AVG - Calculation of the average of the differneces between measured and calculated IL values

Flanking Insertion Loss Reached

Regress - Calculated IL Values from Regression Equation

STD - Calculation of the standard deviation relative to the DIFF AVG

Figure B.78: Data Comparison for 2-in Rectangular Ducts

APPENDIX C E.H. PRICE + UNLV DATA FOR 1-IN RECTANGULAR DUCTS

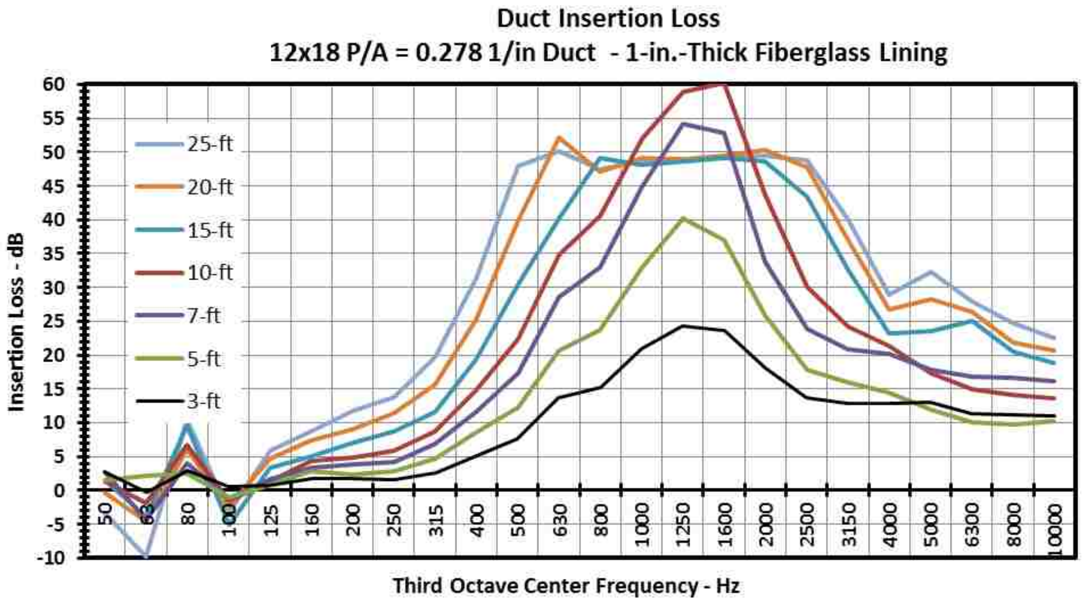

Figure C.1: Insertion Loss for 12x18 ducts with 1-in Fiberglass

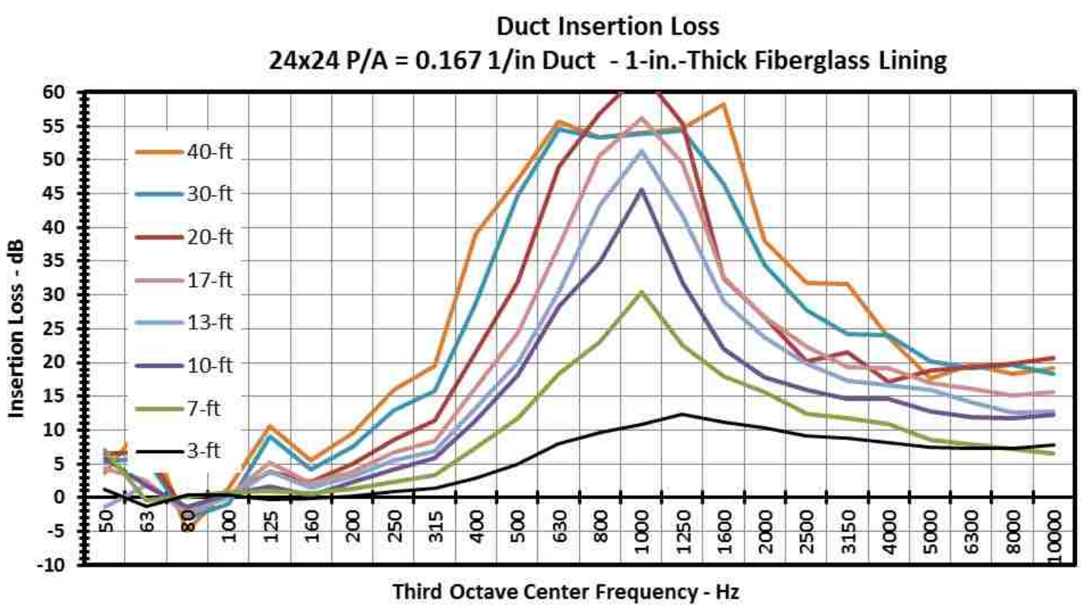

Figure C.2: Insertion Loss for 24x24 ducts with 1-in Fiberglass

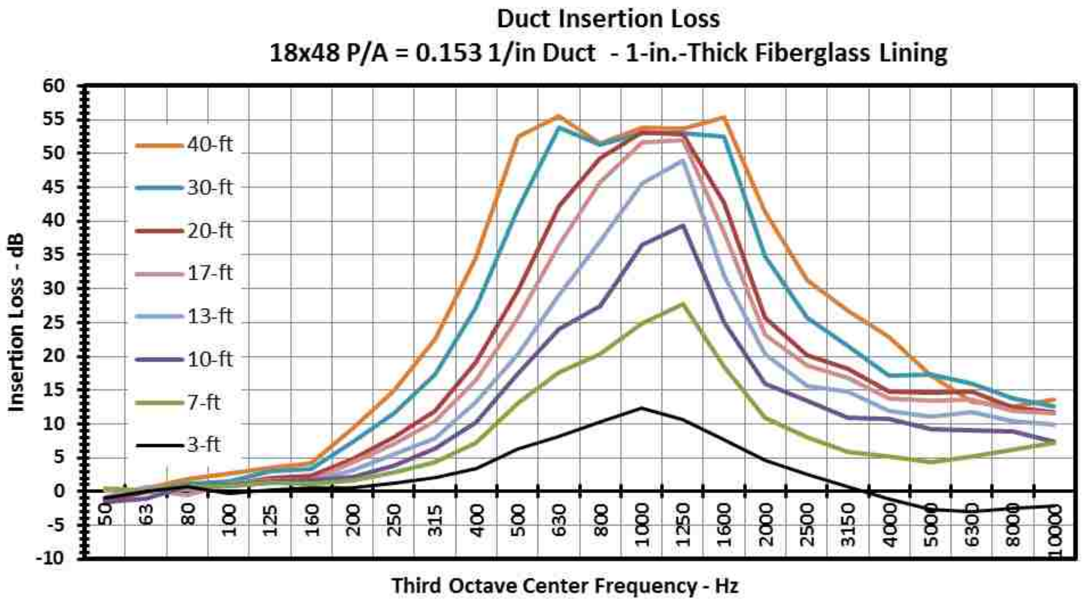

Figure C.3: Insertion Loss for 18x48 ducts with 1-in Fiberglass

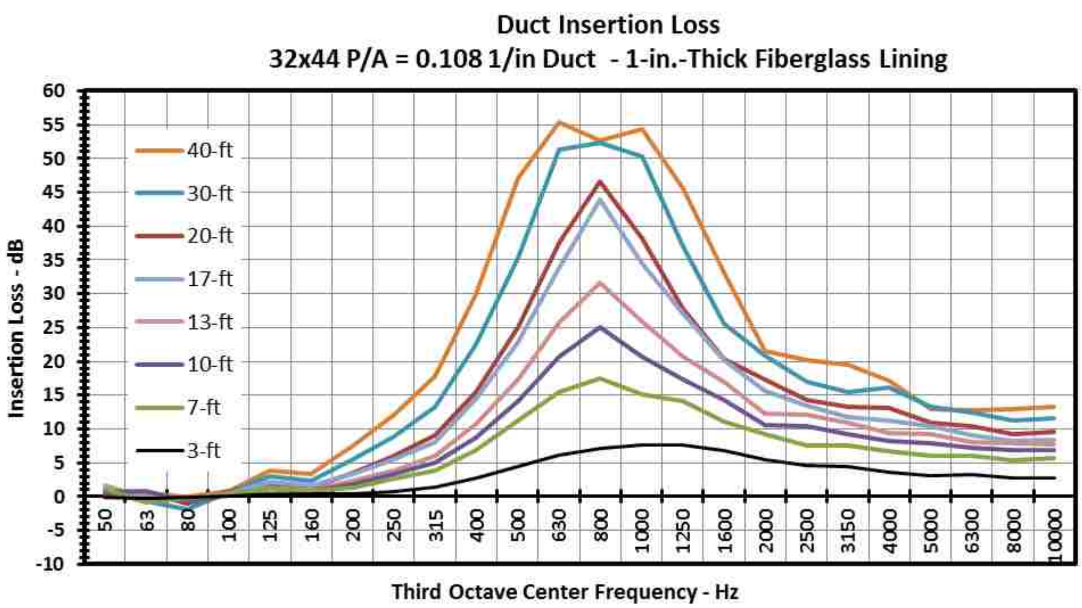

Figure C.4: Insertion Loss for 32x44 ducts with 1-in Fiberglass

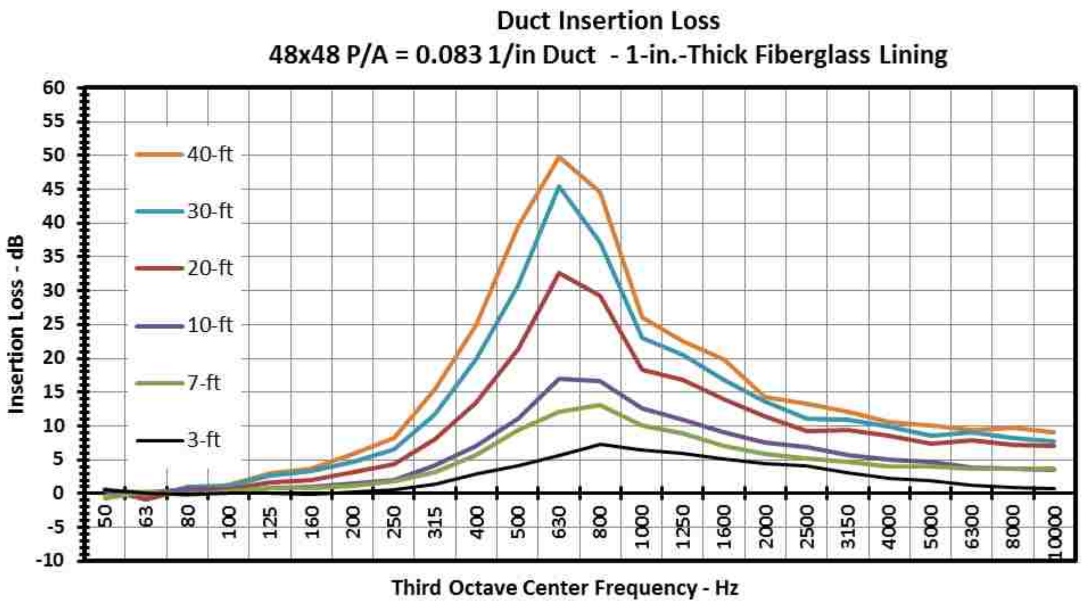

Figure C.5: Insertion Loss for 48x48 ducts with 1-in Fiberglass

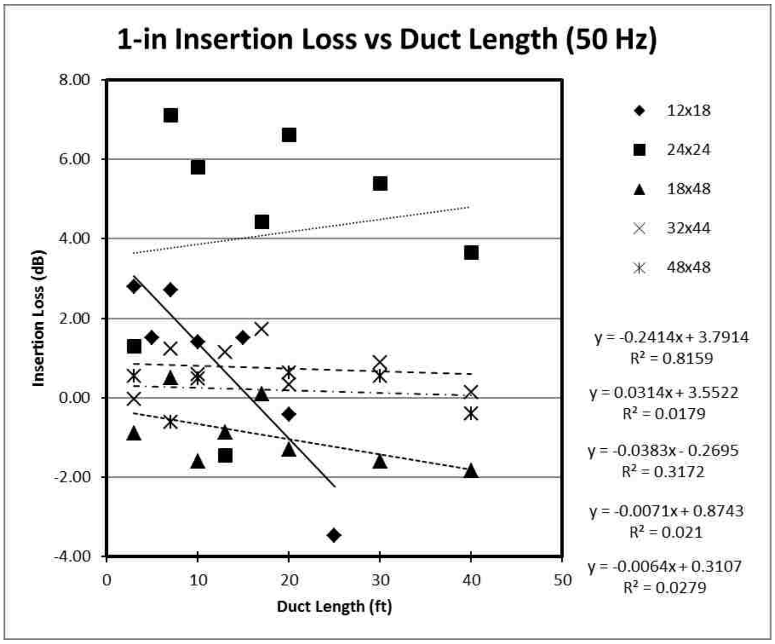

Figure C.6: 1-in Insertion Loss vs Duct Length at 50 Hz

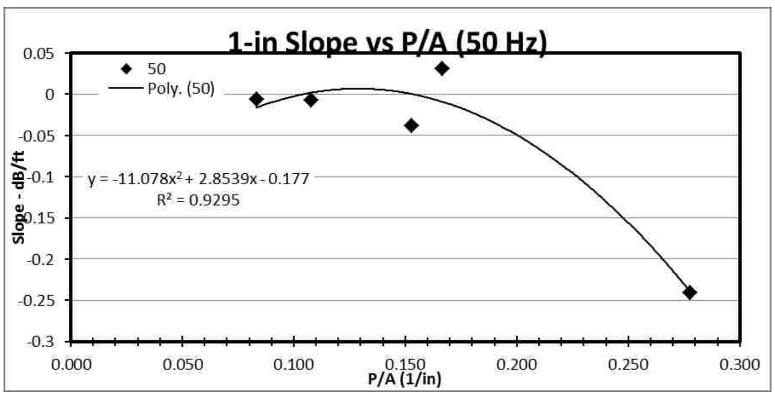

Figure C.7: 1-in Slope vs P/A at 50 Hz

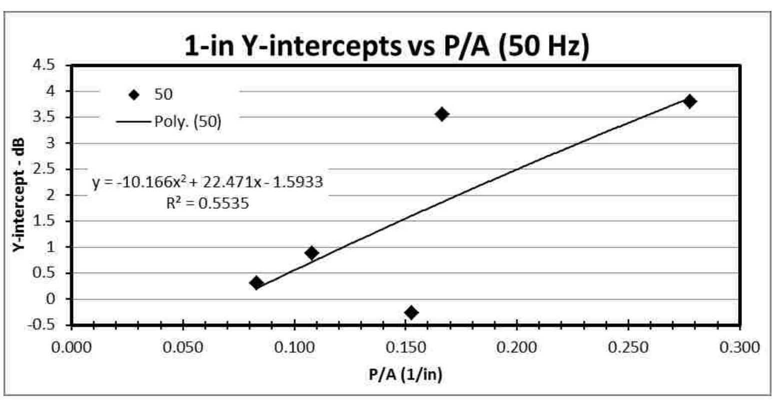

Figure C.8: 1-in Y-intercepts vs P/A at 50 Hz

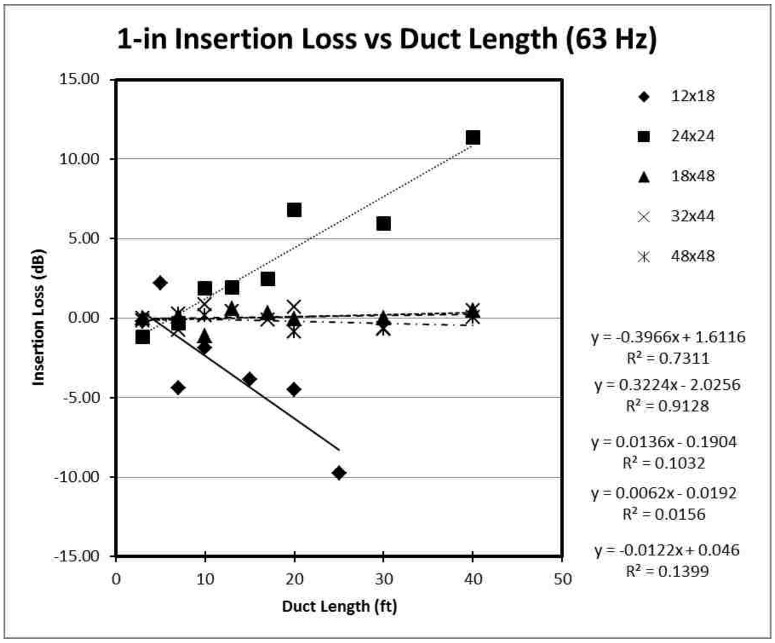

Figure C.9: 1-in Insertion Loss vs Duct Length at 63 Hz

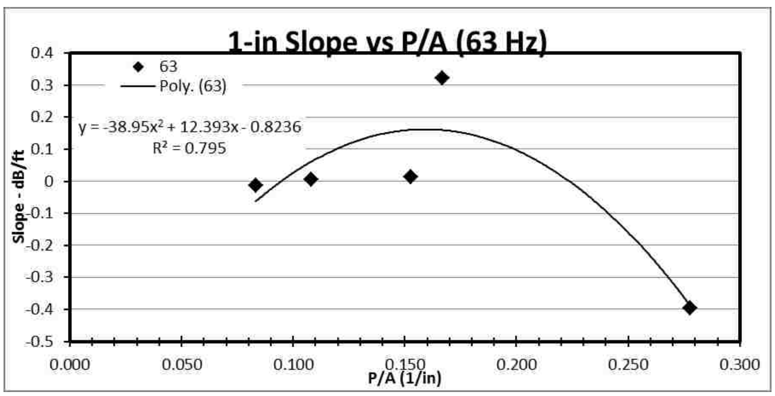

Figure C.10: 1-in Slope vs P/A at 63 Hz

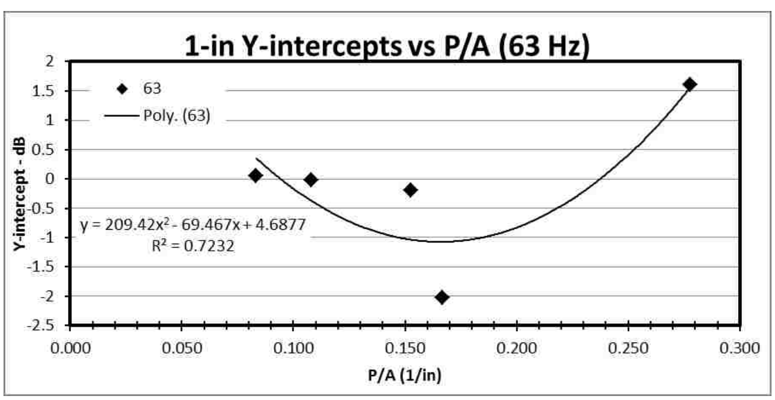

Figure C.11: 1-in Y-intercepts vs P/A at 63 Hz

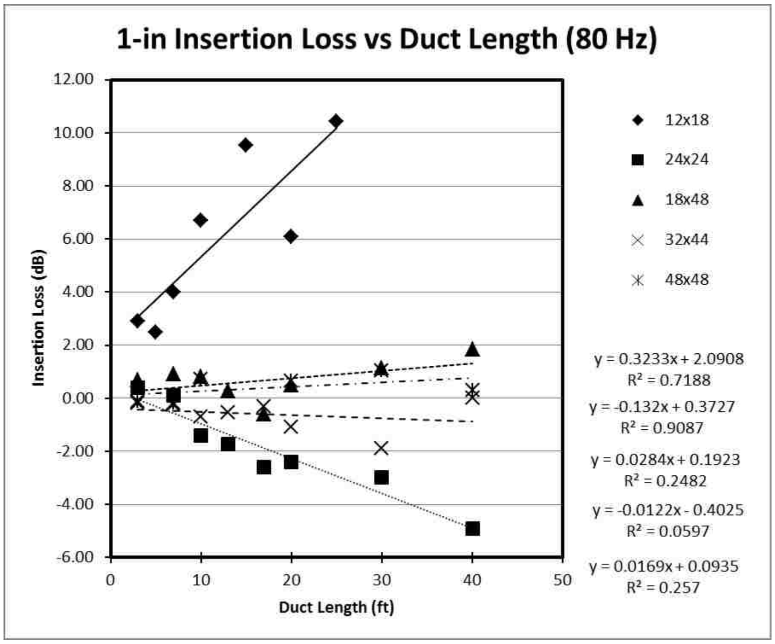

Figure C.12: 1-in Insertion Loss vs Duct Length at 80 Hz

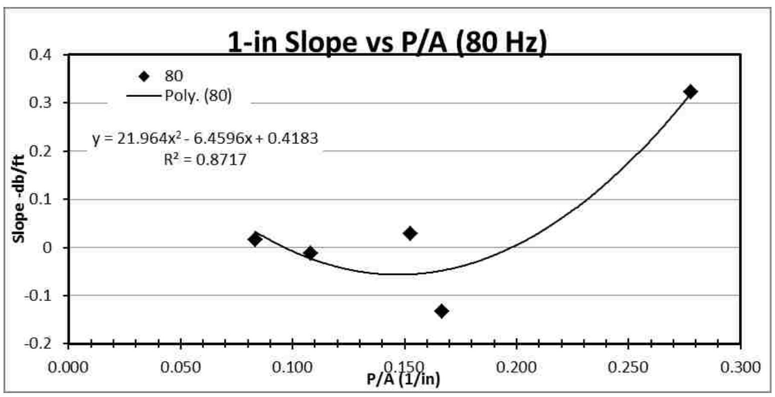

Figure C.13: 1-in Slope vs P/A at 80 Hz

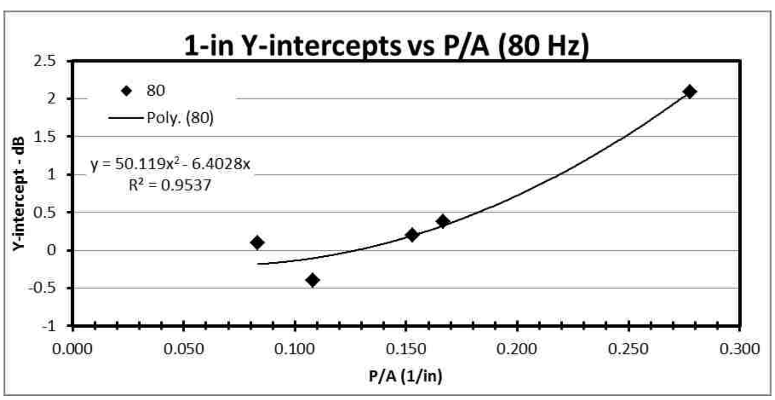

Figure C.14: 1-in Y-intercepts vs P/A at 80 Hz

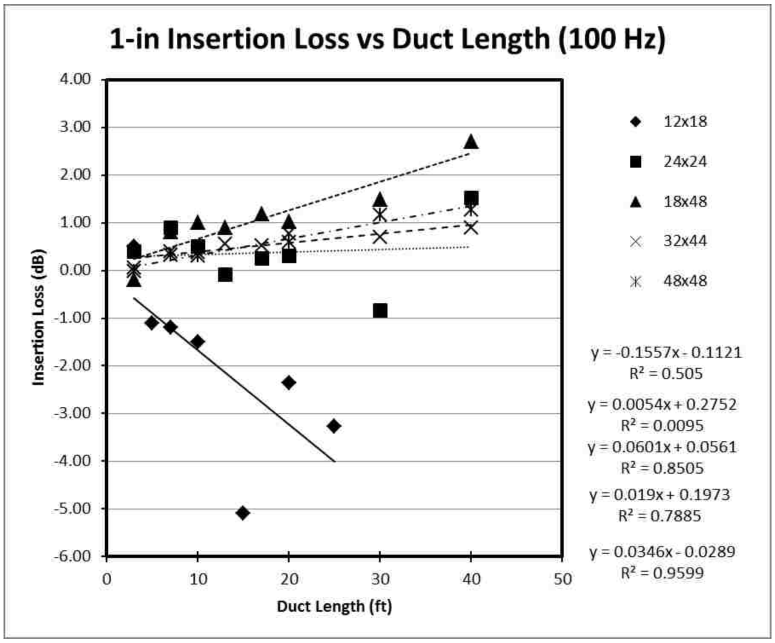

Figure C.15: 1-in Insertion Loss vs Duct Length at 100 Hz

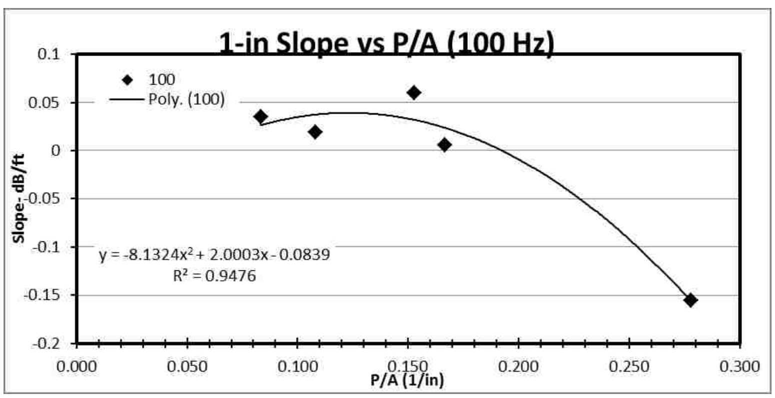

Figure C.16: 1-in Slope vs P/A at 100 Hz

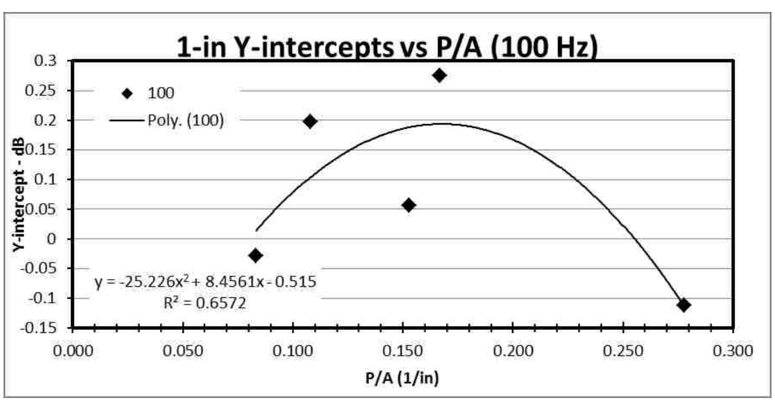

Figure C.17: 1-in Y-intercepts vs P/A at 100 Hz

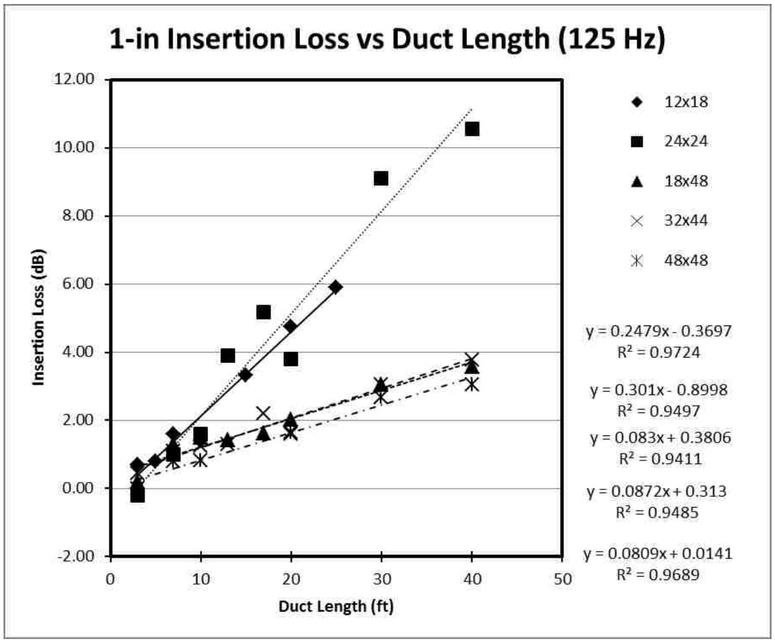

Figure C.18: 1-in Insertion Loss vs Duct Length at 125 Hz

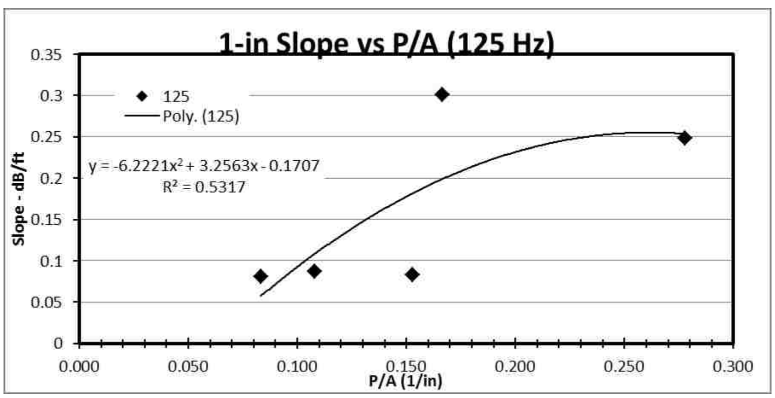

Figure C.19: 1-in Slope vs P/A at 125 Hz

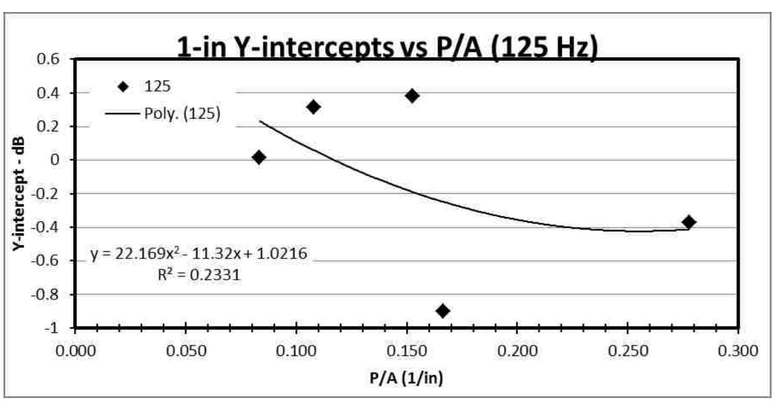

Figure C.20: 1-in Y-intercepts vs P/A at 125 Hz

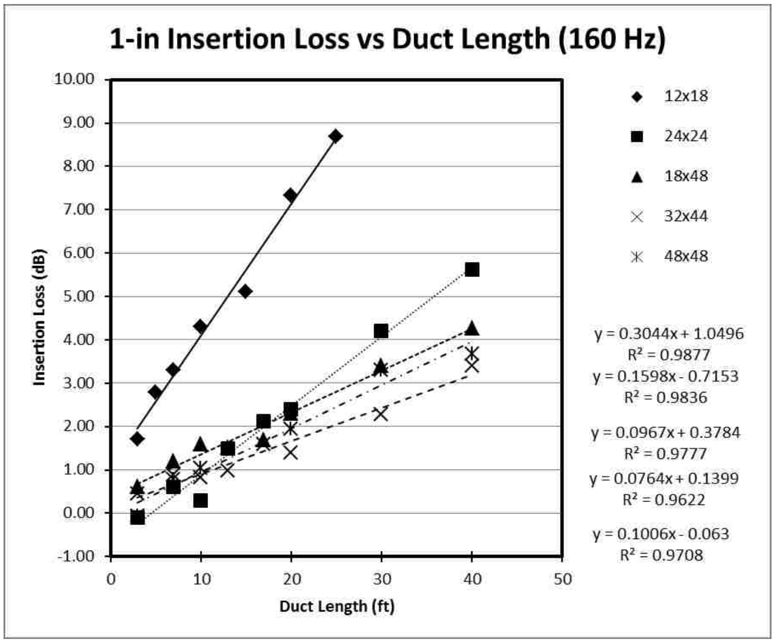

Figure C.21: 1-in Insertion Loss vs Duct Length at 160 Hz

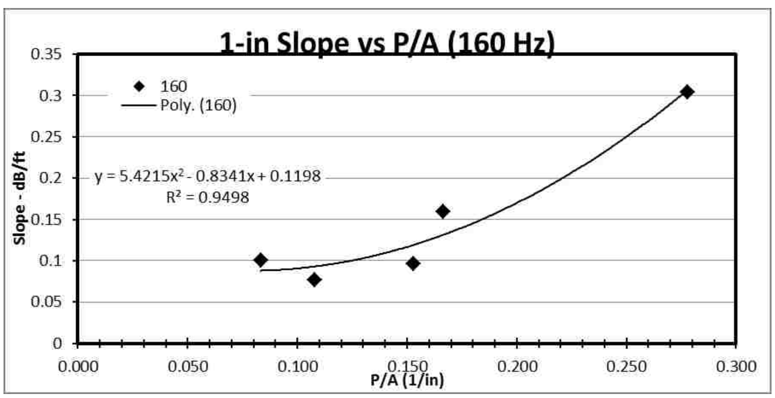

Figure C.22: 1-in Slope vs P/A at 160 Hz

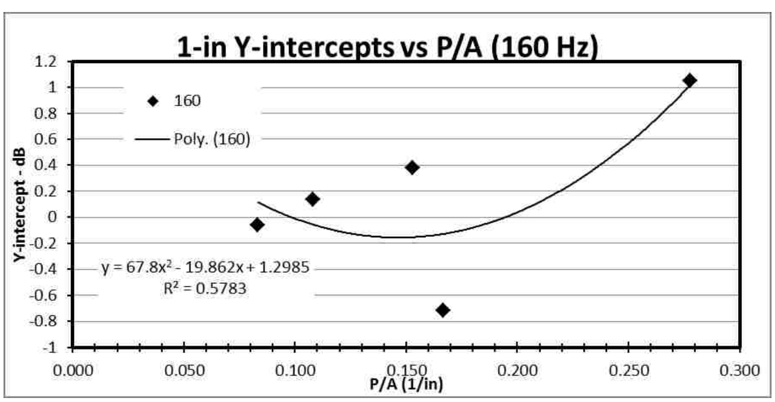

Figure C.23: 1-in Y-intercepts vs P/A at 160 Hz

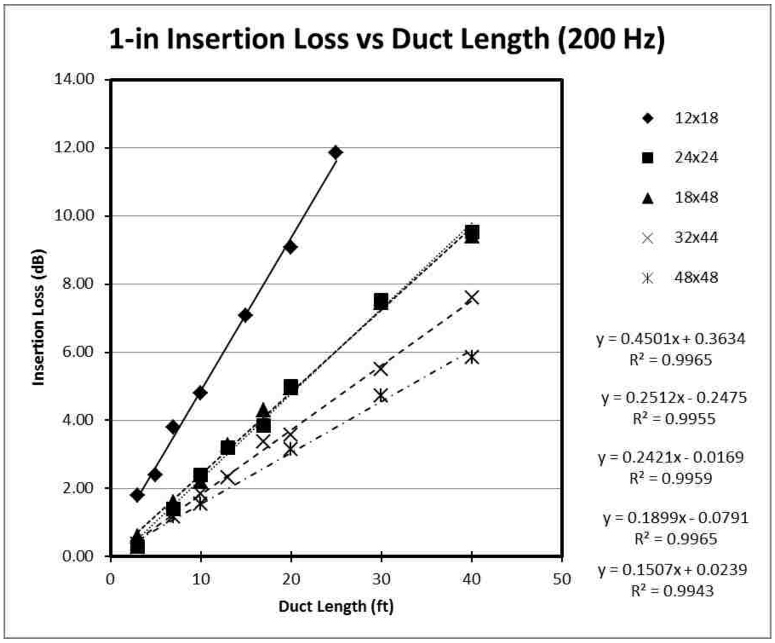

Figure C.24: 1-in Insertion Loss vs Duct Length at 200 Hz

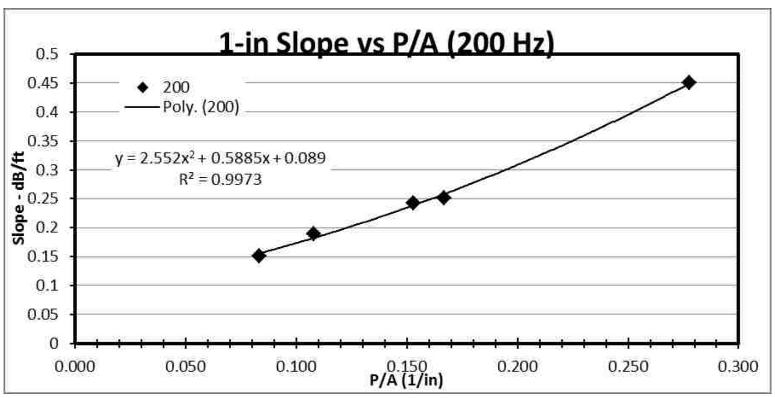

Figure C.25: 1-in Slope vs P/A at 200 Hz

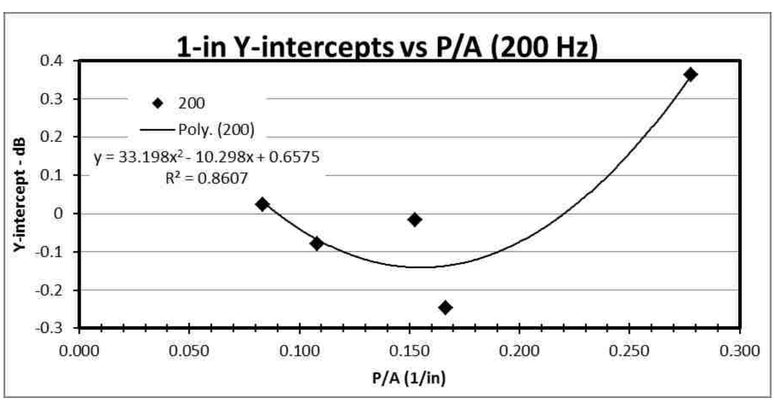

Figure C.26: 1-in Y-intercepts vs P/A at 200 Hz

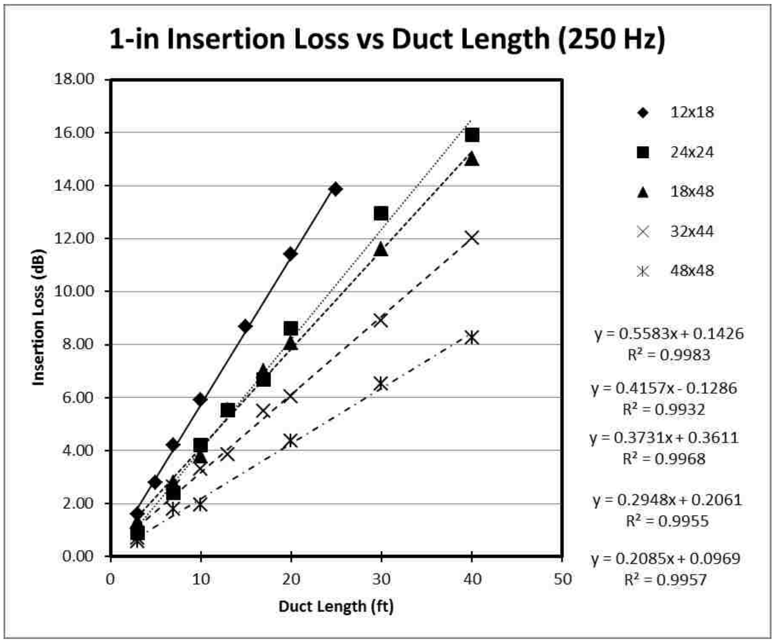

Figure C.27: 1-in Insertion Loss vs Duct Length at 250 Hz

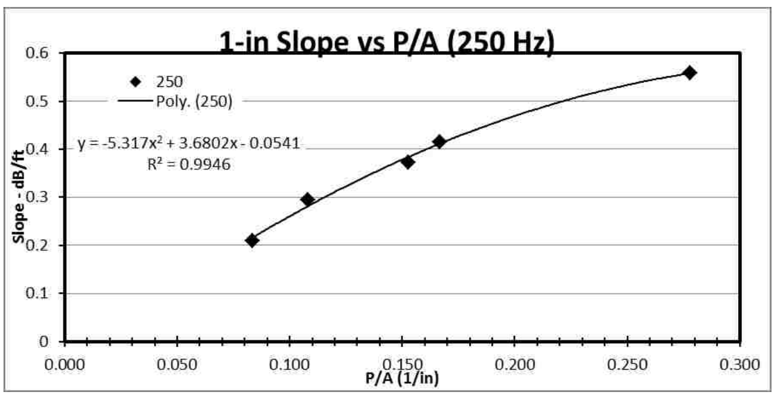

Figure C.28: 1-in Slope vs P/A at 250 Hz

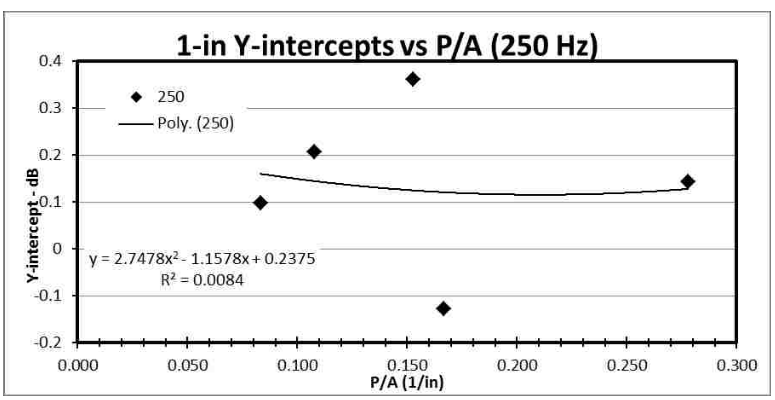

Figure C.29: 1-in Y-intercepts vs P/A at 250 Hz

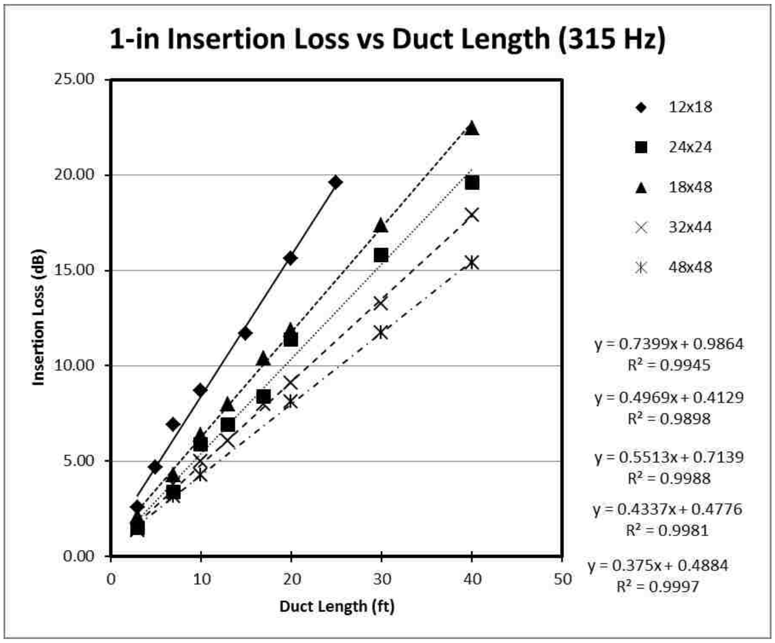

Figure C.30: 1-in Insertion Loss vs Duct Length at 315 Hz

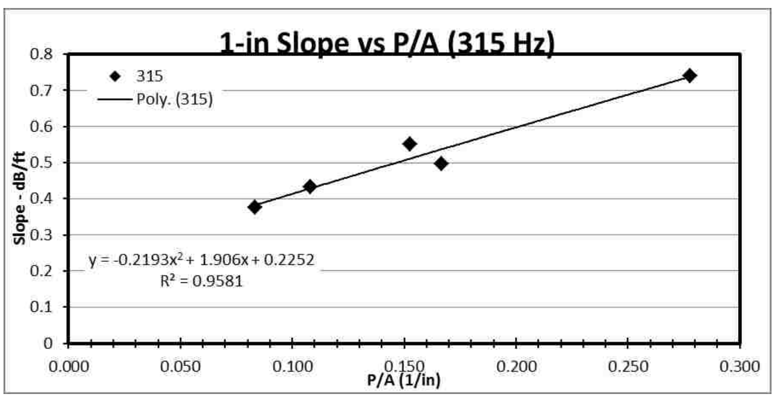

Figure C.31: 1-in Slope vs P/A at 315 Hz

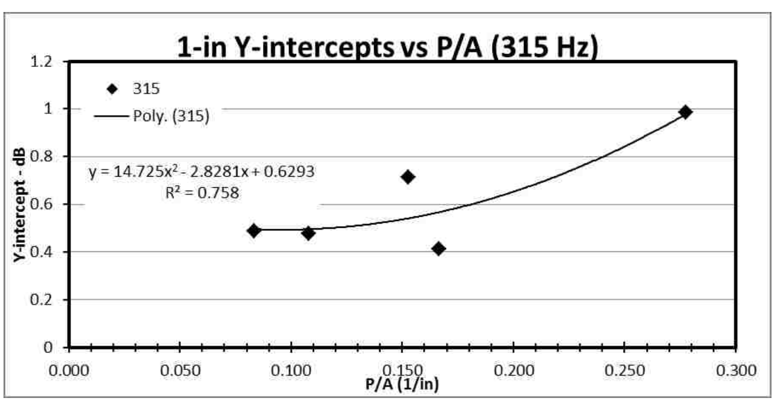

Figure C.32: 1-in Y-intercepts vs P/A at 315 Hz

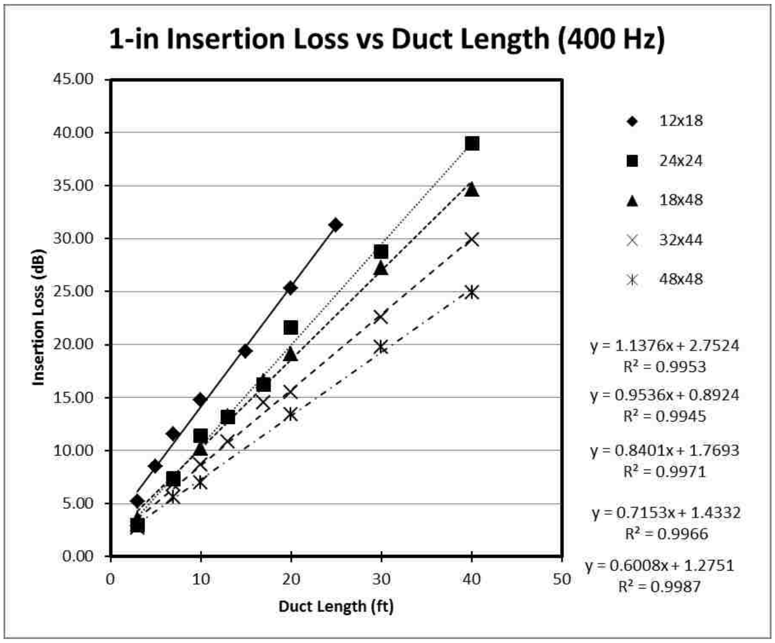

Figure C.33: 1-in Insertion Loss vs Duct Length at 400 Hz

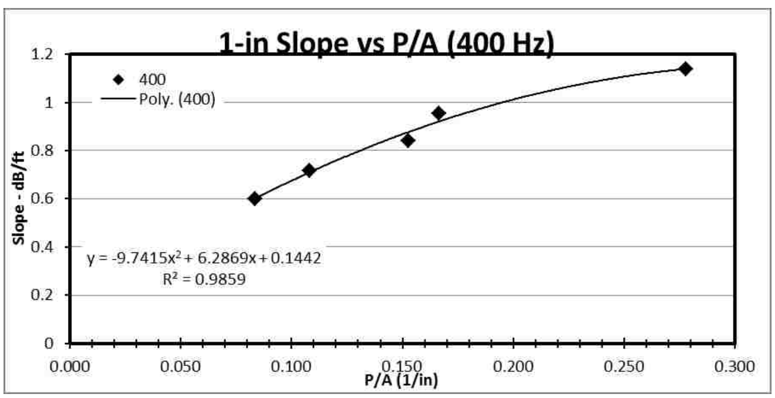

Figure C.34: 1-in Slope vs P/A at 400 Hz

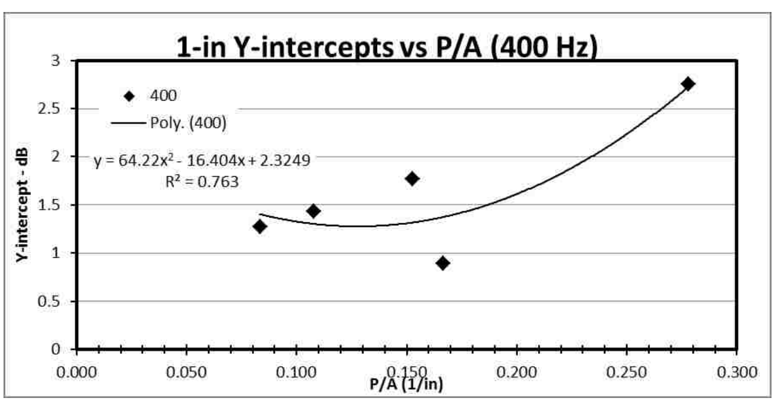

Figure C.35: 1-in Y-intercepts vs P/A at 400 Hz

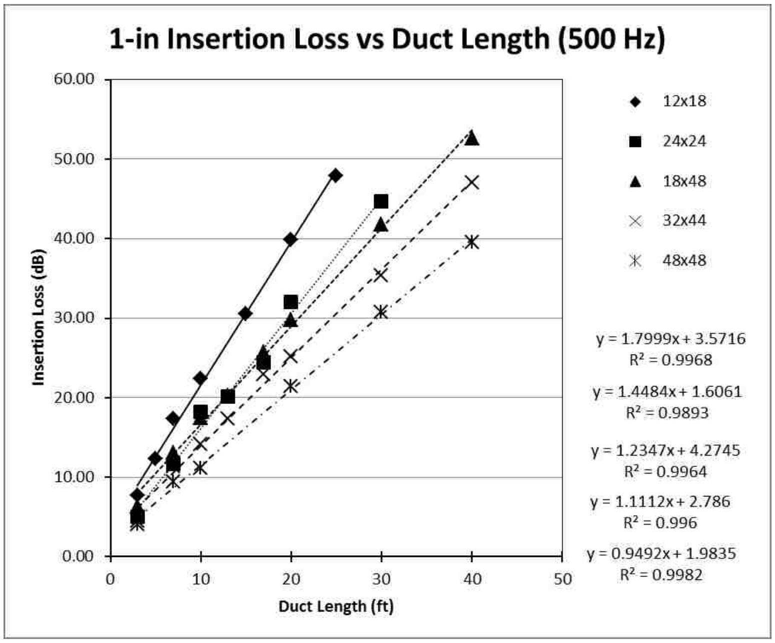

Figure C.36: 1-in Insertion Loss vs Duct Length at 500 Hz

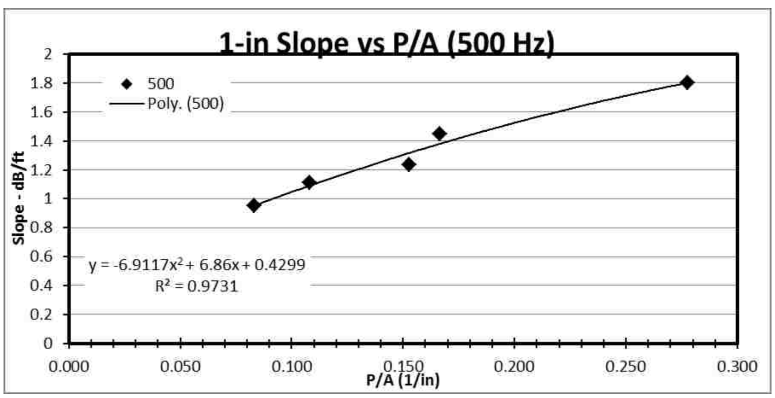

Figure C.37: 1-in Slope vs P/A at 500 Hz

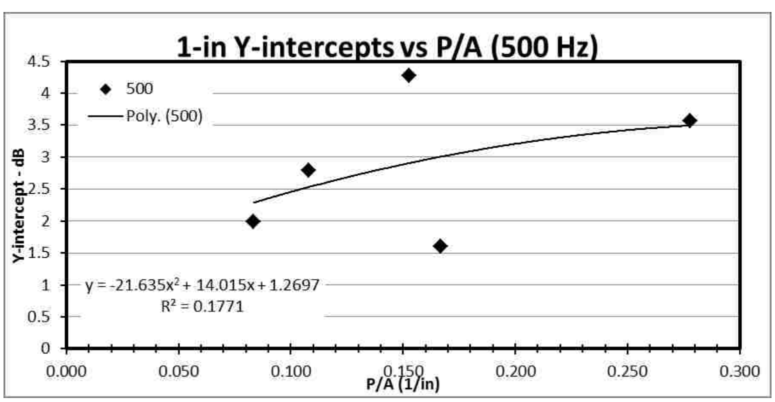

Figure C.38: 1-in Y-intercepts vs P/A at 500 Hz

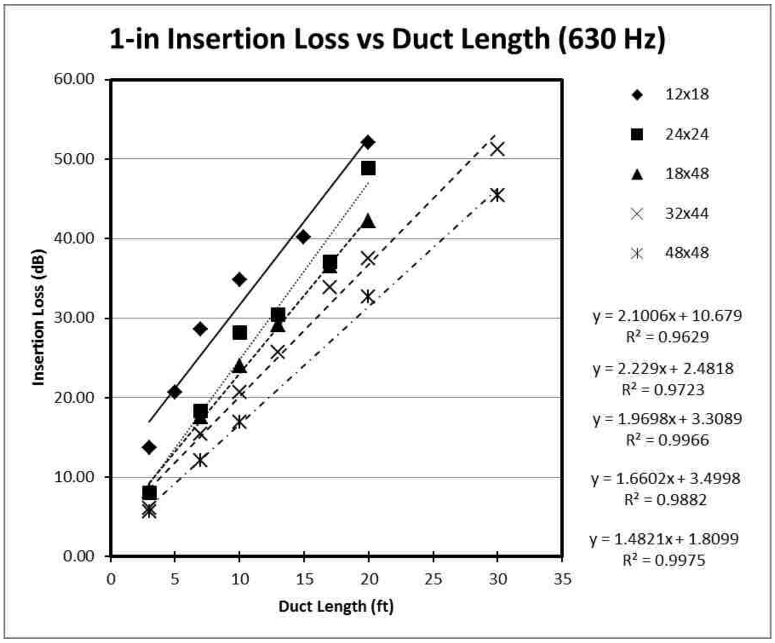

Figure C.39: 1-in Insertion Loss vs Duct Length at 630 Hz

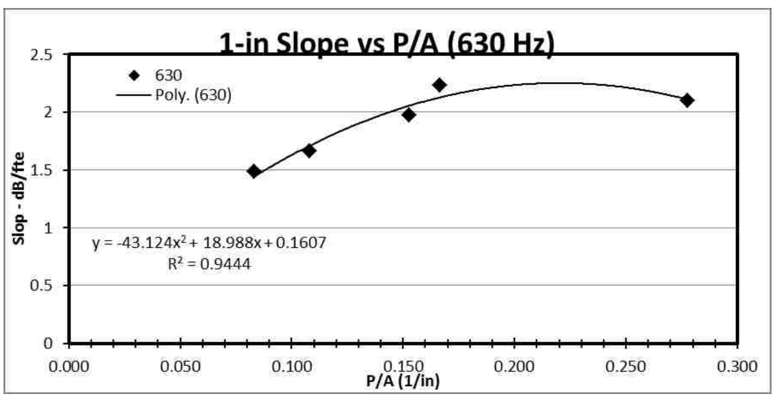

Figure C.40: 1-in Slope vs P/A at 630 Hz

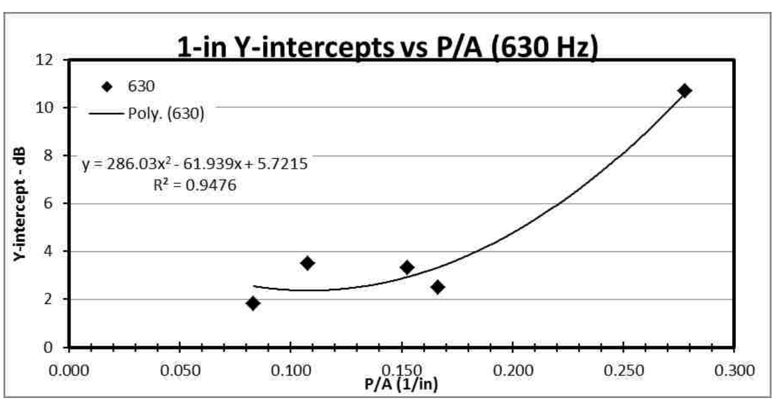

Figure C.41: 1-in Y-intercepts vs P/A at 630 Hz

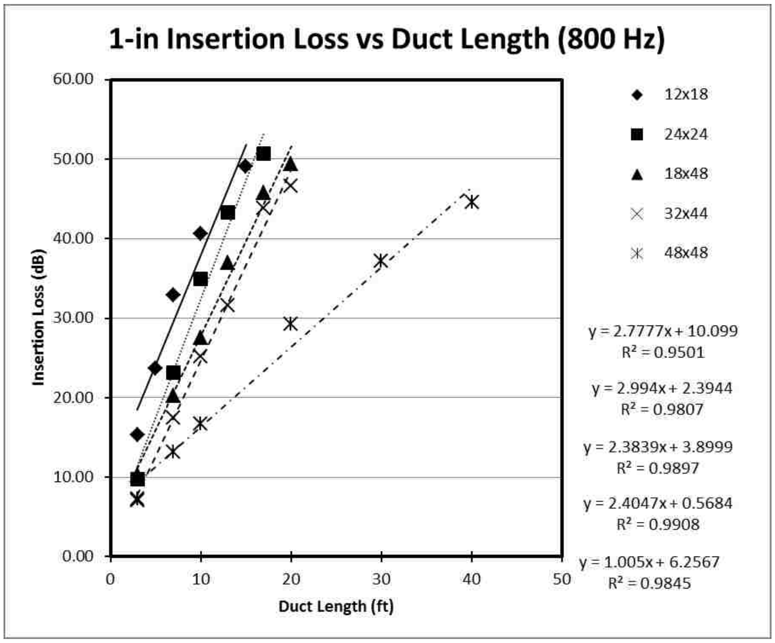

Figure C.42: 1-in Insertion Loss vs Duct Length at 800 Hz

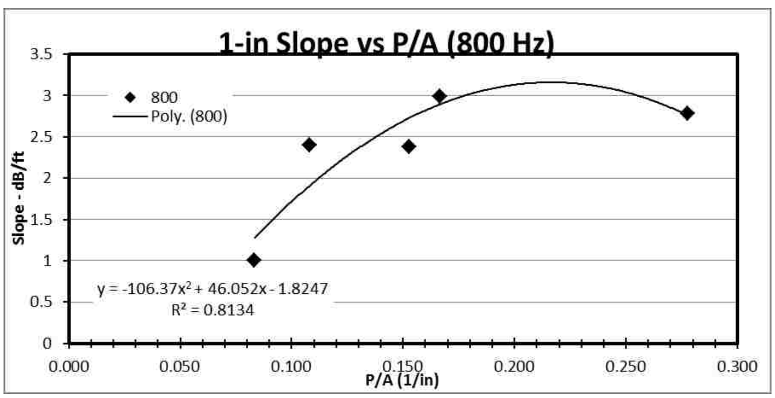

Figure C.43: 1-in Slope vs P/A at 800 Hz

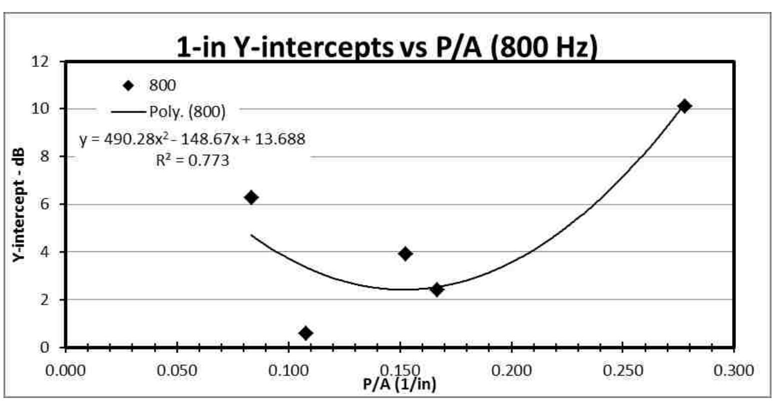

Figure C.44: 1-in Y-intercepts vs P/A at 800 Hz

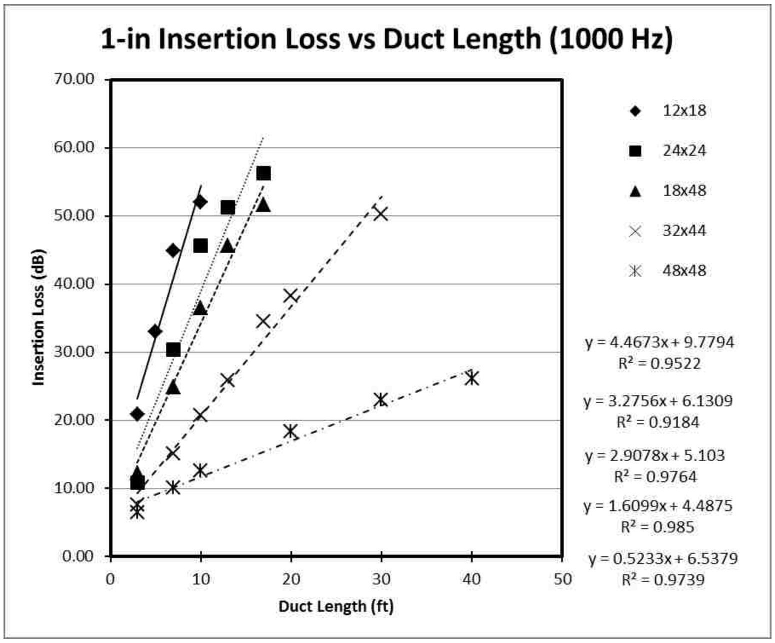

Figure C.45: 1-in Insertion Loss vs Duct Length at 1000 Hz

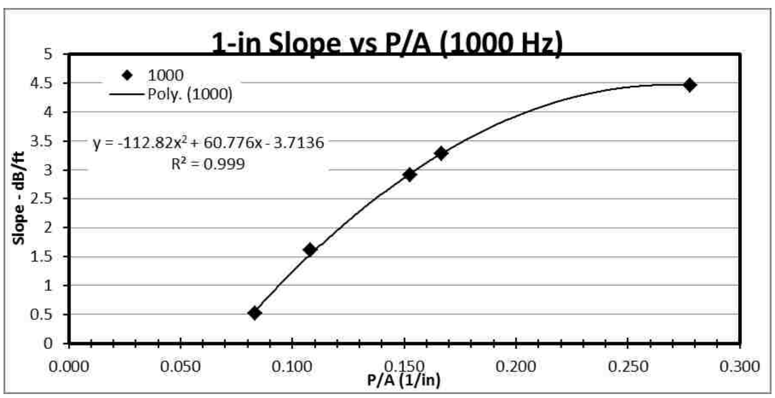

Figure C.46: 1-in Slope vs P/A at 1000 Hz

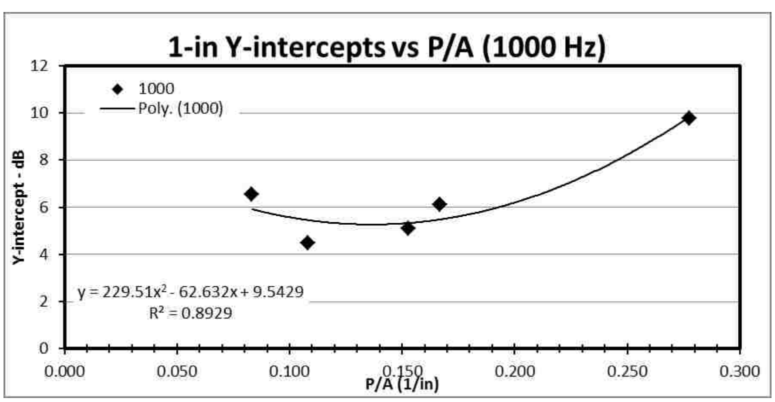

Figure C.47: 1-in Y-intercepts vs P/A at 1000 Hz

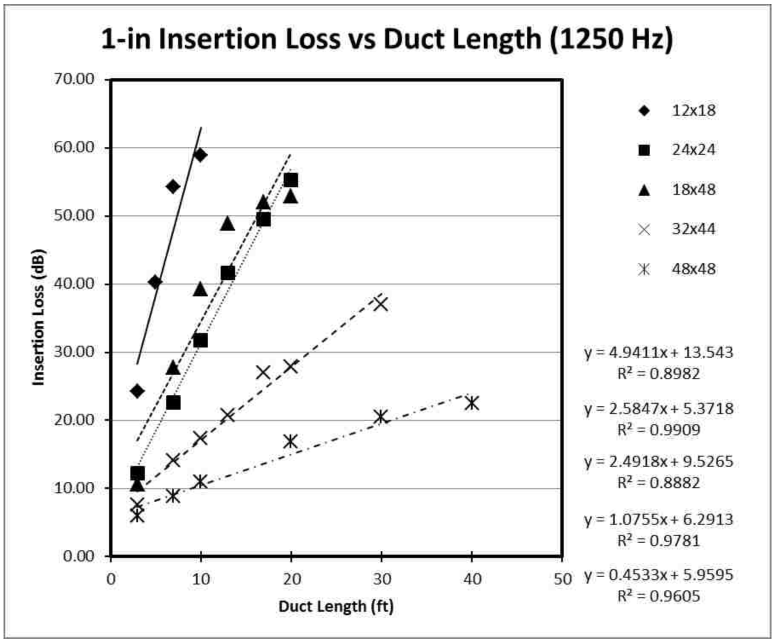

Figure C.48: 1-in Insertion Loss vs Duct Length at 1250 Hz

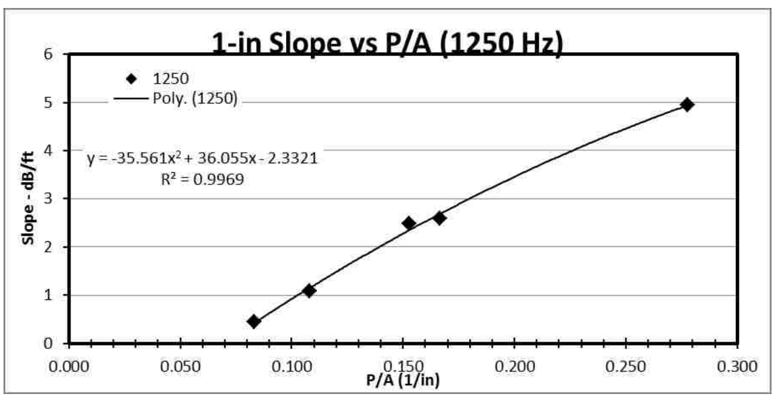

Figure C.49: 1-in Slope vs P/A at 1250 Hz

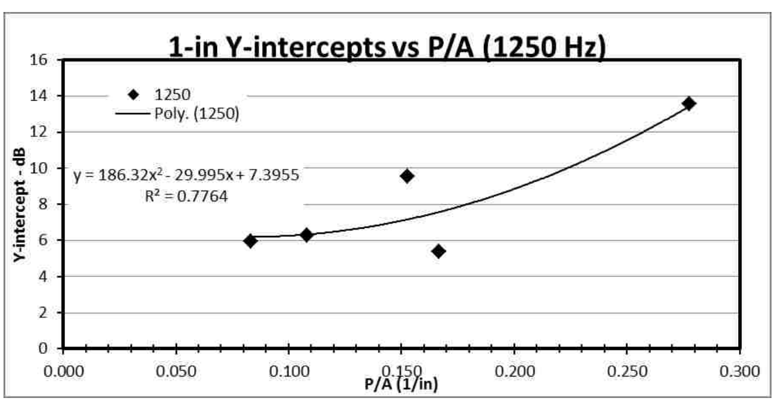

Figure C.50: 1-in Y-intercepts vs P/A at 1250 Hz

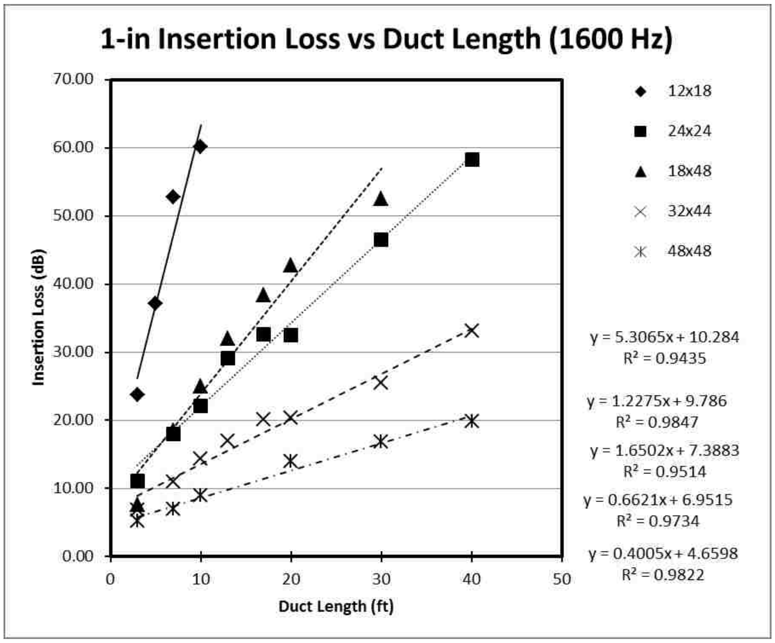

Figure C.51: 1-in Insertion Loss vs Duct Length at 1600 Hz

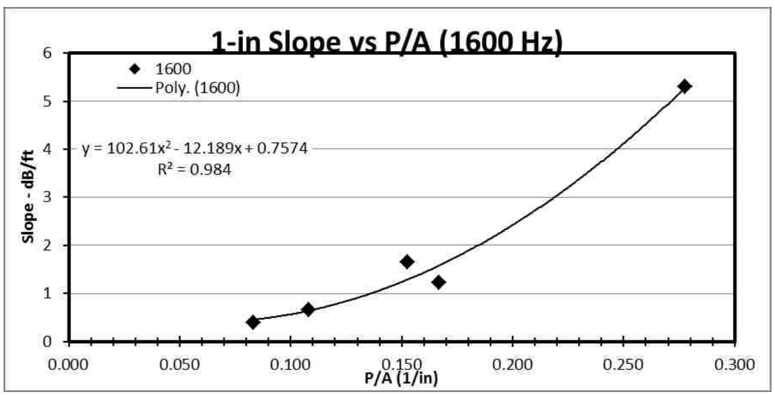

Figure C.52: 1-in Slope vs P/A at 1600 Hz

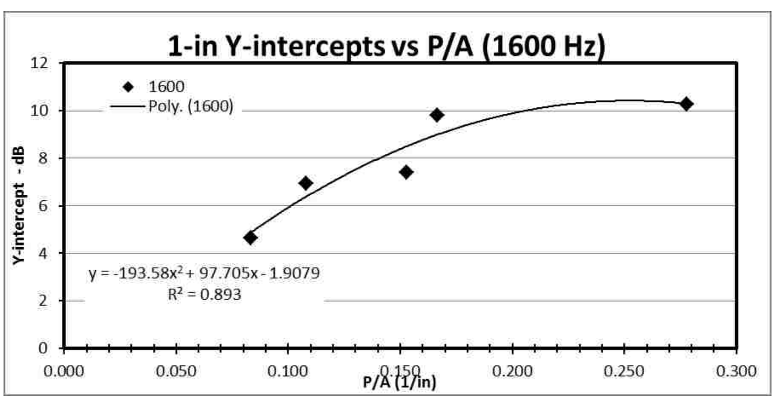

Figure C.53: 1-in Y-intercepts vs P/A at 1600 Hz

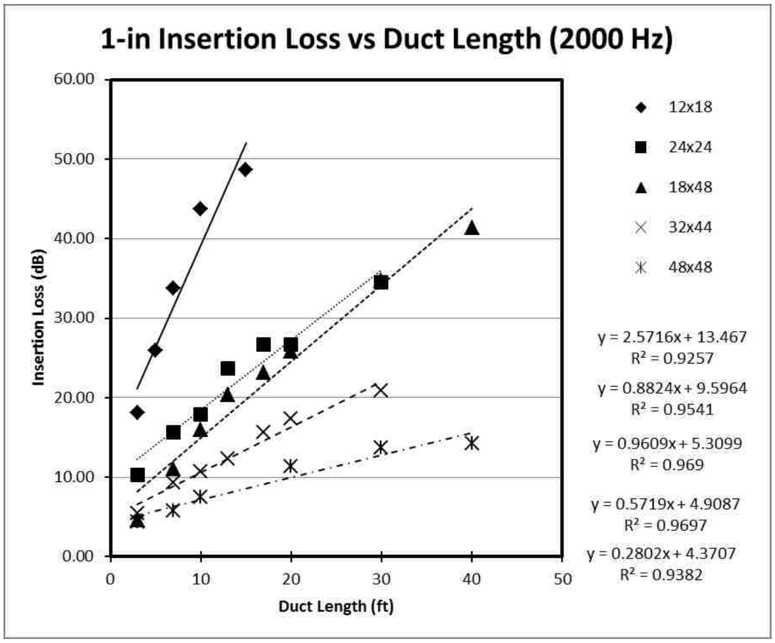

Figure C.54: 1-in Insertion Loss vs Duct Length at 2000 Hz

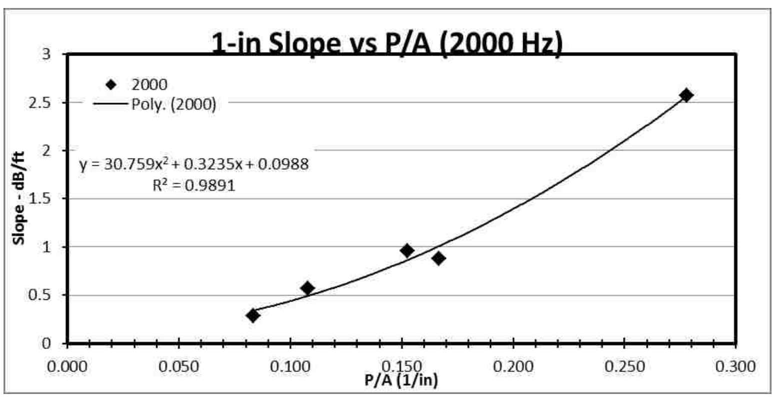

Figure C.55: 1-in Slope vs P/A at 2000 Hz

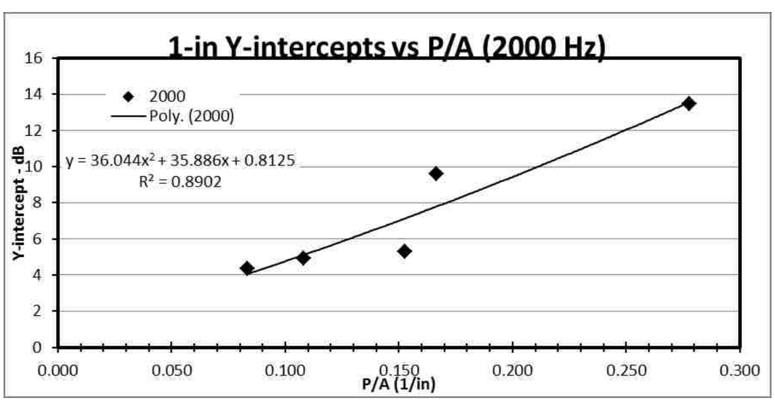

Figure C.56: 1-in Y-intercepts vs P/A at 2000 Hz

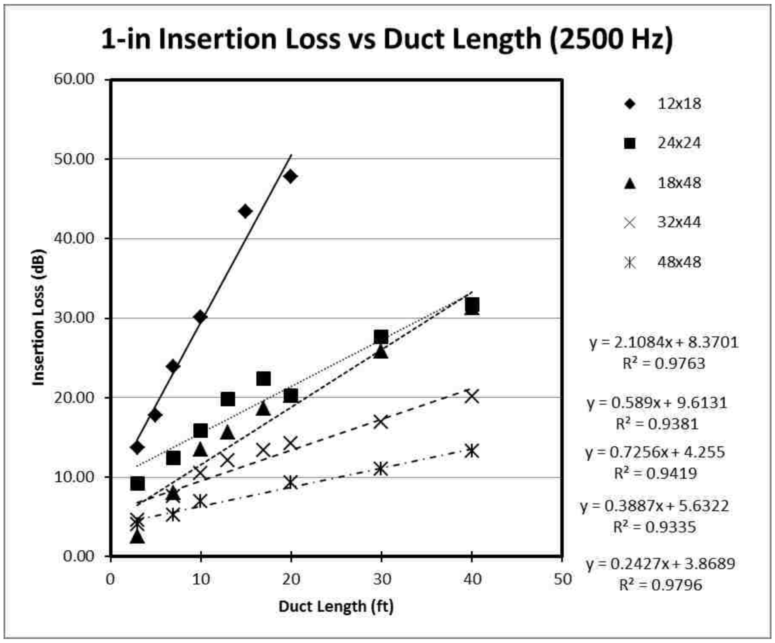

Figure C.57: 1-in Insertion Loss vs Duct Length at 2500 Hz

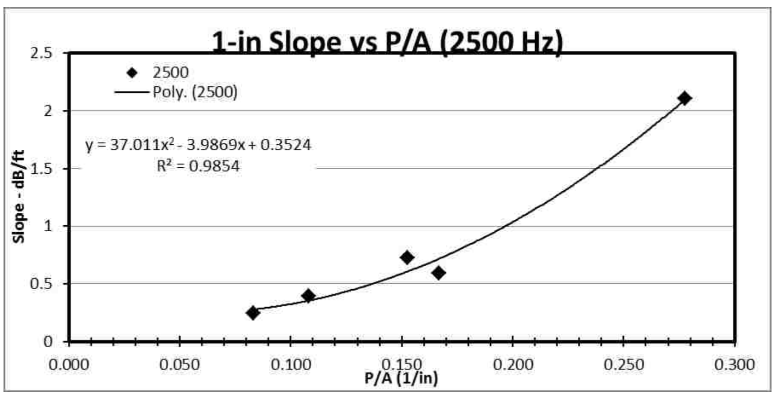

Figure C.58: 1-in Slope vs P/A at 2500 Hz

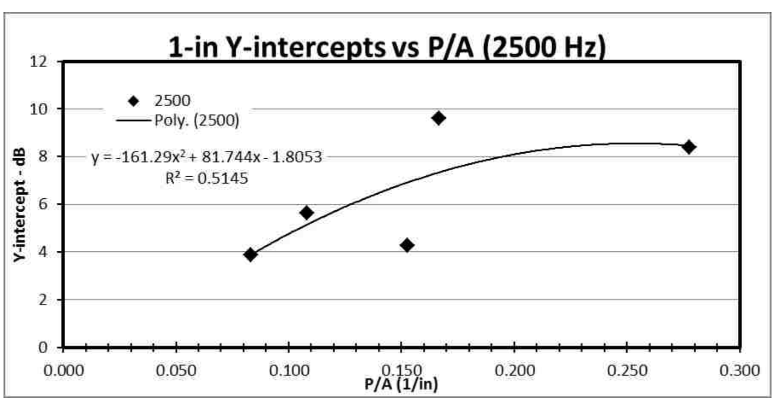

Figure C.59: 1-in Y-intercepts vs P/A at 2500 Hz

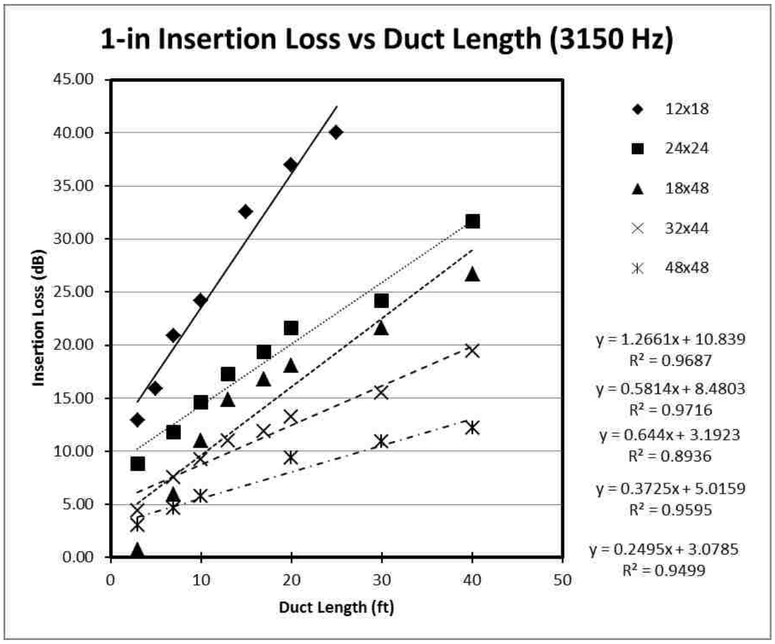

Figure C.60: 1-in Insertion Loss vs Duct Length at 3150 Hz

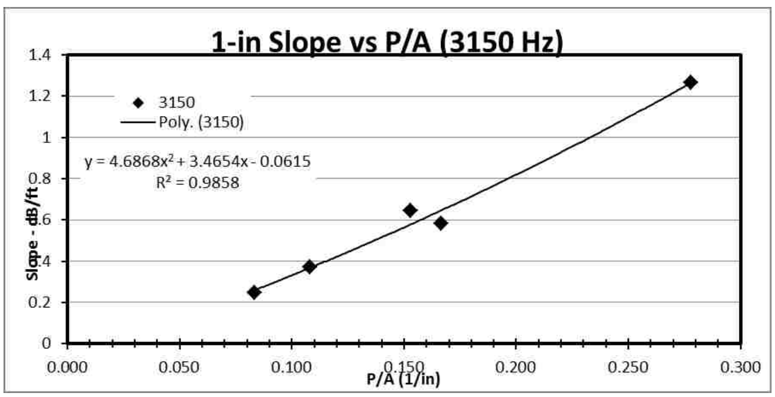

Figure C.61: 1-in Slope vs P/A at 3150 Hz

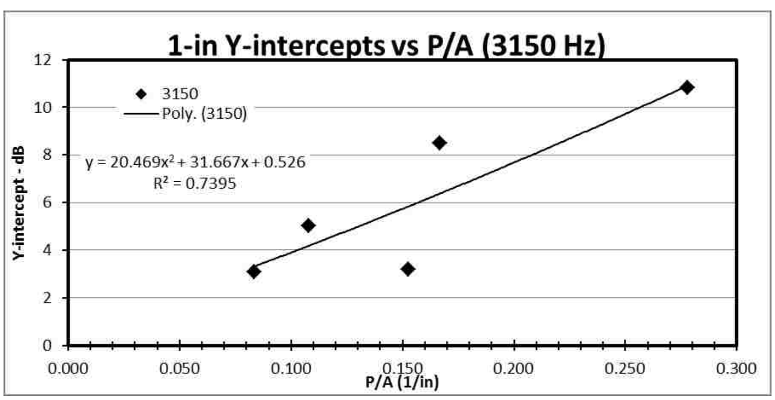

Figure C.62: 1-in Y-intercepts vs P/A at 3150 Hz

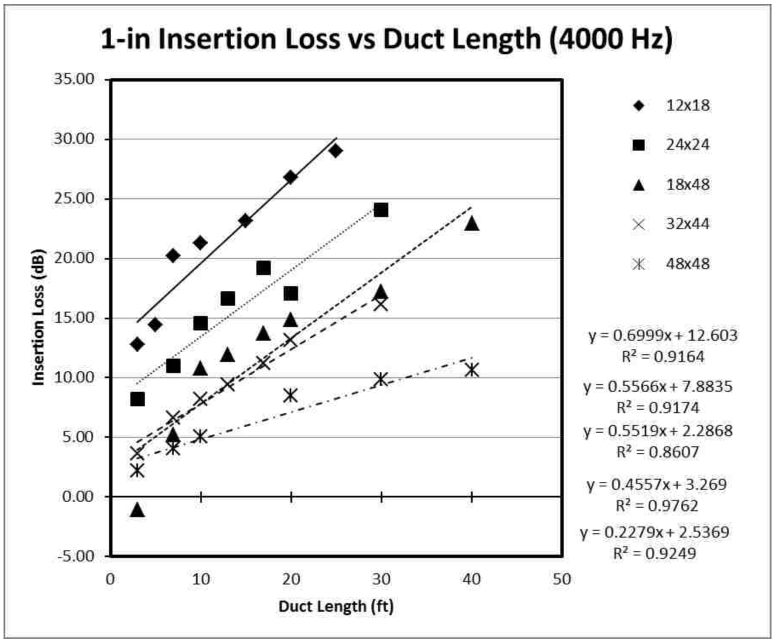

Figure C.63: 1-in Insertion Loss vs Duct Length at 4000 Hz

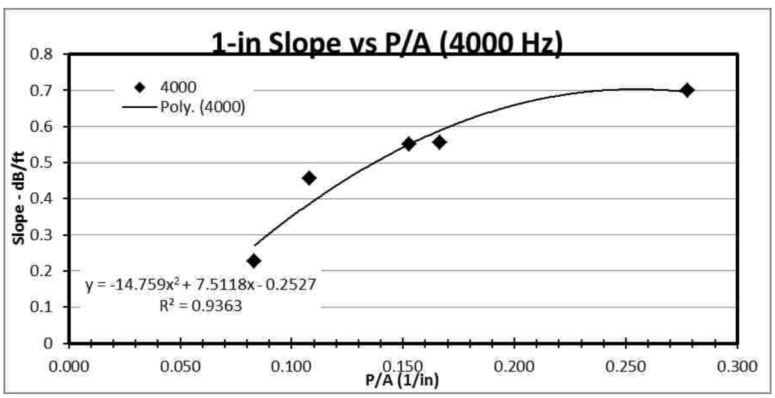

Figure C.64: 1-in Slope vs P/A at 4000 Hz

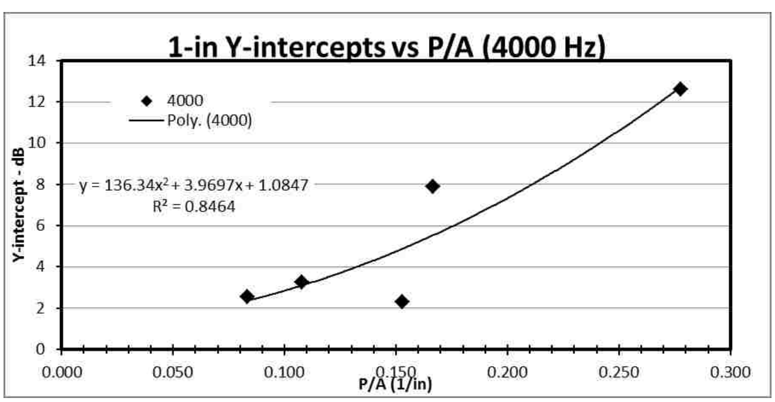

Figure C.65: 1-in Y-intercepts vs P/A at 4000 Hz

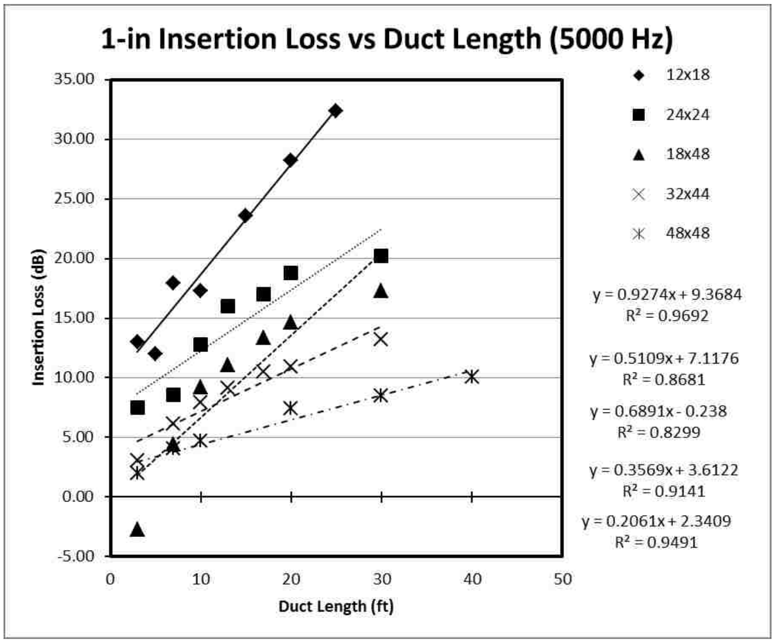

Figure C.66: 1-in Insertion Loss vs Duct Length at 5000 Hz

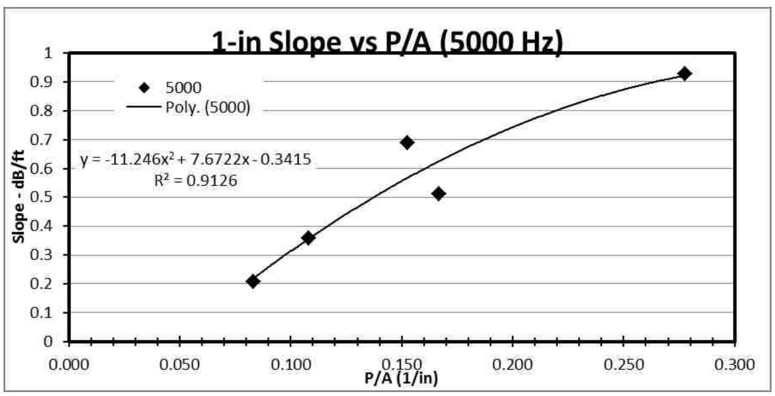

Figure C.67: 1-in Slope vs P/A at 5000 Hz

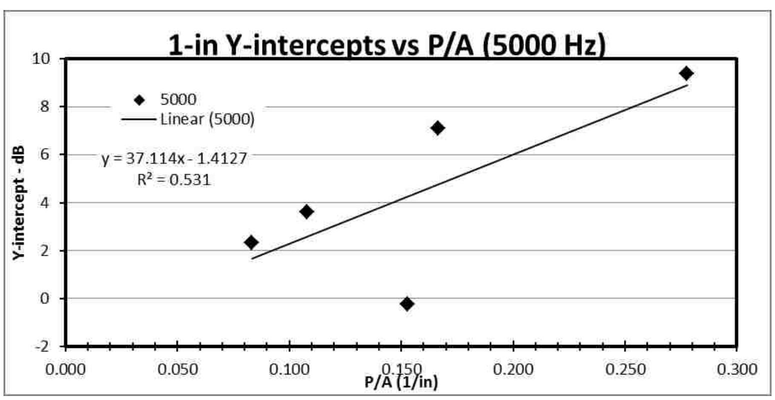

Figure C.68: 1-in Y-intercepts vs P/A at 5000 Hz

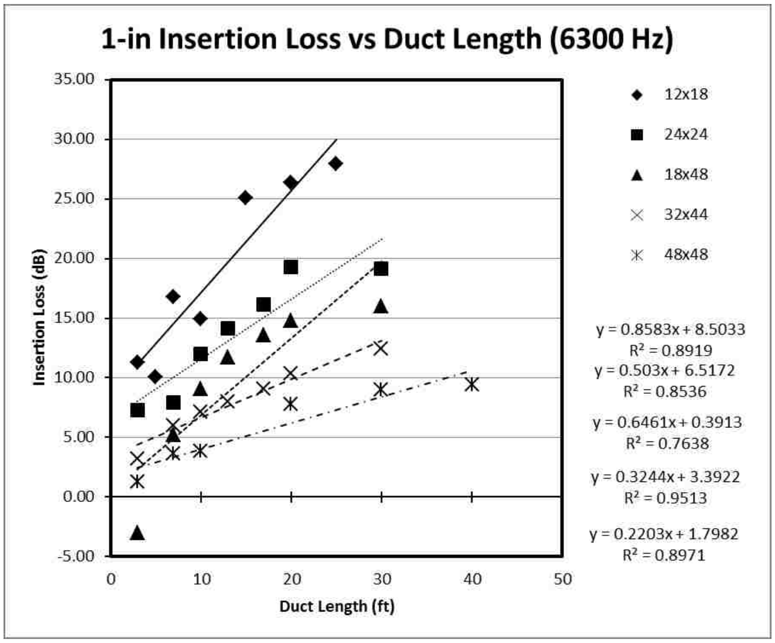

Figure C.69: 1-in Insertion Loss vs Duct Length at 6300 Hz

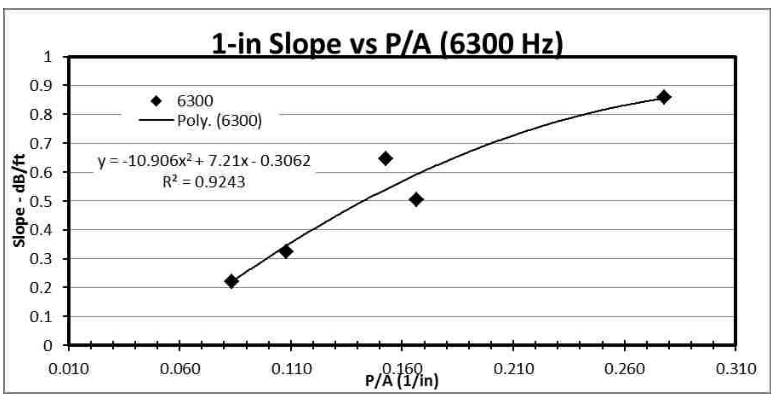

Figure C.70: 1-in Slope vs P/A at 6300 Hz

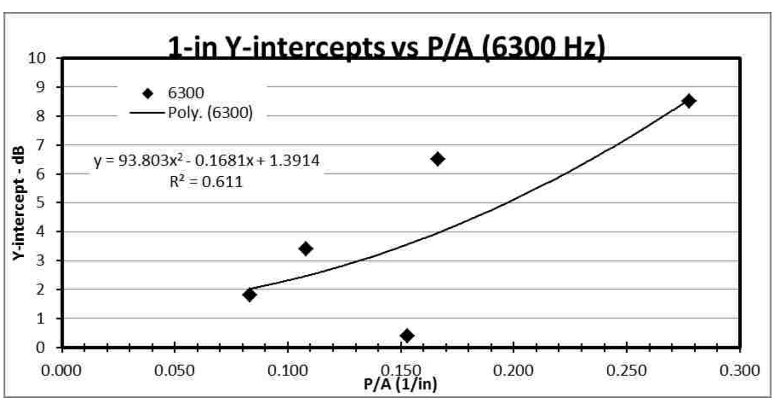

Figure C.71: 1-in Y-intercepts vs P/A at 6300 Hz

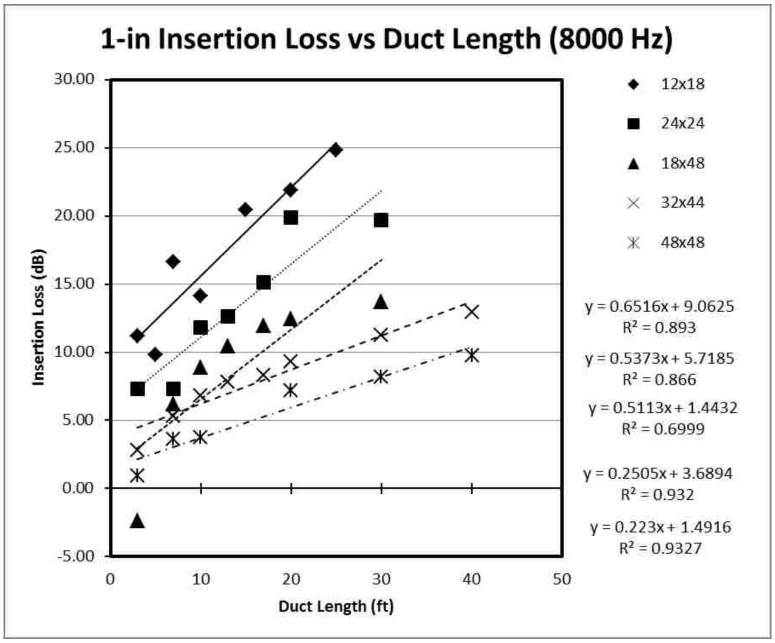

Figure C.72: 1-in Insertion Loss vs Duct Length at 8000 Hz

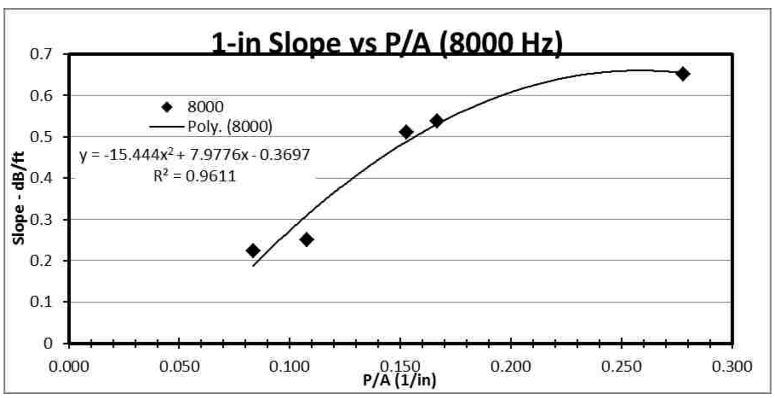

Figure C.73: 1-in Slope vs P/A at 8000 Hz

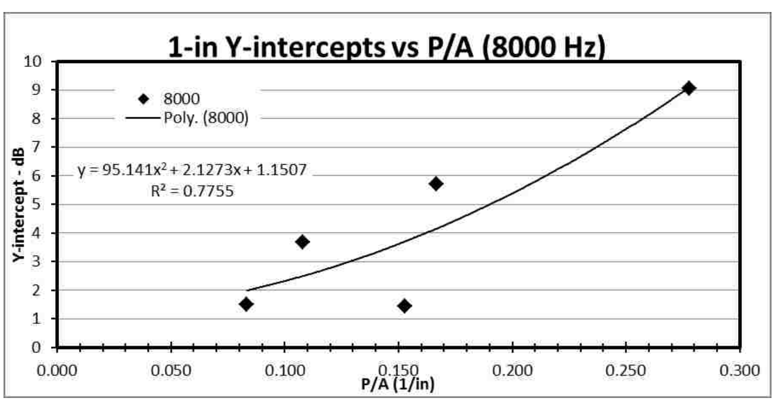

Figure C.74: 1-in Y-intercepts vs P/A at 8000 Hz

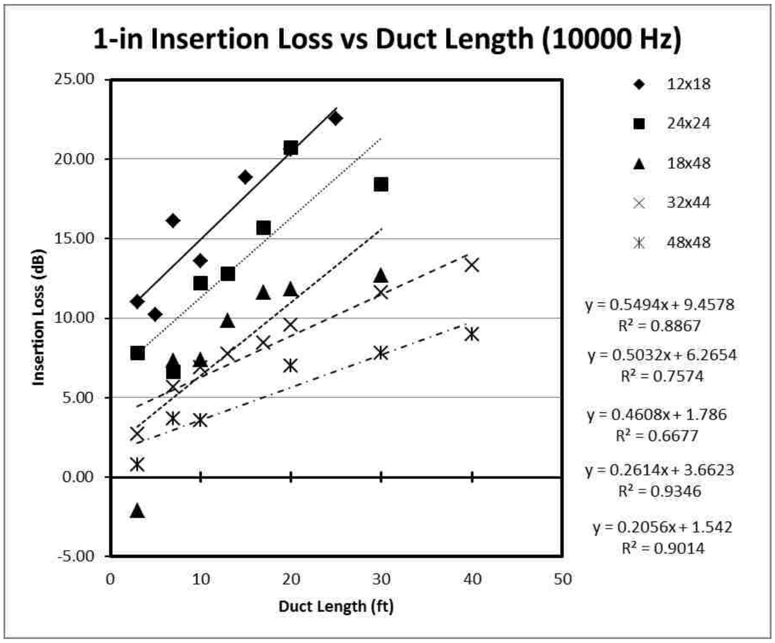

Figure C.75: 1-in Insertion Loss vs Duct Length at 10000 Hz

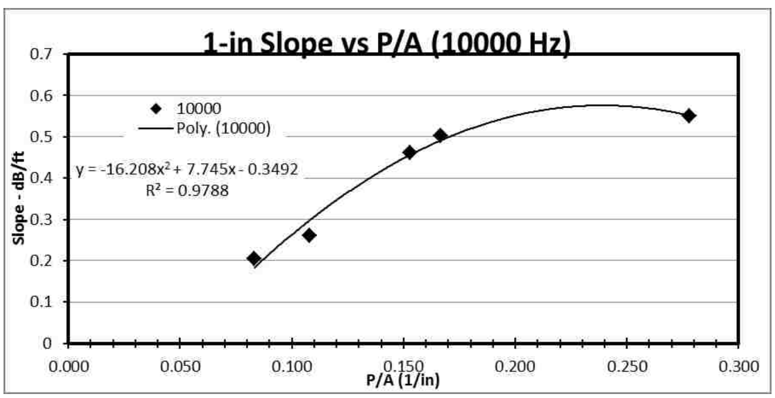

Figure C.76: 1-in Slope vs P/A at 10000 Hz

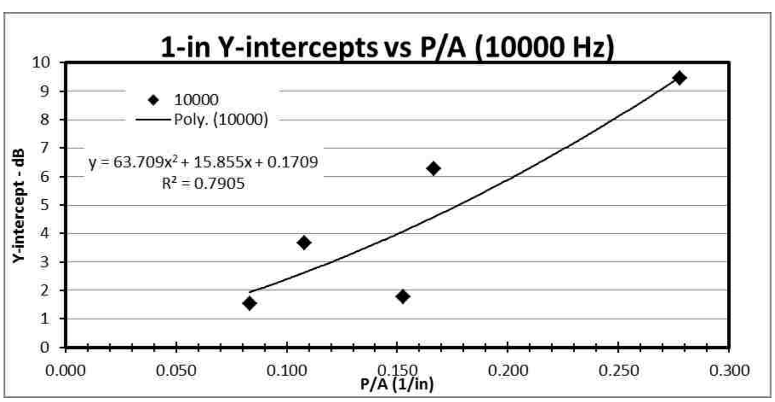

Figure C.77: 1-in Y-intercepts vs P/A at 10000 Hz

Duct Size - in x in		12x18	18x48	24x24	32x44	48x48	12x18	12x18	24x24	18x48	32x44	48x48	12x18	24x24	18x48	32x44	48x48	24x24	18x48	32x44	12x18	24x24	18x48	32x44	12x18	24x24	18x48	32x44	48x48	12x18	24x24	18x48	32x44	48x48	24x24	18x48	32x44	48x48			
Length -ft		3	3	3	3	3	5	7	7	7	7	7	10	10	10	10	10	13	13	13	15	17	17	17	20	20	20	20	20	25	30	30	30	30	40	40	40	40			
P/A - 1/in		0.278	0.153	0.167	0.108	0.083	0.278	0.278	0.167	0.153	0.108	0.083	0.278	0.167	0.153	0.108	0.083	0.167	0.153	0.108	0.278	0.167	0.153	0.108	0.278	0.167	0.153	0.108	0.083	0.278	0.167	0.153	0.108	0.083	0.167	0.153	0.108	0.083	AVG	STD	Freq
meas	50	-1.5	-0.2	-1.0	0.0	0.5	1.5	-2.3	1.2	0.0	1.2	-0.6	-6.3	-3.1	-0.5	0.6	0.5	-1.4	-0.9	1.1	1.5	4.4	0.1	1.7	-0.4	6.4	-1.3	0.3	0.6	-3.5	5.4	-1.6	0.9	0.5	3.7	-1.8	0.1	-0.4			50
regres	50	3.1	1.6	1.8	0.7	0.2	2.7	2.2	1.8	1.6	0.7	0.1	1.5	1.8	1.6	0.7	0.0	1.8	1.6	0.7	0.3	1.7	1.6	0.7	-0.9	1.7	1.6	0.8	-0.1	-2.1	1.6	1.6	0.8	-0.3	1.5	1.6	0.8	-0.4			50
DIFF AVG		-4.6	-1.8	-2.9	-0.8	0.4	-1.1	-4.5	-0.6	-1.6	0.5	-0.7	-7.8	-4.9	-2.1	-0.1	0.4	-3.2	-2.5	0.4	1.2	2.7	-1.5	1.0	0.5	4.7	-2.9	-0.4	0.7	-1.4	3.8	-3.2	0.1	0.8	2.2	-3.5	-0.6	0.0	-0.9	2.483	
meas	63	-3.0	0.2	0.3	-0.2	0.0	-1.8	-2.0	2.3	0.0	-0.8	0.3	-3.6	4.0	0.8	0.8	0.2	1.9	0.6	0.4	-3.9	2.5	0.3	-0.1	-4.5	0.9	0.0	0.7	-0.9	-9.7	5.9	0.0	-0.7	-0.7	11.4	0.5	0.5	0.0			63
regres	63	0.4	-0.6	-0.6	-0.2	0.2	-0.4	-1.2	0.0	0.1	0.1	-0.1	-2.3	0.5	0.6	0.2	-0.3	1.0	1.1	0.4	-4.2	1.6	1.7	0.7	-6.2	2.1	2.2	0.8	-0.9	-8.1	3.7	3.8	1.4	-1.5	5.3	5.4	2.0	-2.1			63
DIFF AVG		-3.4	0.8	0.9	0.0	-0.2	-1.4	-0.8	2.3	-0.1	-0.8	0.3	-1.3	3.5	0.3	0.6	0.4	0.9	-0.4	0.0	0.4	0.8	-1.3	-0.8	1.7	-1.3	-2.2	-0.2	0.0	-1.6	2.2	-3.8	-2.1	0.8	6.0	-4.9	-1.6	2.1	-0.1	2	
meas	80	-1.3	-0.1	-1.2	-0.2	-0.1	0.8	0.2	-1.3	-0.3	-0.3	-0.2	7.9	-3.2	0.2	-0.7	0.7	-1.7	0.3	-0.5	9.5	-2.6	-0.6	-0.3	6.1	-2.2	0.5	-1.1	0.7	10.4	-3.0	1.1	-1.9	1.0	-4.9	1.8	0.0	0.3			80
regres	80	3.1	0.0	0.1	-0.1	0.0	3.7	4.3	-0.1	-0.2	-0.2	0.1	5.3	-0.2	-0.4	-0.3	0.2	-0.4	-0.6	-0.4	6.9	-0.5	-0.8	-0.5	8.5	-0.7	-1.0	-0.5	0.6	10.1	-1.2	-1.5	-0.8	0.9	-1.7	-2.1	-1.0	1.2			80
DIFF AVG		-4.3	-0.1	-1.3	0.0	-0.1	-2.9	-4.1	-1.3	-0.1	0.0	-0.3	2.6	-2.9	0.6	-0.4	0.5	-1.4	0.8	-0.2	2.6	-2.1	0.2	0.2	-2.4	-1.5	1.5	-0.6	0.1	0.3	-1.8	2.7	-1.1	0.1	-3.2	3.9	1.0	-0.9	-0.4	1.829	
meas	100	-1.5	0.1	0.1	0.0	0.0	-4.3	0.4	0.3	0.4	0.4	0.3	-3.4	0.4	0.6	0.4	0.3	-0.1	0.9	0.5	-5.1	0.3	1.2	0.5	-2.4	1.1	1.0	0.8	0.6	-3.3	-0.8	1.5	0.7	1.2	1.5	2.7	0.9	1.3			100
regres	100	-0.6	0.3	0.3	0.2	0.1	-0.9	-1.2	0.4	0.4	0.4	0.2	-1.7	0.4	0.5	0.5	0.3	0.5	0.6	0.6	-2.4	0.6	0.7	0.7	-3.2	0.7	0.8	0.9	0.5	-4.0	0.9	1.1	1.2	0.8	1.1	1.5	1.6	1.1			100
DIFF AVG		-0.9	-0.2	-0.2	-0.2	-0.1	-3.4	1.6	-0.1	0.0	0.0	0.1	-1.8	0.0	0.1	-0.1	0.0	-0.6	0.3	0.0	-2.6	-0.3	0.4	-0.2	0.9	0.5	0.2	-0.1	0.1	0.7	-1.7	0.3	-0.5	0.3	0.4	1.2	-0.7	0.2	-0.2	0.946	
meas	125	0.9	0.7	0.6	0.4	0.0	1.4	2.2	2.2	0.9	1.1	0.8	2.0	2.6	0.8	1.2	0.8	3.9	1.4	1.3	3.3	5.2	1.6	2.2	4.7	6.8	2.0	1.6	1.7	5.9	9.1	3.0	3.0	2.7	10.6	3.6	3.8	3.0			125
regres	125	0.3	0.4	0.3	0.4	0.4	0.9	1.4	1.1	1.1	0.8	0.6	2.1	1.7	1.6	1.1	0.8	2.3	2.2	1.5	3.4	3.1	2.9	1.9	4.7	3.7	3.4	2.2	1.4	5.9	5.7	5.3	3.3	2.0	7.7	7.1	4.4	2.5			125
DIFF AVG		0.6	0.3	0.3	0.1	-0.4	0.5	0.8	1.1	-0.2	0.3	0.2	-0.1	0.8	-0.8	0.1	0.0	1.6	-0.8	-0.2	-0.1	2.0	-1.3	0.3	0.1	3.1	-1.4	-0.6	0.3	0.0	3.4	-2.2	-0.3	0.7	2.8	-3.5	-0.6	0.5	0.2	1.309	
meas	160	1.5	0.3	0.8	0.4	-0.1	2.3	3.3	1.3	0.6	0.9	0.8	3.6	1.6	1.2	0.8	1.0	1.5	1.5	1.0	5.1	2.1	1.7	1.6	7.3	3.2	2.3	1.4	1.9	8.7	4.2	3.4	2.3	3.3	5.6	4.3	3.4	3.7			160
regres	160	1.9	0.2	0.3	0.2	0.4	2.5	3.2	0.8	0.7	0.6	0.7	4.1	1.2	1.0	0.9	1.0	1.6	1.4	1.2	5.6	2.1	1.9	1.5	7.1	2.5	2.2	1.8	1.9	8.7	3.8	3.4	2.7	2.8	5.1	4.6	3.7	3.6			160
DIFF AVG		-0.4	0.1	0.5	0.2	-0.4	-0.3	0.1	0.5	-0.1	0.3	0.0	-0.5	0.4	0.2	0.0	0.0	-0.1	0.1	-0.2	-0.5	0.0	-0.2	0.1	0.2	0.7	0.1	-0.4	0.1	0.0	0.4	0.0	-0.5	0.6	0.5	-0.3	-0.3	0.0	0.0	0.319	
meas	200	1.7	0.6	0.6	0.4	0.3	2.8	3.4	2.0	1.6	1.4	1.2	4.8	2.2	2.5	1.9	1.5	3.2	3.3	2.3	7.1	3.8	4.3	3.4	9.1	5.5	4.9	3.6	3.2	11.9	7.5	7.5	5.5	4.7	9.5	9.4	7.6	5.9			200
regres	200	1.7	0.6	0.6	0.5	0.5	2.6	3.5	1.7	1.5	1.2	1.1	4.9	2.4	2.2	1.8	1.6	3.2	3.0	2.3	7.1	4.2	3.9	3.0	9.3	5.0	4.6	3.6	3.1	11.6	7.6	7.0	5.4	4.7	10.2	9.4	7.2	6.3			200
DIFF AVG		0.0	0.0	0.0	-0.1	-0.2	0.2	-0.1	0.3	0.1	0.2	0.1	-0.1	-0.2	0.2	0.1	0.0	0.0	0.3	0.0	0.0	-0.4	0.4	0.3	-0.3	0.5	0.3	0.0	0.0	0.3	-0.1	0.4	0.1	0.0	-0.6	0.0	0.4	-0.4	0.0	0.249	
meas	250	1.5	1.4	1.2	0.7	0.6	2.8	4.6	2.6	2.8	2.6	1.8	6.1	3.5	4.2	3.3	2.0	5.5	5.5	3.9	8.7	6.7	7.0	5.5	11.4	8.9	8.1	6.0	4.4	13.9	12.9	11.6	8.9	6.5	15.9	15.0	12.0	8.3			250
regres	250	1.8	1.3	1.4	1.0	0.8	2.9	4.0	3.0	2.8	2.1	1.7	5.7	4.2	4.0	3.0	2.3	5.5	5.1	3.8	8.5	7.1	6.7	4.9	11.3	8.4	7.8	5.8	4.5	14.1	12.5	11.6	8.6	6.6	16.6	15.5	11.4	8.8			250
DIFF AVG		-0.3	0.1	-0.2	-0.3	-0.2	-0.1	0.5	-0.4	0.0	0.5	0.1	0.3	-0.7	0.2	0.3	-0.4	0.1	0.4	0.1	0.2	-0.4	0.4	0.6	0.1	0.5	0.3	0.3	-0.1	-0.2	0.5	0.0	0.3	-0.1	-0.7	-0.5	0.6	-0.5	0.0	0.368	
meas	315	2.0	2.3	1.6	1.4	1.5	4.1	6.4	3.3	4.1	3.8	3.1	8.2	4.9	6.3	5.0	4.3	6.9	8.0	6.1	11.7	8.4	10.4	8.0	15.6	10.9	11.9	9.1	8.1	19.6	15.8	17.4	13.3	11.8	19.6	22.5	17.9	15.4			315
regres	315	3.2	2.1	2.2	1.8	1.6	4.7	6.1	4.3	4.1	3.5	3.2	8.4	5.9	5.7	4.8	4.3	7.5	7.2	6.1	12.0	9.7	9.2	7.8	15.7	11.3	10.8	9.1	8.1	19.4	16.7	15.9	13.3	12.0	22.0	21.0	17.6	15.8			315
DIFF AVG		-1.2	0.2	-0.5	-0.4	-0.2	-0.5	0.3	-1.0	0.0	0.3	0.0	-0.1	-1.0	0.6	0.2	0.0	-0.6	0.8	0.0	-0.4	-1.3	1.2	0.2	-0.1	-0.4	1.1	0.1	0.0	0.2	-0.9	1.5	-0.1	-0.2	-2.5	1.5	0.3	-0.4	-0.1	0.778	
meas	400	4.2	3.8	3.2	2.7	3.0	7.4	10.3	6.9	7.4	6.8	5.6	13.2	9.6	10.6	8.7	7.0	13.2	13.3	10.8	19.3	16.3	16.5	14.5	25.3	19.9	19.1	15.5	13.4	31.2	28.8	27.2	22.6	19.8	39.0	34.6	29.9	24.9			400
regres	400	6.1	3.9	4.1	3.4	3.2	8.4	10.7	7.8	7.5	6.3	5.6	14.1	10.6	10.1	8.4	7.4	13.4	12.7	10.5	19.8	17.0	16.2	13.4	25.5	19.8	18.9	15.5	13.4	31.2	29.0	27.6	22.6	19.4	38.2	36.4	29.7	25.4			400
DIFF AVG		-1.9	-0.2	-0.9	-0.7	-0.2	-1.0	-0.4	-1.0	-0.1	0.5	0.0	-0.9	-1.0	0.5	0.3	-0.4	-0.2	0.5	0.3	-0.5	-0.8	0.3	1.1	-0.2	0.1	0.2	0.0	0.0	0.1	-0.2	-0.4	0.0	0.4	0.7	-1.8	0.2	-0.5	-0.2	0.65	
meas	500	7.4	5.8	5.2	4.5	4.1	11.7	16.7	11.0	11.6	11.3	9.4	21.0	14.8	16.2	14.2	11.2	20.1	20.3	17.4	30.5	24.4	25.7	22.9	39.8	29.8	29.8	25.1	21.4	48.0	44.7	41.8	35.4	30.8	47.2	52.6	47.1	39.5			500
regres	500	8.9	6.9	7.1	5.8	5.1	12.5	16.1	12.7	12.1	10.2	9.0	21.5	16.8	16.1	13.4	11.8	21.0	20.0	16.7	30.5	26.5	25.3	21.1	39.5	30.6	29.2	24.3	21.4	48.5	44.4	42.4	35.2	30.9	58.3	55.0	46.1	40.4			500
DIFF AVG		-1.5	-1.1	-2.0	-1.3	-1.1	-0.8	0.6	-1.7	-0.5	1.2	0.4	-0.5	-2.0	0.1	0.7	-0.7	-0.9	0.3	0.7	0.0	-2.1	0.4	1.8	0.3	-0.9	0.5	0.8	0.0	-0.6	0.3	-0.6	0.2	-0.1	-11.1	-2.4	0.9	-0.9	-0.6	2.031	
meas	630	10.3	8.3	8.1	6.0	5.7	16.0	22.6	16.9	15.9	15.5	12.1	28.2	23.0	23.0	20.6	16.9	30.4	29.2	25.8	40.2	37.1	36.5	33.8	52.1	44.0	42.3	37.5	32.7	50.1	54.6	53.8	51.3	45.4	55.6	55.5	55.3	49.8			630
regres	630	16.9	9.1	9.7	7.5	6.9	21.1	25.3	18.2	17.3	14.3	12.7	31.7	24.6	23.5	19.4	17.0	31.0	29.7	24.6	42.2	39.5	37.9	31.4	52.7	45.9	44.0	36.5	31.4	55.0	55.0	55.0	53.6	45.9	55.0	55.0	55.0	55.0			630
DIFF AVG		-6.6	-0.8	-1.7	-1.4	-1.2	-5.1	-2.8	-1.4	-1.4	1.1	-0.5	-3.5	-1.7	-0.5	1.2	-0.1	-0.6	-0.5	1.2	-2.0	-2.4	-1.3	2.4	-0.6	-1.9	-1.8	1.0	1.3	-4.9	-0.4	-1.2	-2.3	-0.4	0.6	0.5	0.3	-5.2	-1.2	1.973	
meas	800	15.4	11.2	10.4	7.1	7.3	23.6	31.8	24.5	21.8	17.4	13.2	38.7	33.6	29.2	25.1	16.7	43.3	37.0	31.6	49.1	50.6	45.8	43.8	47.1	52.0	49.4	46.6	29.3	47.4	53.3	51.3	52.4	37.1	53.4	51.6	52.7	44.5			800
REGRESS	800	18.5	10.6	11.2	9.1	8.5	24.0	29.5	22.8	21.5	16.7	13.6	37.8	31.5	29.7	22.4	17.4	40.2	37.9	28.1	51.6	51.8	48.8	35.8	55.0	55.0	55.0	41.5	30.2	55.0	55.0	55.0	55.0	42.9	55.0	55.0	55.0	55.0			800
DIFF AVG		-3.1	0.6	-0.8	-2.0	-1.2	-0.4	2.3	1.7	0.2	0.7	-0.5	0.9	2.1	-0.5	2.7	-0.8	3.2	-0.9	3.5	-2.5	-1.1	-3.0	8.1	-7.9	-3.0	-5.6	5.1	-0.9	-7.6	-1.7	-3.7	-2.6	-5.8	-1.6	-3.4	-2.3	-10.5	-1.1	3.601	
meas	1000	19.2	12.5	11.5	7.6	6.5	30.9	40.7	30.6	24.5	15.1	10.1	46.5	42.7	36.2	20.7	12.7	51.3	45.6	25.9	48.2	56.2	51.6	34.5	49.1	53.7	53.1	38.2	18.4	48.7	53.9	53.1	50.3	23.0	53.9	53.8	54.3	26.1			1000
regres	1000	23.2	14.1	15.3	10.1	7.6	32.2	41.1	28.5	25.9	16.2	9.9	54.5	38.3	34.7	20.8	11.6	48.1	43.5	25.4	55.0	55.0	55.3	31.5	55.0	55.0	55.0	36.1	17.3	55.0	55.0	55.0	51.4	22.9	55.0	55.0	55.0	28.6			1000
DIFF AVG		-4.0	-1.7	-3.8	-2.4	-1.1	-1.3	-0.4	2.1	-1.4	-1.1	0.2	-8.0	4.4	1.5	-0.1	1.1	3.2	2.1	0.5	-6.8	1.2	-3.7	3.0	-5.9	-1.3	-1.9	2.1	1.1	-6.3	-1.1	-1.9	-1.1	0.0	-1.1	-1.2	-0.7	-2.5	-1.0	2.807	
meas	1250	23.4	11.9	12.3	7.6	6.0	37.2	45.9	25.2	28.1	14.1	8.9	48.0	33.8	37.9	17.4	10.9	41.7	48.9	20.8	48.6	49.5	52.1	27.0	48.9	55.2	52.9	27.8	16.9	48.6	54.4	53.0	37.0	20.4	54.7	53.8	45.6	22.5			1250
regres	1200	28.3	14.2	15.6	9.8	7.5	38.1	48.0	26.4	23.6	14.3	9.2	62.8	34.5	30.6	17.8	10.4	42.5	37.7	21.2	55.0	53.3	47.0	25.8	55.0	55.0	54.1	29.2	14.7	55.0	55.0	55.0	40.7	19.0	55.0	55.0	52.2	23.2			1200
DIFF AVG		-4.9	-2.3	-3.3	-2.2	-1.5	-0.9	-2.1	-1.2	4.5	-0.3	-0.3		-0.7	7.3	-0.4	0.5	-0.8	11.2	-0.5	-6.4	-3.8	5.0	1.2	-6.1	0.2	-1.2	-1.4	2.2	-6.4	-0.6	-2.0	-3.7	1.5	-0.3	-1.2	-6.6	-0.7	-0.8	3.653	
meas	1600	24.8	10.8	11.6	6.8	5.2	39.3	46.9	20.6	19.6	11.0	7.0	49.0	25.0	26.6	14.3	9.0	29.1	32.0	17.0	49.1	32.6	38.4	20.1	49.4	35.7	42.8	20.3	14.0	49.4	46.5	52.5	25.6	16.9	58.2	55.4	33.1	19.9			1600
regres	1600	26.2	12.4	13.7	8.3	6.3	36.7	47.3	20.0	17.5	10.8	8.1	63.2	24.8	21.4	12.8	9.4	29.5	25.3	14.7	55.0	35.8	30.4	17.2	55.0	40.5	34.3	19.1	14.0	55.0	56.3	47.2	25.5	18.5	55.0	55.0	31.9	23.1			1600
DIFF AVG		-1.3	-1.5	-2.1	-1.5	-1.1	2.6	-0.4	0.6	2.1	0.2	-1.0	-14.2	0.2	5.2	1.5	-0.4	-0.4	6.7	2.3	-5.9	-3.1	8.0	2.9	-5.6	-4.8	8.5	1.2	0.0	-5.6	-9.8	5.3	0.0	-1.6	3.2	0.4	1.2	-3.1	-0.3	4.494	
meas	2000	19.0	8.6	10.6	5.5	4.4	28.1	35.2	17.9	14.0	9.3	5.8	43.7	20.8	16.7	10.7	7.5	23.7	20.3	12.3	48.7	26.7	23.2	15.6	50.3	28.5	25.8	17.4	11.4	49.5	34.5	34.8	20.9	13.7	38.1	41.4	21.5	14.3			2000
regres	2000	21.2	9.7	10.8	6.6	5.1	26.4	31.5	14.8	13.2	8.6	6.4	39.2	17.9	15.8	10.0	7.4	20.9	18.4	11.5	52.0	24.9	21.9	13.5	55.0	27.9	24.5	15.0	10.8	55.0	38.0	33.1	19.9	14.2	48.1	41.8	24.8	17.6			2000
DIFF AVG		-2.3	-1.1	-0.2	-1.1	-0.6	1.7	3.8	3.0	0.8	0.7	-0.6	4.5	2.9	0.9	0.6	0.0	2.8	1.9	0.8	-3.3	1.8	1.3	2.1	-4.7	0.6	1.3	2.4	0.5	-5.5	-3.5	1.6	1.0	-0.6	-10.0	-0.4	-3.3	-3.3	-0.1	2.875	
meas	2500	16.2	7.1	8.9	4.6	4.0	22.7	27.1	15.3	11.8	7.6	5.3	33.1	17.8	13.9	10.5	6.9	19.9	15.7	12.0	43.4	22.4	18.6	13.4	47.8	23.4	20.2	14.3	9.3	48.8	27.7	25.8	17.0	11.1	31.8	31.3	20.1	13.3			2500
regres	2500	14.8	8.7	9.5	6.2	4.7	19.0	23.2	12.4	11.2	7.6	5.8	29.5	14.5	13.0	8.7	6.7	16.6	14.8	9.7	40.0	19.5	17.2	11.1	50.5	21.7	19.1	12.2	9.4	61.0	28.8	25.1	15.7	12.2	36.0	31.2	19.3	15.0			2500
DIFF AVG		1.4	-1.6	-0.6	-1.6	-0.7	3.7	4.0	2.9	0.6	0.0	-0.5	3.6	3.3	0.9	1.8	0.3	3.2	0.8	2.3	3.5	2.8	1.4	2.3	-2.7	1.8	1.1	2.1	-0.1	-12.2	-1.1	0.6	1.2	-1.1	-4.2	0.1	0.8	-1.7	0.5	2.88	
meas	3150	16.5	6.9	8.3	4.4	3.0	21.5	24.7	13.3	11.4	7.6	4.6	28.2	15.8	14.3	9.3	5.8	17.2	14.9	11.0	32.6	19.4	16.8	11.9	37.0	20.2	18.1	13.3	9.4	40.0	24.2	21.6	15.5	10.9	31.6	26.7	19.5	12.2			3150
regres	3150	14.7	7.6	8.3	5.3	4.1	17.2	19.7	10.9	9.9	6.8	5.1	23.5	12.8	11.6	7.9	5.9	14.8	13.3	9.0	29.8	17.4	15.7	10.4	36.2	19.3	17.4	11.5	8.5	42.5	25.8	23.2	15.2	11.1	32.2	28.9	18.9	13.7			3150
DIFF AVG		1.8	-0.7	0.0	-0.9	-1.1	4.3	5.0	2.4	1.5	0.8	-0.5	4.7	3.0	2.7	1.4	-0.1	2.5	1.5	2.0	2.7	2.0	1.1	1.4	0.8	0.9	0.7	1.7	0.9	-2.4	-1.6	-1.6	0.3	-0.2	-0.6	-2.2	0.6	-1.5	0.9	1.821	
meas	4000	12.1	6.3	7.6	3.7	2.2	15.5	17.2	12.3	9.3	6.6	4.1	20.0	14.8	11.2	8.2	5.0	16.7	11.9	9.5	23.2	19.2	13.7	11.2	26.8	20.3	14.9	13.1	8.5	29.0	24.1	17.2	16.1	9.8	23.7	22.9	17.1	10.6			4000
regres	4000	14.8	6.5	7.3	4.3	3.2	16.2	17.6	9.7	8.7	5.8	4.3	19.7	11.4	10.4	7.0	5.1	13.2	12.0	8.1	23.1	15.6	14.2	9.7	26.6	17.3	15.9	10.8	7.8	30.1	23.2	21.4	14.7	10.5	29.1	26.9	18.6	13.2			4000
DIFF AVG		-2.7	-0.2	0.3	-0.6	-1.0	-0.7	-0.4	2.6	0.6	0.8	-0.2	0.3	3.3	0.8	1.2	0.0	3.5	-0.1	1.3	0.0	3.7	-0.5	1.6	0.2	3.0	-1.0	2.3	0.7	-1.1	0.8	-4.2	1.4	-0.6	-5.4	-4.0	-1.5	-2.6	0.0	2.056	
meas	5000	12.2	4.8	6.5	3.1	2.0	15.3	16.4	12.1	7.7	6.1	4.1	20.0	14.3	9.7	7.9	4.7	16.0	11.1	9.2	23.6	17.0	13.4	10.5	28.2	17.9	14.6	11.0	7.4	32.4	20.3	17.3	13.2	8.5	17.6	17.2	12.9	10.1			5000
regres	5000	12.2	5.3	5.8	3.8	3.2	14.1	15.9	8.3	7.5	5.2	4.0	18.7	10.2	9.2	6.3	4.7	12.1	10.9	7.3	23.3	14.6	13.2	8.7	27.9	16.5	14.9	9.8	6.9	32.5	22.7	20.6	13.4	9.1	29.0	26.3	16.9	11.3			5000
DIFF AVG		-0.1	-0.4	0.6	-0.7	-1.2	1.2	0.5	3.7	0.1	0.9	0.0	1.3	4.1	0.4	1.7	0.0	3.9	0.1	1.8	0.3	2.4	0.2	1.8	0.3	1.4	-0.3	1.1	0.5	-0.2	-2.5	-3.3	-0.1	-0.6	-11.3	-9.1	-4.0	-1.2	-0.2	2.966	
meas	6300	12.8	5.0	6.1	3.2	1.3	17.4	20.1	10.9	7.7	6.0	3.6	21.7	13.0	9.3	7.1	3.8	14.2	11.7	8.0	25.1	16.1	13.6	9.1	26.4	17.0	14.8	10.4	7.8	27.9	19.1	16.0	12.4	9.0	19.8	13.3	12.8	9.4			6300
regres	6300	11.1	5.2	5.7	3.5	2.7	12.9	14.6	8.1	7.3	4.9	3.6	17.1	9.9	9.0	5.9	4.2	11.7	10.6	7.0	21.4	14.0	12.7	8.3	25.7	15.8	14.4	9.4	6.4	30.0	21.7	19.8	12.8	8.6	27.7	25.2	16.3	10.8			6300
DIFF AVG		1.6	-0.2	0.4	-0.3	-1.4	4.6	5.5	2.8	0.4	1.1	0.0	4.5	3.1	0.4	1.2	-0.4	2.5	1.1	1.0	3.7	2.1	0.8	0.7	0.7	1.2	0.4	1.0	1.4	-2.0	-2.6	-3.7	-0.4	0.4	-7.9	-11.9	-3.5	-1.4	0.2	3.217	
meas	8000	10.5	4.8	5.8	2.8	1.0	14.8	17.1	10.1	7.4	5.3	3.6	19.7	12.2	9.3	6.8	3.7	12.6	10.5	7.8	20.5	15.2	11.9	8.3	21.9	16.6	12.4	9.3	7.2	24.8	19.7	13.7	11.3	8.2	18.4	12.6	12.9	9.8			8000
regres	8000	11.0	5.2	5.7	3.4	2.6	12.4	13.7	7.9	7.1	4.7	3.3	15.6	9.5	8.6	5.6	3.9	11.1	10.0	6.5	18.9	13.2	12.0	7.8	22.2	14.8	13.5	8.7	5.7	25.4	20.1	18.4	11.8	7.6	25.4	23.2	15.0	9.5			8000
DIFF AVG		-0.5	-0.3	0.1	-0.6	-1.6	2.4	3.4	2.3	0.3	0.7	0.3	4.0	2.7	0.7	1.2	-0.1	1.6	0.4	1.3	1.5	2.0	-0.1	0.5	-0.3	1.8	-1.1	0.6	1.4	-0.6	-0.4	-4.6	-0.6	0.6	-7.0	-10.6	-2.0	0.3	0.0	2.684	
meas	10000	8.8	4.6	6.0	2.7	0.8	14.1	16.0	10.4	6.8	5.7	3.7	17.8	12.0	7.7	6.9	3.6	12.8	9.9	7.7	18.8	15.7	11.6	8.4	20.6	16.2	11.8	9.6	7.0	22.5	18.4	12.7	11.6	7.8	19.2	13.6	13.3	9.0			10000
regres	10000	11.1	5.4	6.1	3.5	2.5	12.2	13.4	8.0	7.3	4.7	3.2	15.0	9.5	8.6	5.6	3.8	11.0	10.0	6.5	17.8	12.9	11.8	7.7	20.5	14.4	13.2	8.6	5.6	23.3	19.3	17.8	11.6	7.4	24.2	22.3	14.5	9.3			10000
DIFF AVG		-2.4	-0.8	0.0	-0.8	-1.7	1.9	2.7	2.4	-0.4	1.0	0.5	2.8	2.5	-0.9	1.3	-0.2	1.8	-0.1	1.2	1.1	2.7	-0.2	0.7	0.1	1.8	-1.4	1.0	1.4	-0.7	-0.9	-5.1	0.0	0.4	-5.1	-8.7	-1.2	-0.3	-0.1	2.34	

meas - Measured IL Values

DIF AVG - Calculation of the average of the differneces between measured and calculated IL values

Flanking Insertion Loss Reached

Regress - Calculated IL Values from Regression Equat

STD - Calculation of the standard deviation relative to the DIFF AVG

Figure C.78: Data Comparison for 1-in Rectangular Ducts

APPENDIX D E.H. PRICE + UNLV DATA FOR 2-IN RECTANGULAR DUCTS

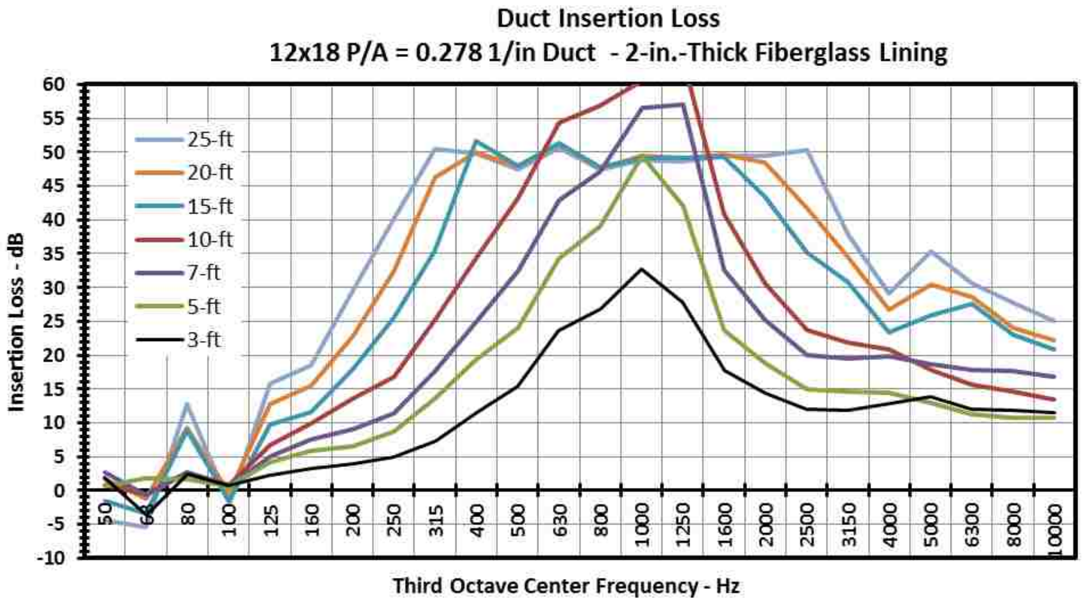

Figure D.1: Insertion Loss for 12x18 ducts with 2-in Fiberglass

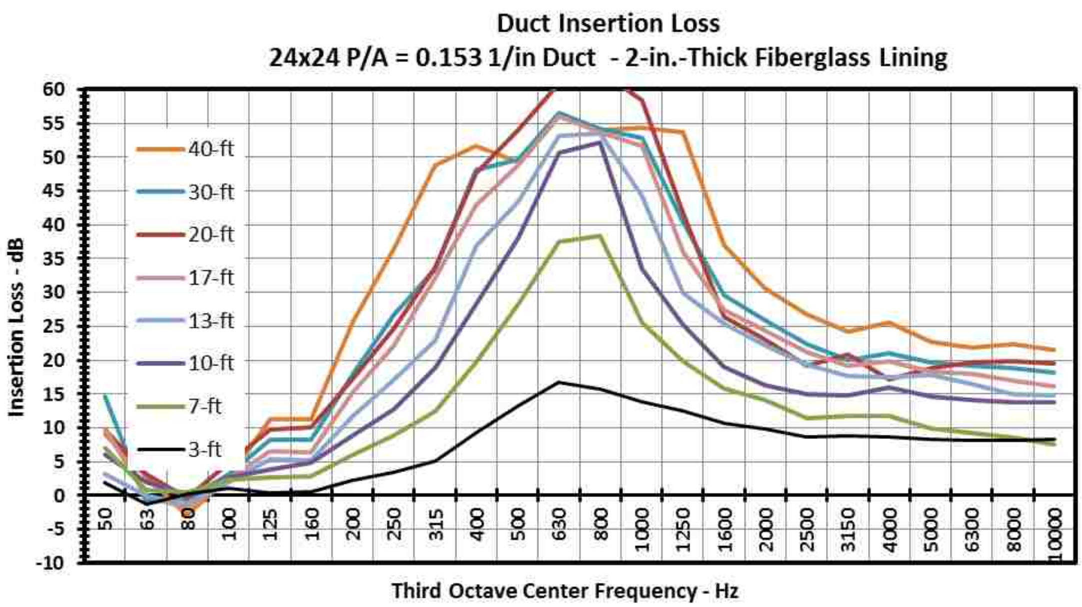

Figure D.2: Insertion Loss for 24x24 ducts with 2-in Fiberglass

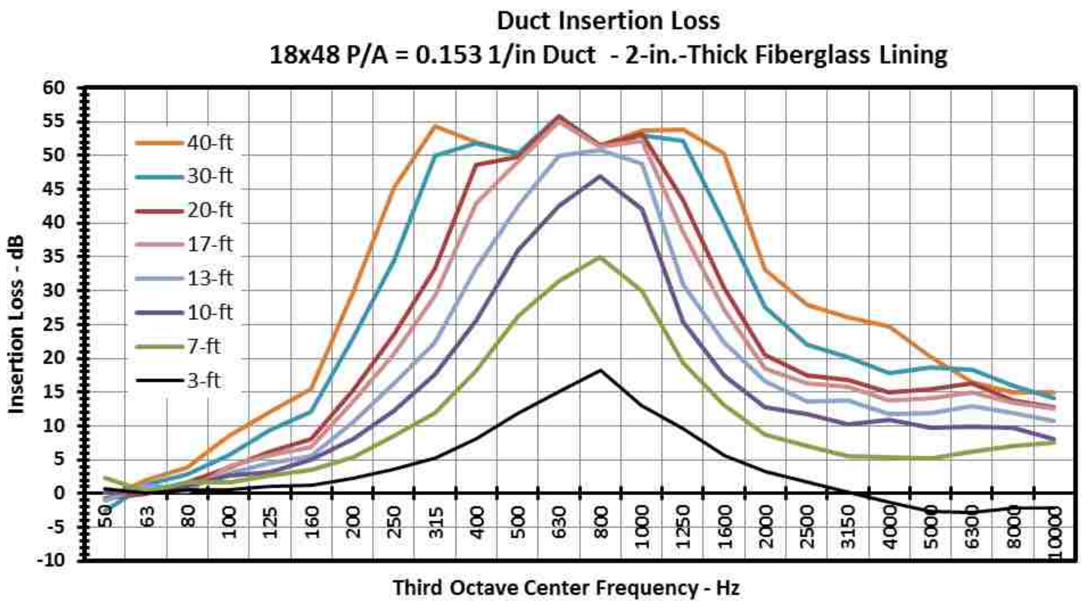

Figure D.3: Insertion Loss for 18x48 ducts with 2-in Fiberglass

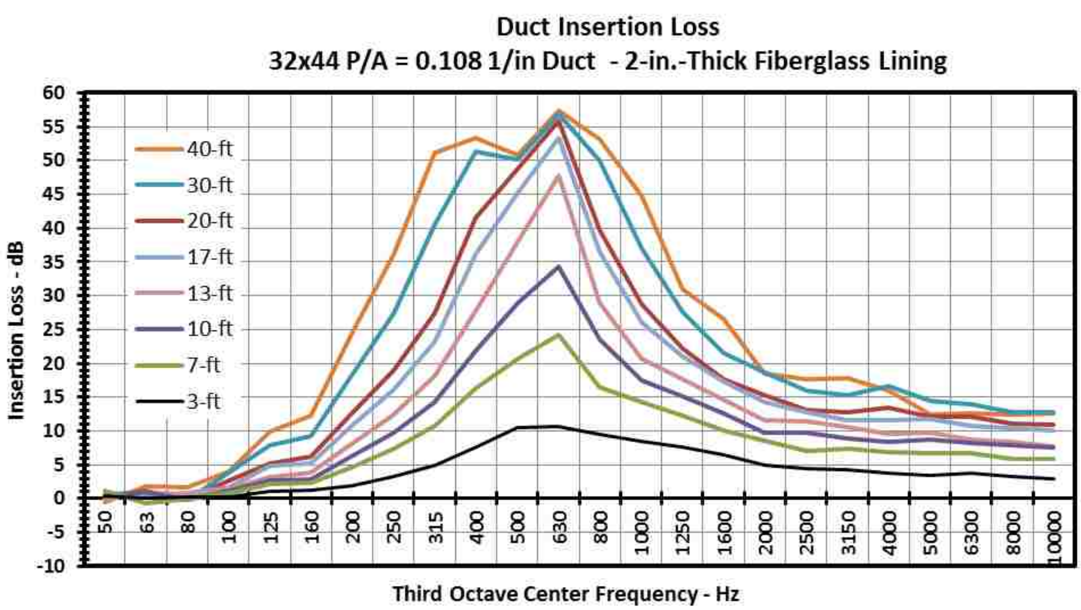

Figure D.4: Insertion Loss for 32x44 ducts with 2-in Fiberglass

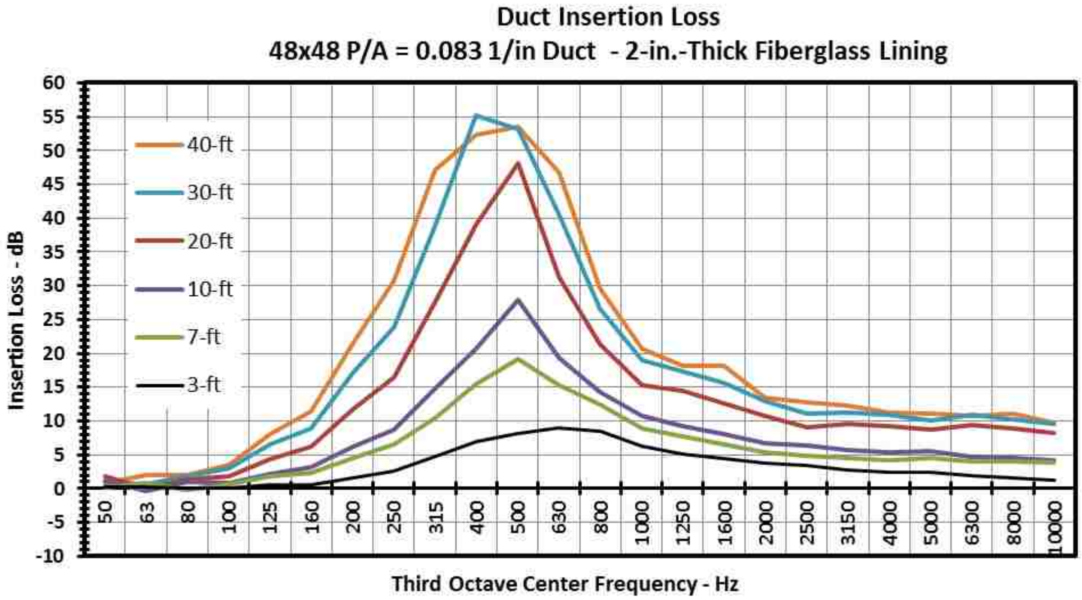

Figure D.5: Insertion Loss for 48x48 ducts with 2-in Fiberglass

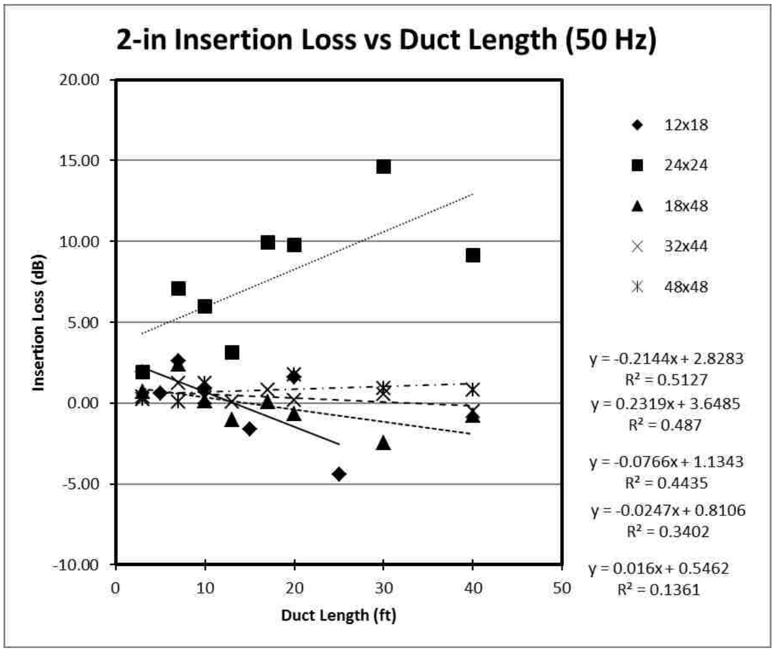

Figure D.6: 2-in Insertion Loss vs Duct Length at 50 Hz

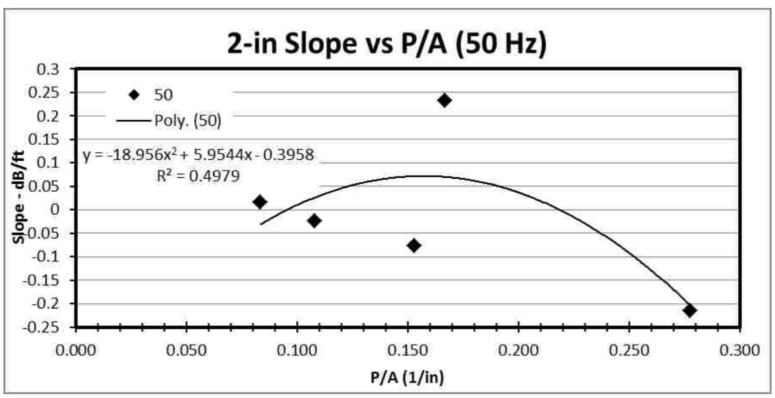

Figure D.7: 2-in Slope vs P/A at 50 Hz

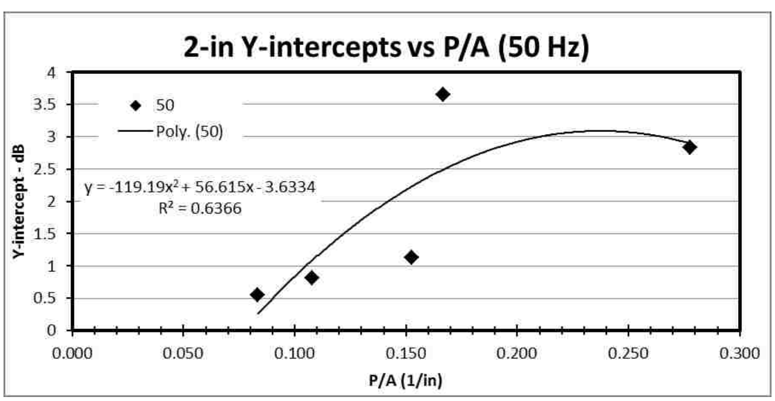

Figure D.8: 2-in Y-intercepts vs P/A at 50 Hz

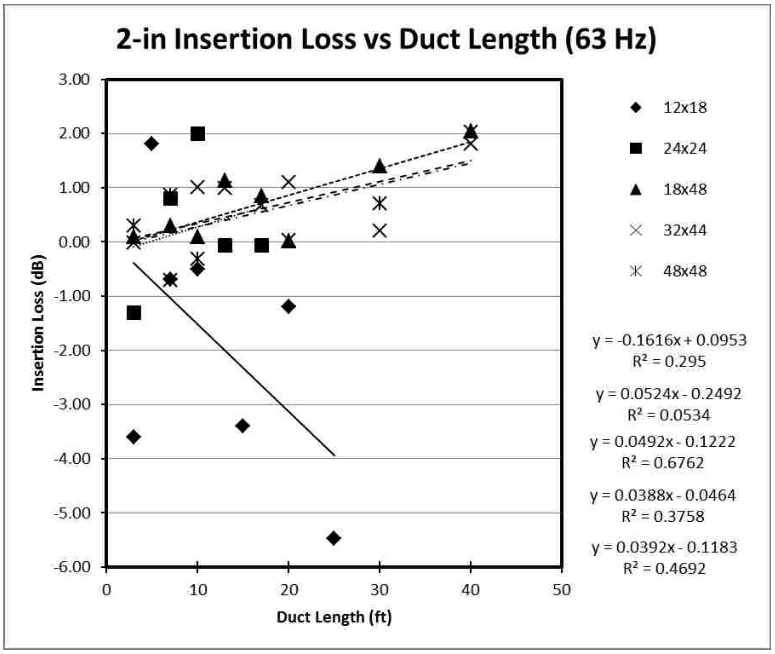

Figure D.9: 2-in Insertion Loss vs Duct Length at 63 Hz

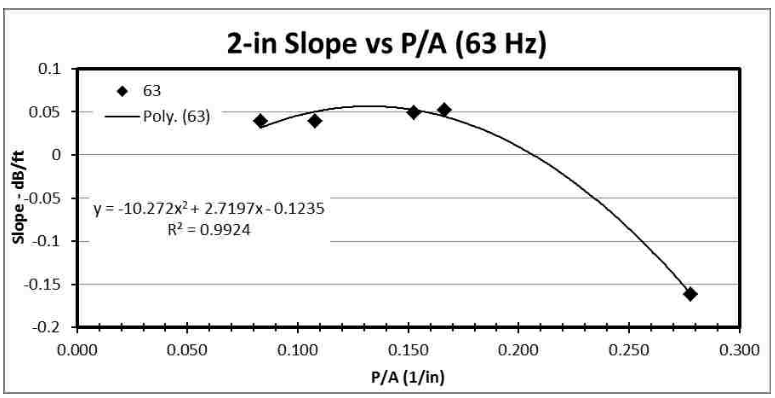

Figure D.10: 2-in Slope vs P/A at 63 Hz

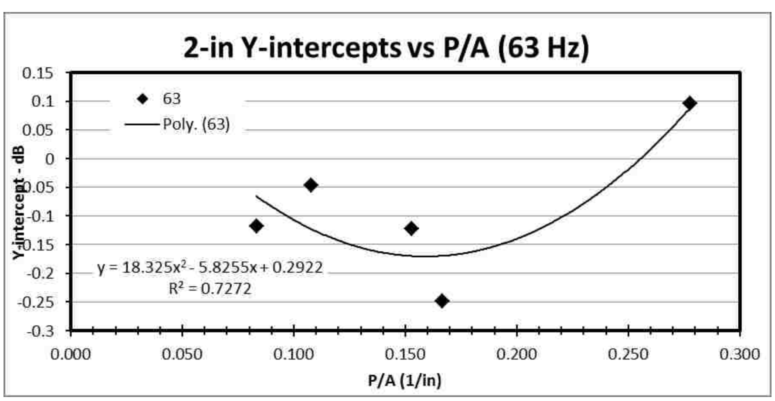

Figure D.11: 2-in Y-intercepts vs P/A at 63 Hz

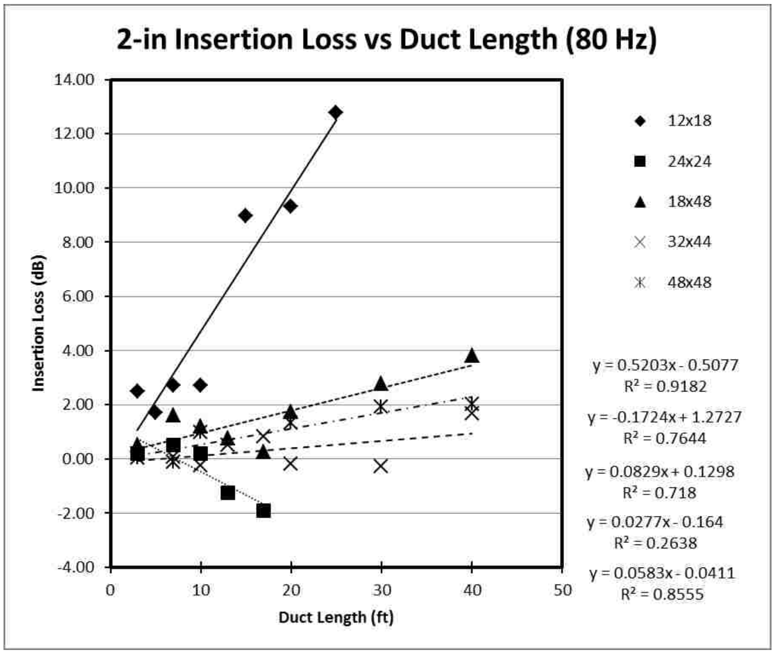

Figure D.12: 2-in Insertion Loss vs Duct Length at 80 Hz

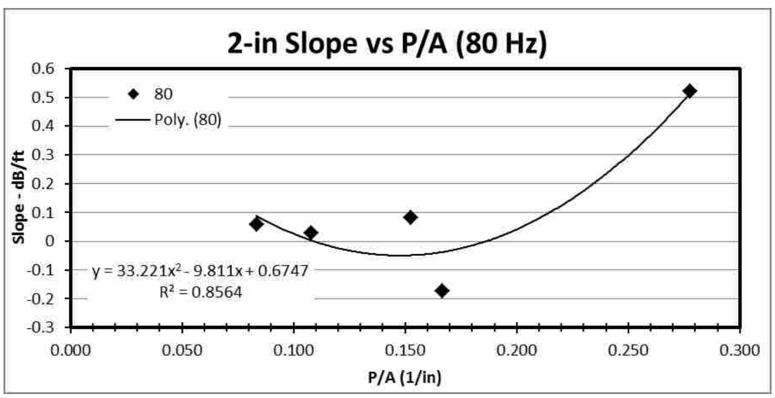

Figure D.13: 2-in Slope vs P/A at 80 Hz

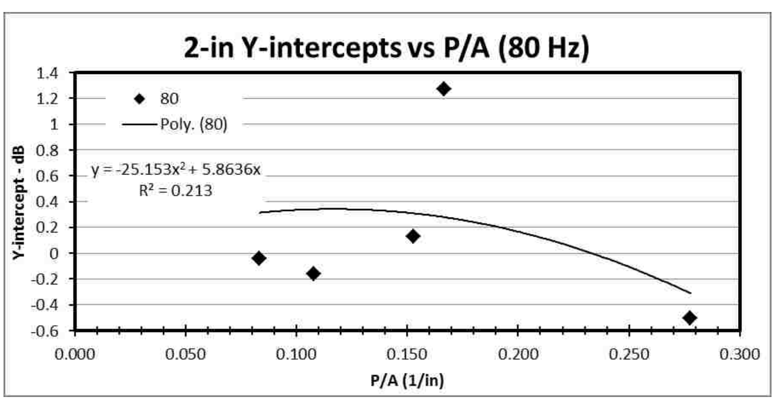

Figure D.14: 2-in Y-intercepts vs P/A at 80 Hz

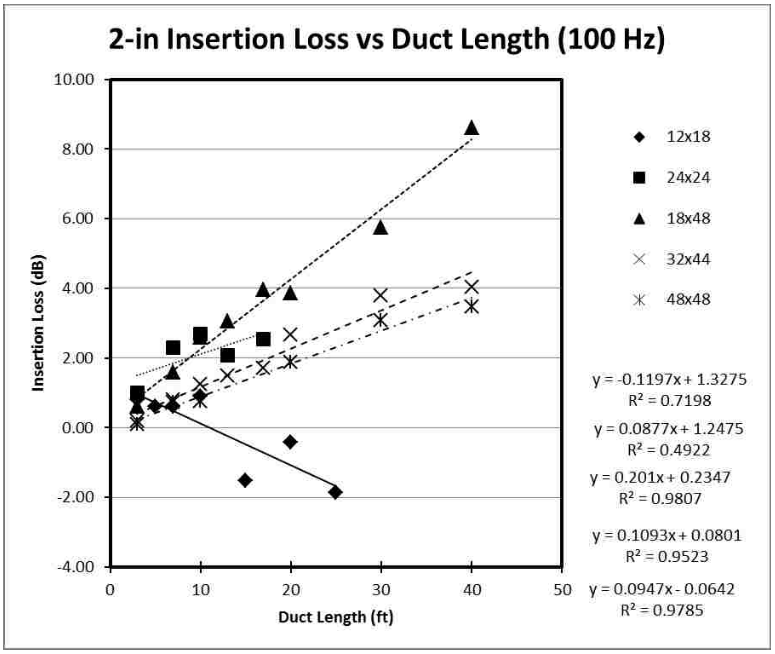

Figure D.15: 2-in Insertion Loss vs Duct Length at 100 Hz

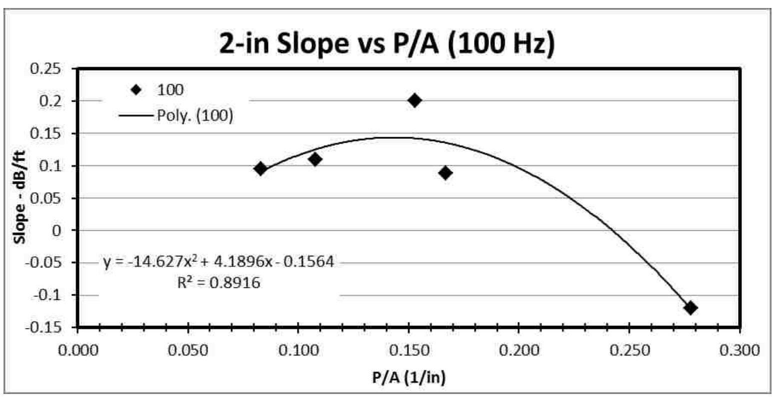

Figure D.16: 2-in Slope vs P/A at 100 Hz

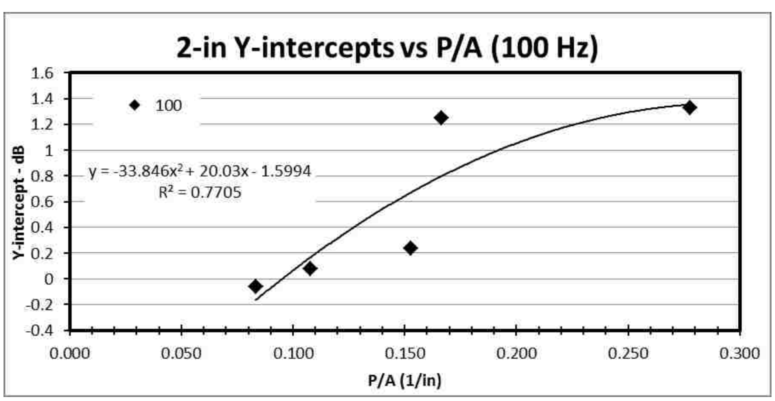

Figure D.17: 2-in Y-intercepts vs P/A at 100 Hz

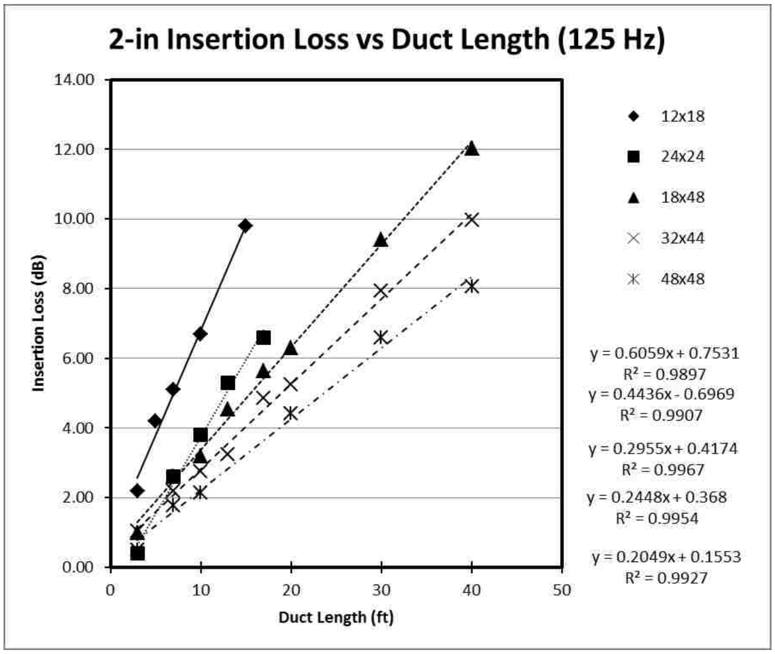

Figure D.18: 2-in Insertion Loss vs Duct Length at 125 Hz

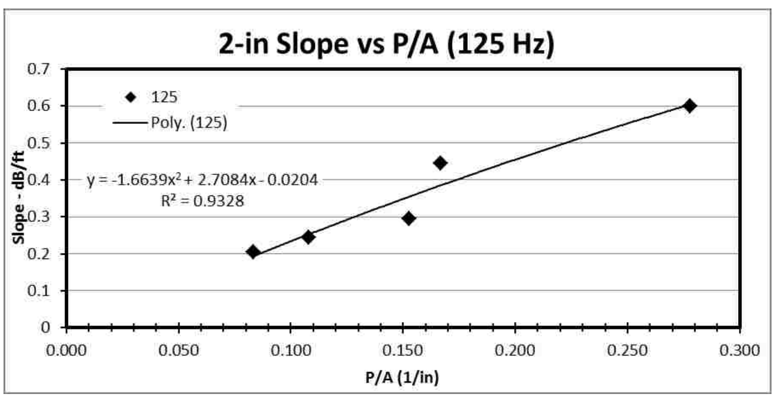

Figure D.19: 2-in Slope vs P/A at 125 Hz

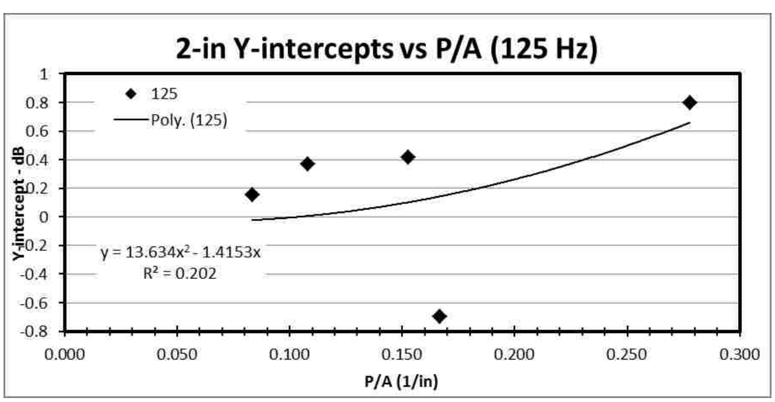

Figure D.20: 2-in Y-intercepts vs P/A at 125 Hz

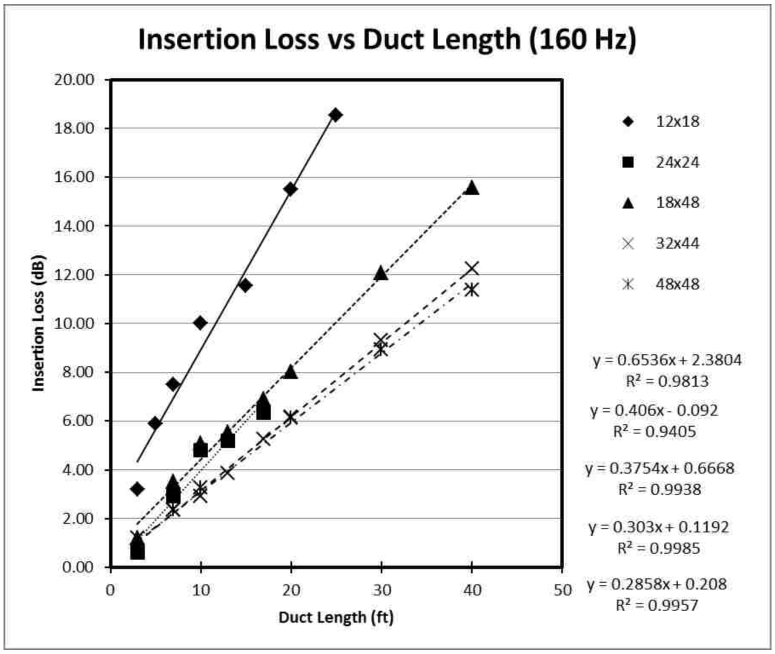

Figure D.21: 2-in Insertion Loss vs Duct Length at 160 Hz

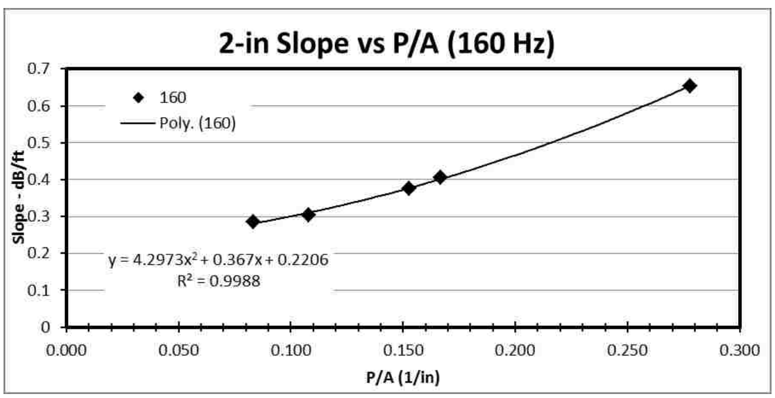

Figure D.22: 2-in Slope vs P/A at 160 Hz

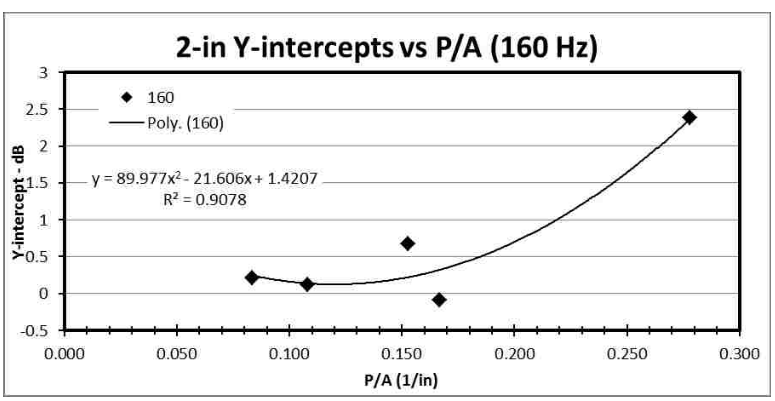

Figure D.23: 2-in Y-intercepts vs P/A at 160 Hz

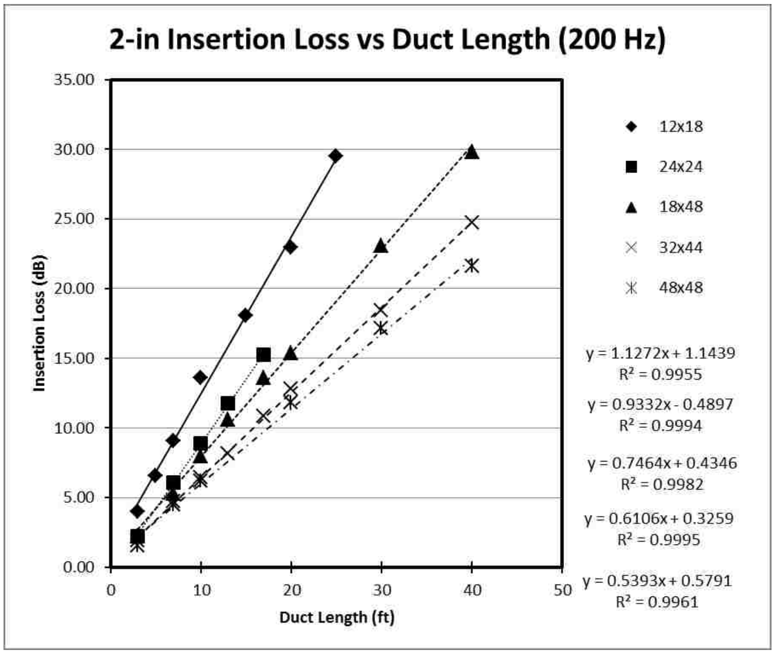

Figure D.24: 2-in Insertion Loss vs Duct Length at 200 Hz

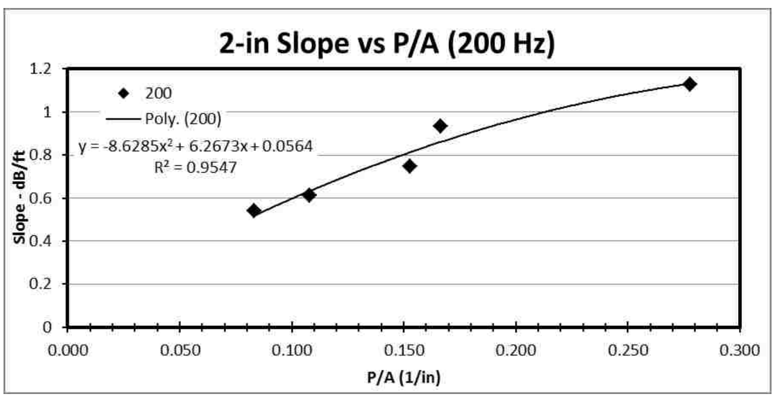

Figure D.25: 2-in Slope vs P/A at 200 Hz

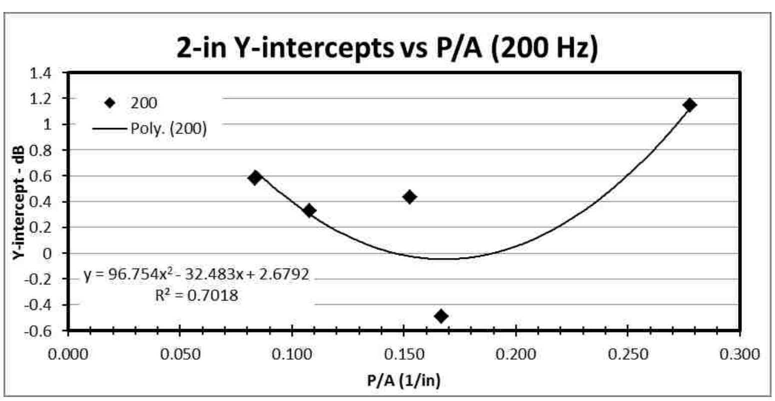

Figure D.26: 2-in Y-intercepts vs P/A at 200 Hz

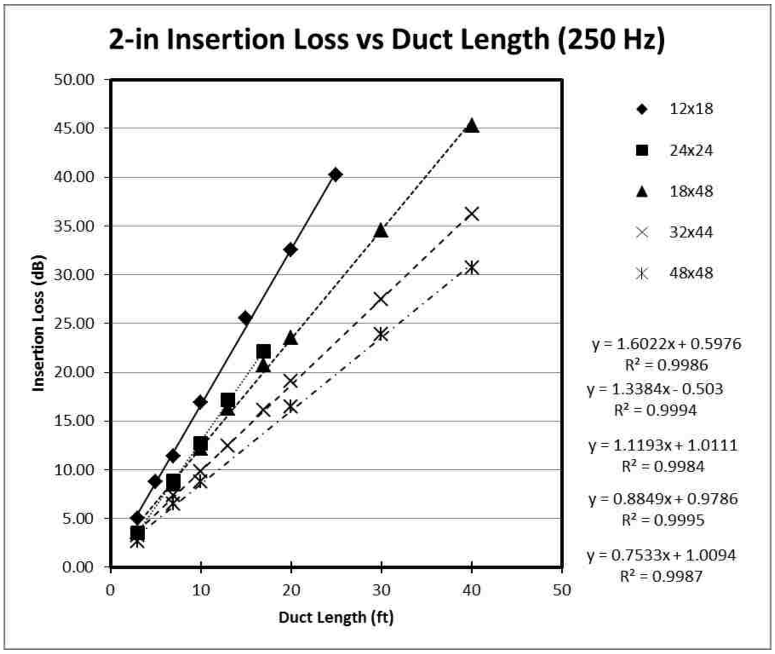

Figure D.27: 2-in Insertion Loss vs Duct Length at 250 Hz

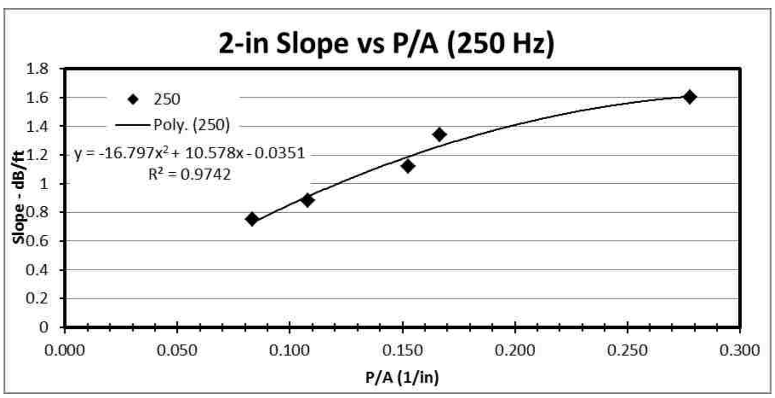

Figure D.28: 2-in Slope vs P/A at 250 Hz

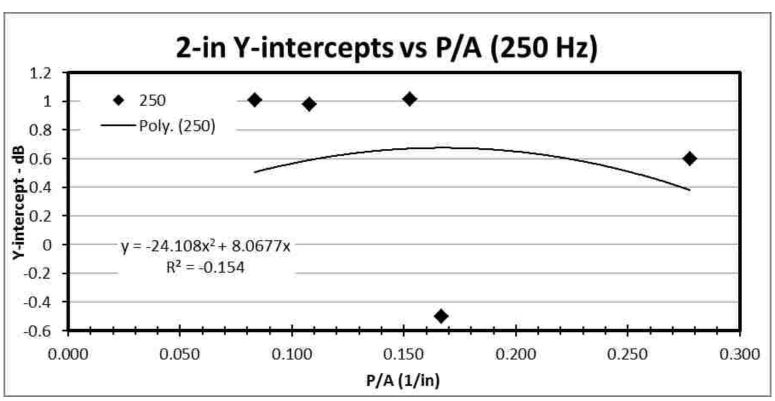

Figure D.29: 2-in Y-intercepts vs P/A at 250 Hz

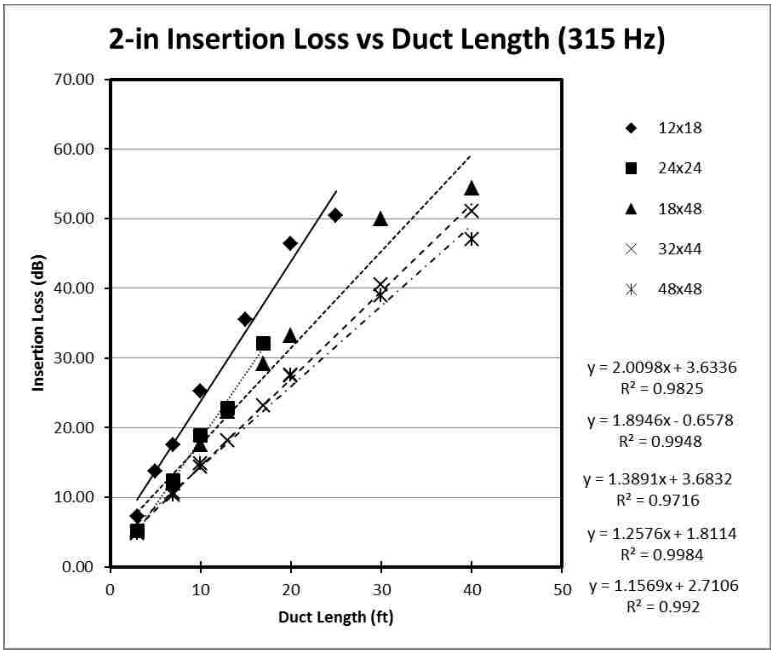

Figure D.30: 2-in Insertion Loss vs Duct Length at 315 Hz

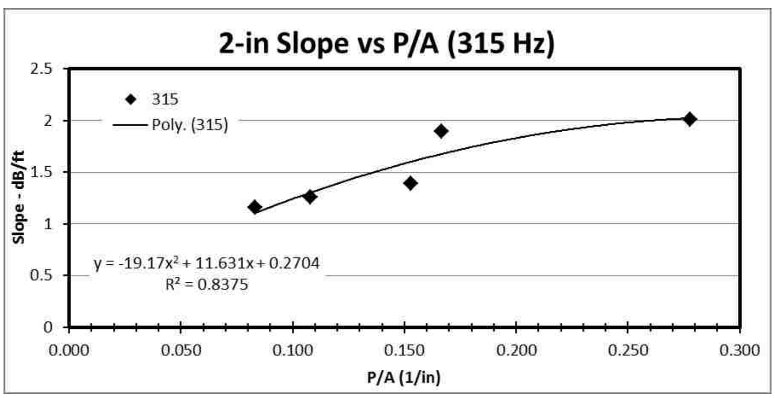

Figure D.31: 2-in Slope vs P/A at 315 Hz

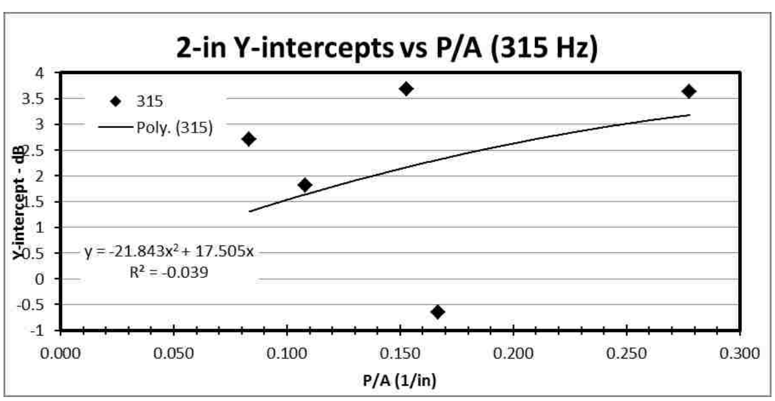

Figure D.32: 2-in Y-intercepts vs P/A at 315 Hz

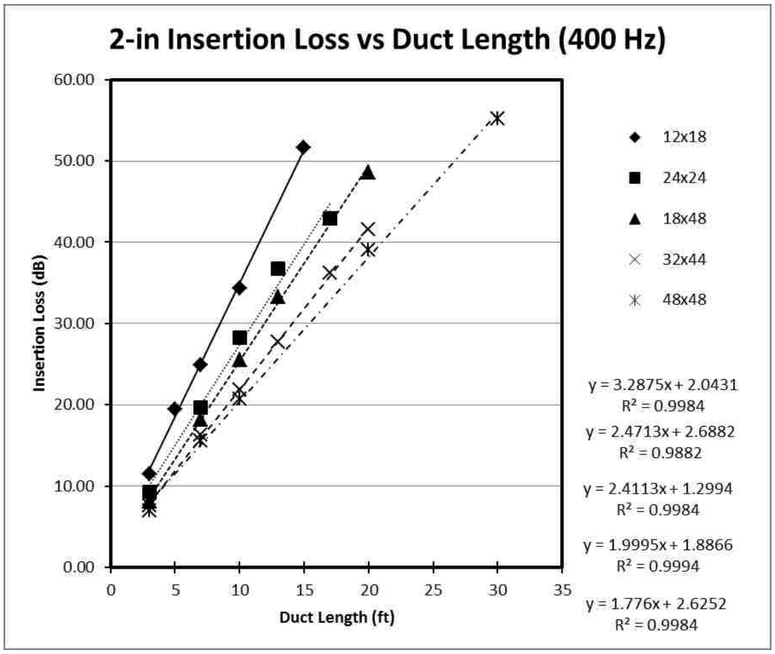

Figure D.33: 2-in Insertion Loss vs Duct Length at 400 Hz

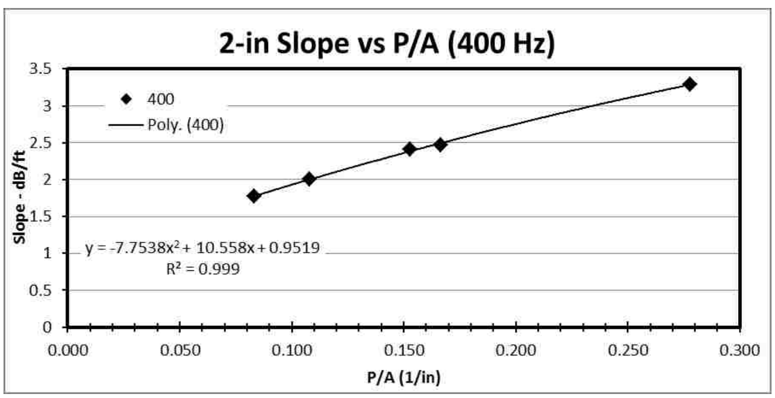

Figure D.34: 2-in Slope vs P/A at 400 Hz

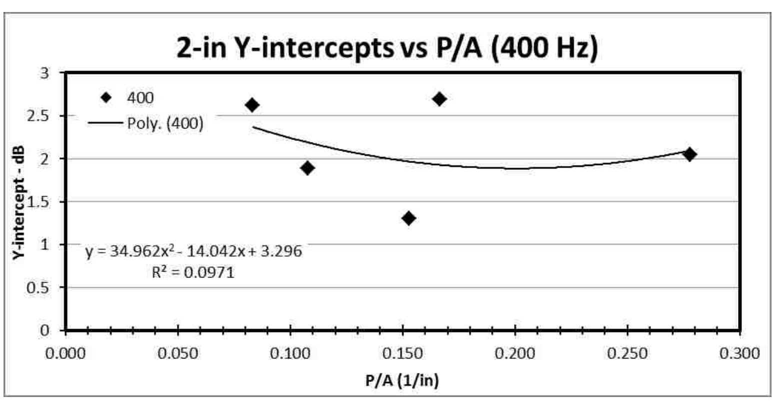

Figure D.35: 2-in Y-intercepts vs P/A at 400 Hz

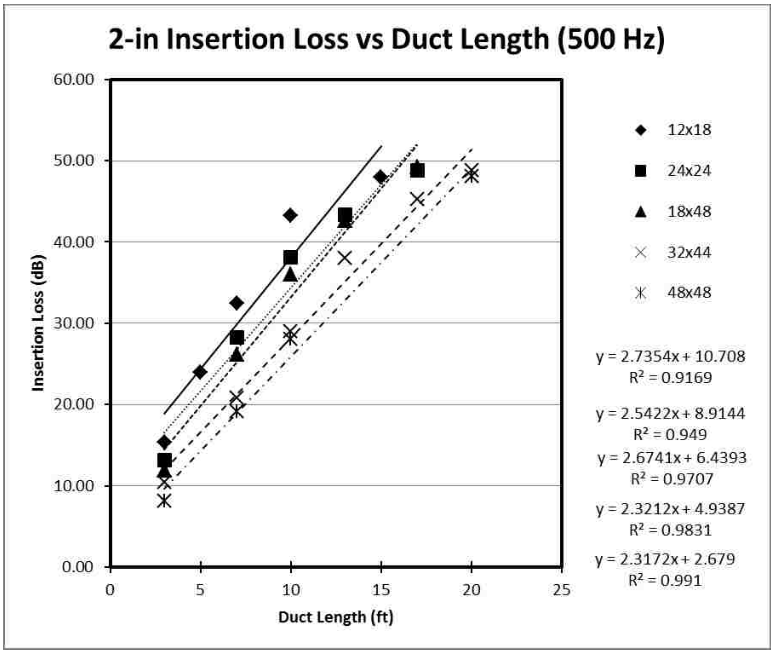

Figure D.36: 2-in Insertion Loss vs Duct Length at 500 Hz

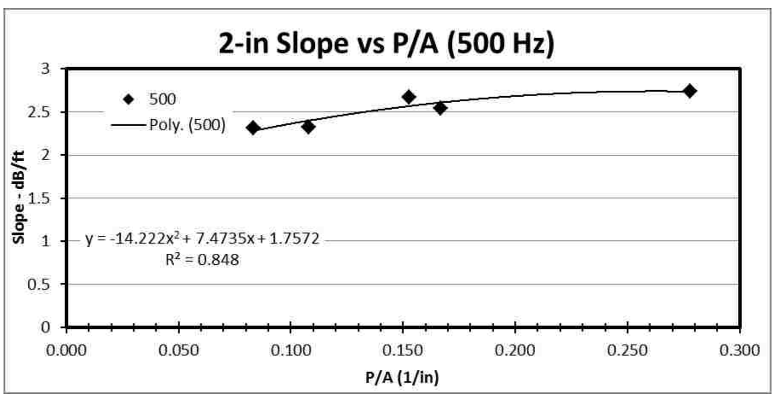

Figure D.37: 2-in Slope vs P/A at 500 Hz

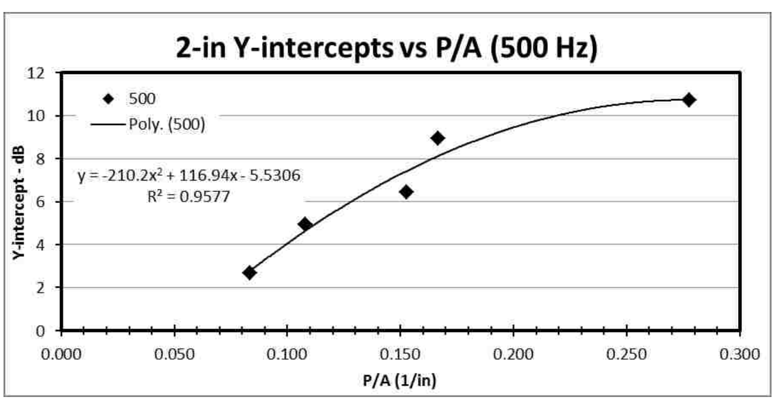

Figure D.38: 2-in Y-intercepts vs P/A at 500 Hz

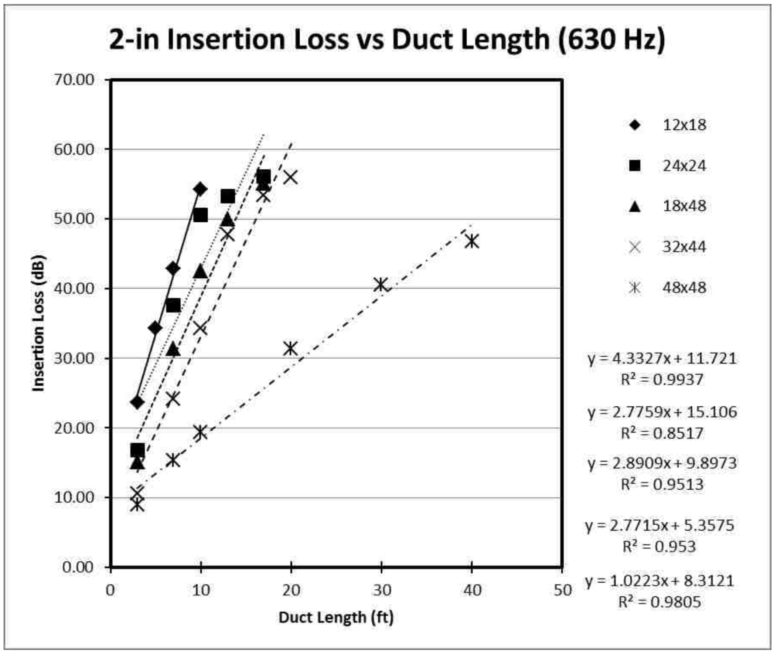

Figure D.39: 2-in Insertion Loss vs Duct Length at 630 Hz

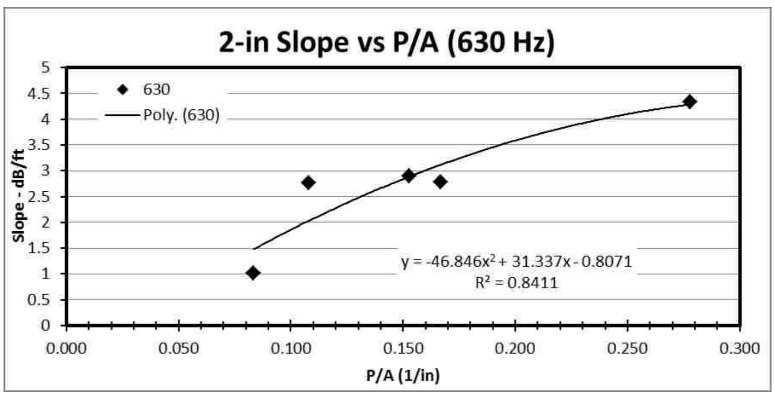

Figure D.40: 2-in Slope vs P/A at 630 Hz

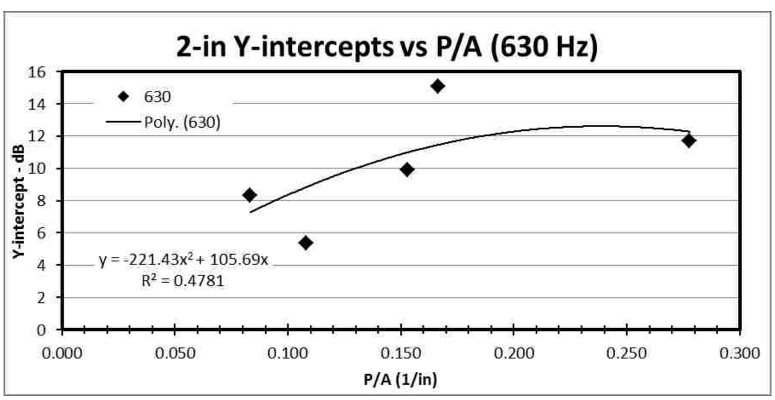

Figure D.41: 2-in Y-intercepts vs P/A at 630 Hz

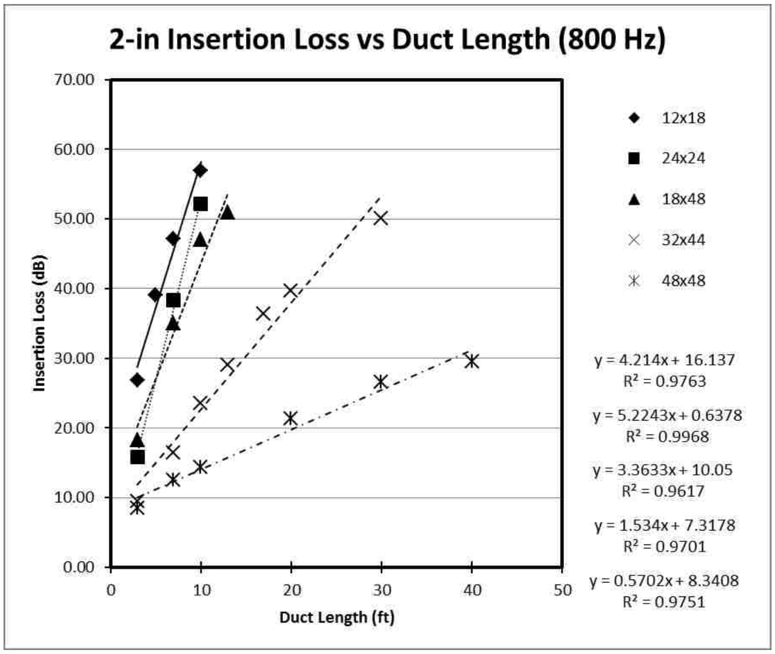

Figure D.42: 2-in Insertion Loss vs Duct Length at 800 Hz

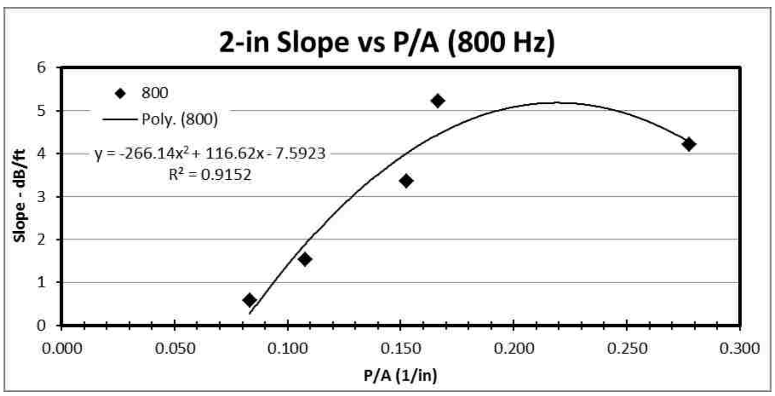

Figure D.43: 2-in Slope vs P/A at 800 Hz

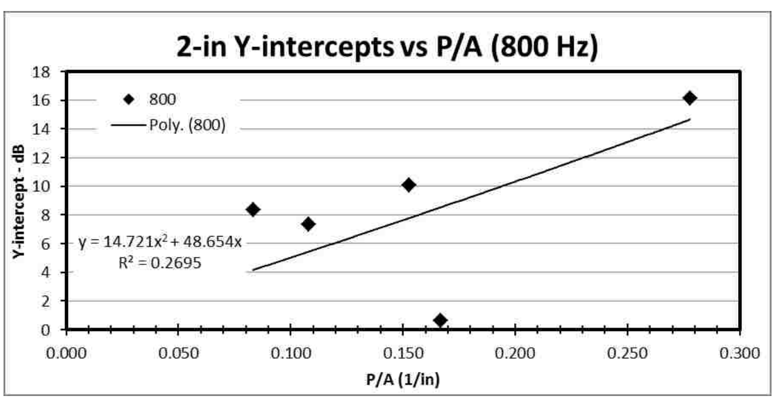

Figure D.44: 2-in Y-intercepts vs P/A at 800 Hz

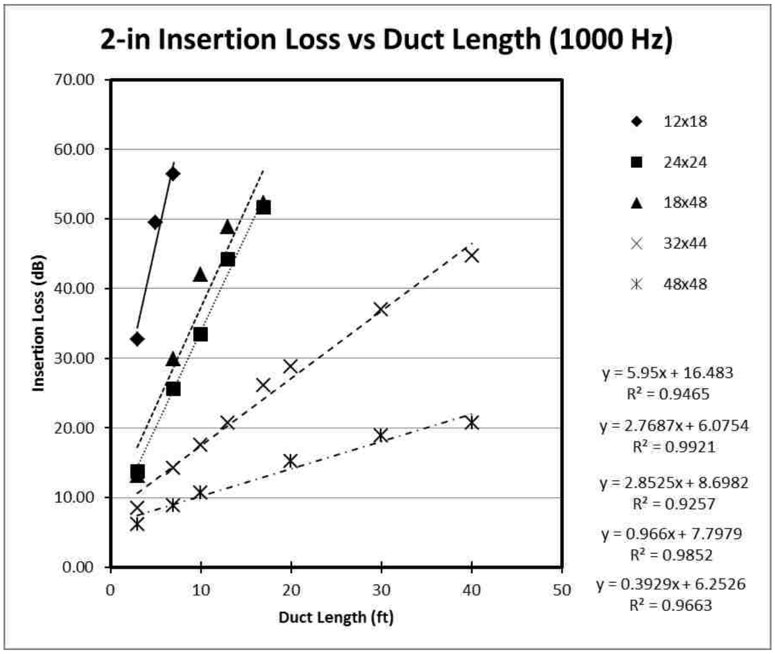

Figure D.45: 2-in Insertion Loss vs Duct Length at 1000 Hz

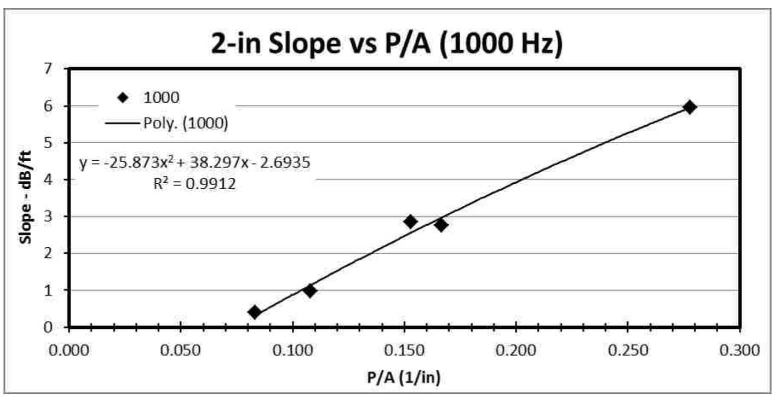

Figure D.46: 2-in Slope vs P/A at 1000 Hz

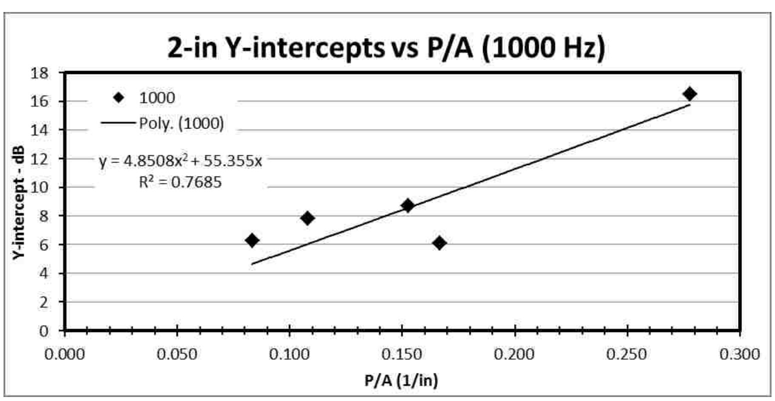

Figure D.47: 2-in Y-intercepts vs P/A at 1000 Hz

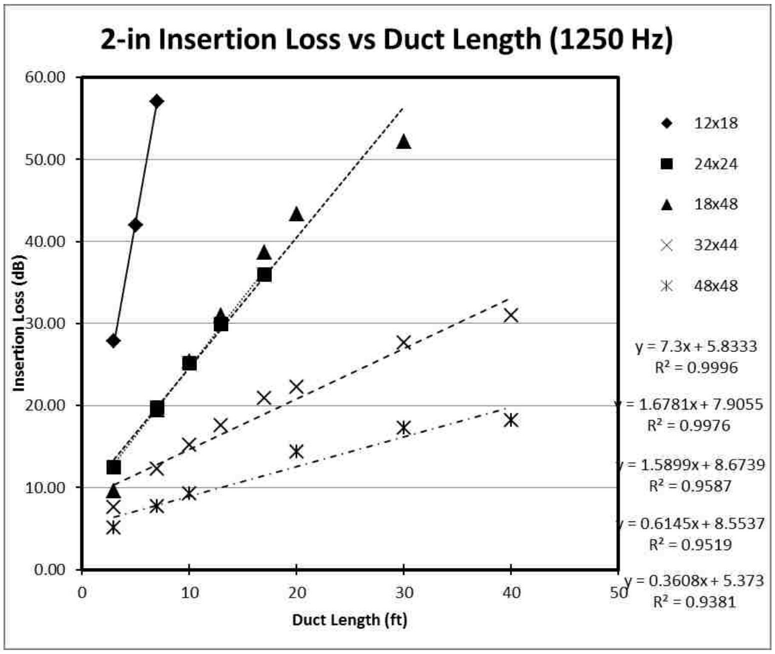

Figure D.48: 2-in Insertion Loss vs Duct Length at 1250 Hz

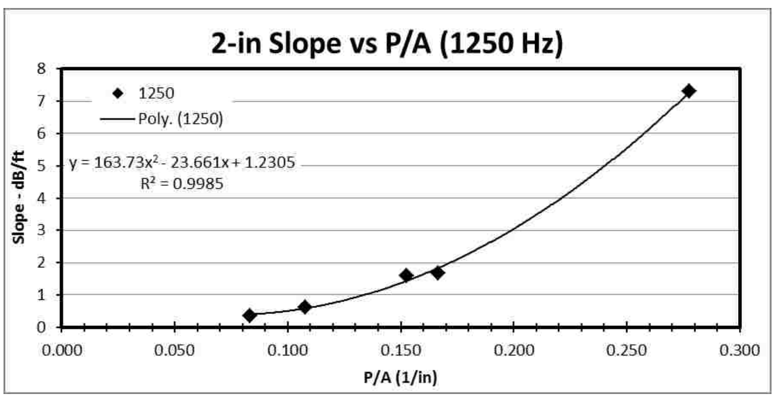

Figure D.49: 2-in Slope vs P/A at 1250 Hz

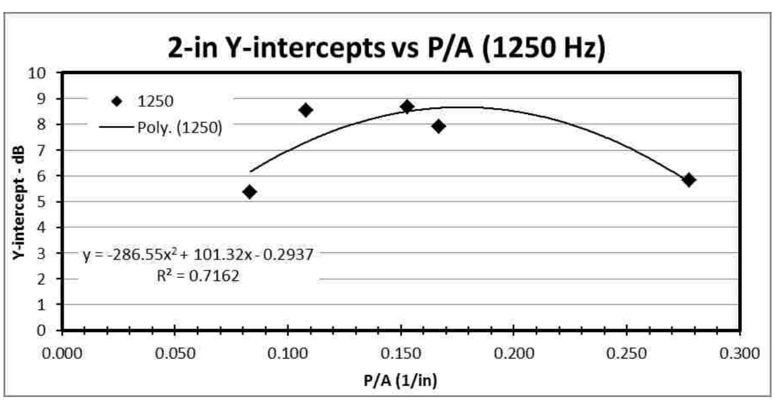

Figure D.50: 2-in Y-intercepts vs P/A at 1250 Hz

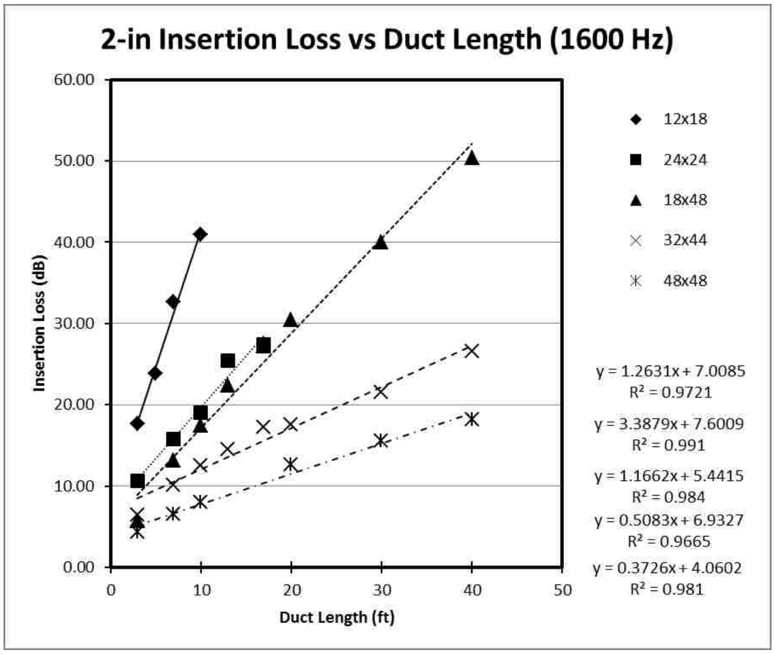

Figure D.51: 2-in Insertion Loss vs Duct Length at 1600 Hz

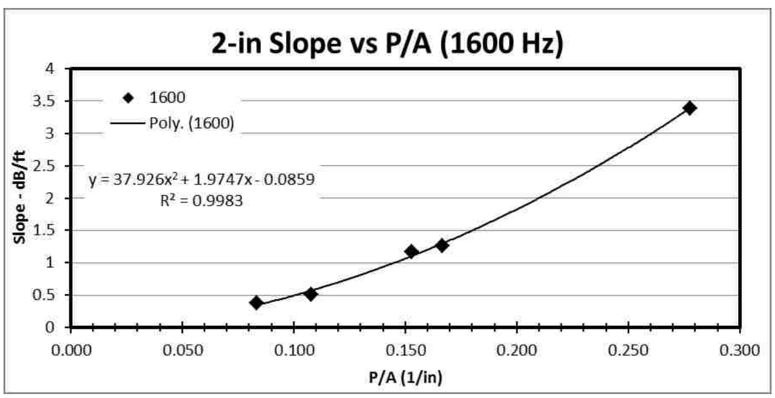

Figure D.52: 2-in Slope vs P/A at 1600 Hz

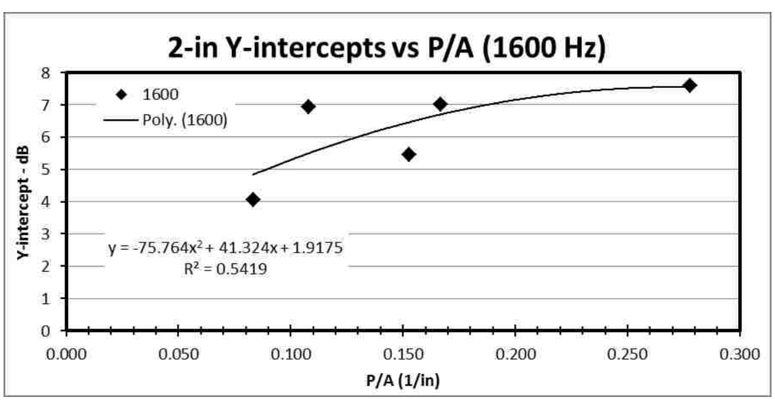

Figure D.53: 2-in Y-intercepts vs P/A at 1600 Hz

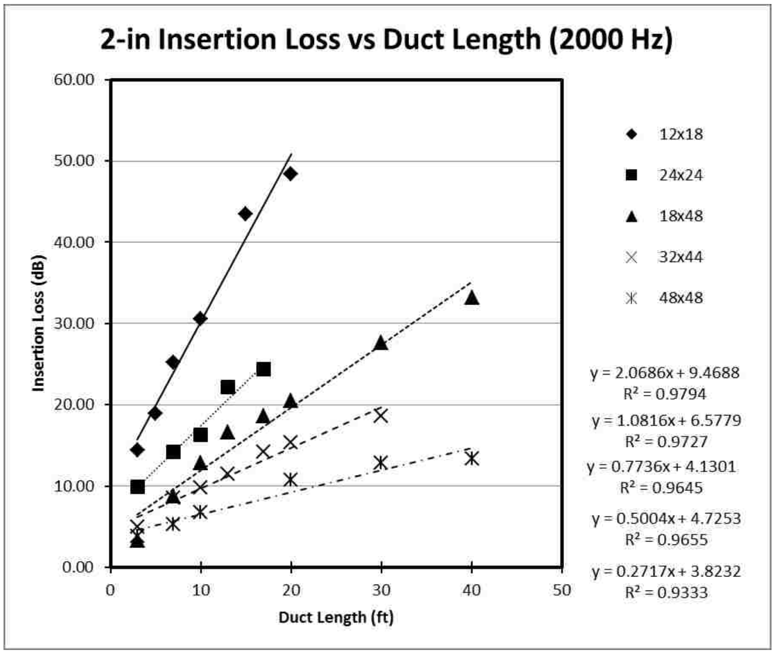

Figure D.54: 2-in Insertion Loss vs Duct Length at 2000 Hz

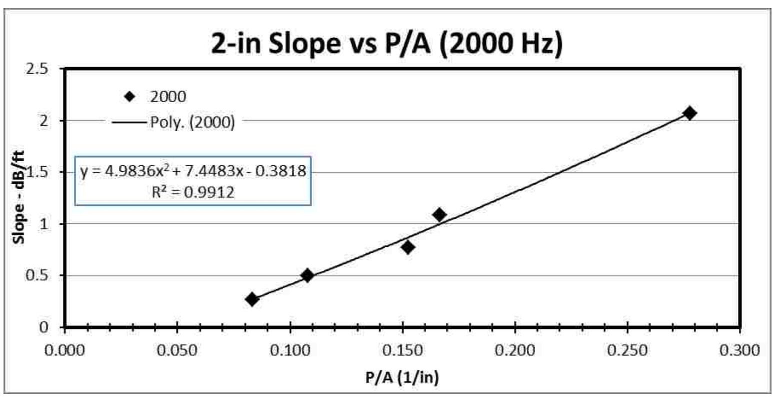

Figure D.55: 2-in Slope vs P/A at 2000 Hz

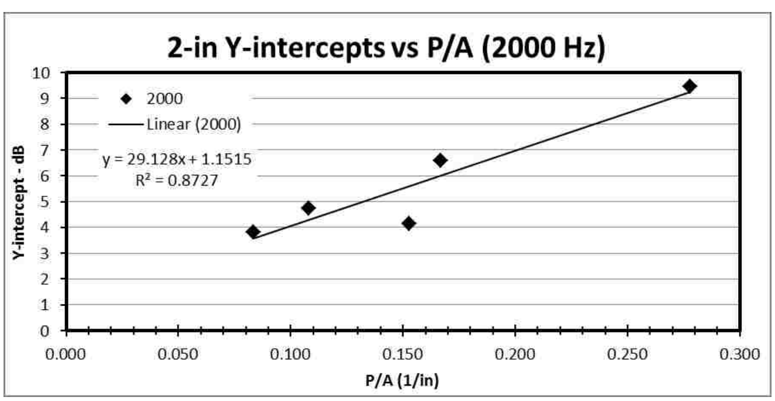

Figure D.56: 2-in Y-intercepts vs P/A at 2000 Hz

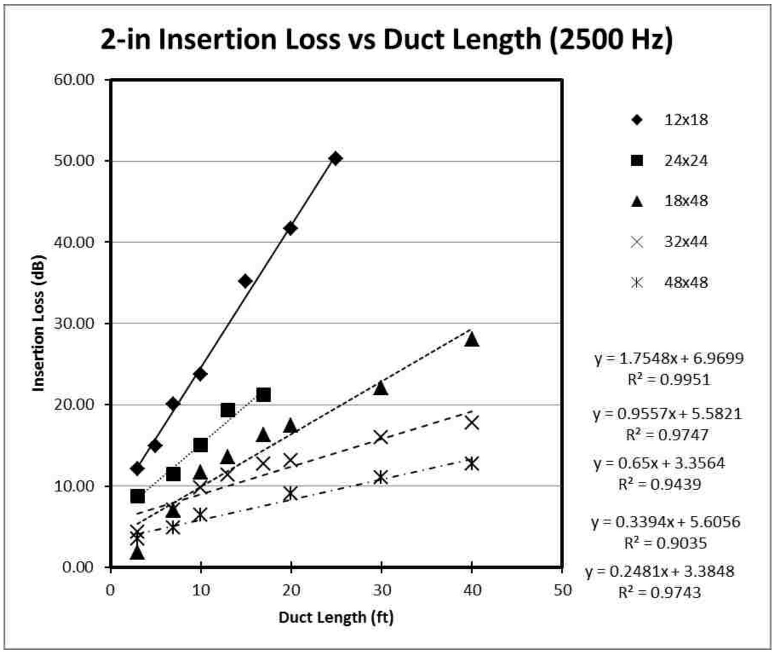

Figure D.57: 2-in Insertion Loss vs Duct Length at 2500 Hz

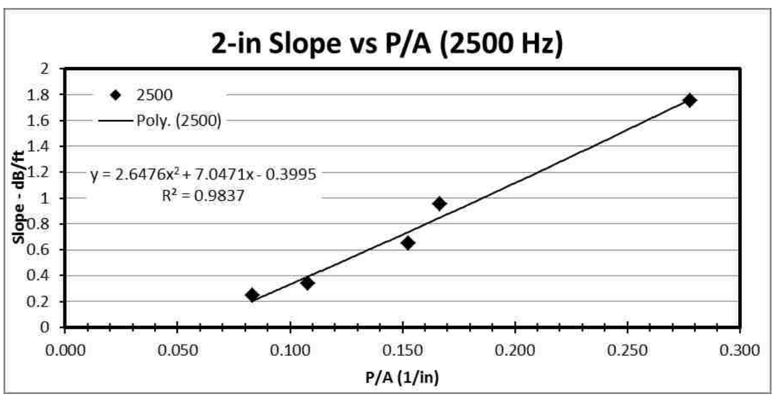

Figure D.58: 2-in Slope vs P/A at 2500 Hz

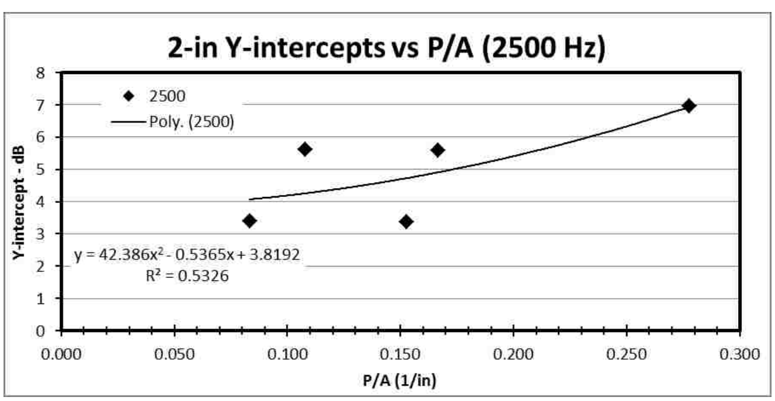

Figure D.59: 2-in Y-intercepts vs P/A at 2500 Hz

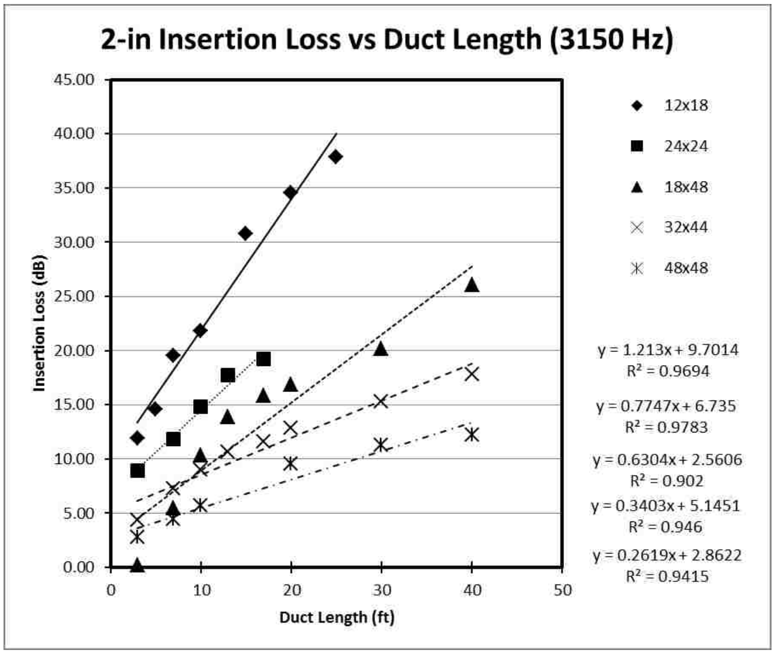

Figure D.60: 2-in Insertion Loss vs Duct Length at 3150 Hz

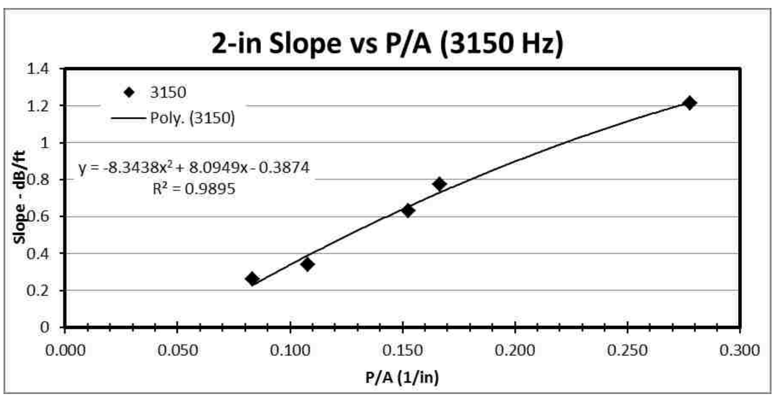

Figure D.61: 2-in Slope vs P/A at 3150 Hz

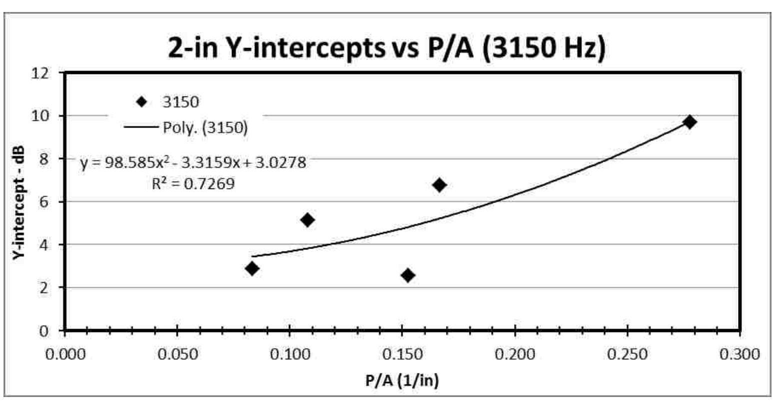

Figure D.62: 2-in Y-intercepts vs P/A at 3150 Hz

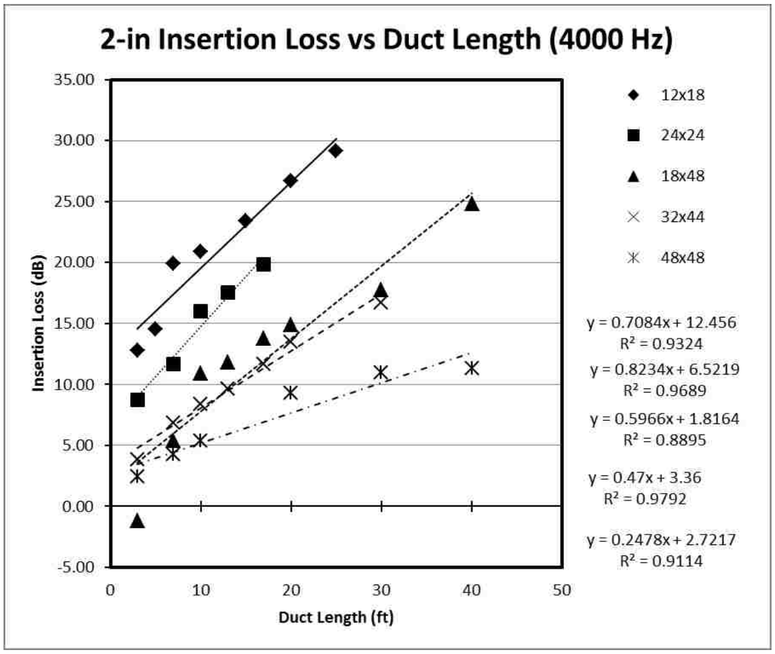

Figure D.63: 2-in Insertion Loss vs Duct Length at 4000 Hz

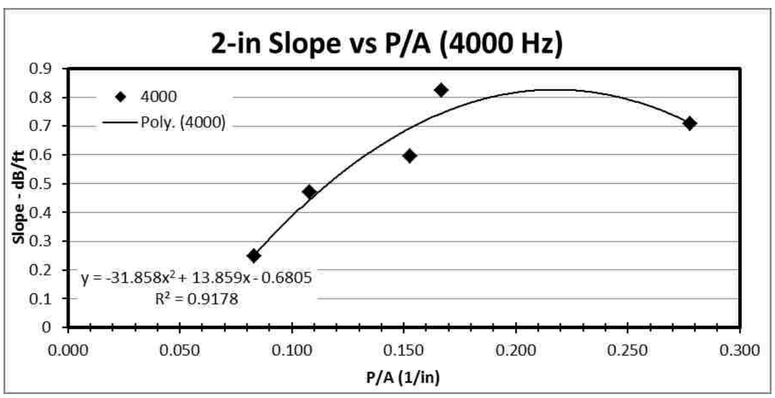

Figure D.64: 2-in Slope vs P/A at 4000 Hz

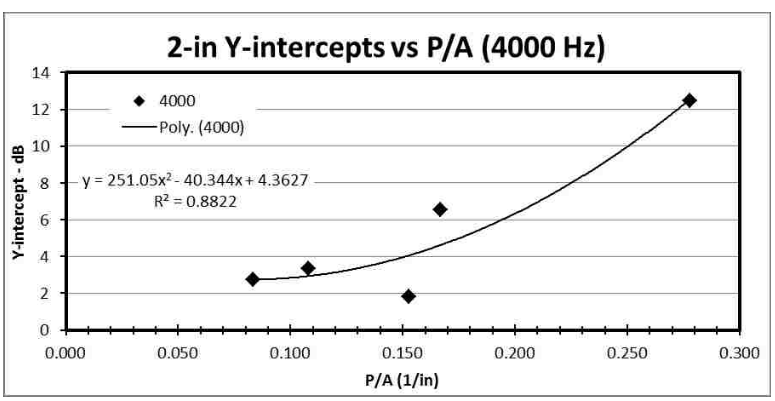

Figure D.65: 2-in Y-intercepts vs P/A at 4000 Hz

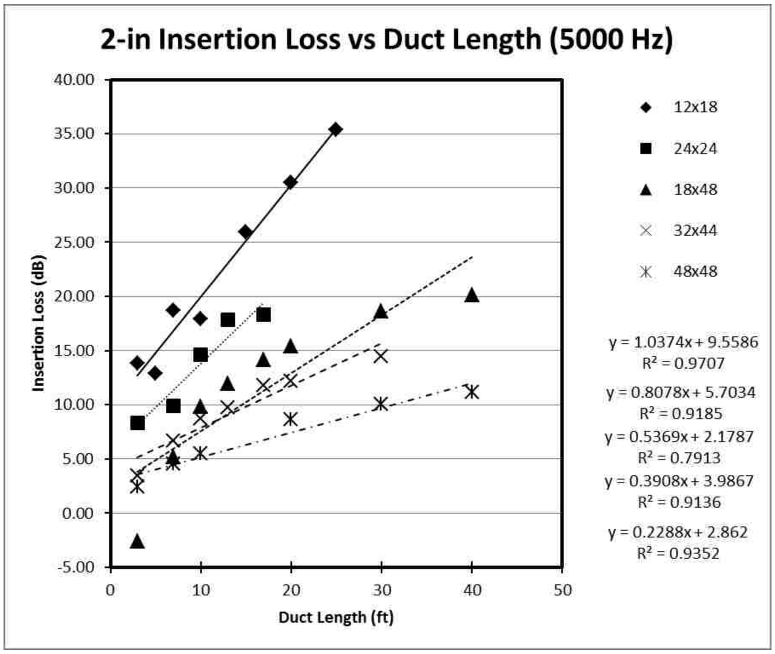

Figure D.66: 2-in Insertion Loss vs Duct Length at 5000 Hz

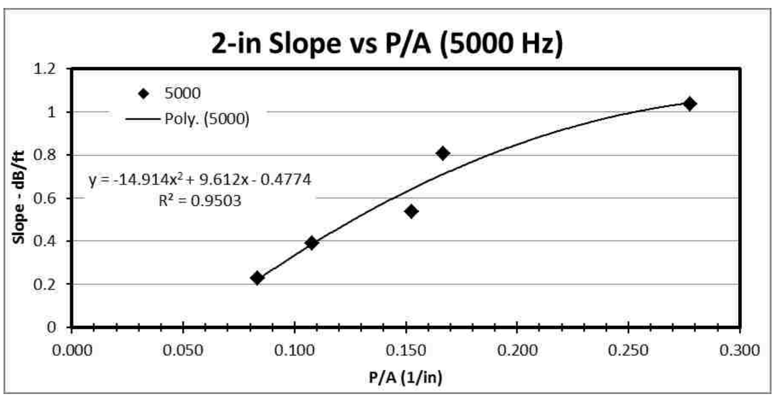

Figure D.67: 2-in Slope vs P/A at 5000 Hz

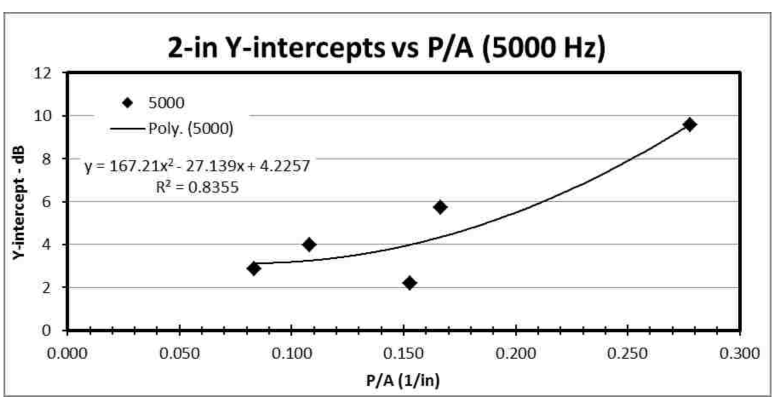

Figure D.68: 2-in Y-intercepts vs P/A at 5000 Hz

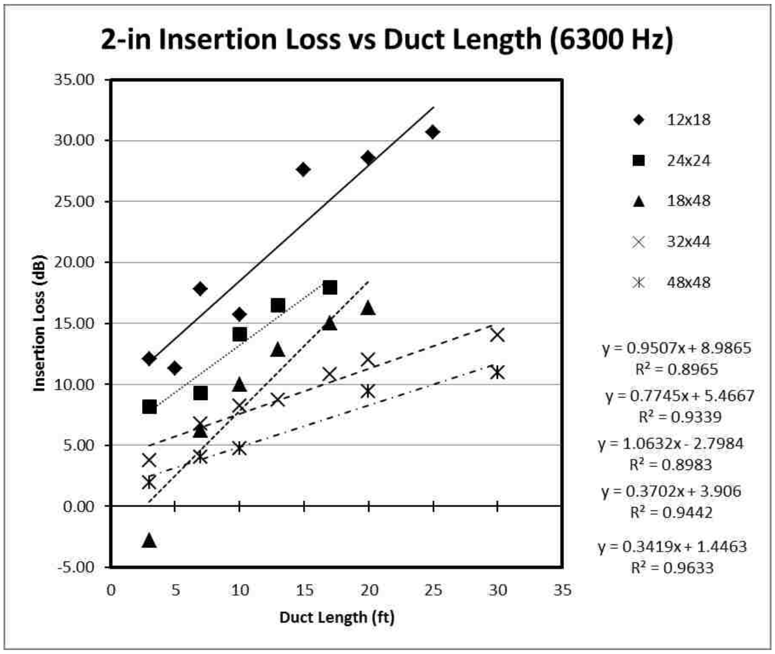

Figure D.69: 2-in Insertion Loss vs Duct Length at 6300 Hz

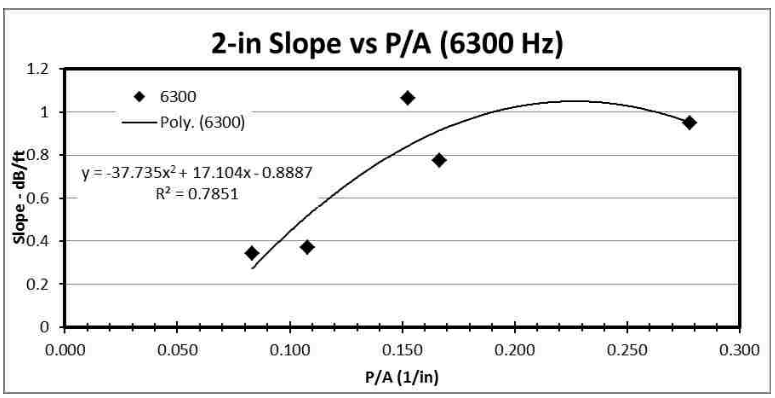

Figure D.70: 2-in Slope vs P/A at 6300 Hz

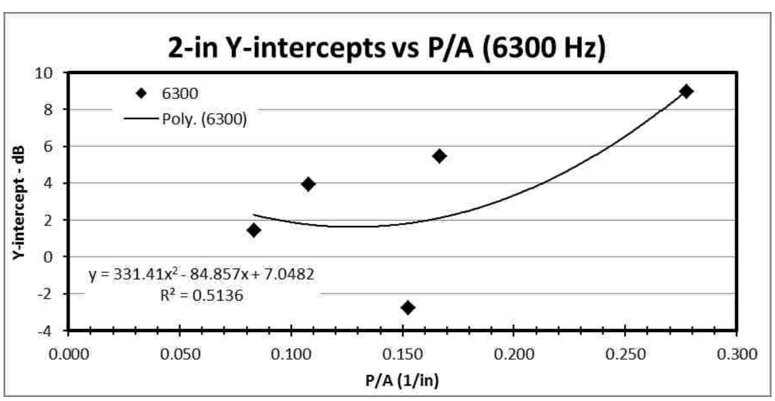

Figure D.71: 2-in Y-intercepts vs P/A at 6300 Hz

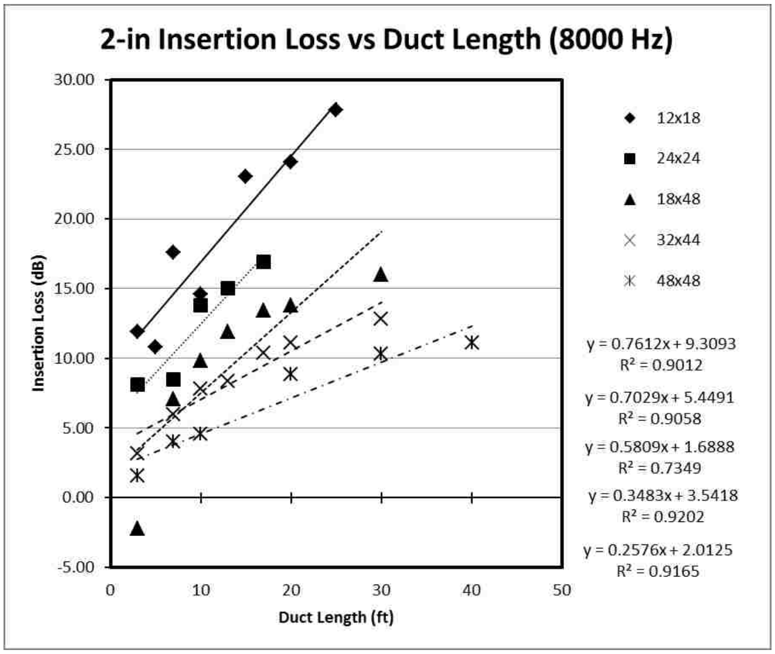

Figure D.72: 2-in Insertion Loss vs Duct Length at 8000 Hz

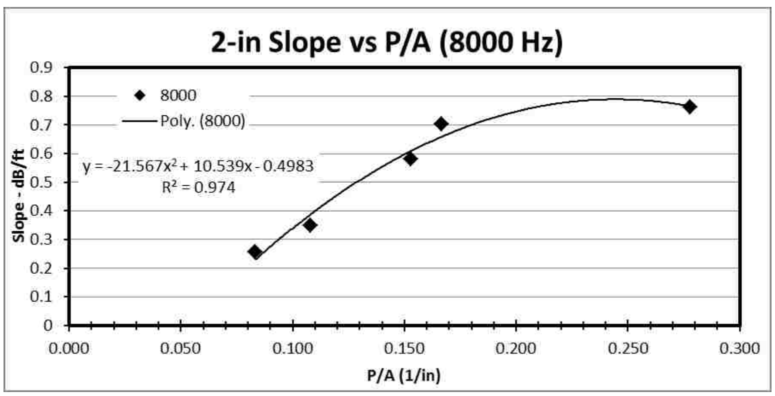

Figure D.73: 2-in Slope vs P/A at 8000 Hz

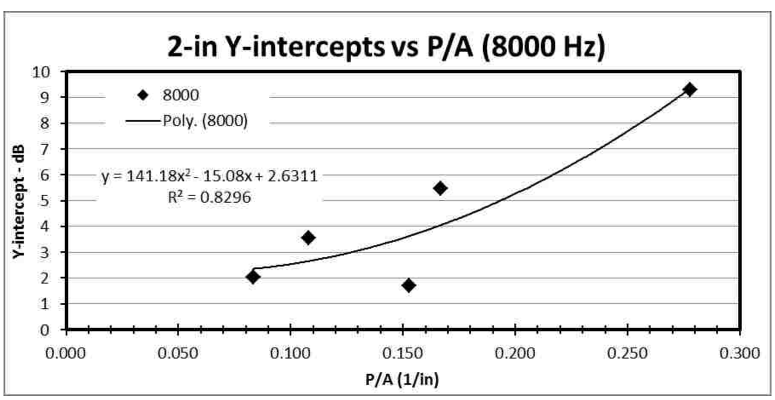

Figure D.74: 2-in Y-intercepts vs P/A at 8000 Hz

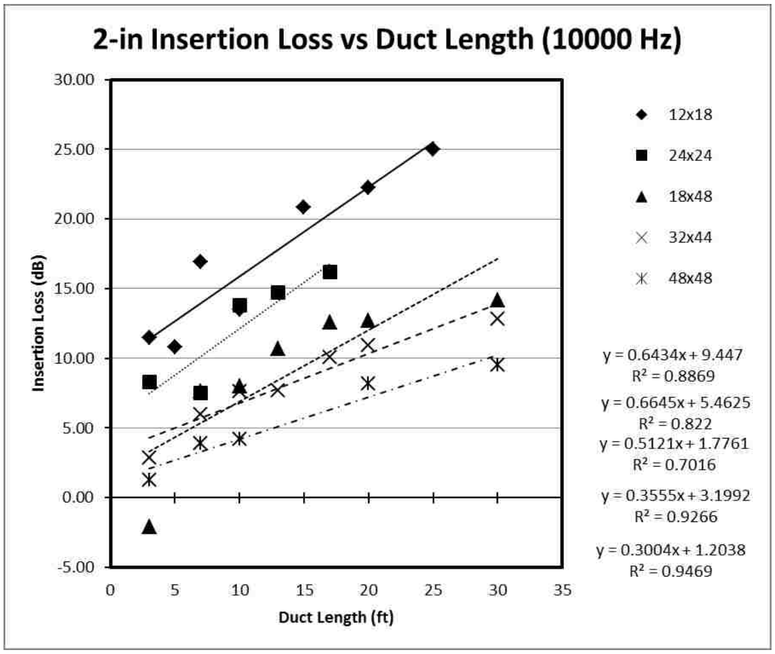

Figure D.75: 2-in Insertion Loss vs Duct Length at 10000 Hz

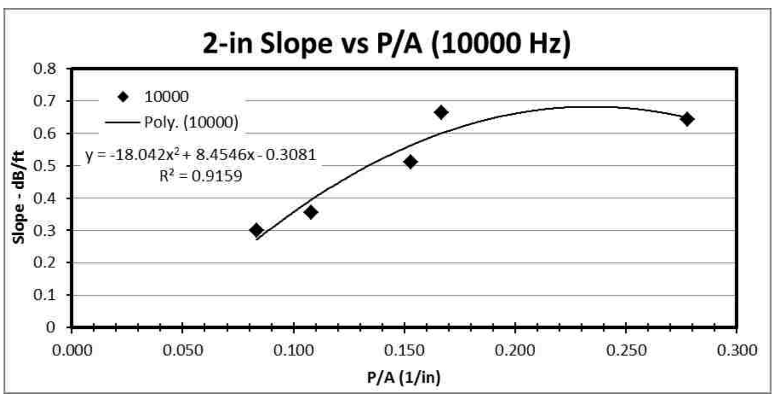

Figure D.76: 2-in Slope vs P/A at 10000 Hz

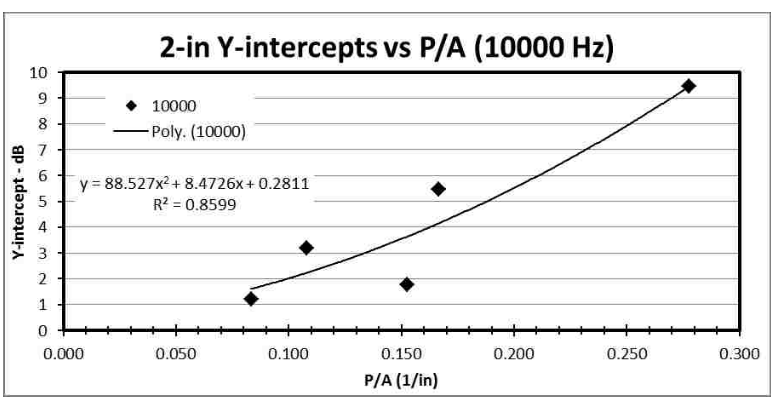

Figure D.77: 2-in Y-intercepts vs P/A at 10000 Hz

Duct Size - in x in		12x18	24x24	18x48	32x44	48x48	12x18	12x18	24x24	18x48	32x44	48x48	12x18	24x24	18x48	32x44	48x48	24x24	18x48	32x44
Length -ft		3	3	3	3	3	5	7	7	7	7	7	10	10	10	10	10	13	13	13
P/A - 1/in		0.278	0.167	0.153	0.108	0.083	0.278	0.278	0.167	0.153	0.108	0.083	0.278	0.167	0.153	0.108	0.083	0.167	0.153	0.108
meas	50	1.9	1.9	0.7	0.4	0.2	0.6	2.6	7.1	2.4	1.2	0.1	0.9	6.0	0.1	0.3	1.2	3.1	-1.0	0.1
regres	50	2.3	2.7	2.4	1.2	0.2	1.9	1.5	3.0	2.7	1.3	0.0	0.9	3.2	2.9	1.4	-0.1	3.4	3.2	1.4
DIFF AVG		-0.4	-0.8	-1.7	-0.8	0.1	-1.3	1.1	4.1	-0.3	0.0	0.0	0.0	2.8	-2.8	-1.0	1.3	-0.3	-4.2	-1.4
meas	63	-3.6	-1.3	0.1	0.0	0.3	1.8	-0.7	0.8	0.3	-0.7	0.9	-0.5	2.0	0.1	1.0	-0.3	-0.1	1.1	1.0
regres	63	-0.4	0.0	0.0	0.0	0.0	-0.7	-1.0	0.1	0.2	0.2	0.2	-1.5	0.3	0.4	0.4	0.3	0.4	0.5	0.5
DIFF AVG		-3.2	-1.3	0.1	0.0	0.3	2.5	0.3	0.7	0.1	-0.9	0.7	1.0	1.7	-0.3	0.6	-0.6	-0.5	0.6	0.5
meas	80	2.5	0.2	0.5	0.2	0.0	1.7	2.7	0.5	1.6	0.1	-0.1	2.7	0.2	1.2	-0.2	1.0	-1.3	0.8	0.5
regres	80	1.1	0.6	0.5	0.2	0.0	2.1	3.1	0.4	0.3	0.2	0.3	4.7	0.3	0.1	0.2	0.6	0.2	0.0	0.2
DIFF AVG		1.4	-0.4	0.0	0.0	0.1	-0.4	-0.4	0.1	1.3	-0.1	-0.4	-2.0	-0.1	1.1	-0.4	0.4	-1.4	0.8	0.3
meas	100	0.8	1.0	0.6	0.2	0.1	0.6	0.6	2.3	1.6	0.8	0.7	0.9	2.7	2.6	1.2	0.8	2.1	3.1	1.5
regres	100	1.0	1.2	1.1	0.5	0.1	0.7	0.5	1.7	1.7	1.0	0.5	0.1	2.2	2.1	1.4	0.7	2.6	2.5	1.8
DIFF AVG		-0.2	-0.2	-0.5	-0.3	0.0	-0.1	0.1	0.6	-0.1	-0.2	0.3	0.8	0.5	0.5	-0.2	0.0	-0.5	0.5	-0.3
meas	125	2.2	0.4	1.0	1.0	0.5	4.2	5.1	2.6	2.6	2.2	1.8	6.7	3.8	3.2	2.7	2.1	5.3	4.5	3.2
regres	125	2.6	1.0	1.0	0.9	0.9	3.8	5.0	2.6	2.4	1.9	1.7	6.8	3.7	3.5	2.6	2.3	4.9	4.5	3.4
DIFF AVG		-0.4	-0.6	0.0	0.2	-0.4	0.4	0.1	0.0	0.2	0.3	0.0	-0.1	0.1	-0.3	0.1	-0.2	0.4	0.0	-0.2
meas	160	3.2	0.6	1.2	1.2	0.6	5.9	7.5	2.9	3.5	2.4	2.4	10.0	4.8	5.1	2.9	3.3	5.2	5.5	3.9
regres	160	4.3	1.5	1.4	1.1	1.1	5.6	6.9	3.1	2.9	2.3	2.2	8.9	4.3	4.0	3.2	3.1	5.5	5.1	4.2
DIFF AVG		-1.1	-0.9	-0.2	0.1	-0.5	0.3	0.6	-0.2	0.6	0.1	0.1	1.1	0.5	1.1	-0.3	0.2	-0.3	0.4	-0.3
meas	200	4.0	2.2	2.2	1.9	1.5	6.6	9.1	6.1	5.3	4.7	4.5	13.6	8.9	8.0	6.4	6.2	11.8	10.6	8.2
regres	200	4.5	2.5	2.4	2.2	2.2	6.8	9.0	6.0	5.7	4.7	4.3	12.4	8.6	8.1	6.6	5.8	11.1	10.5	8.5
DIFF AVG		-0.5	-0.3	-0.2	-0.3	-0.7	-0.2	0.1	0.1	-0.4	0.0	0.2	1.2	0.3	-0.1	-0.2	0.3	0.6	0.1	-0.3
meas	250	5.0	3.5	3.6	3.2	2.7	8.8	11.4	8.9	8.5	7.4	6.5	16.9	12.7	12.2	9.8	8.7	17.2	16.3	12.5
regres	250	5.4	4.0	3.9	3.5	3.4	8.6	11.8	9.1	8.6	7.2	6.3	16.6	12.8	12.2	9.9	8.5	16.6	15.8	12.6
DIFF AVG		-0.4	-0.5	-0.3	-0.3	-0.7	0.2	-0.4	-0.2	-0.1	0.2	0.2	0.3	-0.1	0.0	-0.1	0.2	0.5	0.5	-0.2
meas	315	7.3	5.2	5.3	5.0	4.8	13.7	17.6	12.4	12.0	10.7	10.4	25.3	18.9	17.6	14.3	14.8	22.8	22.3	18.1
regres	315	9.6	6.4	6.2	6.0	6.1	13.7	17.7	13.1	12.6	11.2	10.5	23.8	18.1	17.4	15.1	13.9	23.1	22.2	19.0
DIFF AVG		-2.3	-1.2	-0.9	-1.0	-1.3	0.0	-0.1	-0.7	-0.6	-0.5	-0.2	1.5	0.8	0.2	-0.8	1.0	-0.3	0.1	-0.9
meas	400	11.5	9.3	8.1	7.6	7.0	19.4	24.9	19.7	18.2	16.3	15.5	34.3	28.3	25.5	21.9	20.7	36.8	33.2	27.7
regres	400	12.0	9.4	9.1	8.2	7.7	18.5	25.1	19.4	18.7	16.2	14.8	35.0	26.9	25.8	22.2	20.1	34.4	33.0	28.2
DIFF AVG		-0.5	-0.1	-1.0	-0.6	-0.7	0.9	-0.2	0.3	-0.5	0.1	0.7	-0.7	1.4	-0.3	-0.3	0.5	2.4	0.3	-0.5
meas	500	15.4	13.2	11.9	10.4	8.2	24.0	32.4	28.2	26.2	20.8	19.2	43.2	38.1	36.0	29.0	28.0	43.3	42.6	38.0
regres	500	18.9	15.9	15.1	11.8	9.6	24.4	29.9	26.4	25.4	21.4	18.7	38.1	34.2	33.1	28.6	25.6	42.0	40.8	35.8
DIFF AVG		-3.5	-2.7	-3.2	-1.4	-1.4	-0.4	2.5	1.8	0.8	-0.7	0.4	5.1	3.9	2.9	0.3	2.4	1.3	1.8	2.2
meas	630	23.7	16.8	15.1	10.6	9.0	34.3	42.9	37.6	31.4	24.2	15.3	54.3	50.6	42.5	34.3	19.4	53.2	50.0	47.7
regres	630	24.9	21.5	20.2	14.6	10.6	33.4	42.0	34.0	31.7	22.7	16.6	54.8	43.3	40.4	28.8	21.0	52.6	49.1	34.9
DIFF AVG		-1.2	-4.7	-5.1	-4.0	-1.6	0.9	0.9	3.6	-0.3	1.5	-1.2	-0.5	7.3	2.1	5.5	-1.6	0.6	0.9	12.8
meas	800	26.8	15.8	18.3	9.4	8.5	39.1	47.1	38.4	35.0	16.5	12.5	56.9	52.2	47.0	23.5	14.3	53.5	50.9	29.0
REGRESS	800	28.7	18.7	17.3	12.6	9.9	37.2	45.8	36.5	33.3	20.2	11.0	58.6	49.8	45.4	25.9	11.9	50.0	50.0	31.6
DIFF AVG		-1.9	-2.9	1.0	-3.2	-1.4	1.9	1.3	1.9	1.7	-3.7	1.5	-1.7	2.4	1.6	-2.4	2.4	3.5	0.9	-2.6
meas	1000	32.7	13.8	13.1	8.5	6.2	49.5	56.5	25.6	29.9	14.2	8.9	60.6	33.5	42.0	17.5	10.7	44.2	48.9	20.8
regres	1000	34.2	16.7	15.0	10.2	8.0	46.1	58.0	28.6	25.2	14.7	9.3	50.0	37.5	32.9	18.2	10.2	46.4	40.5	21.6
DIFF AVG		-1.5	-2.9	-1.9	-1.7	-1.8	3.4	-1.5	-3.0	4.7	-0.5	-0.4	10.6	-4.0	9.1	-0.7	0.5	-2.2	8.3	-0.8
meas	1250	27.9	12.5	9.6	7.6	5.1	42.0	57.1	19.8	19.4	12.3	7.7	63.7	25.2	25.4	15.2	9.3	30.0	31.0	17.6
regres	1250	27.6	14.1	12.8	9.1	7.3	42.2	56.8	21.5	18.6	11.4	8.9	50.0	27.0	22.9	13.1	10.1	32.5	27.2	14.9
DIFF AVG	27.1	0.3	-1.6	-3.2	-1.4	-2.2	-0.2	0.3	-1.7	0.8	0.9	-1.3	13.7	-1.8	2.5	2.0	-0.8	-2.5	3.8	2.7
meas	1600	17.7	10.6	5.7	6.5	4.4	23.8	32.7	15.8	13.2	10.1	6.5	40.9	19.0	17.5	12.6	8.1	25.4	22.4	14.6
regres	1600	17.7	10.6	9.8	7.2	5.9	24.5	31.3	15.8	14.2	9.5	7.2	41.4	19.7	17.5	11.2	8.3	23.6	20.8	12.9
DIFF AVG		0.0	0.0	-4.1	-0.7	-1.5	-0.7	1.4	0.0	-1.0	0.6	-0.7	-0.5	-0.7	0.0	1.4	-0.2	1.8	1.6	1.7
meas	2000	14.4	9.9	3.3	5.0	3.8	18.9	25.2	14.2	8.7	8.6	5.3	30.6	16.3	12.8	9.8	6.7	22.2	16.6	11.5
regres	2000	15.7	8.6	7.9	5.8	4.8	19.9	24.0	12.6	11.4	7.7	5.8	30.2	15.6	14.0	9.1	6.7	18.6	16.6	10.6
DIFF AVG		-1.3	1.3	-4.6	-0.8	-0.9	-1.0	1.2	1.6	-2.7	0.8	-0.6	0.4	0.7	-1.2	0.7	0.1	3.5	0.0	0.9
meas	2500	12.1	8.7	1.8	4.4	3.5	14.9	20.1	11.5	7.0	7.1	4.9	23.7	15.0	11.7	9.8	6.4	19.3	13.6	11.4
regres	2500	12.2	7.5	6.9	5.4	4.7	15.8	19.3	10.8	9.9	7.0	5.5	24.6	13.4	12.1	8.2	6.1	15.9	14.3	9.4
DIFF AVG		-0.1	1.2	-5.1	-1.1	-1.2	-0.9	0.8	0.7	-2.9	0.1	-0.6	-0.9	1.6	-0.4	1.7	0.3	3.4	-0.8	2.1
meas	3150	11.9	8.9	0.2	4.3	2.8	14.6	19.5	11.8	5.5	7.3	4.5	21.8	14.8	10.3	9.0	5.7	17.7	13.9	10.7
regres	3150	13.4	7.4	6.8	5.0	4.1	15.8	18.2	10.3	9.4	6.5	5.0	21.9	12.5	11.4	7.7	5.7	14.7	13.3	8.9
DIFF AVG		-1.5	1.5	-6.6	-0.7	-1.3	-1.2	1.3	1.5	-3.9	0.8	-0.6	-0.1	2.3	-1.1	1.3	-0.1	3.0	0.5	1.8
meas	4000	12.8	8.7	-1.2	3.8	2.4	14.5	19.9	11.7	5.4	6.8	4.3	20.9	16.0	10.9	8.4	5.4	17.5	11.8	9.6
regres	4000	14.7	6.8	6.1	4.3	3.5	16.1	17.5	9.8	8.9	6.0	4.5	19.6	12.1	11.0	7.4	5.3	14.3	13.1	8.7
DIFF AVG		-1.9	1.9	-7.3	-0.4	-1.1	-1.6	2.4	1.9	-3.5	0.8	-0.3	1.3	3.9	-0.1	1.0	0.1	3.2	-1.3	0.9
meas	5000	13.8	8.3	-2.6	3.5	2.4	12.9	18.7	9.9	5.2	6.7	4.6	17.9	14.6	9.8	8.7	5.5	17.8	11.9	9.7
regres	5000	12.7	6.5	5.9	4.4	3.8	14.8	16.9	9.3	8.5	5.9	4.7	20.0	11.5	10.4	7.1	5.3	13.6	12.3	8.3
DIFF AVG		1.1	1.8	-8.5	-0.9	-1.4	-1.9	1.8	0.6	-3.3	0.8	-0.1	-2.1	3.1	-0.6	1.6	0.1	4.2	-0.4	1.5
meas	6300	12.1	8.2	-2.8	3.8	1.9	11.3	17.8	9.3	6.2	6.8	4.1	15.7	14.1	10.0	8.3	4.8	16.5	12.9	8.7
regres	6300	11.9	4.9	4.4	3.3	3.1	13.8	15.7	8.5	7.7	5.4	4.2	18.6	11.2	10.3	6.9	5.0	14.0	12.8	8.5
DIFF AVG		0.2	3.3	-7.2	0.4	-1.2	-2.5	2.1	0.8	-1.5	1.4	-0.1	-2.9	2.9	-0.3	1.3	-0.3	2.5	0.1	0.2
meas	8000	11.9	8.1	-2.2	3.2	1.6	10.8	17.6	8.5	7.1	6.0	4.0	14.6	13.8	9.8	7.8	4.6	15.1	11.9	8.4
regres	8000	11.6	6.0	5.4	3.8	3.0	13.2	14.7	8.7	7.9	5.4	4.0	17.0	10.6	9.7	6.5	4.7	12.6	11.5	7.7
DIFF AVG		0.3	2.1	-7.6	-0.6	-1.5	-2.4	2.9	-0.2	-0.8	0.6	0.0	-2.4	3.2	0.1	1.3	-0.1	2.4	0.4	0.7
meas	10000	11.5	8.3	-2.1	2.9	1.3	10.8	16.9	7.5	7.6	6.0	3.9	13.5	13.8	8.0	7.6	4.2	14.7	10.7	7.7
regres	10000	11.4	6.0	5.3	3.4	2.4	12.7	14.0	8.4	7.6	5.0	3.5	15.9	10.2	9.3	6.2	4.3	11.9	11.0	7.4
DIFF AVG		0.1	2.3	-7.4	-0.5	-1.2	-1.9	2.9	-0.9	0.0	1.0	0.4	-2.4	3.6	-1.3	1.4	-0.1	2.8	-0.3	0.3

Duct Size - in x in	12x18	24x24	18x48	32x44	12x18	24x24	18x48	32x44	48x48	12x18	24x24	18x48	32x44	48x48	24x24	18x48	32x44	48x48			
Length -ft	15	17	17	17	20	20	20	20	20	25	30	30	30	30	40	40	40	40			
P/A - 1/in	0.278	0.167	0.153	0.108	0.278	0.167	0.153	0.108	0.083	0.278	0.167	0.153	0.108	0.083	0.167	0.153	0.108	0.083	AVG	STD	Freq
meas	-1.6	10.0	0.1	0.8	1.6	9.8	-0.7	0.2	1.8	-4.4	14.6	-2.5	0.5	0.9	9.1	-0.8	-0.5	0.8			50
regres	-0.2	3.7	3.4	1.5	-1.2	3.9	3.7	1.6	-0.4	-2.2	4.6	4.4	1.9	-0.7	5.3	5.1	2.1	-1.0			50
DIFF AVG	-1.4	6.3	-3.4	-0.7	2.8	5.9	-4.3	-1.4	2.1	-2.2	10.0	-6.8	-1.3	1.6	3.8	-5.9	-2.7	1.8	0.0	3.335	
meas	-3.4	-0.1	0.8	0.7	-1.2	3.2	0.0	1.1	0.0	-5.5	-0.8	1.4	0.2	0.7	2.8	2.0	1.8	2.0			63
regres	-2.3	0.6	0.7	0.7	-3.1	0.7	0.9	0.9	0.6	-3.9	1.2	1.4	1.4	0.9	1.6	1.9	1.9	1.2			63
DIFF AVG	-1.1	-0.6	0.1	-0.1	1.9	2.5	-0.9	0.2	-0.5	-1.5	-2.0	0.0	-1.2	-0.2	1.2	0.1	-0.1	0.8	0.0	1.159	
meas	9.0	-1.9	0.3	0.8	9.3	-0.4	1.7	-0.2	1.3	12.8	-0.6	2.8	-0.3	1.9	-2.8	3.8	1.7	2.0			80
regres	7.2	0.0	-0.2	0.2	9.8	-0.1	-0.4	0.2	1.5	12.4	-0.5	-0.8	0.2	2.3	-0.8	-1.3	0.3	3.2			80
DIFF AVG	1.7	-1.9	0.5	0.6	-0.5	-0.3	2.1	-0.4	-0.2	0.4	-0.2	3.6	-0.5	-0.4	-2.0	5.1	1.4	-1.2	0.2	1.404	
meas	-1.5	2.6	4.0	1.7	-0.4	4.9	3.9	2.7	1.9	-1.9	3.3	5.7	3.8	3.1	2.6	8.6	4.0	3.5			100
regres	-0.5	3.1	3.1	2.3	-1.1	3.5	3.5	2.7	1.7	-1.7	4.9	4.9	3.9	2.6	6.2	6.4	5.2	3.5			100
DIFF AVG	-1.1	-0.6	0.9	-0.6	0.7	1.4	0.4	0.0	0.2	-0.2	-1.6	0.8	-0.1	0.5	-3.6	2.2	-1.2	0.0	0.0	0.919	
meas	9.8	6.6	5.6	4.8	12.9	9.8	6.3	5.2	4.4	15.7	8.2	9.4	7.9	6.6	11.3	12.0	10.0	8.0			125
regres	9.8	6.4	5.9	4.4	12.8	7.6	7.0	5.2	4.2	15.8	11.4	10.5	7.7	6.2	15.3	14.1	10.2	8.1			125
DIFF AVG	0.0	0.2	-0.3	0.4	0.0	2.2	-0.7	0.1	0.2	-0.1	-3.2	-1.1	0.2	0.4	-4.0	-2.1	-0.3	-0.1	-0.2	1.018	
meas	11.6	6.3	6.9	5.2	15.5	10.1	8.0	6.2	6.1	18.6	8.2	12.1	9.3	8.9	11.3	15.6	12.3	11.4			160
regres	12.2	7.1	6.6	5.4	15.4	8.4	7.8	6.3	5.9	18.7	12.4	11.5	9.4	8.7	16.4	15.3	12.6	11.5			160
DIFF AVG	-0.6	-0.8	0.3	-0.2	0.1	1.7	0.3	-0.2	0.3	-0.2	-4.2	0.5	-0.1	0.2	-5.1	0.3	-0.3	-0.1	-0.2	1.218	
meas	18.0	15.2	13.6	10.9	22.9	17.3	15.4	12.8	11.8	29.5	18.0	23.1	18.5	17.2	25.7	29.8	24.7	21.6			200
regres	18.1	14.6	13.8	11.1	23.8	17.2	16.2	12.9	11.0	29.4	25.8	24.4	19.3	16.2	34.4	32.5	25.6	21.4			200
DIFF AVG	-0.1	0.6	-0.2	-0.2	-0.8	0.1	-0.9	-0.1	0.8	0.1	-7.8	-1.3	-0.8	1.0	-8.7	-2.7	-0.9	0.2	-0.6	1.975	
meas	25.5	22.1	20.8	16.1	32.5	24.8	23.6	19.1	16.4	40.2	26.7	34.6	27.4	23.9	36.6	45.3	36.2	30.7			250
regres	24.7	21.7	20.5	16.3	32.7	25.5	24.1	19.0	15.8	40.7	38.1	36.0	28.1	23.1	50.7	47.9	37.2	30.4			250
DIFF AVG	0.9	0.5	0.2	-0.2	-0.2	-0.7	-0.5	0.1	0.7	-0.5	-11.4	-1.4	-0.7	0.8	-14.1	-2.6	-1.0	0.4	-0.8	2.976	
meas	35.5	32.1	29.2	23.2	46.4	33.7	33.2	27.5	27.5	50.5	33.4	49.9	40.6	38.9	48.8	54.4	51.1	47.1			315
regres	33.9	29.9	28.6	24.2	44.0	34.9	33.4	28.1	24.9	54.1	51.6	49.4	41.2	36.0	50.0	50.0	54.2	47.0			315
DIFF AVG	1.6	2.3	0.6	-1.1	2.4	-1.2	-0.2	-0.6	2.6	-3.6	-18.2	0.5	-0.6	2.9	-1.2	4.4	-3.1	0.0	-0.5	3.392	
meas	51.6	42.9	43.0	36.2	49.9	47.6	48.6	41.6	39.0	49.7	48.1	51.8	51.3	55.2	51.7	52.0	53.3	52.3			400
regres	51.4	44.4	42.5	36.2	50.0	51.0	52.0	42.2	37.9	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			400
DIFF AVG	0.2	-1.4	0.5	0.0	-0.1	-3.4	-3.4	-0.6	1.1	-0.3	-1.9	1.8	1.3	5.2	1.7	2.0	3.3	2.3	0.3	1.635	
meas	48.0	48.8	49.2	45.2	47.9	54.0	49.8	48.8	48.1	47.5	49.7	50.4	50.2	53.1	49.3	50.4	50.8	53.4			500
regres	51.8	52.5	51.1	45.4	50.0	51.0	52.0	52.6	48.4	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			500
DIFF AVG	-3.8	-3.6	-1.9	-0.2	-2.1	3.0	-2.2	-3.8	-0.3	-2.5	-0.3	0.4	0.2	3.1	-0.7	0.4	0.8	3.4	0.1	2.385	
meas	51.3	56.1	55.0	53.4	51.3	61.0	55.7	55.9	31.3	50.7	56.5	55.9	56.9	40.6	56.3	55.7	57.3	46.7			630
regres	55.0	55.0	55.0	55.0	55.0	56.0	57.0	55.0	35.8	55.0	55.0	55.0	55.0	50.6	55.0	55.0	55.0	55.0			630
DIFF AVG	-3.7	1.1	0.0	-1.6	-3.7	5.0	-1.3	0.9	-4.5	-4.3	1.5	0.9	1.9	-10.0	1.3	0.7	2.3	-8.3	-0.2	4.154	
meas	47.7	53.7	51.4	36.4	47.7	62.7	51.6	39.7	21.3	47.5	54.1	51.4	50.1	26.6	53.9	51.5	53.2	29.5			800
REGRESS	50.0	50.0	50.0	39.2	50.0	51.0	52.0	44.8	14.7	50.0	50.0	50.0	50.0	17.4	50.0	50.0	50.0	20.2			800
DIFF AVG	-2.3	3.7	1.4	-2.7	-2.3	11.7	-0.4	-5.2	6.6	-2.5	4.1	1.4	0.1	9.1	3.9	1.5	3.2	9.3	1.1	3.78	
meas	49.1	51.7	52.2	26.2	49.4	58.4	53.2	28.8	15.3	48.8	52.9	53.1	36.9	19.0	54.4	53.7	44.7	20.7			1000
regres	50.0	50.0	50.8	26.1	50.0	51.0	52.0	29.5	13.4	50.0	50.0	50.0	40.9	16.6	50.0	50.0	50.0	19.8			1000
DIFF AVG	-0.9	1.7	1.5	0.0	-0.6	7.4	1.2	-0.7	1.9	-1.2	2.9	3.1	-4.0	2.4	4.4	3.7	-5.3	0.9	0.9	3.706	
meas	49.1	35.9	38.7	20.9	49.2	41.8	43.4	22.2	14.4	48.6	40.4	52.2	27.7	17.2	53.8	53.9	31.0	18.2			1250
regres	50.0	39.8	32.9	17.2	50.0	51.0	52.0	19.0	14.1	50.0	55.0	51.6	24.8	18.0	50.0	50.0	30.7	22.0			1250
DIFF AVG	-0.9	-3.9	5.8	3.7	-0.8	-9.2	-8.6	3.2	0.3	-1.4	-14.6	0.6	2.8	-0.8	3.8	3.9	0.3	-3.8	-0.2	4.583	
meas	49.3	27.4	27.2	17.3	49.7	26.4	30.4	17.6	12.6	49.5	29.6	40.0	21.5	15.6	37.1	50.4	26.5	18.2			1600
regres	50.0	28.7	25.2	15.2	50.0	32.7	28.5	16.9	11.7	50.0	45.6	39.5	22.6	15.1	58.6	50.5	28.3	18.5			1600
DIFF AVG	-0.7	-1.3	2.0	2.1	-0.3	-6.3	1.9	0.7	1.0	-0.5	-16.0	0.5	-1.1	0.5	-21.5	-0.1	-1.7	-0.4	-1.2	4.61	
meas	43.4	24.4	18.6	14.2	48.4	23.1	20.5	15.4	10.7	49.4	25.9	27.6	18.6	12.9	30.7	33.2	18.5	13.4			2000
regres	40.6	22.6	20.1	12.5	50.9	25.7	22.7	13.9	9.4	50.0	35.6	31.5	18.7	12.1	45.6	40.2	23.6	14.9			2000
DIFF AVG	2.9	1.8	-1.6	1.7	-2.5	-2.6	-2.2	1.4	1.3	-0.6	-9.7	-3.9	-0.1	0.8	-14.9	-7.0	-5.0	-1.5	-1.2	3.532	
meas	35.2	21.2	16.3	12.8	41.7	19.1	17.4	13.2	9.0	50.3	22.3	22.1	16.0	11.1	26.8	28.0	17.7	12.7			2500
regres	33.4	19.3	17.3	10.9	42.2	21.9	19.5	12.1	8.2	51.0	30.4	26.9	16.0	10.3	38.8	34.3	19.9	12.3			2500
DIFF AVG	1.8	1.9	-1.0	1.8	-0.5	-2.8	-2.1	1.1	0.8	-0.7	-8.0	-4.8	-0.1	0.8	-12.0	-6.3	-2.2	0.4	-0.9	3.054	
meas	30.8	19.2	15.8	11.6	34.6	20.8	16.8	12.9	9.5	37.9	20.0	20.1	15.3	11.3	24.3	26.1	17.8	12.2			3150
regres	28.0	17.6	16.0	10.4	34.1	19.9	17.9	11.6	8.0	40.1	27.1	24.5	15.5	10.3	34.4	31.0	19.4	12.6			3150
DIFF AVG	2.8	1.6	-0.1	1.2	0.5	0.9	-1.1	1.2	1.5	-2.3	-7.1	-4.3	-0.2	1.0	-10.1	-4.9	-1.6	-0.4	-0.7	2.883	
meas	23.4	19.8	13.7	11.7	26.7	17.1	14.9	13.5	9.3	29.2	21.0	17.8	16.7	11.0	25.5	24.8	16.0	11.3			4000
regres	23.2	17.3	15.8	10.5	26.7	19.5	17.9	11.8	7.8	30.3	26.9	24.9	16.3	10.3	34.4	31.8	20.7	12.9			4000
DIFF AVG	0.3	2.6	-2.1	1.2	0.0	-2.4	-3.0	1.6	1.5	-1.1	-5.9	-7.1	0.4	0.6	-8.9	-7.0	-4.8	-1.6	-1.0	3.145	
meas	25.9	18.3	14.1	11.8	30.5	18.9	15.4	12.2	8.7	35.4	19.7	18.6	14.4	10.1	22.7	20.1	12.4	11.1			5000
regres	25.2	16.4	14.9	9.8	30.4	18.6	16.8	11.0	7.5	35.6	25.7	23.3	14.8	9.7	32.8	29.7	18.7	11.9			5000
DIFF AVG	0.7	1.9	-0.8	2.0	0.0	0.3	-1.4	1.2	1.1	-0.2	-6.0	-4.7	-0.4	0.4	-10.1	-9.6	-6.3	-0.8	-1.0	3.361	
meas	27.6	17.9	15.0	10.8	28.6	19.7	16.3	12.0	9.4	30.7	19.1	18.4	14.0	11.0	21.9	16.6	12.7	10.8			6300
regres	23.3	17.6	16.2	10.6	28.1	20.4	18.7	12.1	7.8	32.8	29.5	27.1	17.3	10.5	38.7	35.6	22.5	13.3			6300
DIFF AVG	4.3	0.3	-1.1	0.2	0.5	-0.7	-2.4	-0.1	1.6	-2.1	-10.4	-8.7	-3.3	0.5	-16.8	-19.0	-9.8	-2.5	-1.9	5.125	
meas	23.1	16.9	13.5	10.4	24.1	19.8	13.8	11.1	8.9	27.8	18.9	16.0	12.8	10.3	22.3	14.9	12.5	11.1			8000
regres	20.8	15.2	14.0	9.2	24.6	17.3	15.8	10.4	7.0	28.5	23.8	21.9	14.3	9.3	30.4	28.0	18.2	11.6			8000
DIFF AVG	2.2	1.7	-0.5	1.1	-0.5	2.5	-2.0	0.7	1.9	-0.6	-4.9	-5.9	-1.4	1.1	-8.1	-13.1	-5.7	-0.5	-0.9	3.451	
meas	20.8	16.2	12.6	10.0	22.3	19.5	12.7	10.9	8.2	25.0	18.1	14.2	12.8	9.5	21.5	15.0	12.6	9.7			10000
regres	19.2	14.3	13.2	8.9	22.4	16.2	14.9	10.1	7.0	25.7	22.1	20.5	14.1	9.7	28.1	26.1	18.0	12.4			10000
DIFF AVG	1.7	1.9	-0.6	1.1	-0.2	3.3	-2.2	0.8	1.1	-0.7	-4.0	-6.4	-1.2	-0.2	-6.7	-11.1	-5.4	-2.8	-0.9	3.201	

(shaded cell) Flanking Insertion Loss Reached

meas - Measured IL Values

Regress - Calculated IL Values from Regression Equations

DIF AVG - Calculation of the average of the differneces between measured and calculated IL values

STD - Calculation of the standard deviation relative to the DIFF AVG

Figure D.78: Data Comparison for 2-in Rectangular Ducts

APPENDIX E UNLV DATA FOR 1-IN ROUND DUCTS

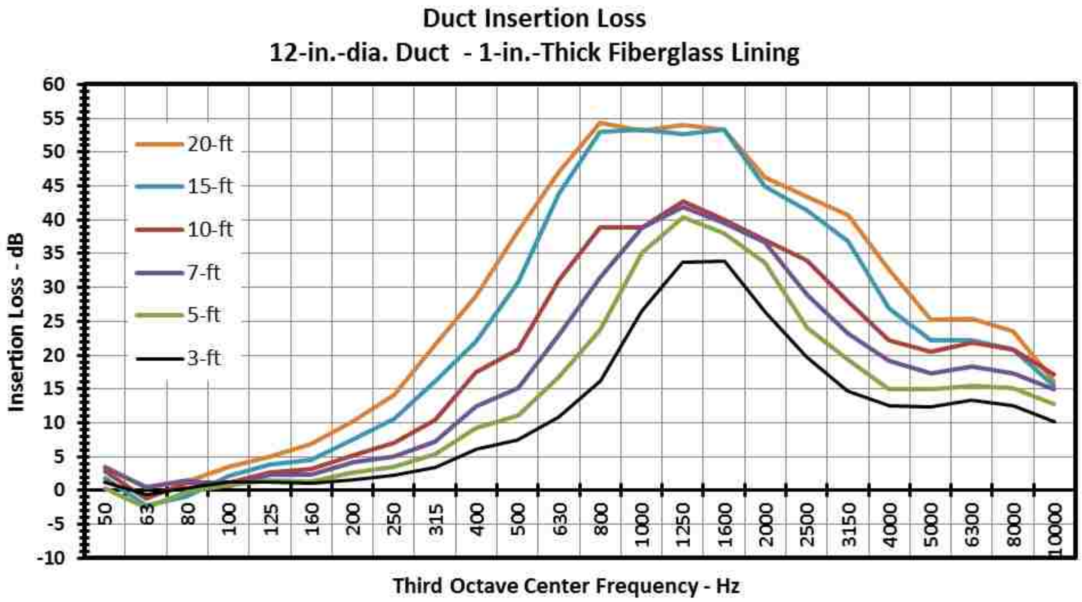

Figure E.1: Insertion Loss for 12-in ducts with 1-in Fiberglass

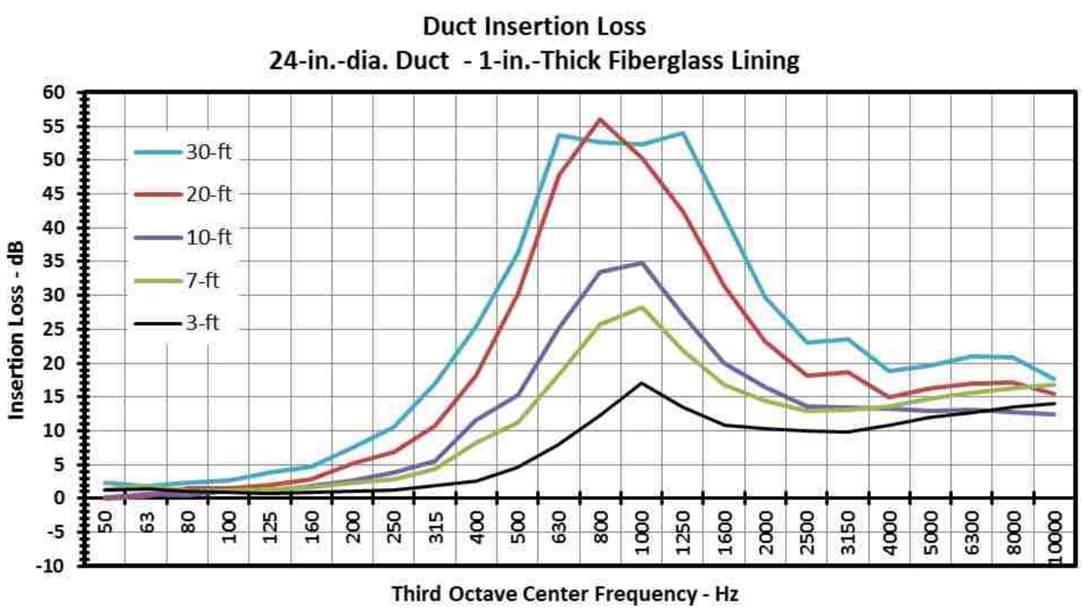

Figure E.2: Insertion Loss for 24-in ducts with 1-in Fiberglass

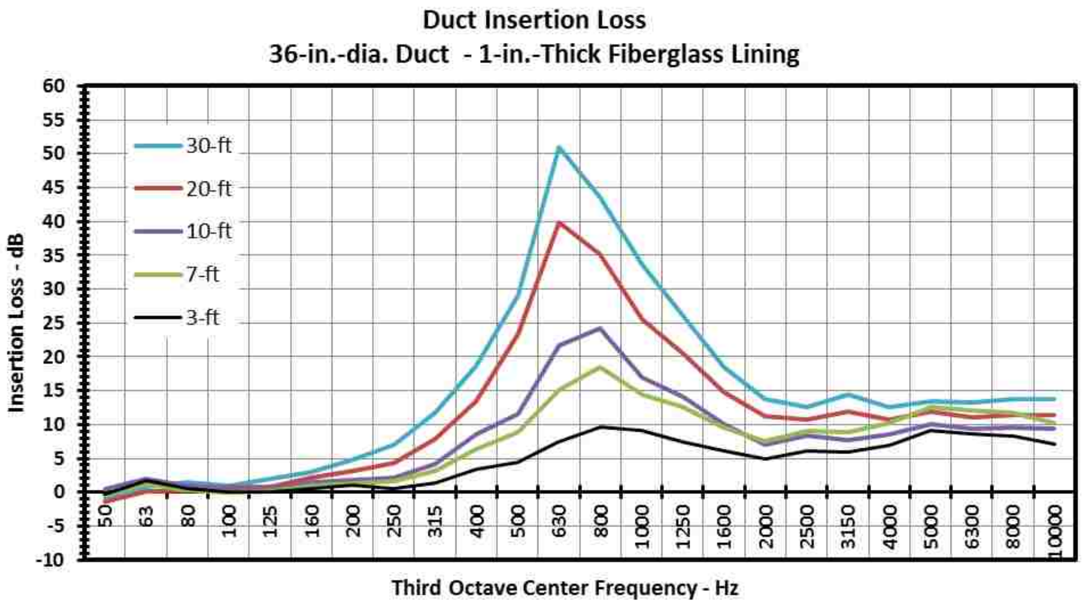

Figure E.3: Insertion Loss for 36-in ducts with 1-in Fiberglass

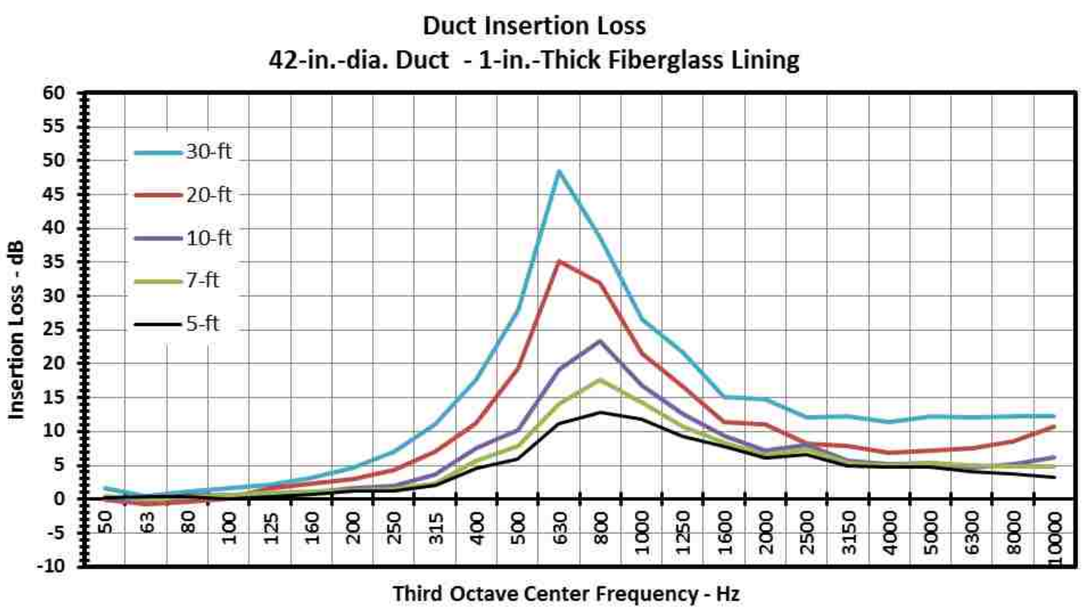

Figure E.4: Insertion Loss for 42-in ducts with 1-in Fiberglass

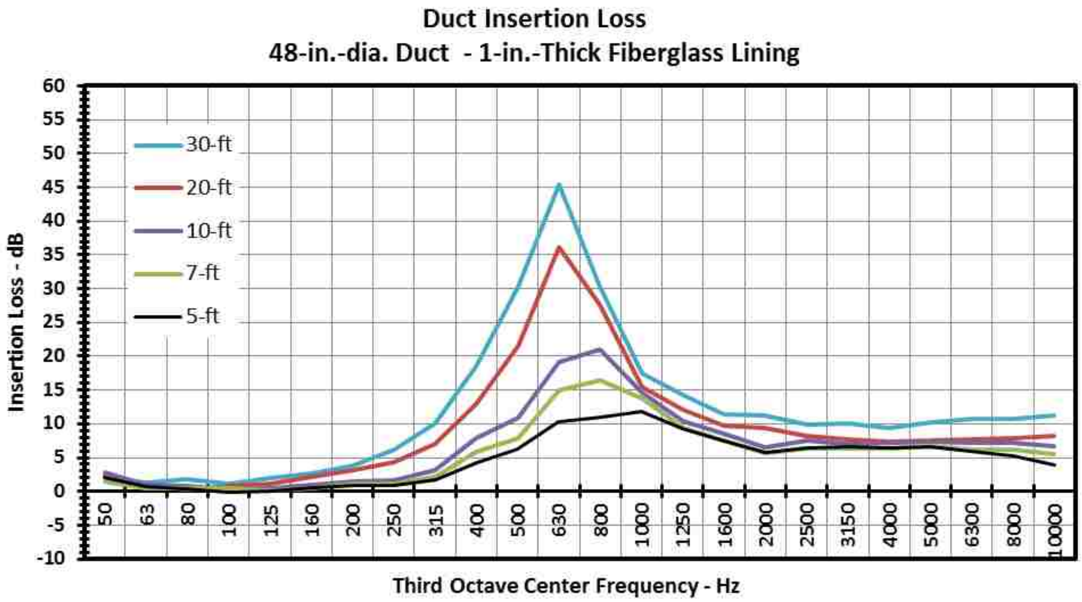

Figure E.5: Insertion Loss for 48-in ducts with 1-in Fiberglass

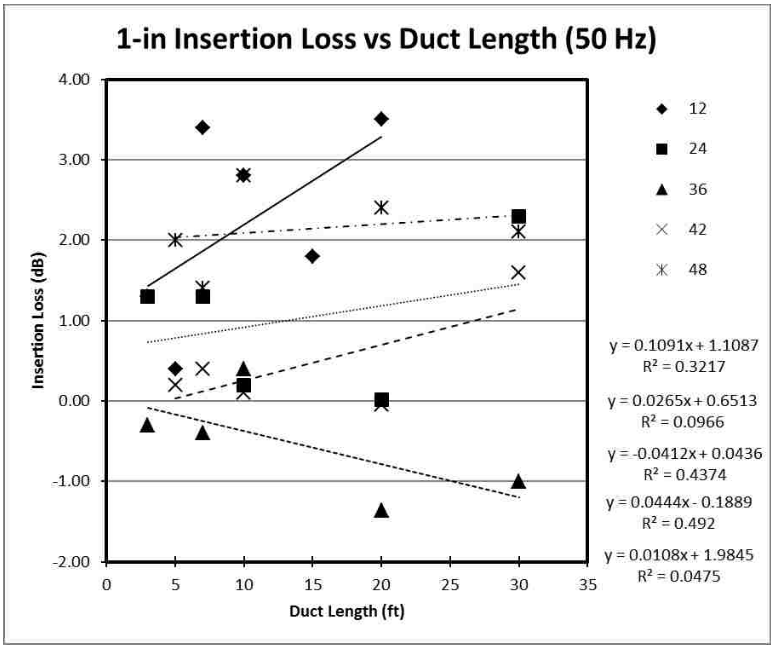

Figure E.6: 1-in Insertion Loss vs Duct Length at 50 Hz

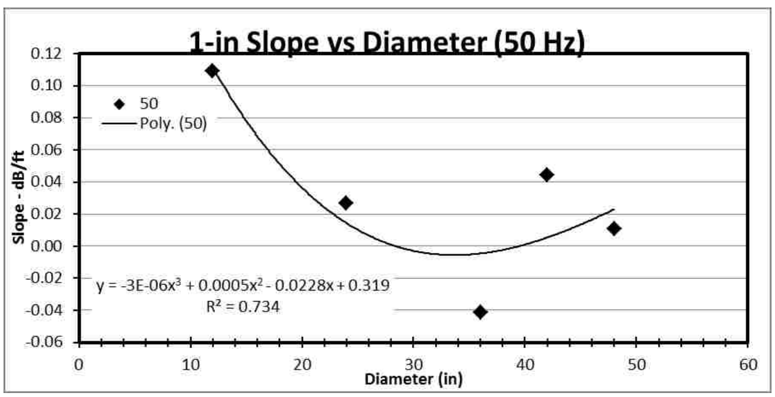

Figure E.7: 1-in Slope vs Diameter at 50 Hz

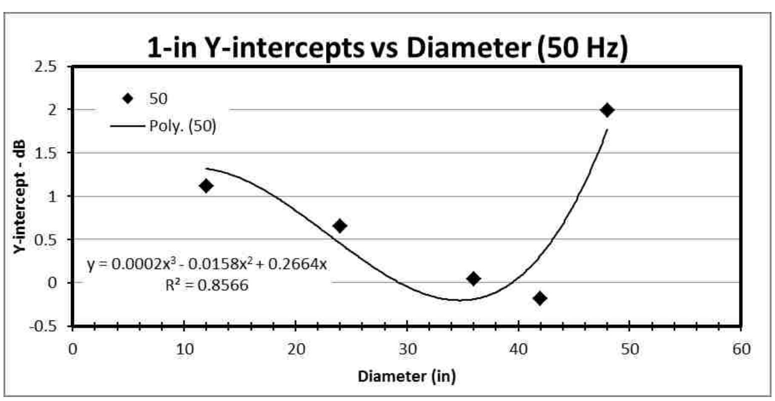

Figure E.8: 1-in Y-intercepts vs Diameter at 50 Hz

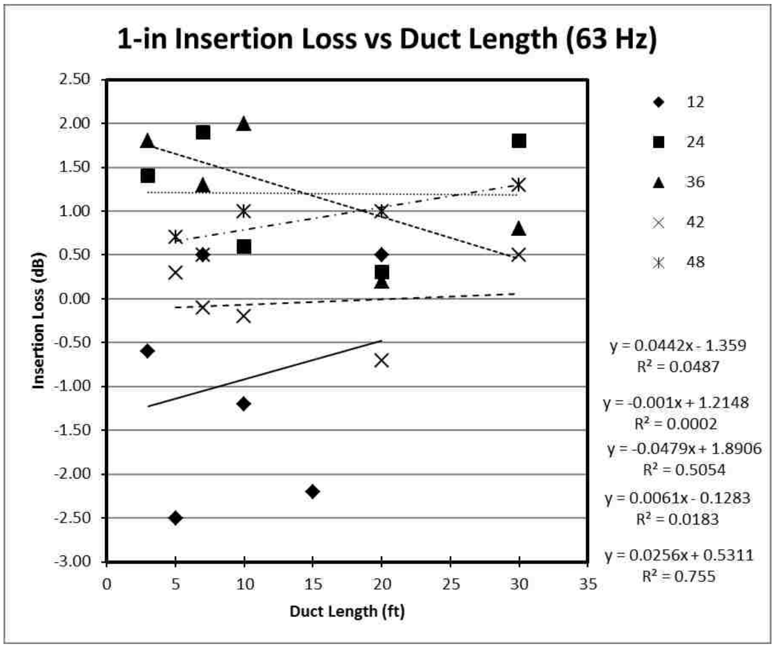

Figure E.9: 1-in Insertion Loss vs Duct Length at 63 Hz

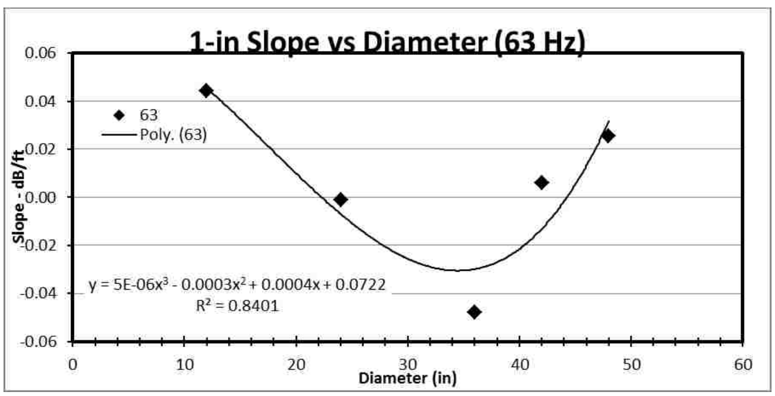

Figure E.10: 1-in Slope vs Diameter at 63 Hz

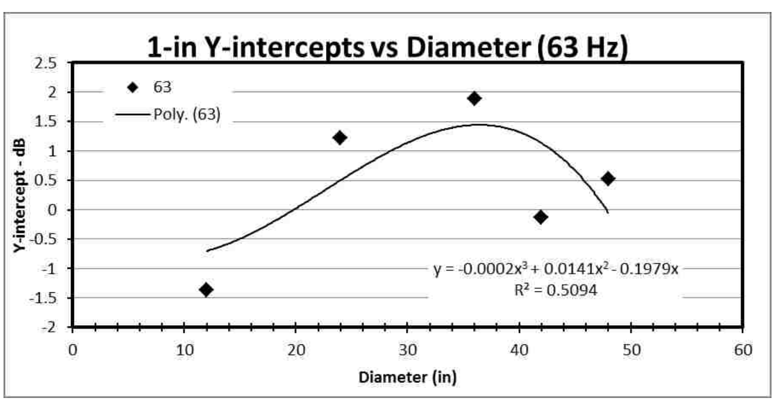

Figure E.11: 1-in Y-intercepts vs Diameter at 63 Hz

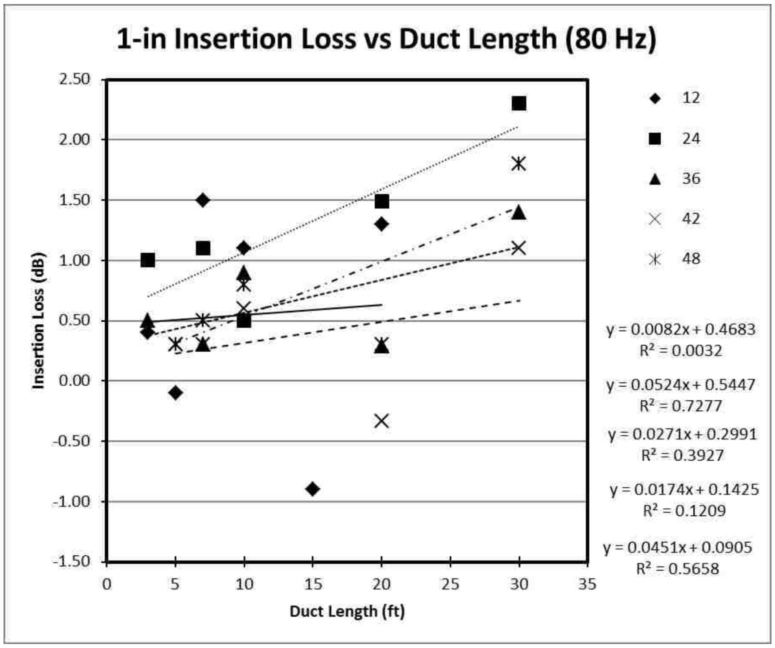

Figure E.12: 1-in Insertion Loss vs Duct Length at 80 Hz

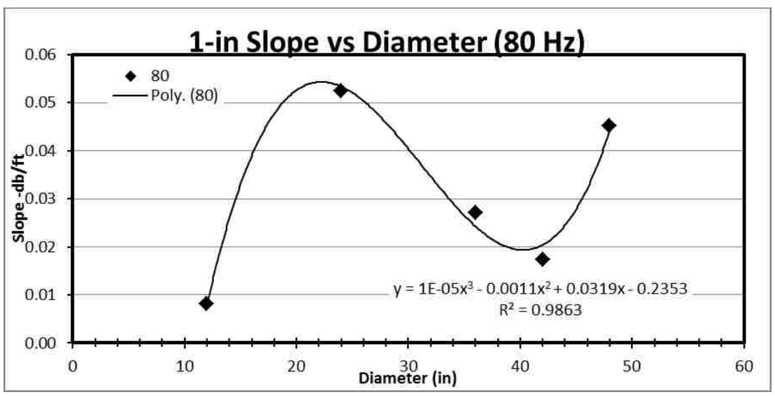

Figure E.13: 1-in Slope vs Diameter at 80 Hz

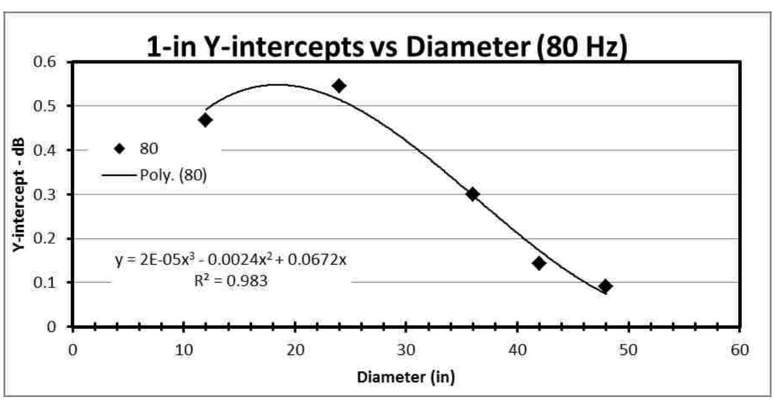

Figure E.14: 1-in Y-intercepts vs Diameter at 80 Hz

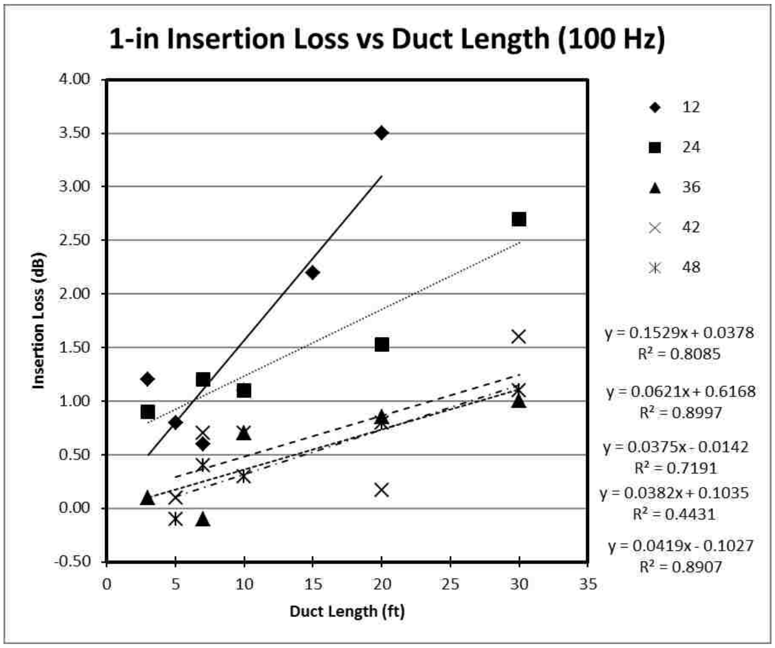

Figure E.15: 1-in Insertion Loss vs Duct Length at 100 Hz

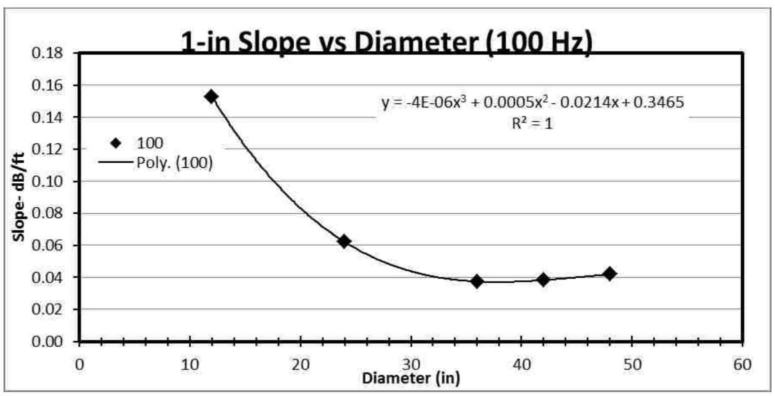

Figure E.16: 1-in Slope vs Diameter at 100 Hz

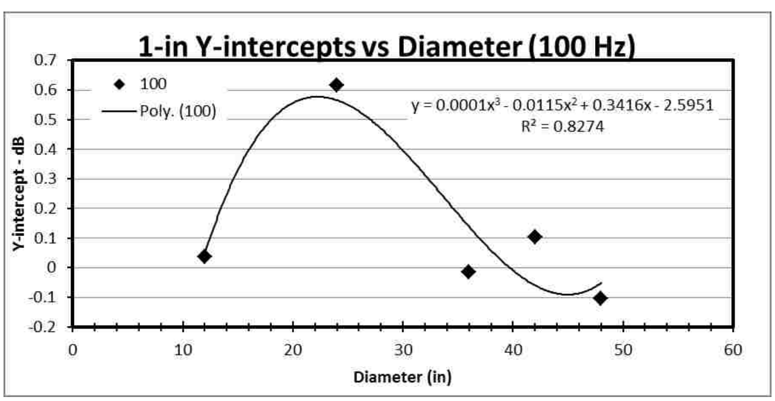

Figure E.17: 1-in Y-intercepts vs Diameter at 100 Hz

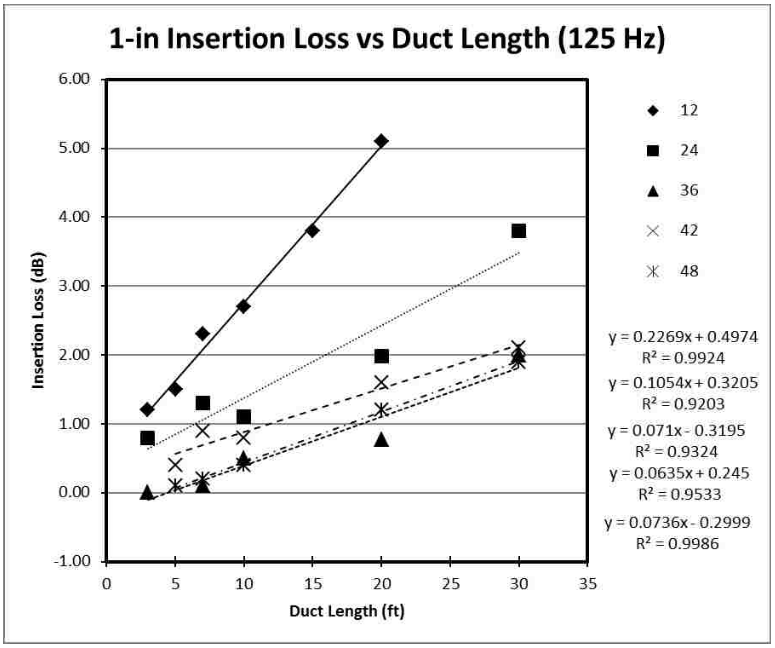

Figure E.18: 1-in Insertion Loss vs Duct Length at 125 Hz

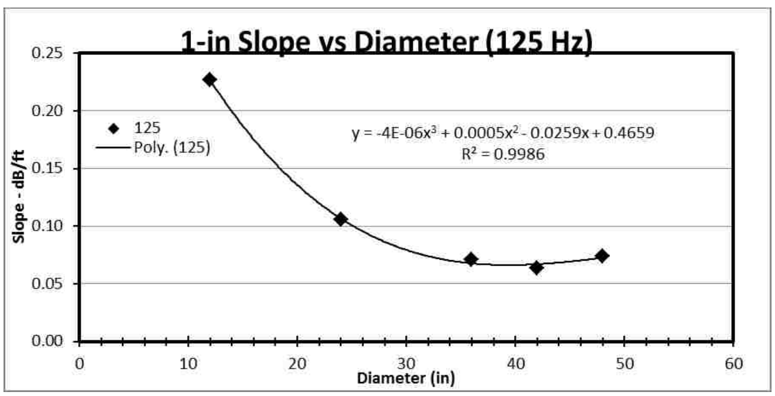

Figure E.19: 1-in Slope vs Diameter at 125 Hz

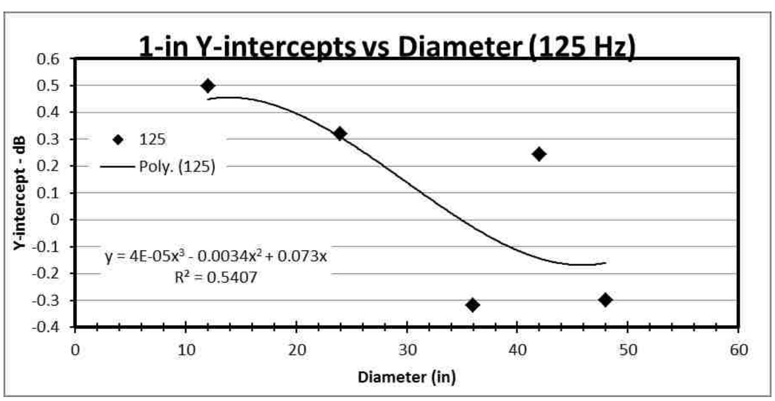

Figure E.20: 1-in Y-intercepts vs Diameter at 125 Hz

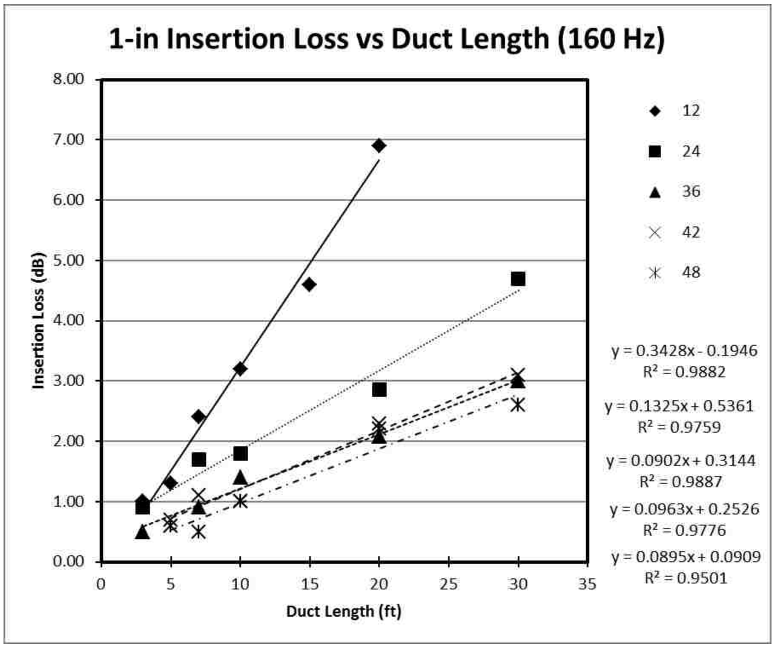

Figure E.21: 1-in Insertion Loss vs Duct Length at 160 Hz

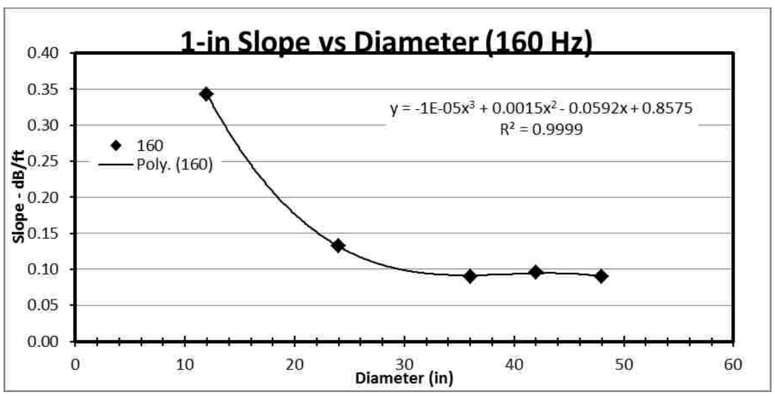

Figure E.22: 1-in Slope vs Diameter at 160 Hz

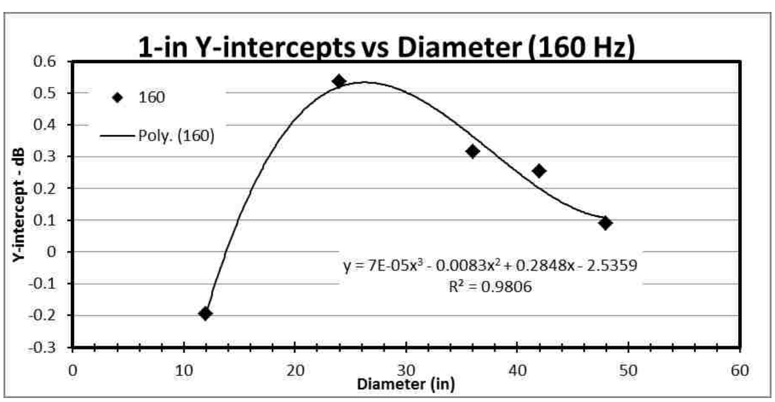

Figure E.23: 1-in Y-intercepts vs Diameter at 160 Hz

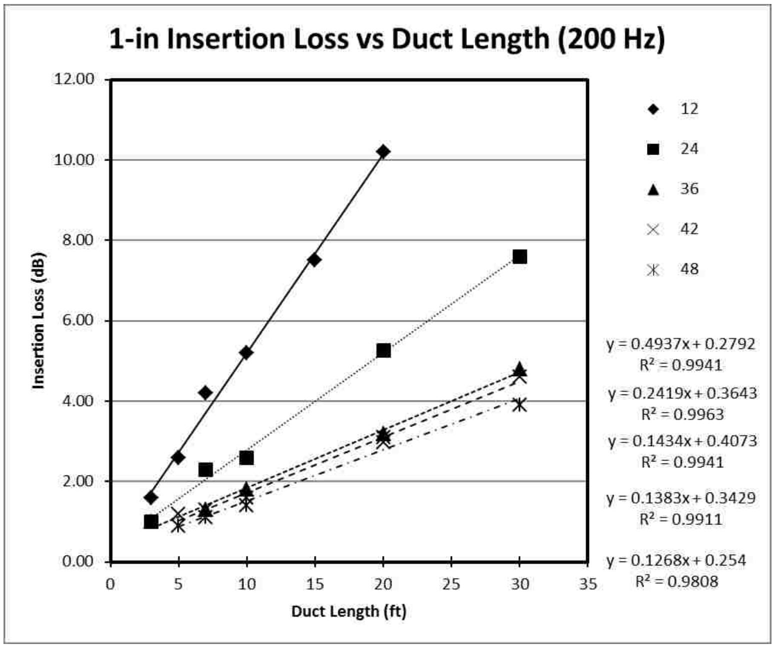

Figure E.24: 1-in Insertion Loss vs Duct Length at 200 Hz

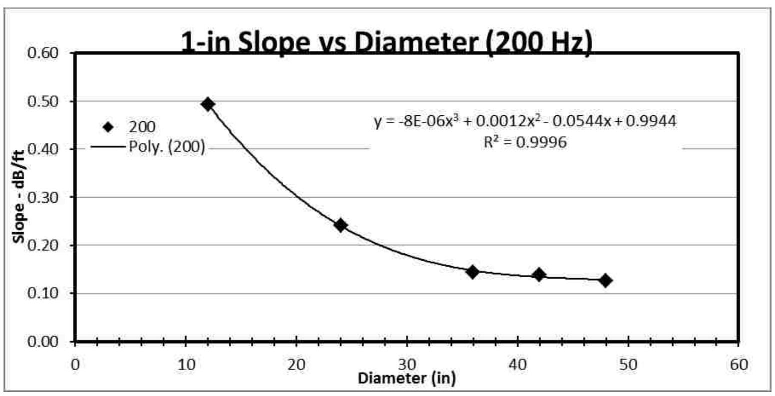

Figure E.25: 1-in Slope vs Diameter at 200 Hz

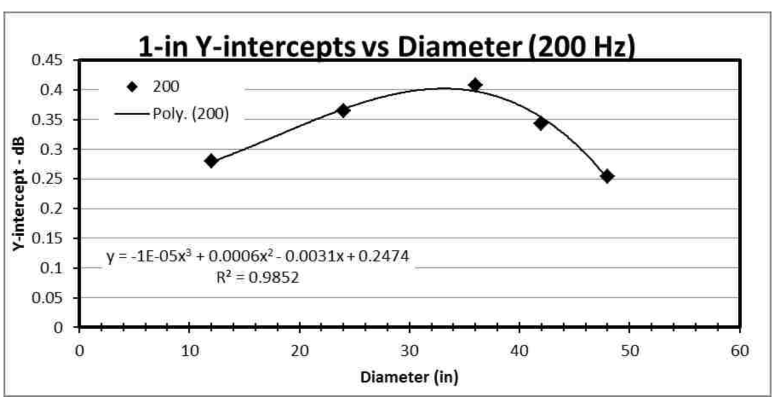

Figure E.26: 1-in Y-intercepts vs Diameter at 200 Hz

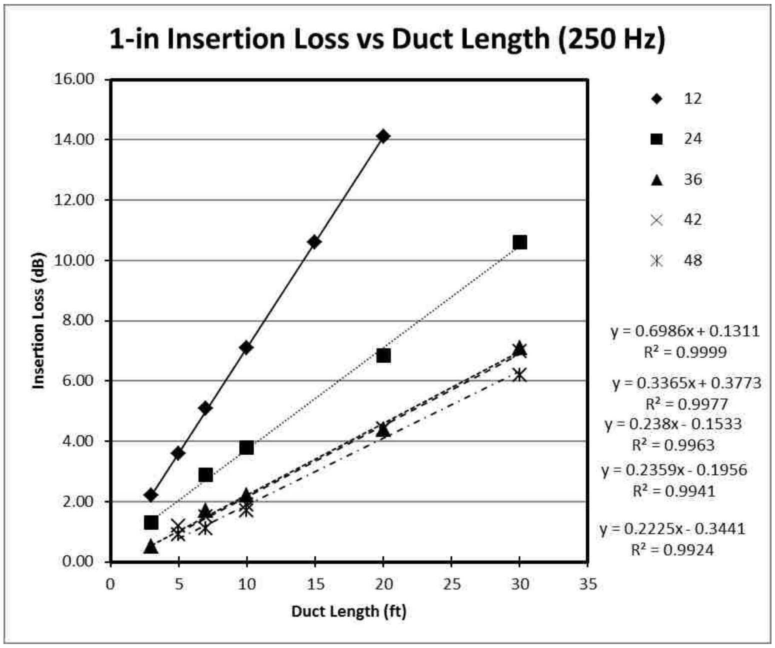

Figure E.27: 1-in Insertion Loss vs Duct Length at 250 Hz

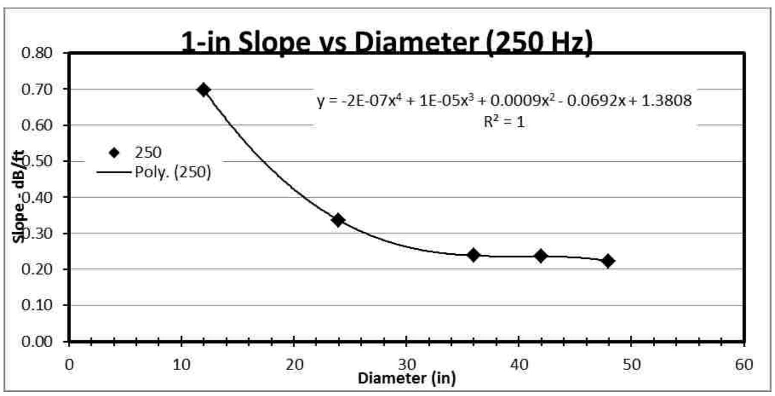

Figure E.28: 1-in Slope vs Diameter at 250 Hz

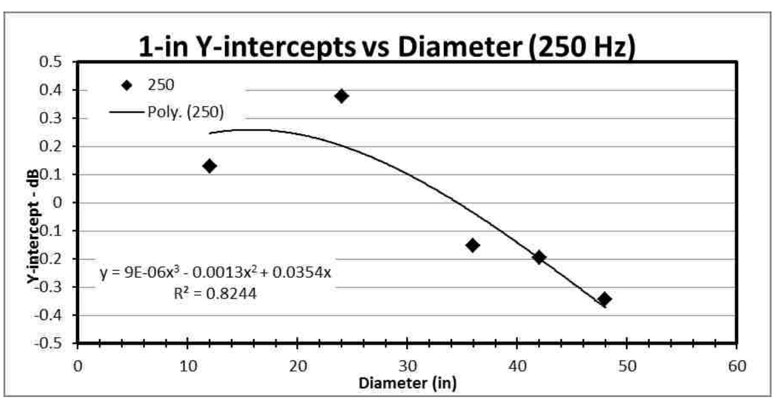

Figure E.29: 1-in Y-intercepts vs Diameter at 250 Hz

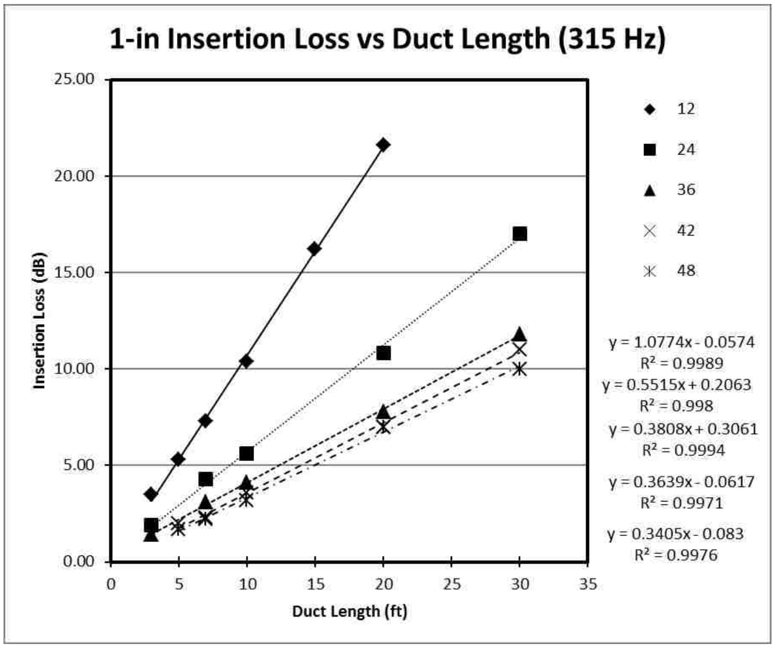

Figure E.30: 1-in Insertion Loss vs Duct Length at 315 Hz

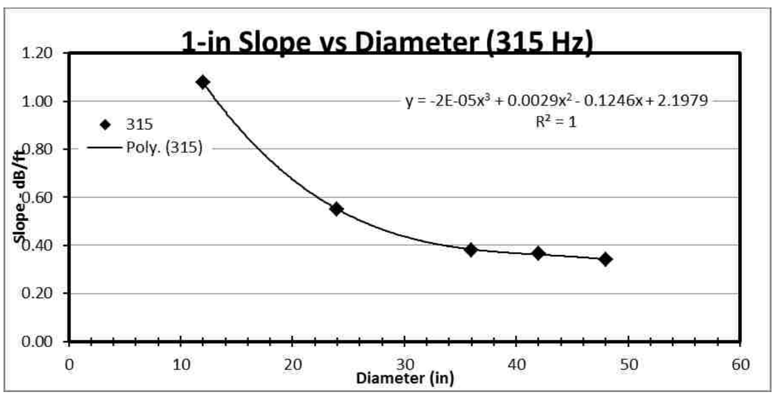

Figure E.31: 1-in Slope vs Diameter at 315 Hz

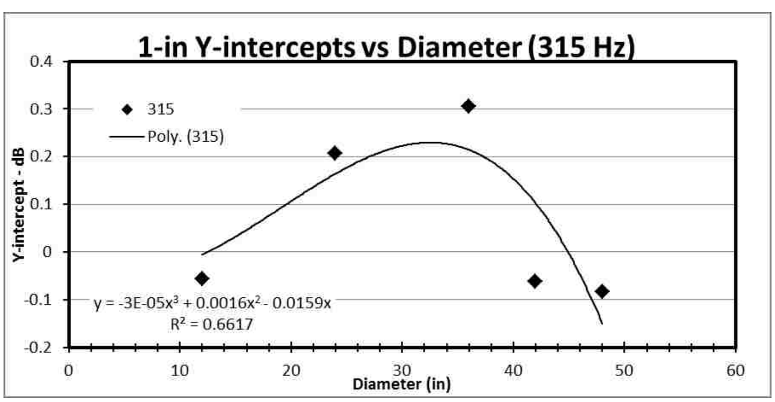

Figure E.32: 1-in Y-intercepts vs Diameter at 315 Hz

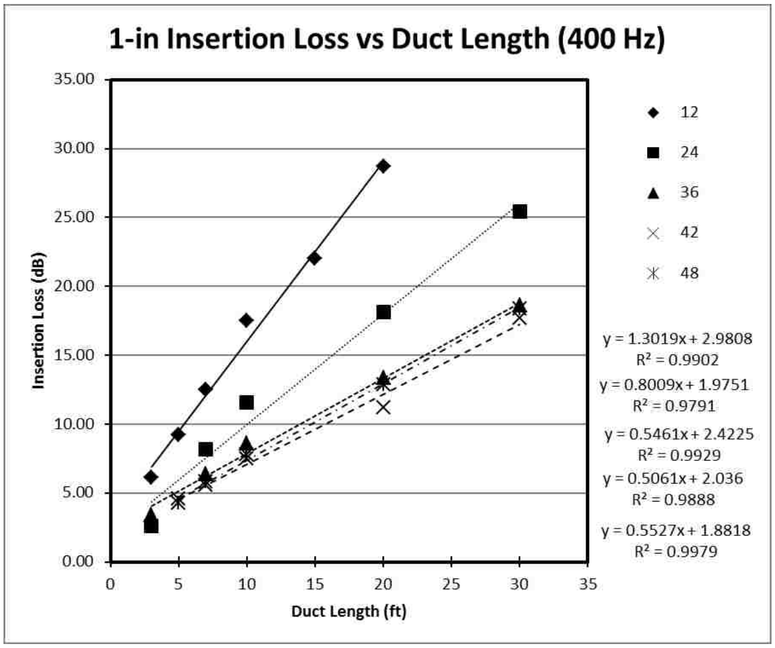

Figure E.33: 1-in Insertion Loss vs Duct Length at 400 Hz

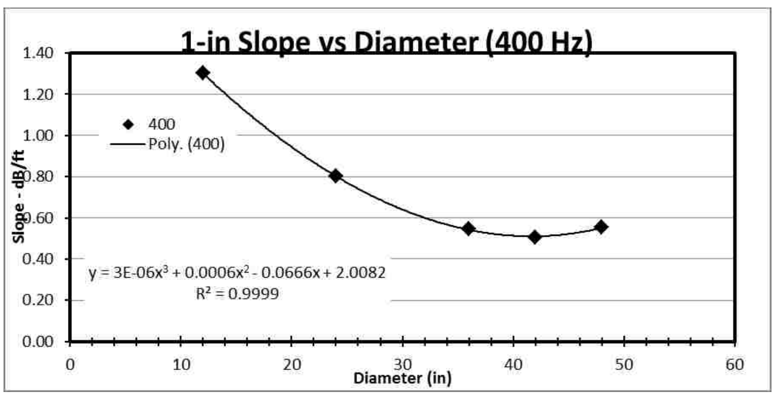

Figure E.34: 1-in Slope vs Diameter at 400 Hz

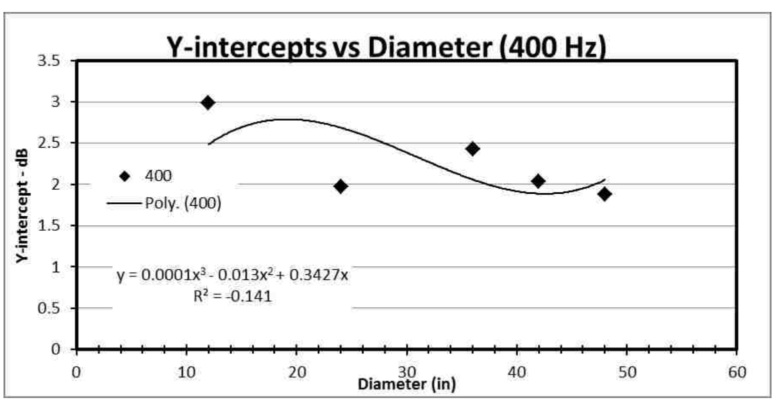

Figure E.35: 1-in Y-intercepts vs Diameter at 400 Hz

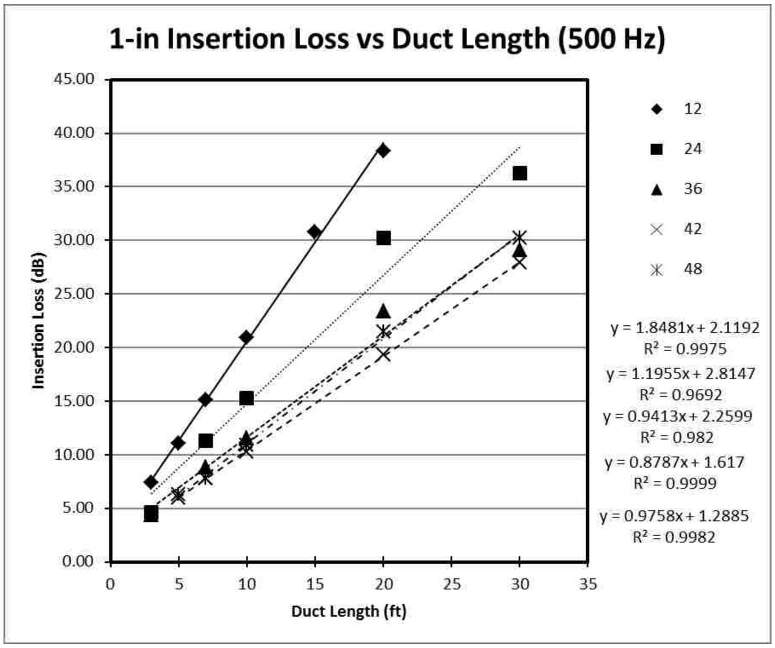

Figure E.36: 1-in Insertion Loss vs Duct Length at 500 Hz

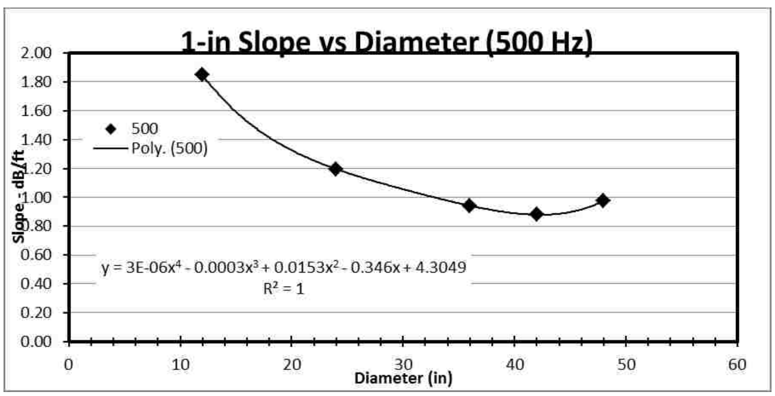

Figure E.37: 1-in Slope vs Diameter at 500 Hz

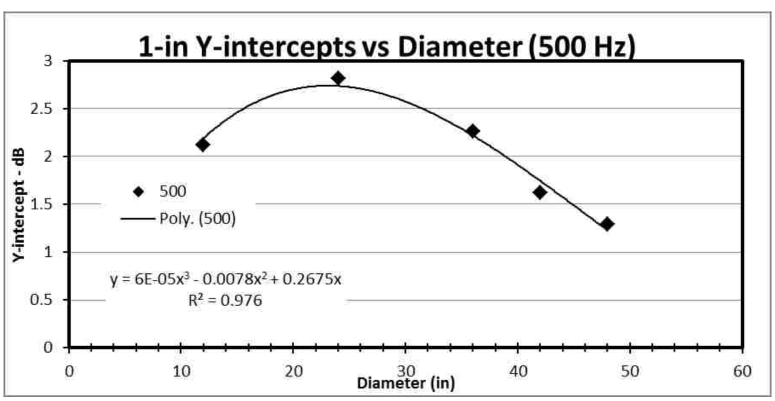

Figure E.38: 1-in Y-intercepts vs Diameter at 500 Hz

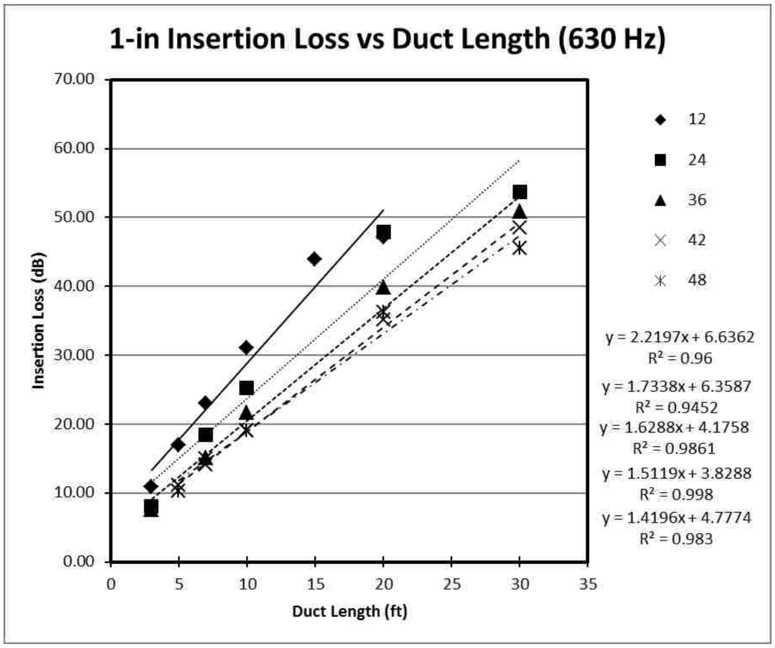

Figure E.39: 1-in Insertion Loss vs Duct Length at 630 Hz

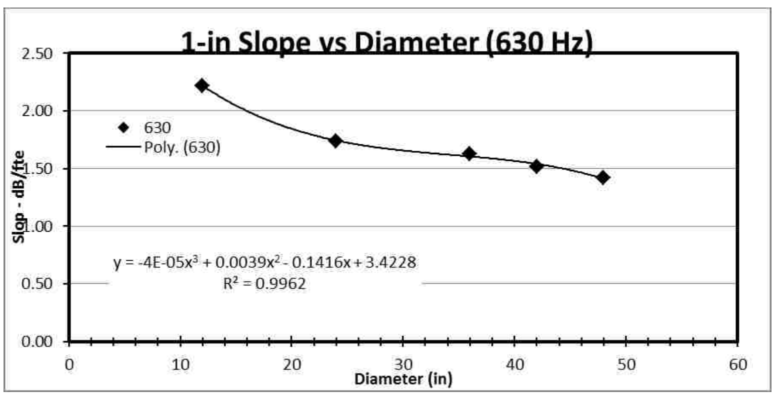

Figure E.40: 1-in Slope vs Diameter at 630 Hz

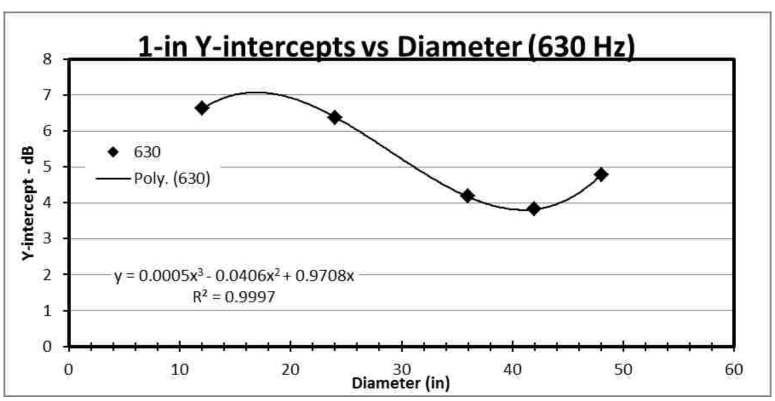

Figure E.41: 1-in Y-intercepts vs Diameter at 630 Hz

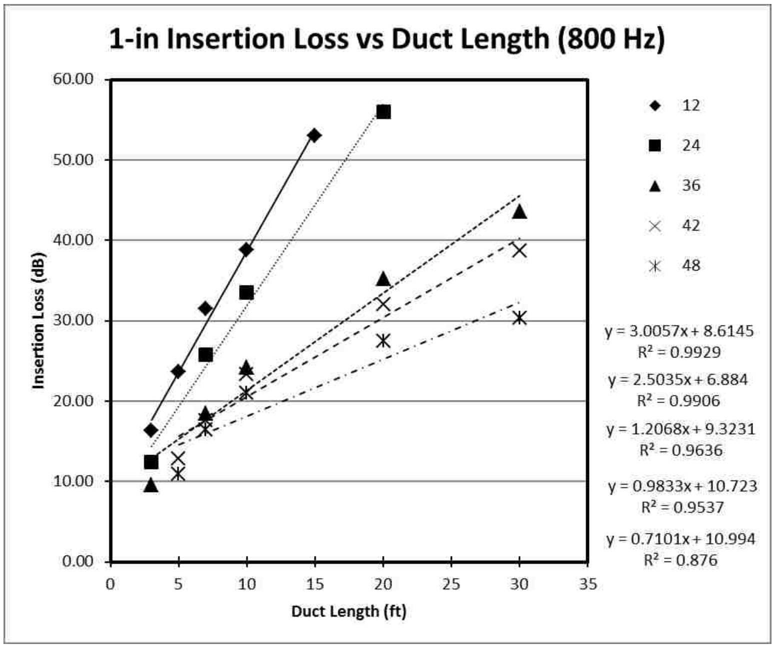

Figure E.42: 1-in Insertion Loss vs Duct Length at 800 Hz

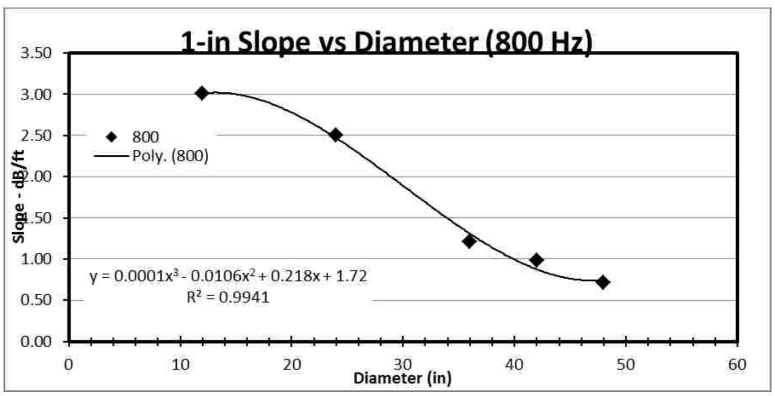

Figure E.43: 1-in Slope vs Diameter at 800 Hz

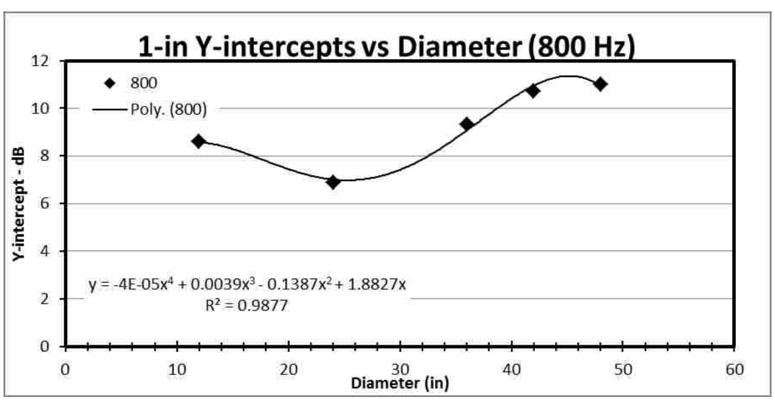

Figure E.44: 1-in Y-intercepts vs Diameter at 800 Hz

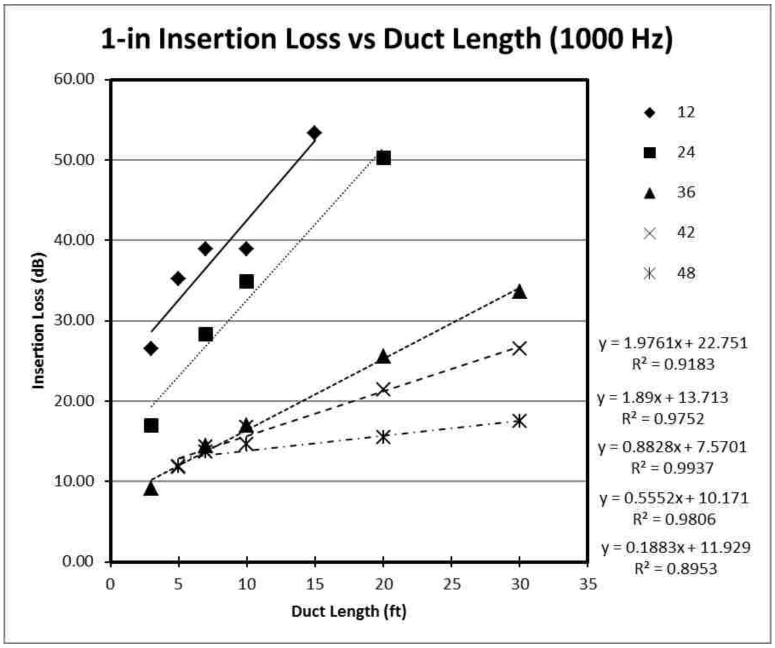

Figure E.45: 1-in Insertion Loss vs Duct Length at 1000 Hz

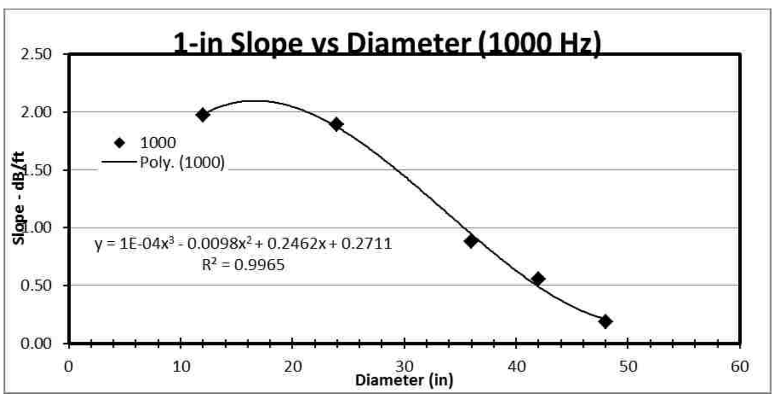

Figure E.46: 1-in Slope vs Diameter at 1000 Hz

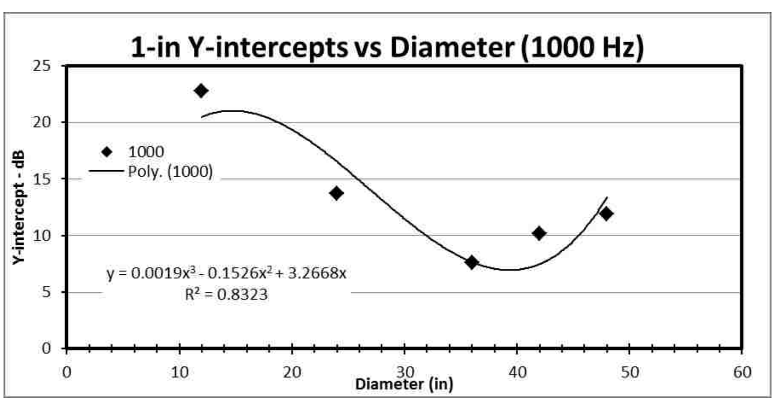

Figure E.47: 1-in Y-intercepts vs Diameter at 1000 Hz

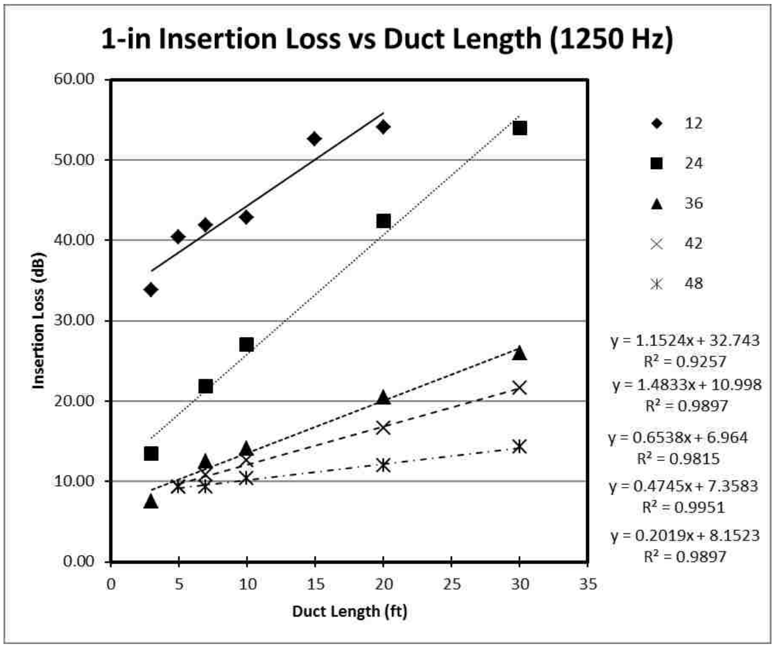

Figure E.48: 1-in Insertion Loss vs Duct Length at 1250 Hz

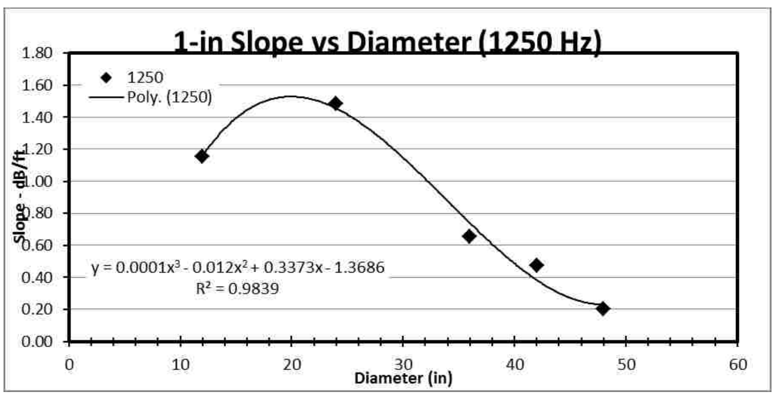

Figure E.49: 1-in Slope vs Diameter at 1250 Hz

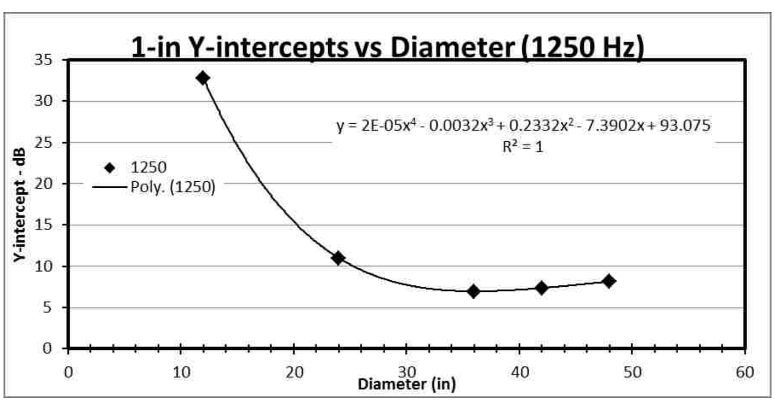

Figure E.50: 1-in Y-intercepts vs Diameter at 1250 Hz

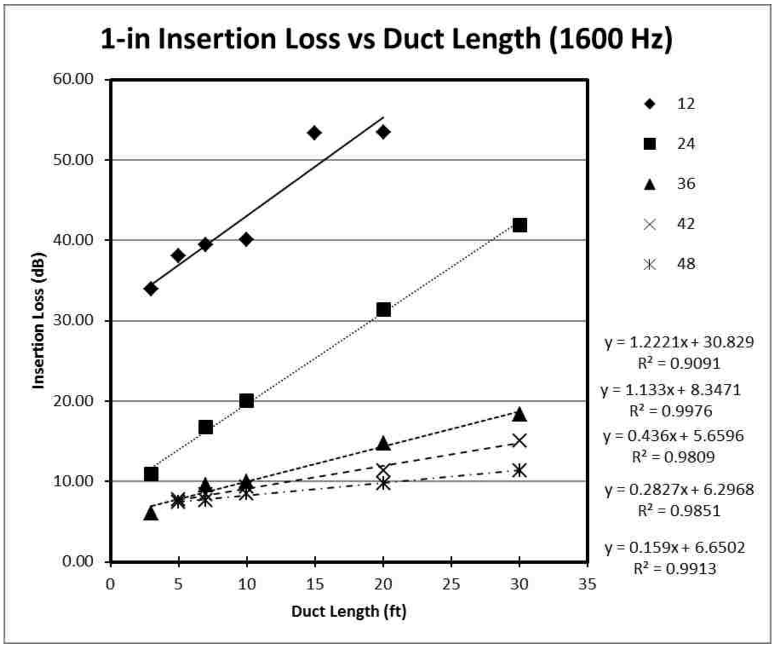

Figure E.51: 1-in Insertion Loss vs Duct Length at 1600 Hz

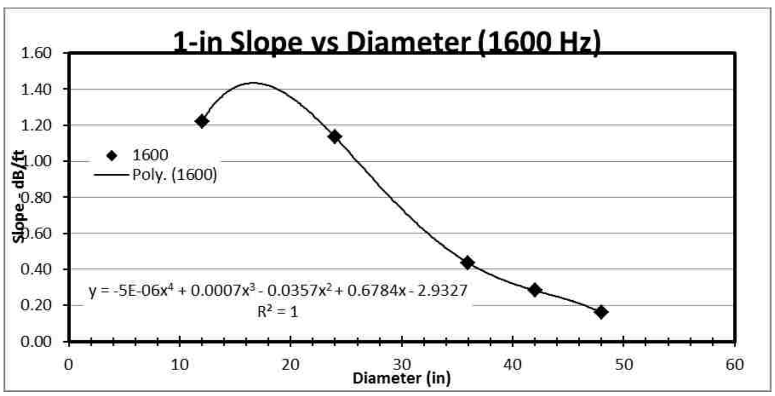

Figure E.52: 1-in Slope vs Diameter at 1600 Hz

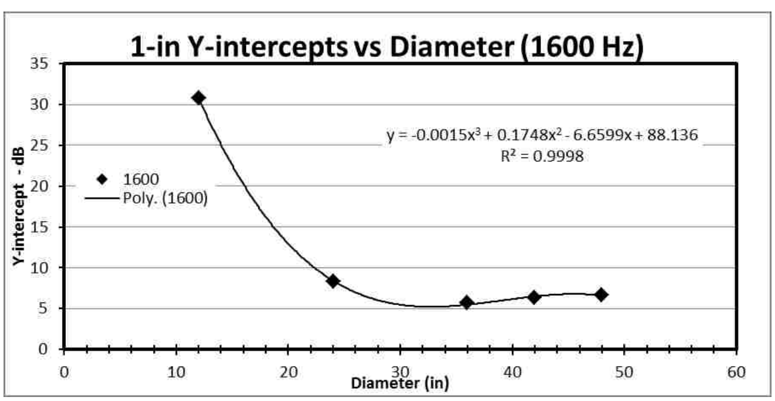

Figure E.53: 1-in Y-intercepts vs Diameter at 1600 Hz

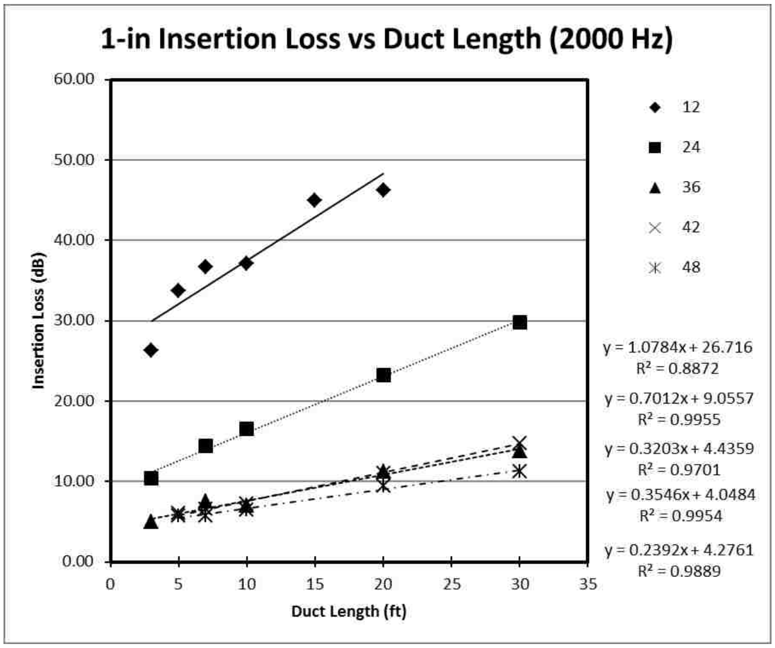

Figure E.54: 1-in Insertion Loss vs Duct Length at 2000 Hz

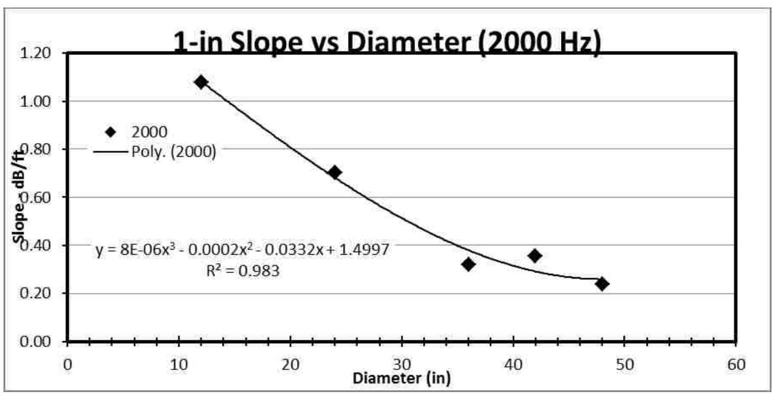

Figure E.55: 1-in Slope vs Diameter at 2000 Hz

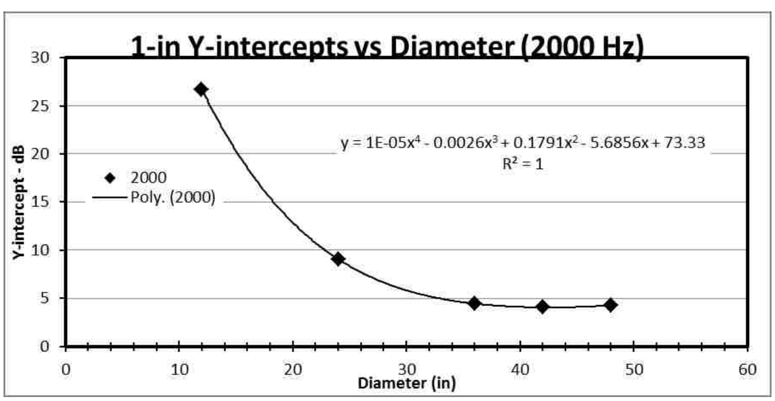

Figure E.56: 1-in Y-intercepts vs Diameter at 2000 Hz

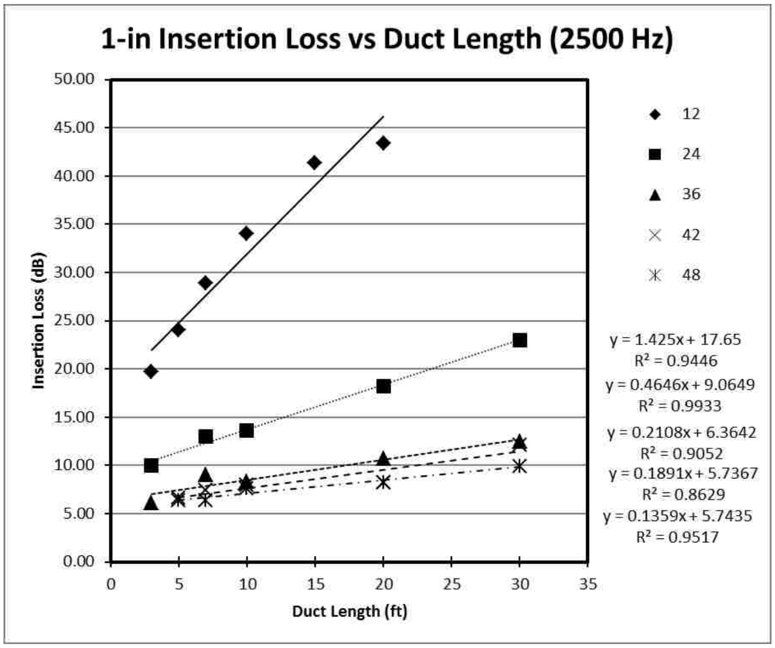

Figure E.57: 1-in Insertion Loss vs Duct Length at 2500 Hz

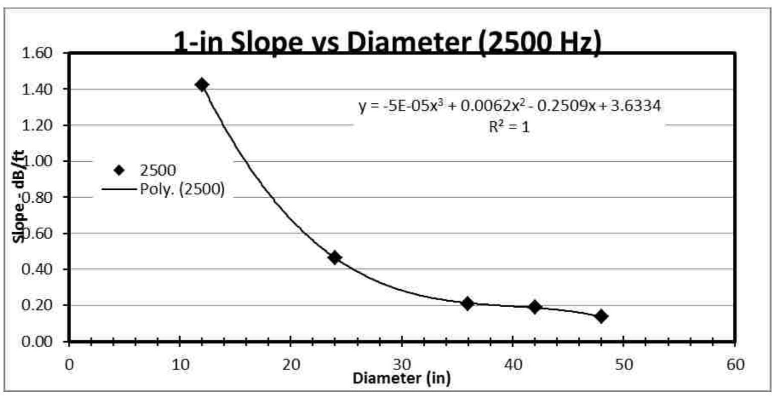

Figure E.58: 1-in Slope vs Diameter at 2500 Hz

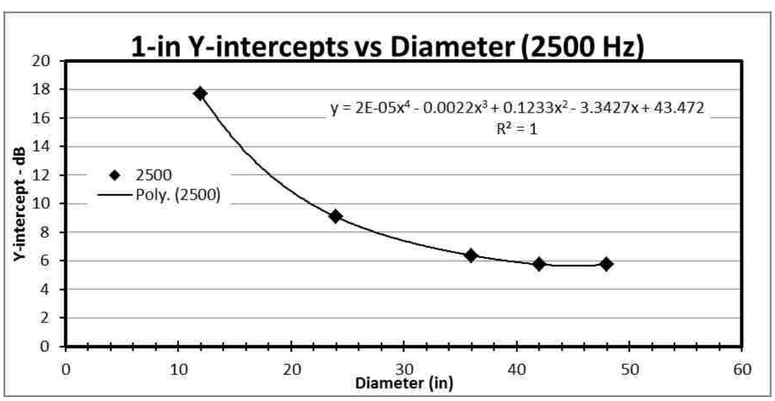

Figure E.59: 1-in Y-intercepts vs Diameter at 2500 Hz

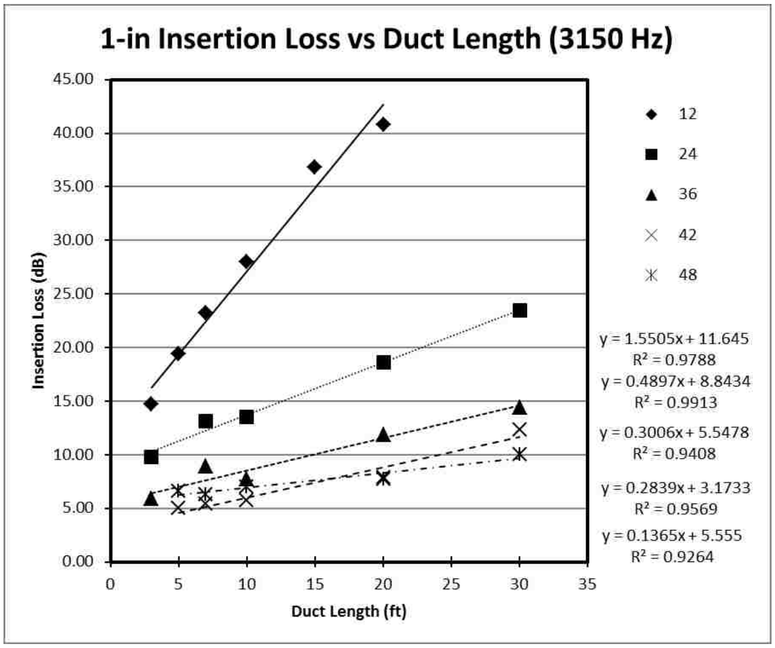

Figure E.60: 1-in Insertion Loss vs Duct Length at 3150 Hz

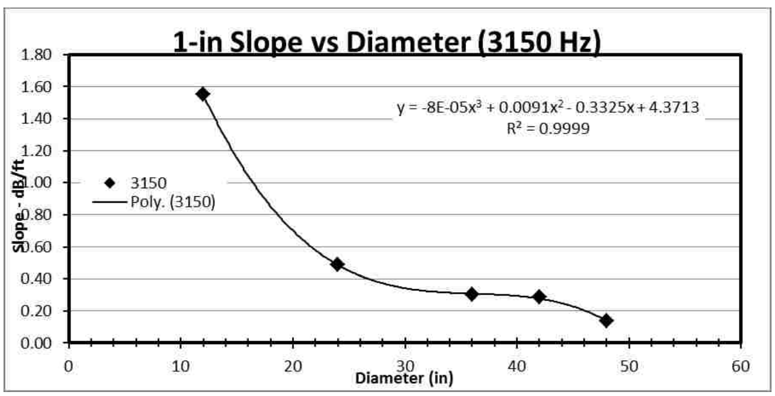

Figure E.61: 1-in Slope vs Diameter at 3150 Hz

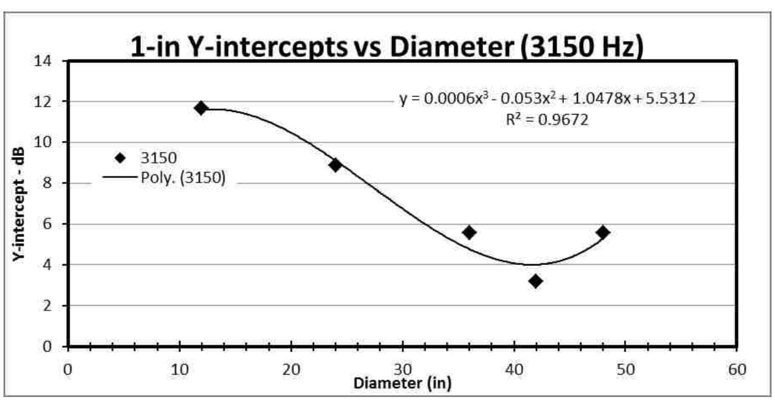

Figure E.62: 1-in Y-intercepts vs Diameter at 3150 Hz

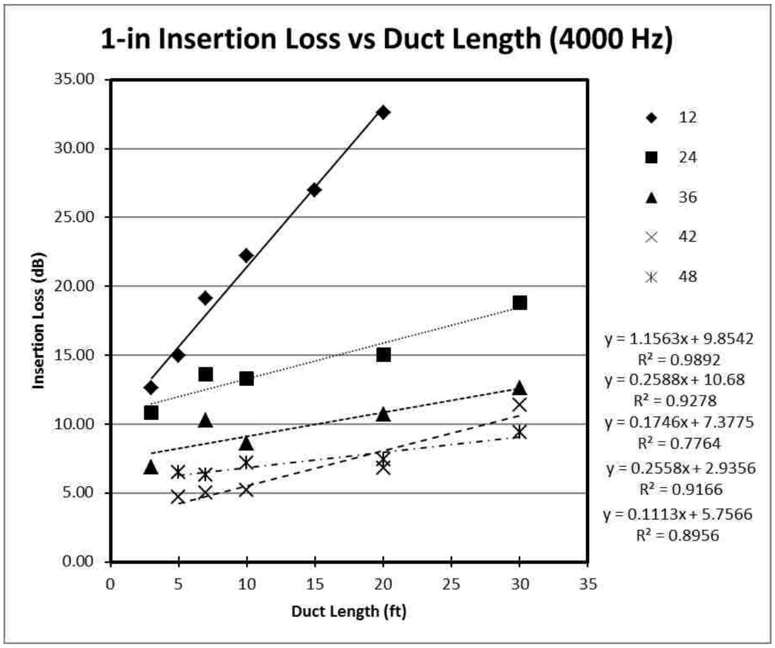

Figure E.63: 1-in Insertion Loss vs Duct Length at 4000 Hz

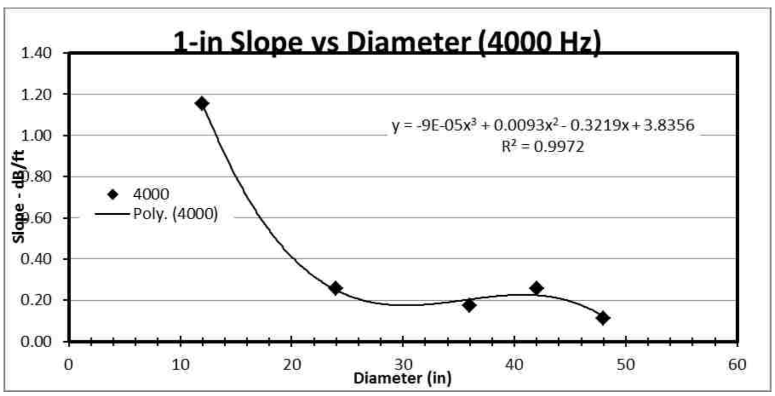

Figure E.64: 1-in Slope vs Diameter at 4000 Hz

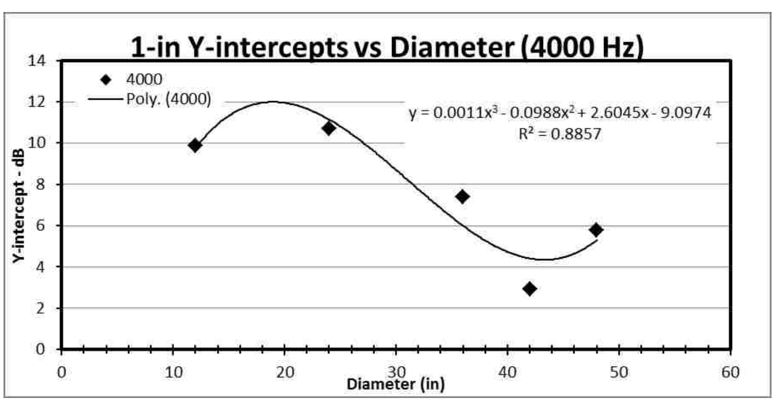

Figure E.65: 1-in Y-intercepts vs Diameter at 4000 Hz

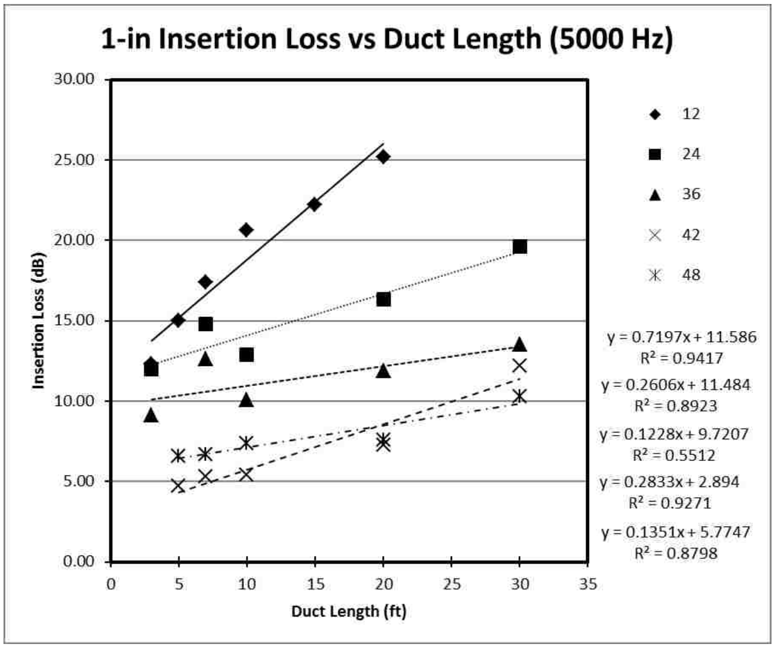

Figure E.66: 1-in Insertion Loss vs Duct Length at 5000 Hz

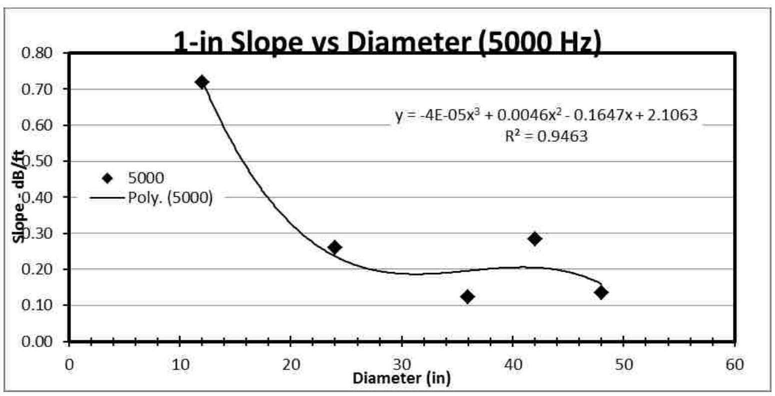

Figure E.67: 1-in Slope vs Diameter at 5000 Hz

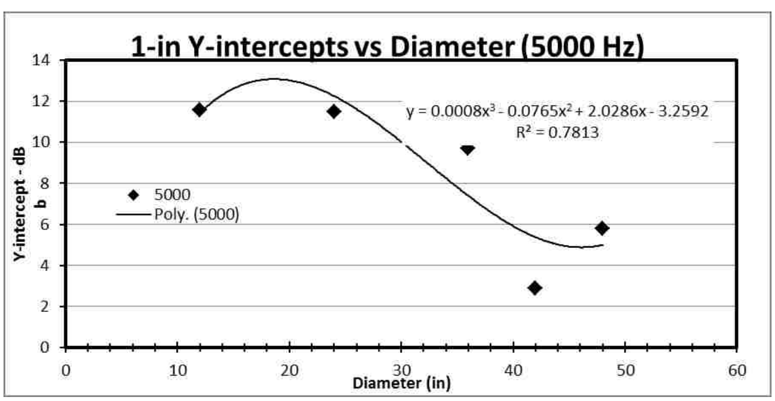

Figure E.68: 1-in Y-intercepts vs Diameter at 5000 Hz

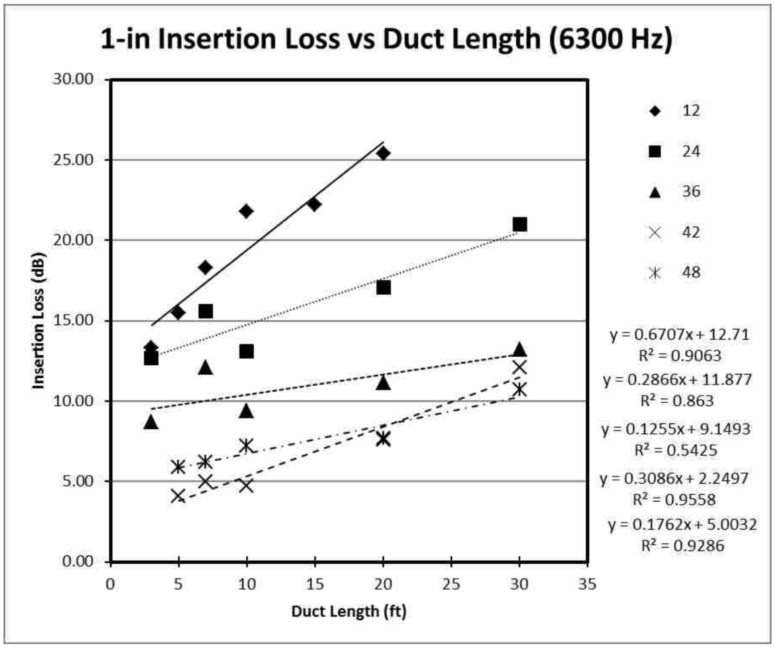

Figure E.69: 1-in Insertion Loss vs Duct Length at 6300 Hz

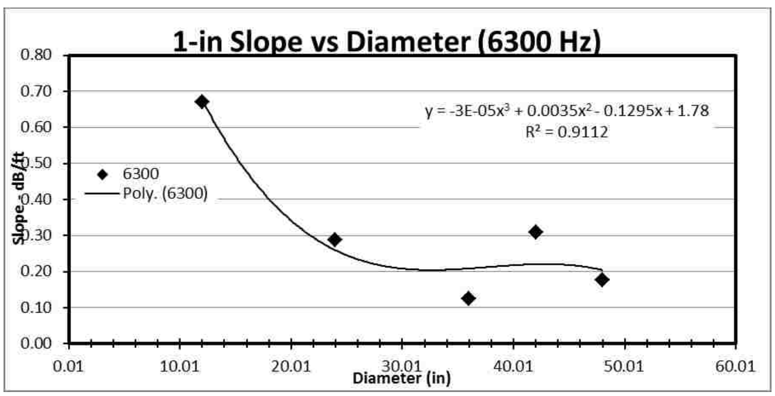

Figure E.70: 1-in Slope vs Diameter at 6300 Hz

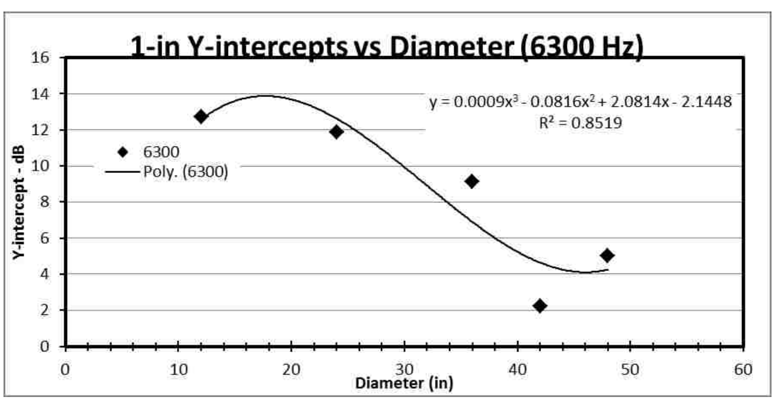

Figure E.71: 1-in Y-intercepts vs Diameter at 6300 Hz

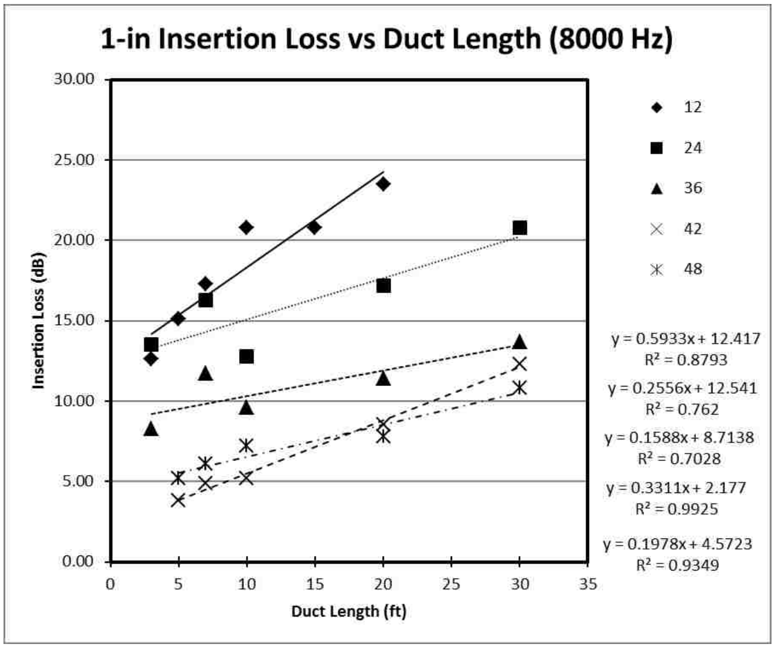

Figure E.72: 1-in Insertion Loss vs Duct Length at 8000 Hz

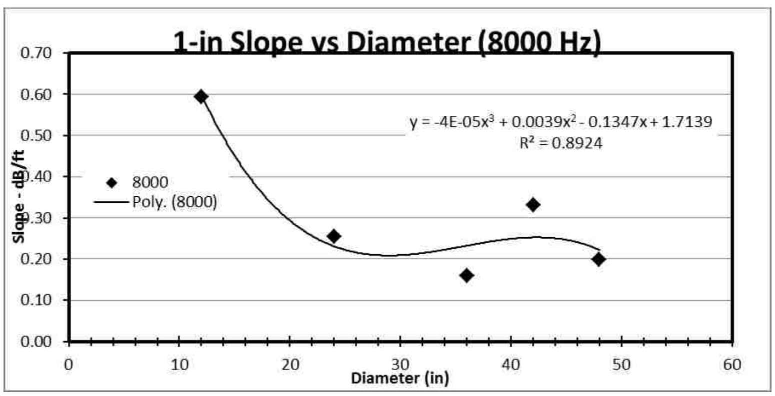

Figure E.73: 1-in Slope vs Diameter at 8000 Hz

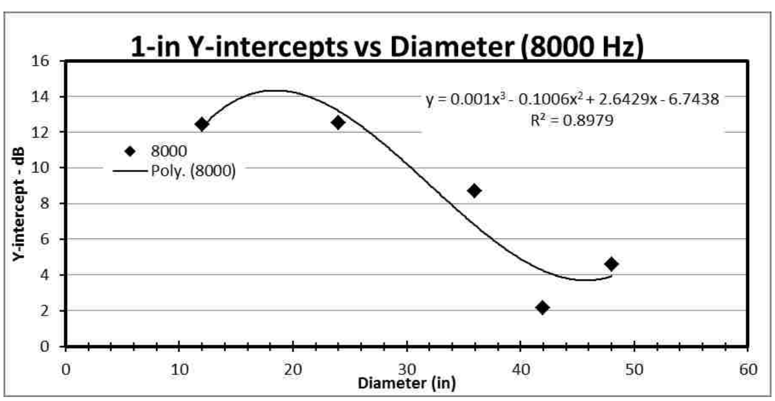

Figure E.74: 1-in Y-intercepts vs Diameter at 8000 Hz

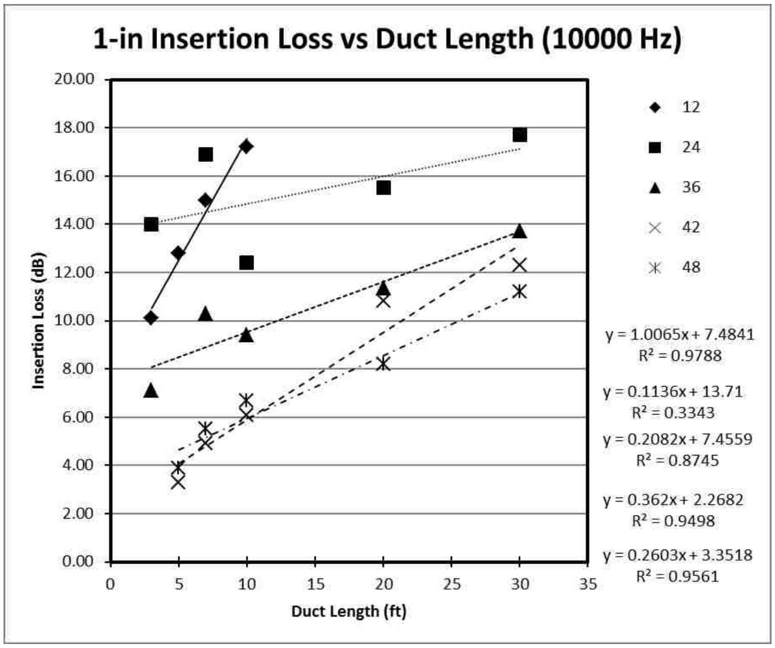

Figure E.75: 1-in Insertion Loss vs Duct Length at 10000 Hz

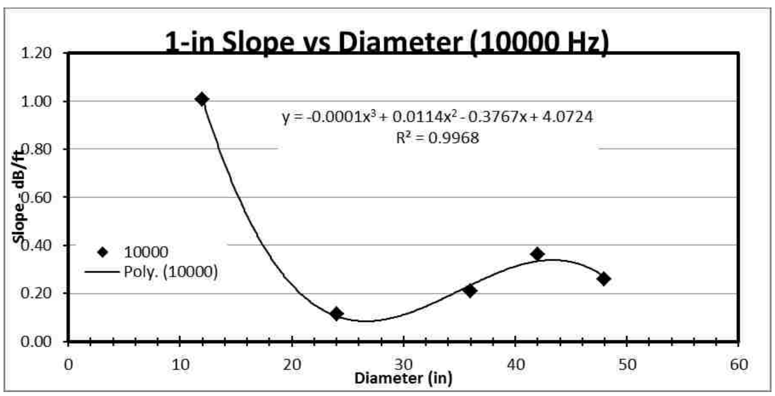

Figure E.76: 1-in Slope vs Diameter at 10000 Hz

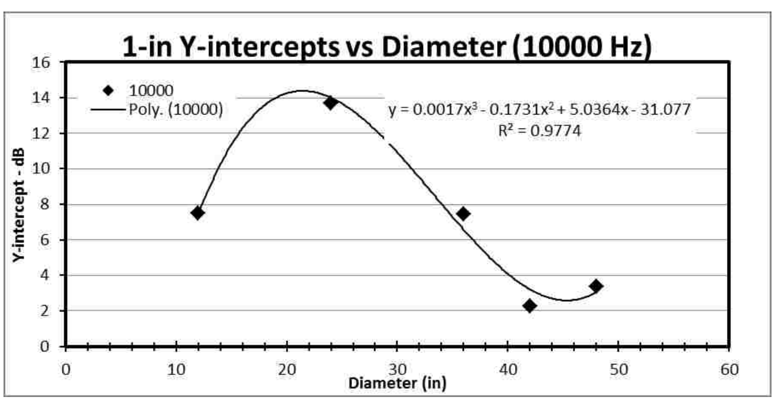

Figure E.77: 1-in Y-intercepts vs Diameter at 10000 Hz

Diameter - in		12	24	36	12	42	48	12	24	36	42	48	12	24	36	42	48	12	12	24	36	42	48	24	36	42	48			
Length -ft		3	3	3	5	5	5	7	7	7	7	7	10	10	10	10	10	15	20	20	20	20	20	30	30	30	30	AVG	STD	Freq
meas	50	1.3	1.3	-0.3	0.4	0.2	2.0	3.4	1.3	-0.4	0.4	1.4	2.8	0.2	0.4	0.1	2.8	1.8	3.5	0.0	-1.4	0.0	2.4	2.3	-1.0	1.6	2.1			50
regres	50	1.4	0.8	-0.3	1.6	0.2	2.0	1.9	0.9	-0.3	0.2	2.0	2.2	0.9	-0.3	0.2	2.1	2.8	3.3	1.0	-0.4	0.3	2.3	1.2	-0.4	0.3	2.6			50
DIFF AVG		-0.1	0.5	0.0	-1.2	0.0	0.0	1.5	0.4	-0.1	0.2	-0.6	0.6	-0.7	0.7	-0.1	0.7	-1.0	0.2	-1.0	-1.0	-0.3	0.1	1.1	-0.6	1.3	-0.5	0.0	0.7	
meas	63	-0.6	1.4	1.8	-2.5	0.3	0.7	0.5	1.9	1.3	-0.1	0.5	-1.2	0.6	2.0	-0.2	1.0	-2.2	0.5	0.3	0.2	-0.7	1.0	1.8	0.8	0.5	1.3			63
regres	63	-1.3	1.4	1.1	-1.2	0.6	0.4	-1.1	1.4	1.0	0.6	0.5	-1.0	1.4	0.9	0.5	0.6	-0.7	-0.5	1.3	0.6	0.4	0.9	1.2	0.3	0.2	1.2			63
DIFF AVG		0.7	0.0	0.7	-1.3	-0.3	0.3	1.6	0.5	0.3	-0.7	0.0	-0.2	-0.8	1.1	-0.7	0.4	-1.5	1.0	-1.0	-0.4	-1.1	0.1	0.6	0.5	0.3	0.1	0.0	0.8	
meas	80	0.4	1.0	0.5	-0.1	0.3	0.3	1.5	1.1	0.3	0.3	0.5	1.1	0.5	0.9	0.6	0.8	-0.9	1.3	1.5	0.3	-0.3	0.3	2.3	1.4	1.1	1.8			80
regres	80	0.5	0.7	0.4	0.5	0.3	0.3	0.5	0.9	0.5	0.3	0.4	0.5	1.1	0.5	0.4	0.5	0.6	0.6	1.6	0.8	0.6	1.0	2.1	1.0	0.8	1.4			80
DIFF AVG		-0.1	0.3	0.1	-0.6	0.0	0.0	1.0	0.2	-0.2	0.0	0.1	0.6	-0.6	0.4	0.2	0.3	-1.5	0.7	-0.1	-0.5	-0.9	-0.7	0.2	0.4	0.3	0.4	0.0	0.5	
meas	100	1.2	0.9	0.1	0.8	0.1	-0.1	0.6	1.2	-0.1	0.7	0.4	1.1	1.1	0.7	0.7	0.3	2.2	3.5	1.5	0.9	0.2	0.8	2.7	1.0	1.6	1.1			100
regres	100	0.5	0.8	0.3	0.8	0.1	0.2	1.1	1.0	0.4	0.2	0.2	1.6	1.2	0.5	0.3	0.4	2.3	3.1	1.8	0.9	0.7	0.8	2.4	1.3	1.1	1.2			100
DIFF AVG		0.7	0.1	-0.2	0.0	0.0	-0.3	-0.5	0.2	-0.5	0.5	0.2	-0.5	-0.1	0.2	0.4	-0.1	-0.1	0.4	-0.3	0.0	-0.5	0.0	0.3	-0.3	0.5	-0.1	0.0	0.3	
meas	125	1.2	0.8	0.0	1.5	0.4	0.1	2.3	1.3	0.1	0.9	0.2	2.7	1.1	0.5	0.8	0.4	3.8	5.1	2.0	0.8	1.6	1.2	3.8	2.0	2.1	1.9			125
regres	125	1.2	0.5	0.2	1.7	0.2	0.2	2.1	1.0	0.5	0.4	0.3	2.8	1.3	0.7	0.6	0.5	3.9	5.1	2.3	1.4	1.2	1.3	3.4	2.0	1.9	2.0			125
DIFF AVG		0.0	0.3	-0.2	-0.2	0.2	-0.1	0.2	0.3	-0.4	0.5	-0.1	-0.1	-0.2	-0.2	0.2	-0.1	-0.1	0.0	-0.4	-0.6	0.4	-0.1	0.4	0.0	0.2	-0.1	0.0	0.3	
meas	160	1.0	0.9	0.5	1.3	0.7	0.6	2.4	1.7	0.9	1.1	0.5	3.2	1.8	1.4	1.0	1.0	4.6	6.9	2.9	2.1	2.3	2.2	4.7	3.0	3.1	2.6			160
regres	160	0.8	0.9	0.6	1.5	0.7	0.6	2.2	1.4	1.0	0.9	0.7	3.2	1.8	1.3	1.1	1.0	5.0	6.7	3.2	2.2	2.1	1.9	4.5	3.1	3.0	2.8			160
DIFF AVG		0.2	0.0	-0.1	-0.2	0.0	0.0	0.2	0.3	-0.1	0.2	-0.2	0.0	0.0	0.1	-0.1	0.0	-0.4	0.2	-0.3	-0.1	0.2	0.3	0.2	-0.1	0.1	-0.2	0.0	0.2	
meas	200	1.6	1.0	1.0	2.6	1.2	0.9	4.2	2.3	1.3	1.3	1.1	5.2	2.6	1.8	1.6	1.4	7.5	10.2	5.3	3.2	3.0	3.1	7.6	4.8	4.6	3.9			200
regres	200	1.8	1.1	0.8	2.7	1.0	0.9	3.7	2.1	1.4	1.3	1.1	5.2	2.8	1.9	1.7	1.5	7.7	10.2	5.2	3.3	3.0	2.8	7.6	4.8	4.4	4.1			200
DIFF AVG		-0.2	-0.1	0.2	-0.1	0.2	0.0	0.5	0.2	-0.1	0.0	0.0	0.0	-0.2	-0.1	-0.1	-0.1	-0.2	0.0	0.1	-0.2	-0.1	0.3	0.0	0.0	0.2	-0.2	0.0	0.2	
meas	250	2.2	1.3	0.5	3.6	1.2	0.9	5.1	2.9	1.7	1.5	1.1	7.1	3.8	2.2	1.9	1.7	10.6	14.1	6.8	4.4	4.4	4.4	10.6	7.1	7.0	6.2			250
regres	250	2.2	1.4	0.6	3.6	0.9	0.8	5.0	2.7	1.6	1.4	1.2	7.1	3.7	2.3	2.1	1.9	10.6	14.1	7.1	4.7	4.4	4.1	10.4	7.1	6.7	6.4			250
DIFF AVG		0.0	-0.1	-0.1	0.0	0.3	0.1	0.1	0.2	0.1	0.1	-0.1	0.0	0.1	-0.1	-0.2	-0.2	0.0	0.0	-0.2	-0.3	0.0	0.3	0.2	0.0	0.3	-0.2	0.0	0.2	
meas	315	3.5	1.9	1.4	5.3	2.0	1.7	7.3	4.3	3.1	2.3	2.2	10.4	5.6	4.1	3.6	3.2	16.2	21.6	10.8	7.8	7.0	7.0	17.0	11.8	11.0	10.0			315
regres	315	3.2	1.9	1.3	5.3	1.9	1.6	7.5	4.1	2.9	2.6	2.3	10.7	5.8	4.0	3.7	3.3	16.1	21.5	11.3	7.9	7.3	6.7	16.8	11.7	10.9	10.1			315
DIFF AVG		0.3	0.0	0.1	0.0	0.1	0.1	-0.2	0.2	0.2	-0.3	-0.1	-0.3	-0.2	0.1	-0.1	-0.1	0.1	0.1	-0.4	-0.1	-0.3	0.3	0.2	0.1	0.1	-0.1	0.0	0.2	
meas	400	6.1	2.6	3.4	9.2	4.6	4.3	12.5	8.2	6.4	5.6	5.8	17.5	11.6	8.6	7.5	7.8	22.0	28.7	18.1	13.3	11.2	12.9	25.4	18.6	17.7	18.4			400
regres	400	6.9	4.4	3.9	9.5	4.8	4.6	12.1	7.7	6.0	5.8	5.7	16.0	10.1	7.7	7.3	7.3	22.5	29.0	18.1	13.1	12.4	12.8	26.1	18.5	17.5	18.4			400
DIFF AVG		-0.8	-1.8	-0.5	-0.3	-0.2	-0.3	0.4	0.5	0.4	-0.2	0.1	1.5	1.5	0.9	0.2	0.5	-0.5	-0.3	0.1	0.3	-1.2	0.1	-0.7	0.1	0.2	0.0	0.0	0.7	
meas	500	7.4	4.6	4.4	11.1	6.0	6.3	15.1	11.3	8.8	7.8	7.8	20.9	15.3	11.5	10.3	10.9	30.8	38.3	30.3	23.4	19.4	21.5	36.3	29.1	27.9	30.2			500
regres	500	7.7	6.4	4.9	11.3	6.2	6.1	15.0	11.3	8.6	8.0	8.0	20.6	14.9	11.4	10.7	10.9	29.8	39.0	26.9	20.6	19.8	20.6	38.9	29.7	28.8	30.3			500
DIFF AVG		-0.3	-1.8	-0.5	-0.2	-0.2	0.2	0.1	0.0	0.2	-0.2	-0.2	0.3	0.4	0.1	-0.4	0.0	1.0	-0.7	3.4	2.8	-0.4	0.9	-2.6	-0.6	-0.9	-0.1	0.0	1.2	
meas	630	10.9	8.0	7.5	16.9	11.1	10.3	23.0	18.4	15.1	14.1	15.0	31.1	25.2	21.6	19.1	19.1	43.9	47.2	47.9	39.8	35.2	36.2	53.7	50.9	48.5	45.5			630
regres	630	13.3	11.6	9.0	17.7	11.5	11.8	22.2	18.6	15.4	14.6	14.7	28.8	23.8	20.2	19.2	18.9	39.9	51.0	41.2	36.2	34.6	33.0	55.0	52.3	50.0	47.1			630
DIFF AVG		-2.4	-3.6	-1.5	-0.8	-0.4	-1.5	0.8	-0.2	-0.3	-0.5	0.3	2.3	1.4	1.4	-0.1	0.2	4.0	-3.8	6.7	3.6	0.6	3.2	-1.3	-1.4	-1.5	-1.6	0.1	2.4	
meas	800	16.3	12.4	9.6	23.7	12.8	10.9	31.5	25.8	18.5	17.6	16.4	38.8	33.5	24.2	23.3	21.0	53.0	54.4	56.0	35.2	32.0	27.5	52.7	43.6	38.7	30.3			800
REGRESS	800	17.7	14.3	13.3	23.7	15.0	14.7	29.7	24.1	18.6	16.8	16.2	38.7	31.6	22.5	19.4	18.5	53.8	55.0	55.0	35.6	28.2	25.9	55.0	48.6	36.9	33.3			800
DIFF AVG		-1.4	-1.9	-3.7	0.0	-2.2	-3.8	1.8	1.7	-0.1	0.8	0.2	0.1	1.9	1.7	3.9	2.5	-0.8	-0.6	1.0	-0.4	3.9	1.6	-2.3	-5.0	1.8	-3.0	-0.1	2.3	
meas	1000	26.5	17.0	9.1	35.2	11.8	11.9	38.9	28.3	14.4	14.3	13.7	38.9	34.9	17.0	16.8	14.6	53.3	53.1	50.3	25.5	21.4	15.5	52.3	33.6	26.5	17.5			1000
regres	1000	28.8	19.0	11.4	32.7	11.6	13.3	36.7	26.5	15.2	12.5	13.7	42.6	32.1	18.0	14.0	14.3	52.5	55.0	50.8	27.4	18.9	16.4	55.0	36.9	23.8	18.5			1000
DIFF AVG		-2.3	-2.0	-2.3	2.5	0.2	-1.4	2.2	1.8	-0.8	1.8	0.0	-3.7	2.8	-1.0	2.8	0.3	0.8	-1.9	-0.5	-1.9	2.5	-0.9	-2.7	-3.3	2.7	-1.0	-0.2	2.1	
meas	1250	33.8	13.5	7.5	40.4	9.3	9.3	41.9	21.8	12.5	10.8	9.3	42.8	27.1	14.1	12.6	10.4	52.6	54.1	42.4	20.5	16.7	12.0	54.0	26.0	21.6	14.3			1250
regres	1200	36.2	15.4	9.0	38.5	9.4	9.3	40.8	21.2	12.0	10.2	9.7	44.3	25.6	14.2	11.3	10.4	50.1	55.0	40.1	21.6	15.2	12.7	54.7	29.0	19.0	15.0			1200
DIFF AVG		-2.4	-1.9	-1.5	1.9	-0.1	0.0	1.1	0.6	0.5	0.6	-0.4	-1.5	1.5	-0.1	1.3	0.0	2.5	-0.9	2.3	-1.1	1.5	-0.7	-0.7	-3.0	2.6	-0.7	0.0	1.5	
meas	1600	33.9	10.9	6.1	38.1	7.7	7.4	39.5	16.8	9.6	8.4	7.6	40.1	20.0	10.0	9.3	8.5	53.3	53.4	31.4	14.7	11.3	9.8	41.9	18.4	15.1	11.4			1600
regres	1600	34.5	11.8	6.9	36.9	7.7	7.5	39.4	16.2	8.9	8.1	7.8	43.1	19.6	10.3	8.8	8.3	49.2	55.0	30.8	15.1	11.2	10.1	41.9	19.9	13.5	11.8			1600
DIFF AVG		-0.6	-0.9	-0.8	1.2	0.0	-0.1	0.1	0.6	0.7	0.3	-0.2	-3.0	0.4	-0.3	0.5	0.2	4.1	-1.6	0.7	-0.4	0.2	-0.3	0.0	-1.5	1.6	-0.4	0.0	1.2	
meas	2000	26.3	10.4	5.0	33.7	6.1	5.7	36.7	14.4	7.5	6.6	5.7	37.1	16.5	7.0	7.2	6.5	45.0	46.2	23.3	11.3	11.1	9.4	29.8	13.8	14.8	11.3			2000
regres	2000	30.0	11.1	5.4	32.1	5.6	5.5	34.3	13.9	7.0	6.2	6.0	37.5	15.9	8.1	7.1	6.8	42.9	48.4	22.7	11.9	10.0	9.4	29.5	15.7	12.9	12.0			2000
DIFF AVG		-3.7	-0.7	-0.4	1.6	0.5	0.2	2.4	0.5	0.5	0.4	-0.3	-0.4	0.6	-1.1	0.1	-0.3	2.1	-2.2	0.5	-0.6	1.1	0.0	0.3	-1.9	1.9	-0.7	0.0	1.3	
meas	2500	19.7	10.0	6.1	24.0	6.6	6.4	28.9	13.0	9.0	7.4	6.4	34.0	13.6	8.3	8.0	7.6	41.4	43.4	18.2	10.7	8.2	8.2	23.0	12.5	12.1	9.9			2500
regres	2500	21.9	10.5	6.9	24.8	6.8	6.4	27.6	12.4	7.7	7.2	6.7	31.9	13.7	8.4	7.7	7.1	39.0	46.1	18.4	10.5	9.6	8.4	23.0	12.6	11.5	9.8			2500
DIFF AVG		-2.2	-0.5	-0.8	-0.8	-0.2	0.0	1.3	0.6	1.3	0.2	-0.3	2.1	-0.1	-0.1	0.3	0.5	2.4	-2.7	-0.1	0.2	-1.4	-0.2	0.0	-0.1	0.6	0.1	0.0	1.1	
meas	3150	14.7	9.8	5.9	19.4	5.0	6.6	23.2	13.1	8.9	5.4	6.3	28.0	13.5	7.7	5.7	7.0	36.8	40.8	18.6	11.9	7.9	7.7	23.5	14.4	12.3	10.0			3150
regres	3150	16.2	10.6	5.7	19.3	5.4	6.0	22.4	12.5	6.9	5.9	6.3	27.1	14.0	7.8	6.8	6.7	34.9	42.6	18.9	10.9	9.5	8.1	23.7	14.0	12.3	9.5			3150
DIFF AVG		-1.5	-0.8	0.2	0.1	-0.4	0.6	0.8	0.6	2.0	-0.5	0.0	0.9	-0.5	-0.1	-1.1	0.3	1.9	-1.8	-0.3	1.0	-1.6	-0.4	-0.2	0.4	0.0	0.5	0.0	0.9	
meas	4000	12.6	10.8	6.9	15.0	4.7	6.5	19.1	13.6	10.3	5.0	6.3	22.2	13.3	8.6	5.2	7.2	27.0	32.6	15.0	10.7	6.8	7.4	18.8	12.6	11.4	9.4			4000
regres	4000	13.2	11.9	6.6	15.6	5.5	5.9	17.9	12.9	7.4	6.0	6.1	21.3	13.6	8.0	6.6	6.5	27.1	32.9	16.1	10.1	8.9	7.7	18.6	12.1	11.1	8.9			4000
DIFF AVG		-0.6	-1.1	0.3	-0.6	-0.8	0.6	1.2	0.7	2.9	-1.0	0.2	0.9	-0.3	0.6	-1.4	0.7	-0.1	-0.3	-1.1	0.6	-2.1	-0.3	0.2	0.5	0.3	0.5	0.0	1	
meas	5000	12.3	12.0	9.1	15.0	4.7	6.6	17.4	14.8	12.6	5.3	6.7	20.6	12.9	10.1	5.4	7.4	22.2	25.2	16.4	11.9	7.3	7.6	19.6	13.5	12.2	10.3			5000
regres	5000	13.6	13.0	8.0	15.1	6.4	5.8	16.5	13.9	8.8	6.8	6.1	18.7	14.6	9.4	7.4	6.6	22.3	25.9	17.0	11.3	9.5	8.2	19.3	13.3	11.5	9.8			5000
DIFF AVG		-1.3	-1.0	1.1	-0.1	-1.7	0.8	0.9	0.9	3.8	-1.5	0.6	1.9	-1.7	0.7	-2.0	0.8	-0.1	-0.7	-0.6	0.6	-2.2	-0.6	0.3	0.2	0.7	0.5	0.0	1.4	
meas	6300	13.3	12.7	8.7	15.5	4.1	5.9	18.3	15.6	12.1	5.0	6.2	21.8	13.1	9.4	4.7	7.2	22.2	25.4	17.1	11.1	7.6	7.7	21.0	13.2	12.1	10.7			6300
regres	6300	14.6	13.4	7.5	15.9	5.7	5.3	17.3	14.4	8.4	6.2	5.7	19.3	15.2	9.0	6.8	6.3	22.7	26.1	17.8	11.1	9.0	8.3	20.4	13.2	11.3	10.4			6300
DIFF AVG		-1.3	-0.7	1.2	-0.4	-1.6	0.6	1.0	1.2	3.7	-1.2	0.5	2.5	-2.1	0.4	-2.1	0.9	-0.5	-0.7	-0.8	0.1	-1.5	-0.6	0.6	0.0	0.8	0.3	0.0	1.4	
meas	8000	12.6	13.5	8.3	15.1	3.8	5.2	17.3	16.3	11.7	4.9	6.1	20.8	12.8	9.6	5.2	7.2	20.8	23.5	17.2	11.4	8.5	7.8	20.8	13.7	12.3	10.8			8000
regres	8000	14.1	13.9	7.5	15.3	5.5	5.0	16.5	14.8	8.4	6.0	5.5	18.3	15.5	9.1	6.8	6.2	21.3	24.3	17.8	11.4	9.3	8.4	20.1	13.8	11.8	10.6			8000
DIFF AVG		-1.5	-0.4	0.8	-0.2	-1.7	0.2	0.8	1.5	3.3	-1.1	0.6	2.5	-2.7	0.5	-1.6	1.0	-0.5	-0.8	-0.6	0.0	-0.8	-0.6	0.7	-0.1	0.5	0.2	0.0	1.3	
meas	10000	10.1	14.0	7.1	12.8	3.3	3.9	15.0	16.9	10.3	4.9	5.5	17.2	12.4	9.4	6.1	6.7	15.4	16.1	15.5	11.4	10.8	8.2	17.7	13.7	12.3	11.2			10000
regres	10000	10.5	14.3	7.3	12.5	4.9	4.4	14.5	14.7	8.2	5.5	4.9	17.5	15.1	8.9	6.5	5.7	22.5	27.6	16.1	11.3	9.9	8.4	17.2	13.6	13.2	11.1			10000
DIFF AVG		-0.4	-0.3	-0.2	0.3	-1.6	-0.5	0.5	2.2	2.1	-0.6	0.6	-0.3	-2.7	0.5	-0.4	1.0	-7.1	-11.5	-0.6	0.1	0.9	-0.2	0.5	0.1	-0.9	0.1	-0.7	2.8	

meas - Measured IL Values

DIF AVG - Calculation of the average of the differneces between measured and calculated IL values

Flanking Insertion Loss Reached

Regress - Calculated IL Values from Regression Equations

STD - Calculation of the standard deviation relative to the DIFF AVG

Figure E.78: Data Comparison for 1-in Round Ducts

APPENDIX F UNLV DATA FOR 2-IN ROUND DUCTS

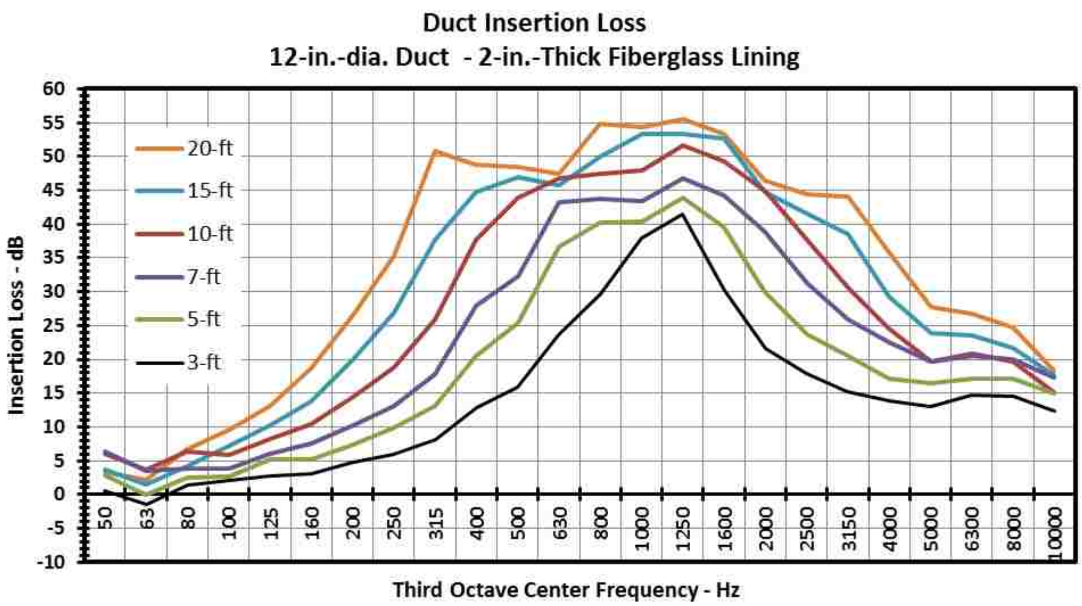

Figure F.1: Insertion Loss for 12-in ducts with 2-in Fiberglass

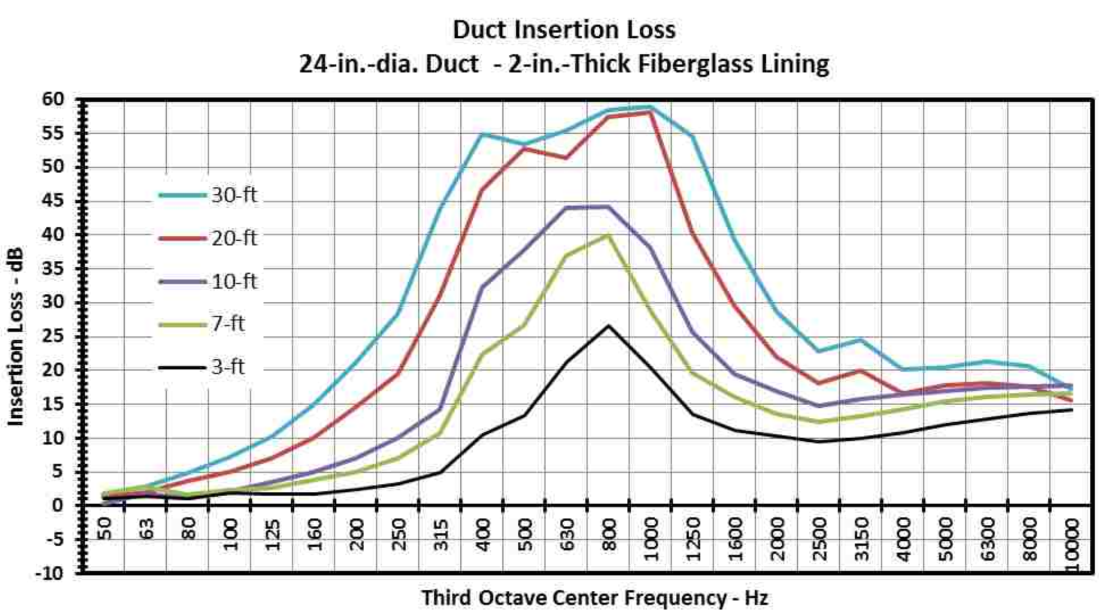

Figure F.2: Insertion Loss for 24-in ducts with 2-in Fiberglass

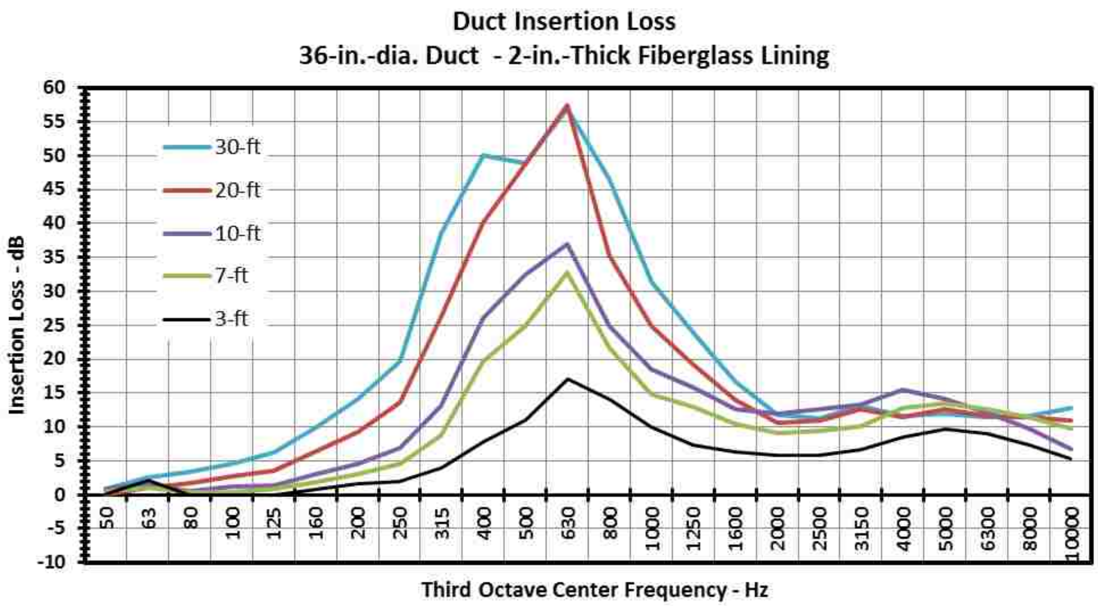

Figure F.3: Insertion Loss for 36-in ducts with 2-in Fiberglass

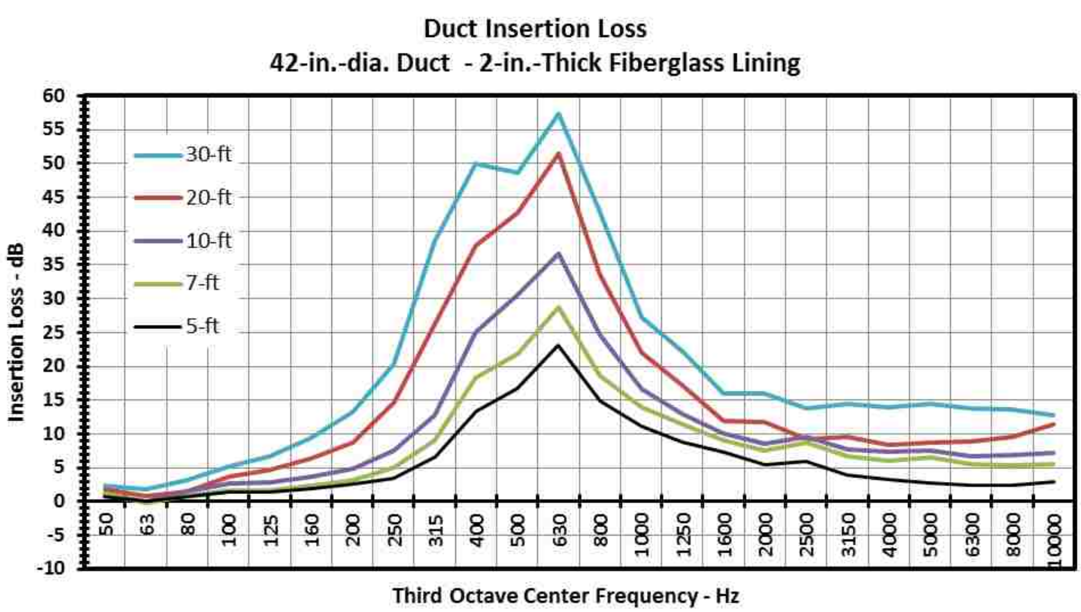

Figure F.4: Insertion Loss for 42-in ducts with 2-in Fiberglass

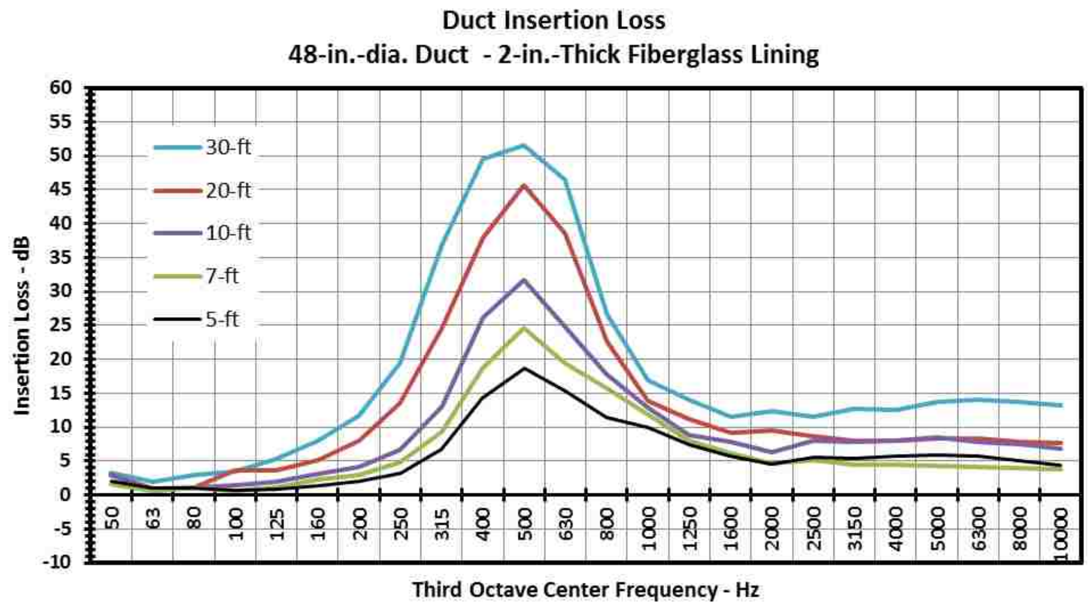

Figure F.5: Insertion Loss for 48-in ducts with 2-in Fiberglass

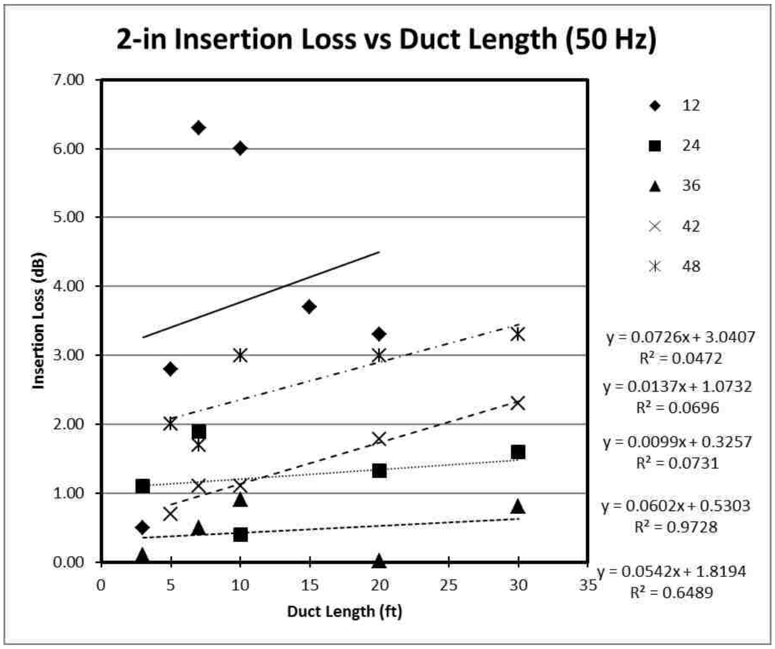

Figure F.6: 2-in Insertion Loss vs Duct Length at 50 Hz

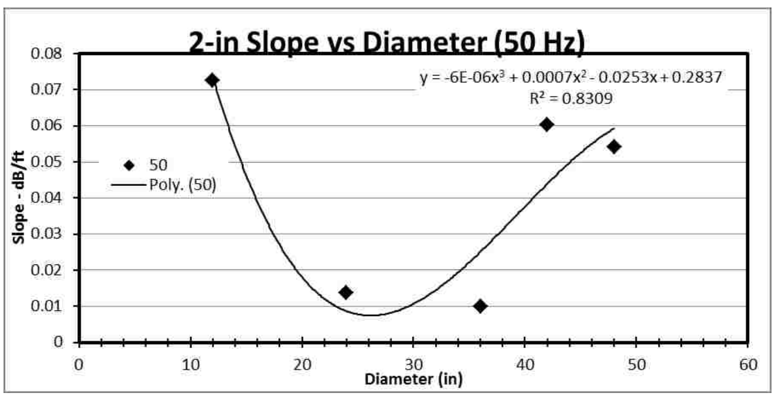

Figure F.7: 2-in Slope vs Diameter at 50 Hz

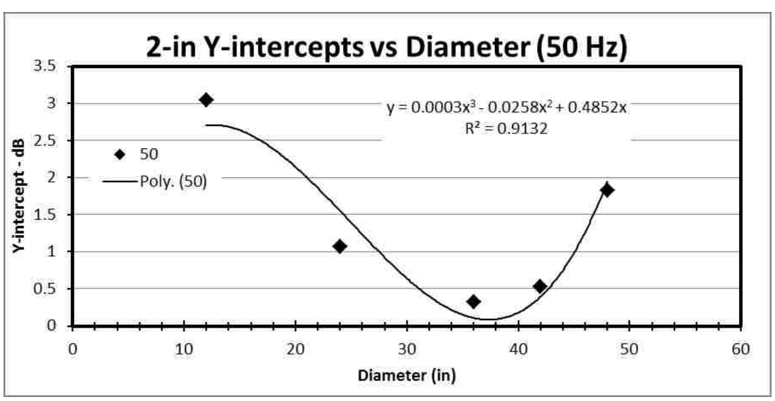

Figure F.8: 2-in Y-intercepts vs Diameter at 50 Hz

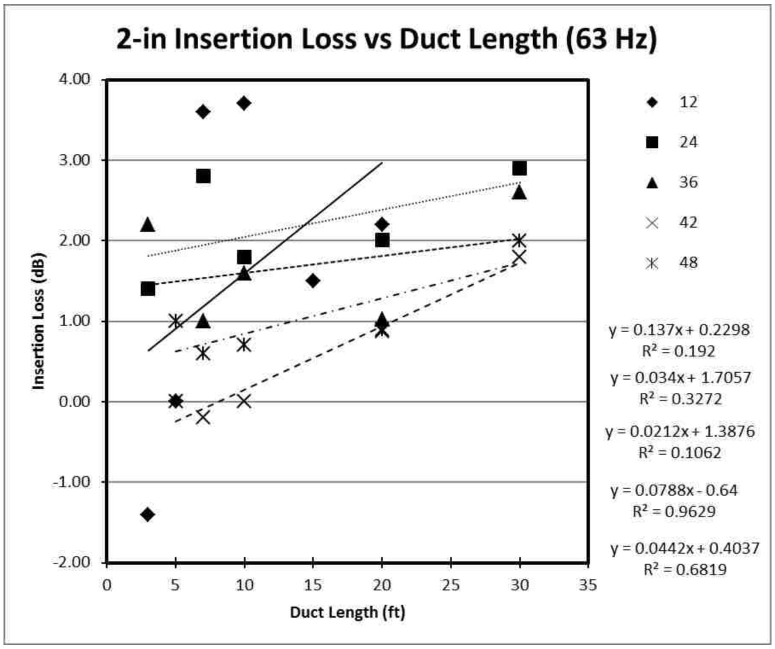

Figure F.9: 2-in Insertion Loss vs Duct Length at 63 Hz

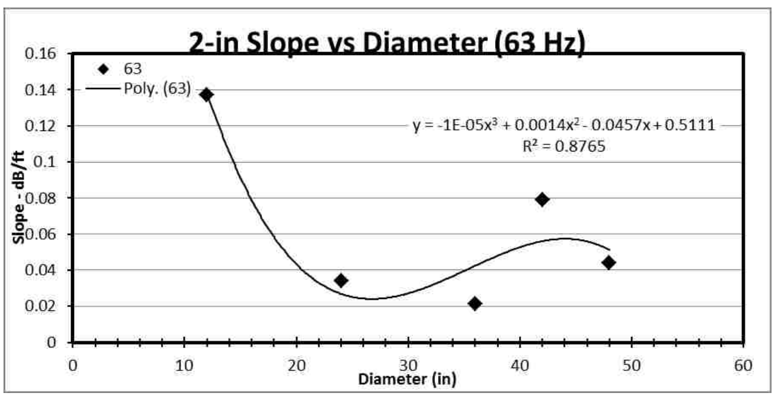

Figure F.10: 2-in Slope vs Diameter at 63 Hz

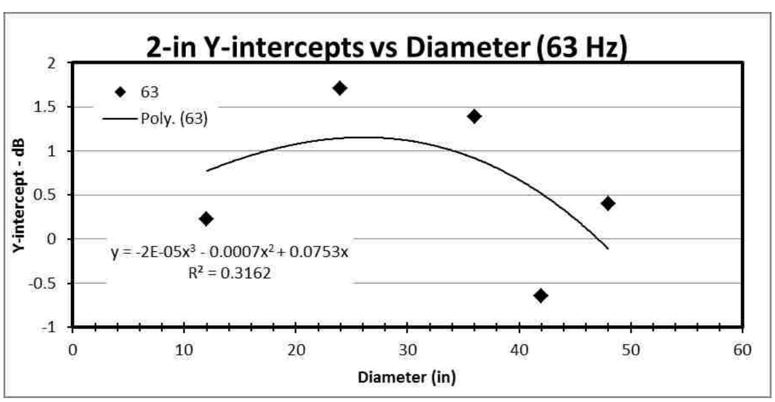

Figure F.11: 2-in Y-intercepts vs Diameter at 63 Hz

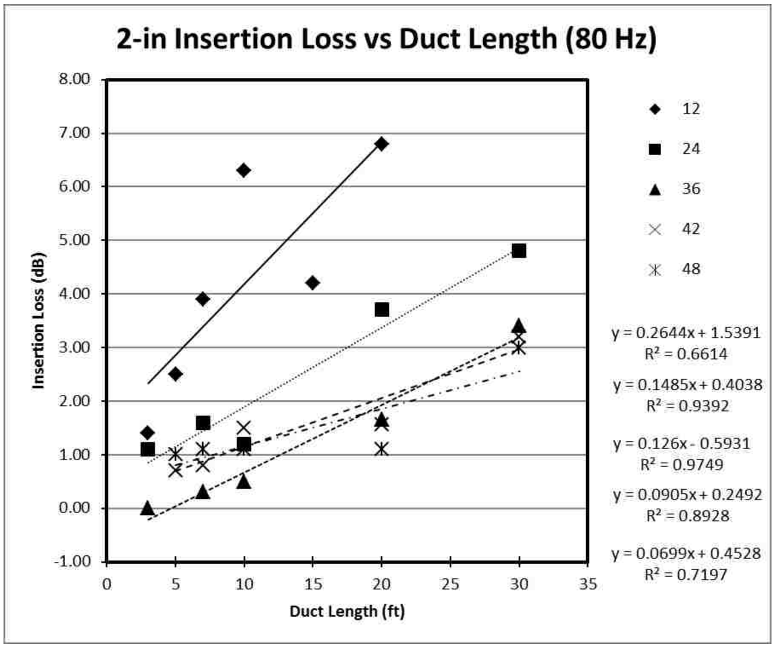

Figure F.12: 2-in Insertion Loss vs Duct Length at 80 Hz

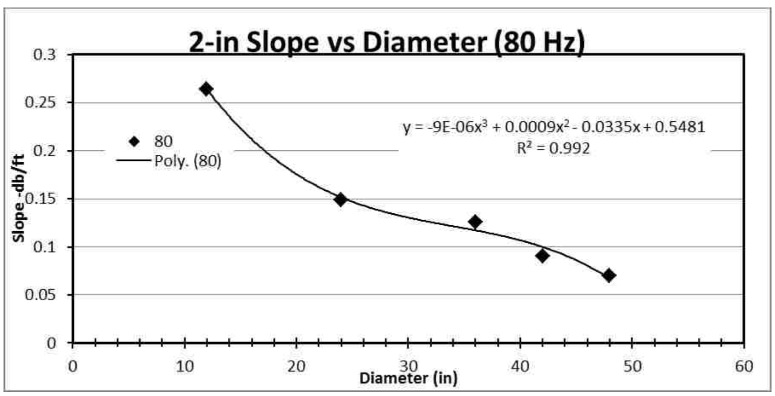

Figure F.13: 2-in Slope vs Diameter at 80 Hz

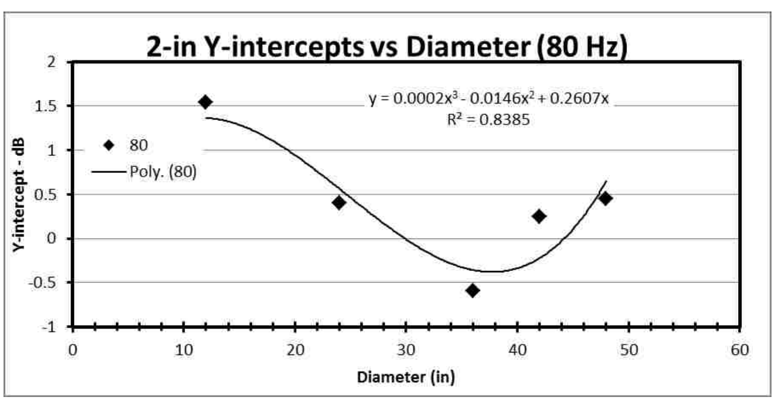

Figure F.14: 2-in Y-intercepts vs Diameter at 80 Hz

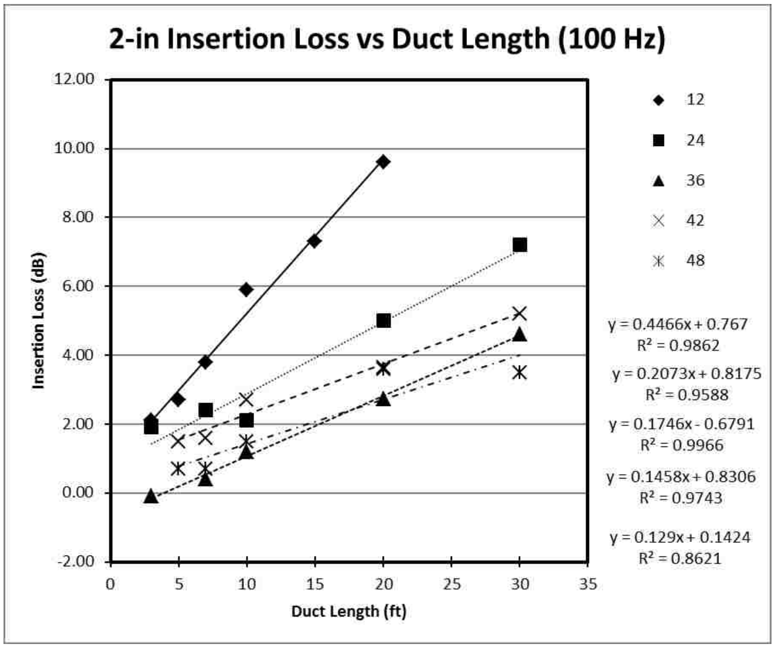

Figure F.15: 2-in Insertion Loss vs Duct Length at 100 Hz

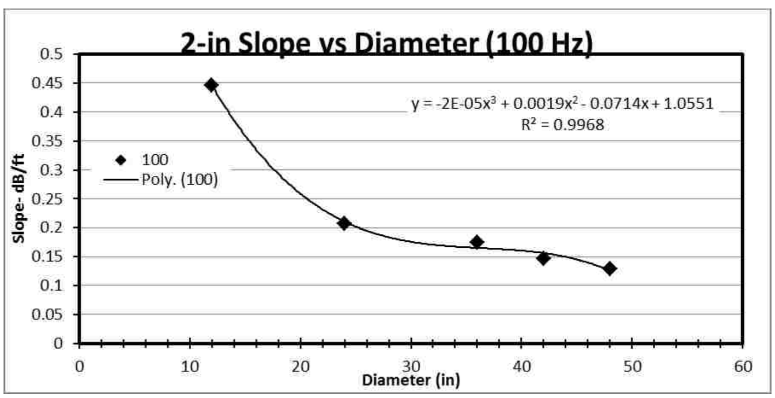

Figure F.16: 2-in Slope vs Diameter at 100 Hz

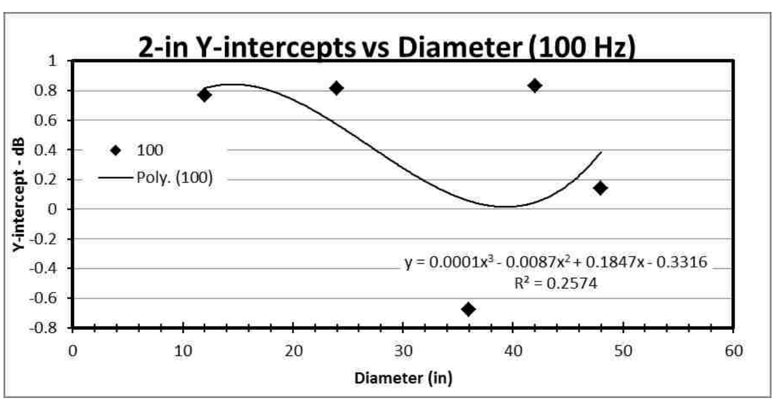

Figure F.17: 2-in Y-intercepts vs Diameter at 100 Hz

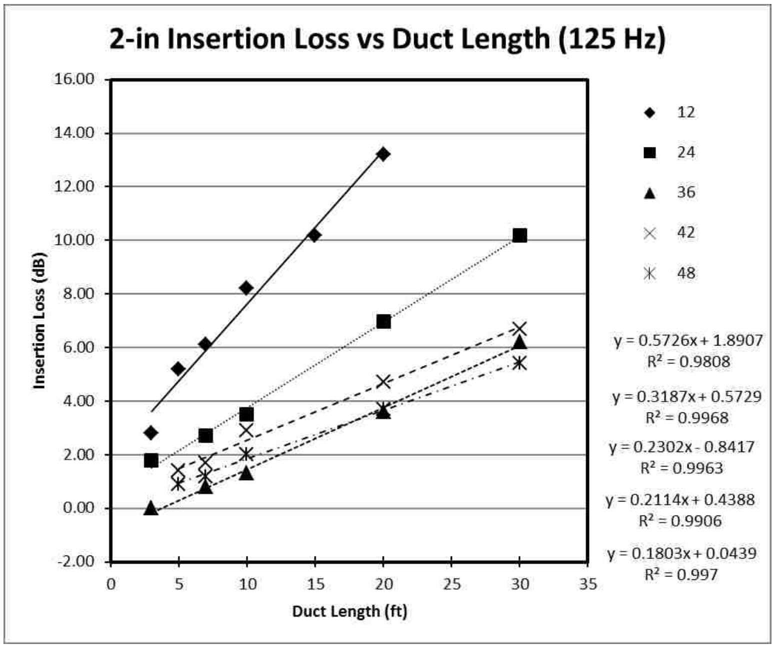

Figure F.18: 2-in Insertion Loss vs Duct Length at 125 Hz

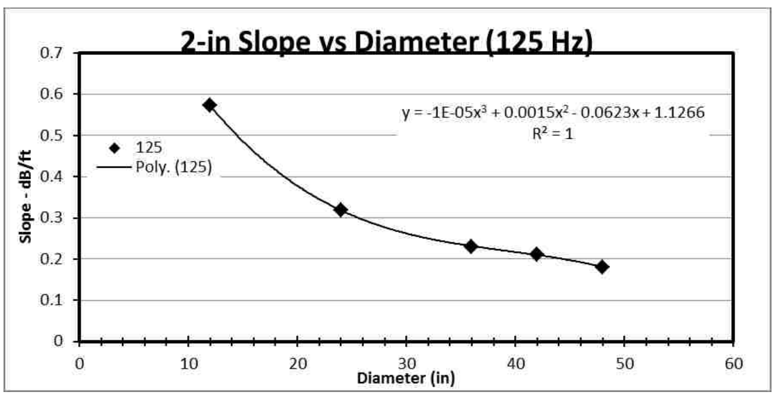

Figure F.19: 2-in Slope vs Diameter at 125 Hz

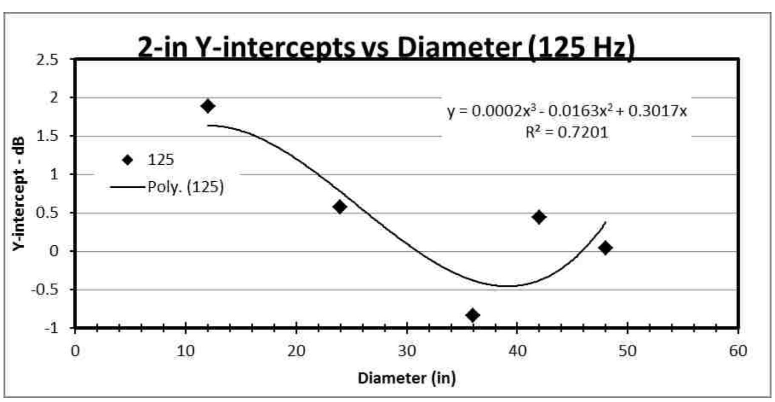

Figure F.20: 2-in Y-intercepts vs Diameter at 125 Hz

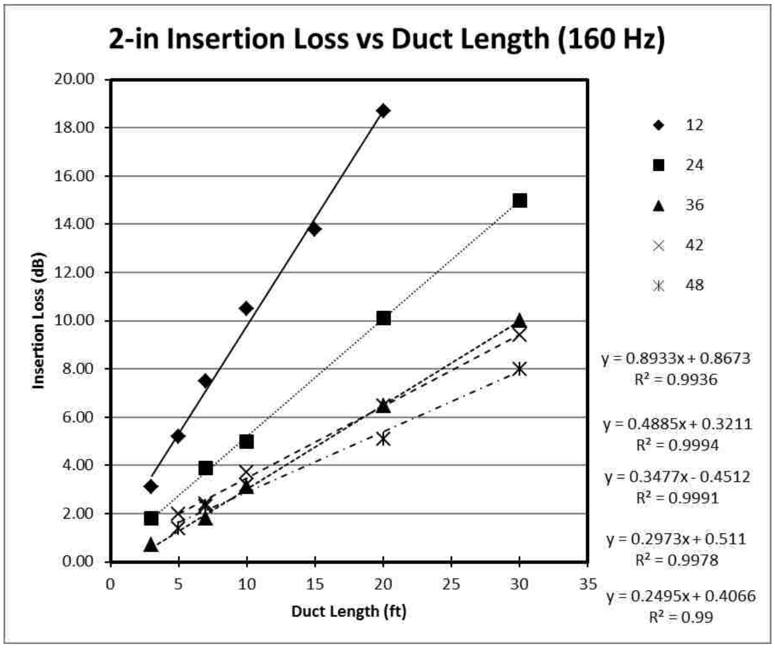

Figure F.21: 2-in Insertion Loss vs Duct Length at 160 Hz

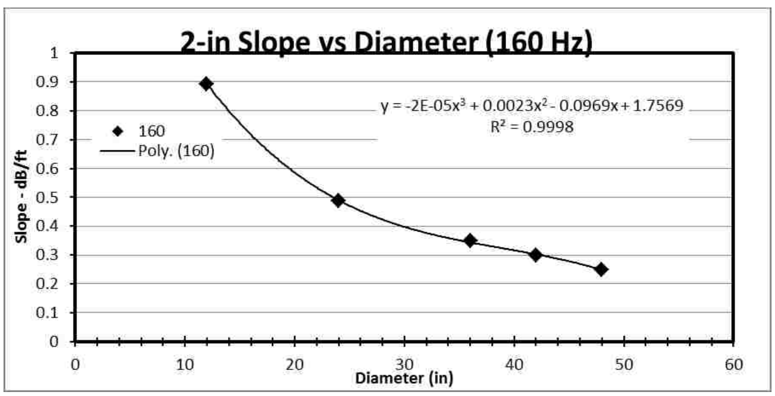

Figure F.22: 2-in Slope vs Diameter at 160 Hz

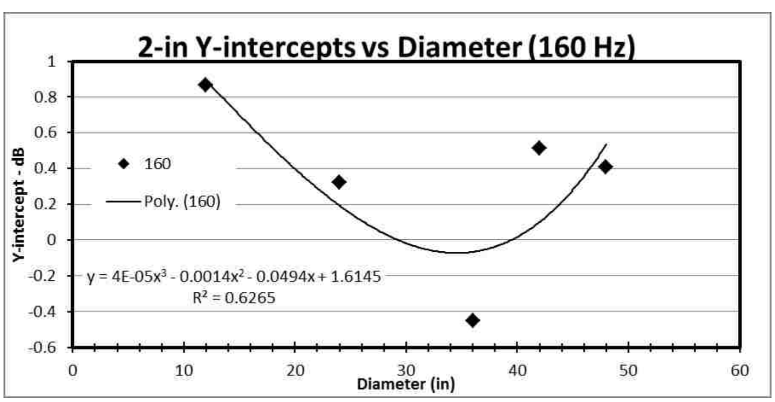

Figure F.23: 2-in Y-intercepts vs Diameter at 160 Hz

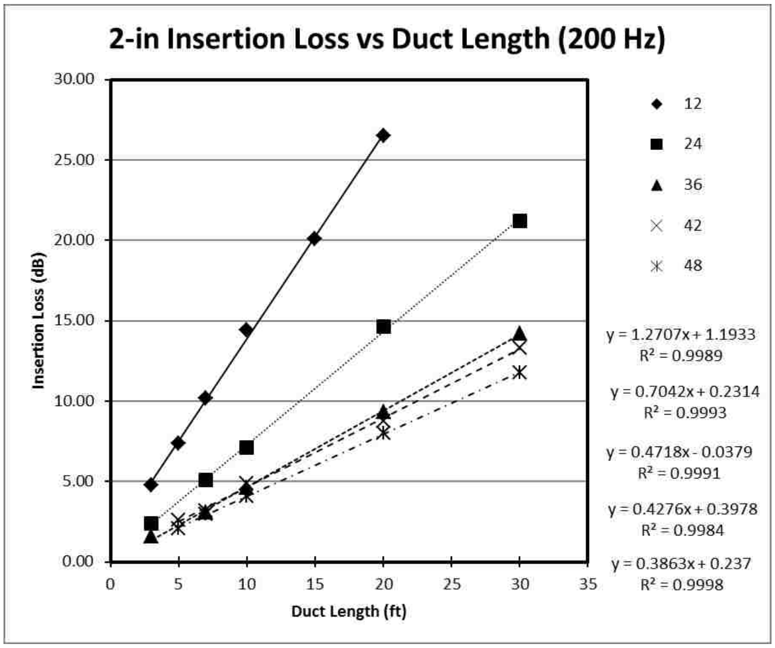

Figure F.24: 2-in Insertion Loss vs Duct Length at 200 Hz

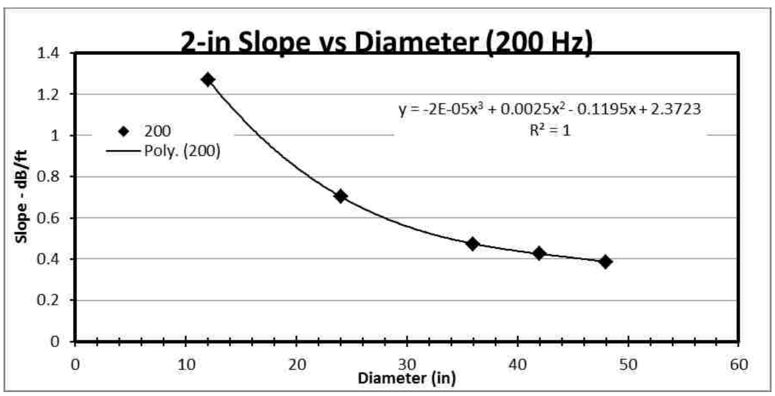

Figure F.25: 2-in Slope vs Diameter at 200 Hz

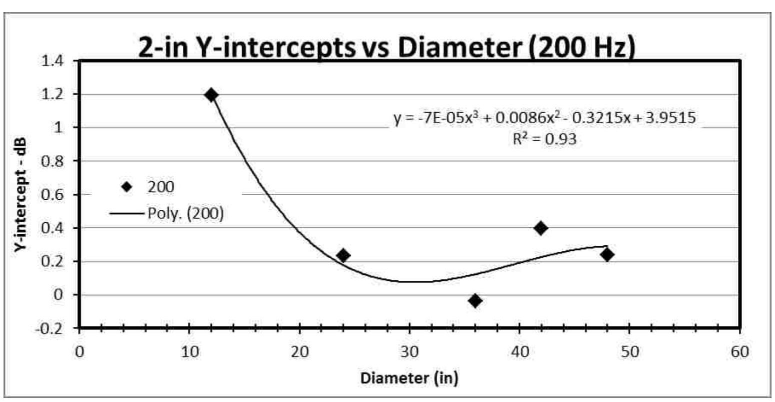

Figure F.26: 2-in Y-intercepts vs Diameter at 200 Hz

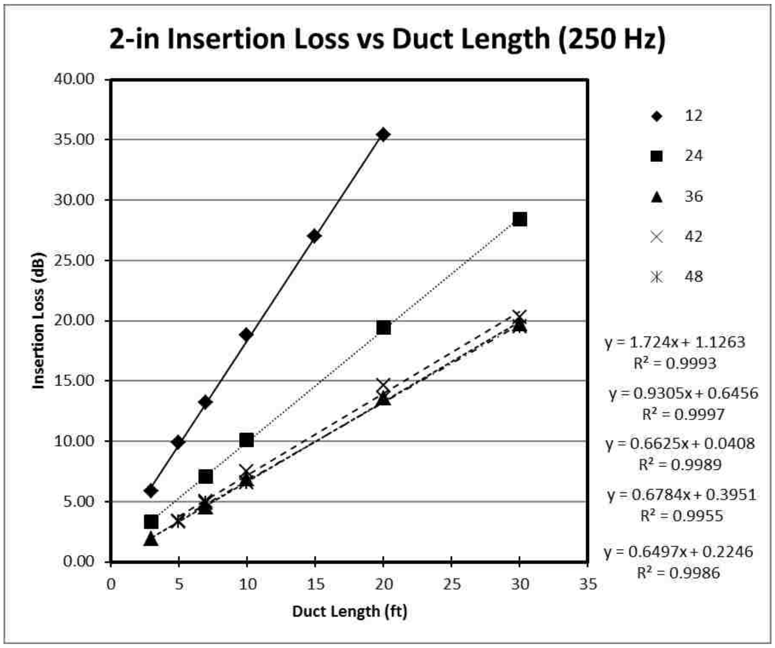

Figure F.27: 2-in Insertion Loss vs Duct Length at 250 Hz

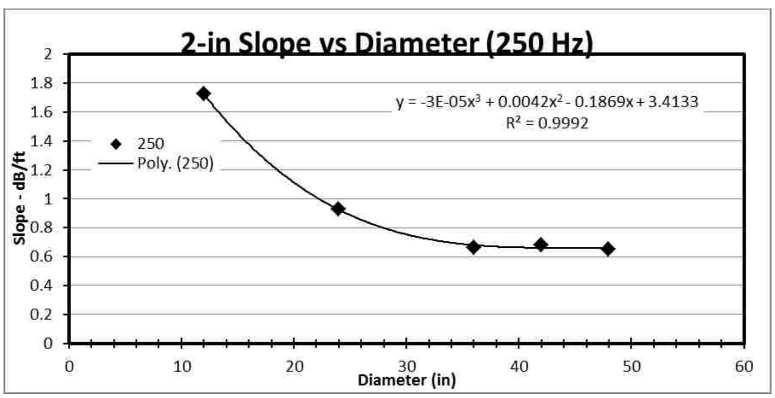

Figure F.28: 2-in Slope vs Diameter at 250 Hz

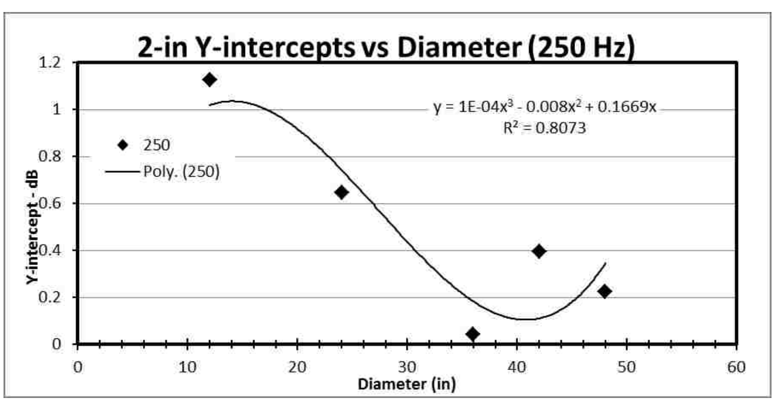

Figure F.29: 2-in Y-intercepts vs Diameter at 250 Hz

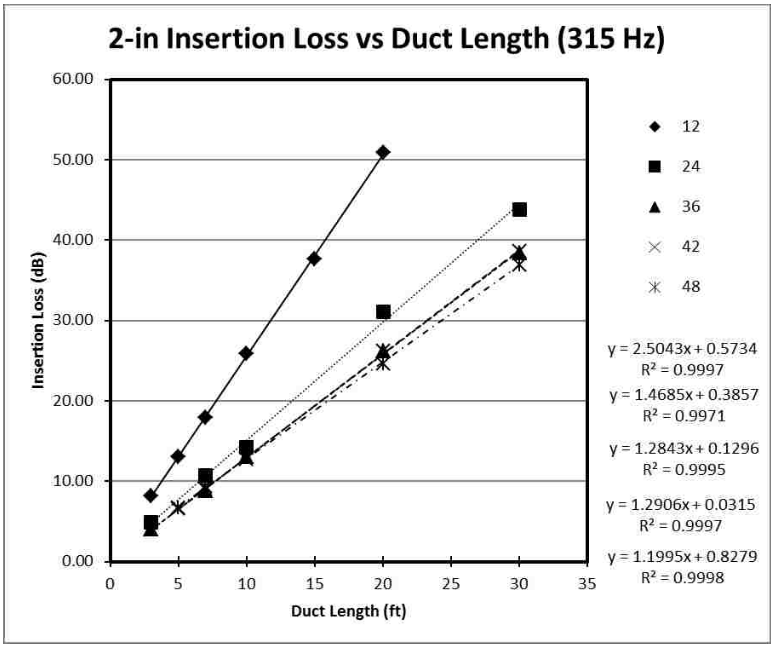

Figure F.30: 2-in Insertion Loss vs Duct Length at 315 Hz

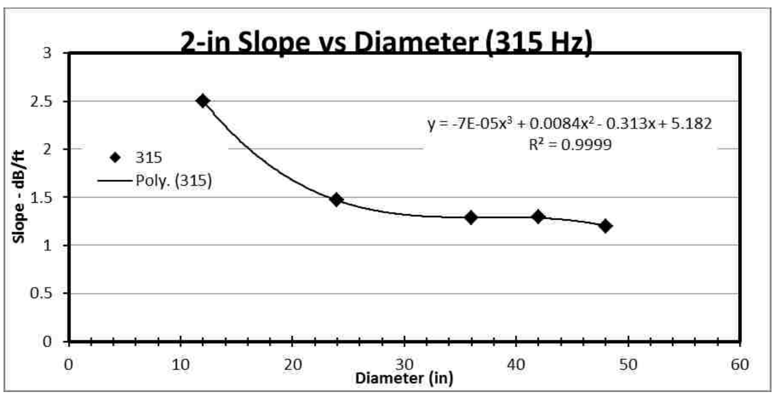

Figure F.31: 2-in Slope vs Diameter at 315 Hz

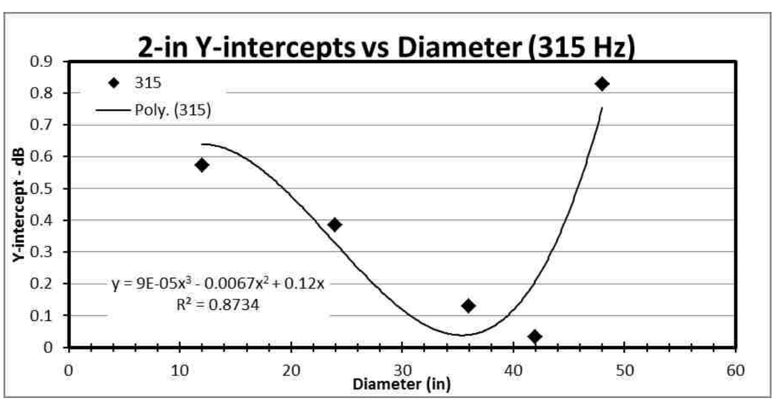

Figure F.32: 2-in Y-intercepts vs Diameter at 315 Hz

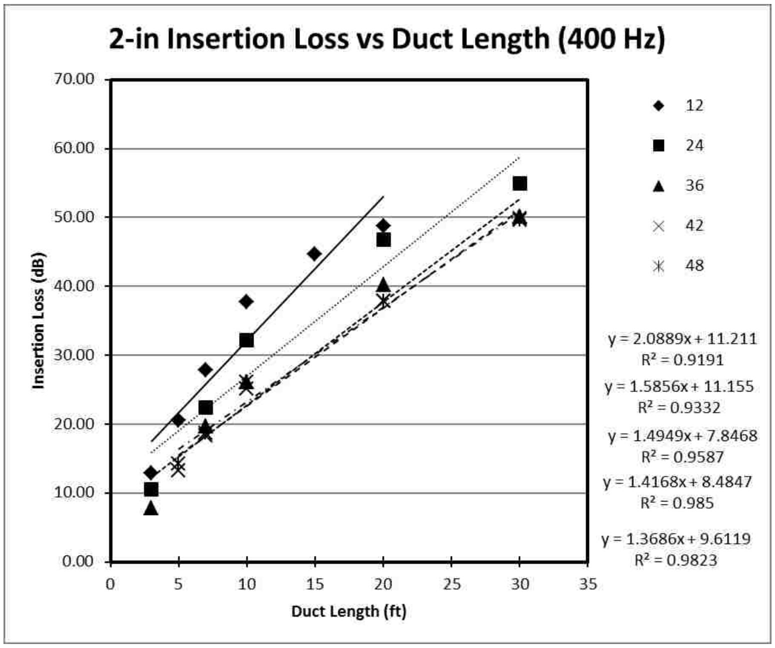

Figure F.33: 2-in Insertion Loss vs Duct Length at 400 Hz

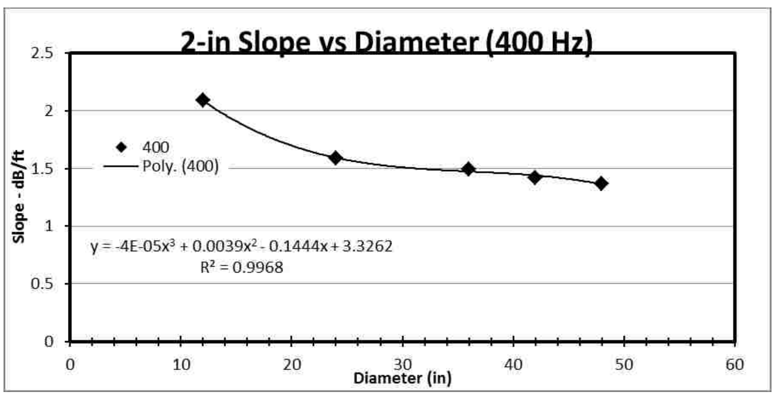

Figure F.34: 2-in Slope vs Diameter at 400 Hz

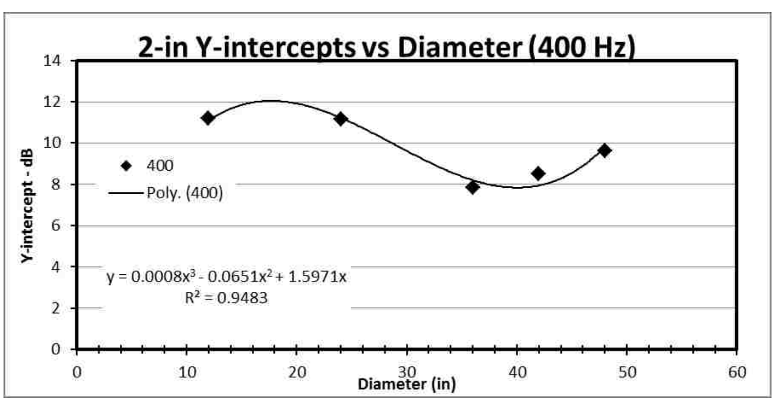

Figure F.35: 2-in Y-intercepts vs Diameter at 400 Hz

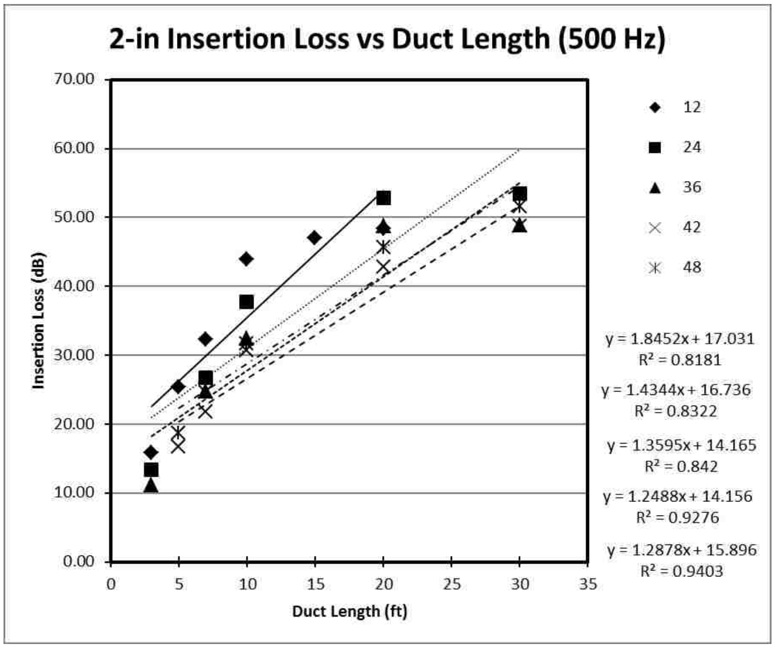

Figure F.36: 2-in Insertion Loss vs Duct Length at 500 Hz

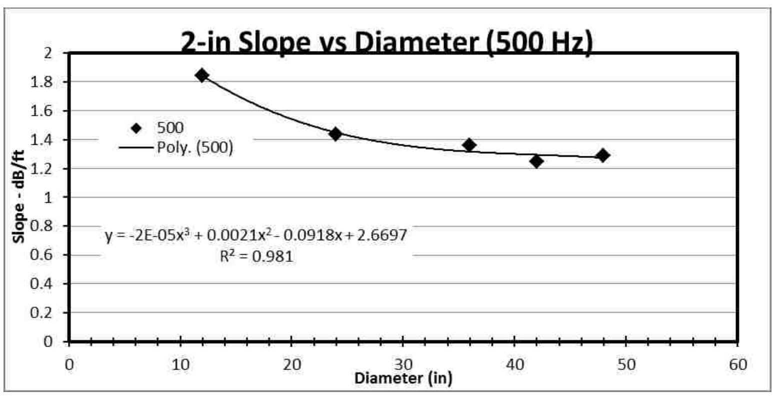

Figure F.37: 2-in Slope vs Diameter at 500 Hz

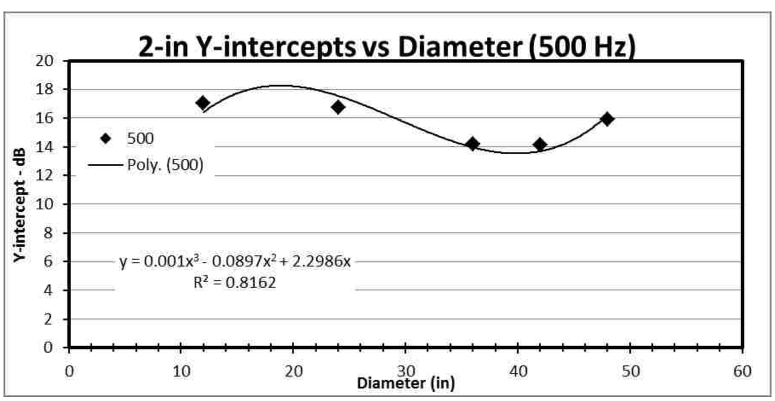

Figure F.38: 2-in Y-intercepts vs Diameter at 500 Hz

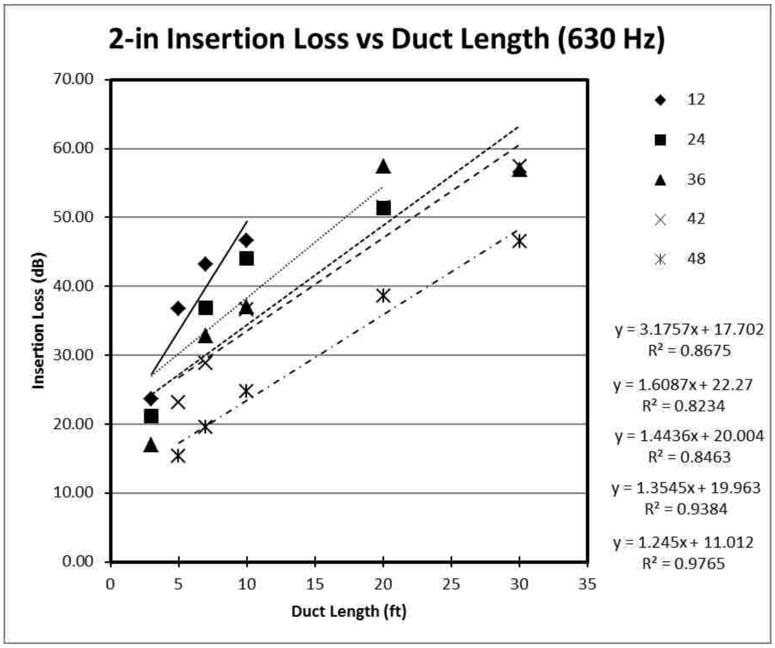

Figure F.39: 2-in Insertion Loss vs Duct Length at 630 Hz

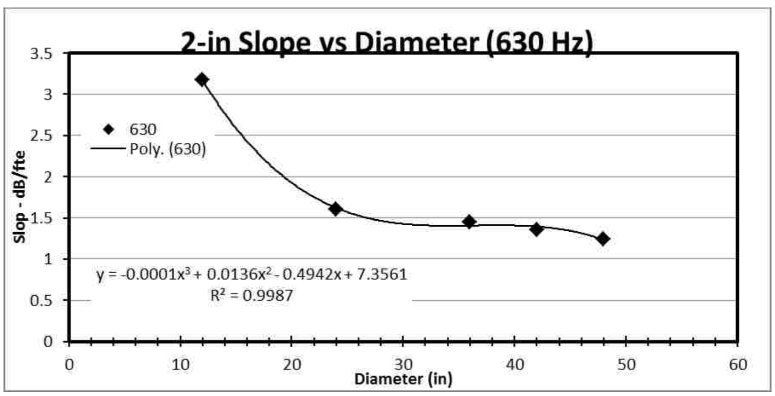

Figure F.40: 2-in Slope vs Diameter at 630 Hz

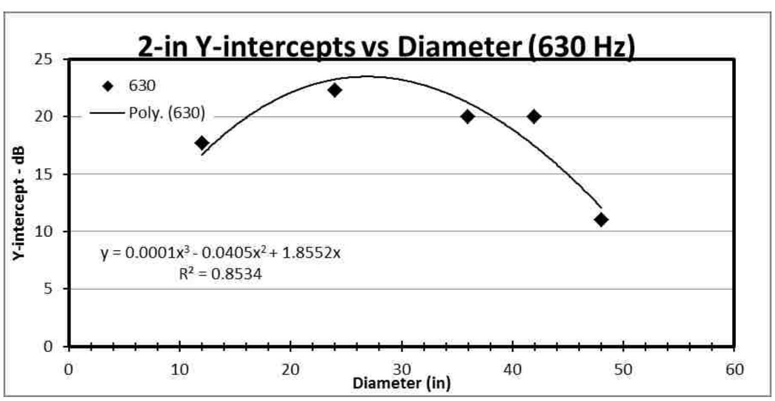

Figure F.41: 2-in Y-intercepts vs Diameter at 630 Hz

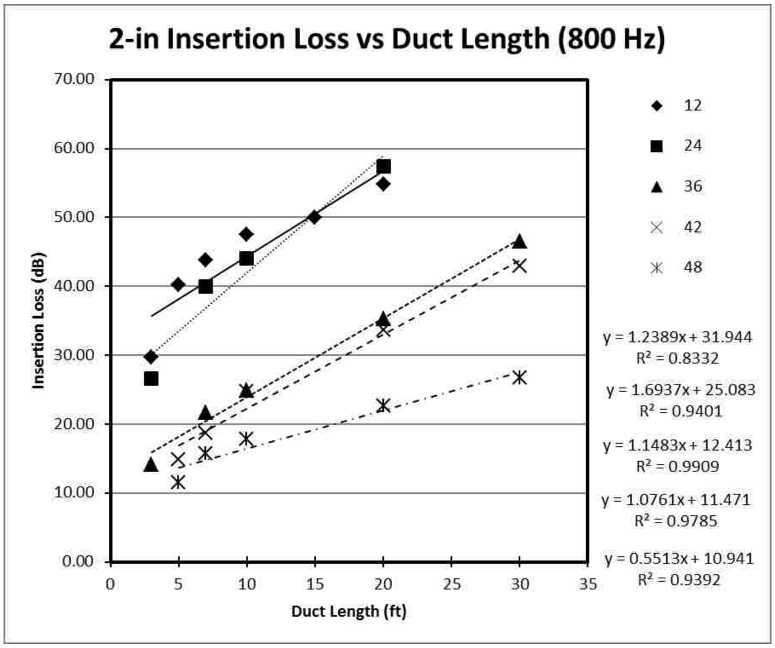

Figure F.42: 2-in Insertion Loss vs Duct Length at 800 Hz

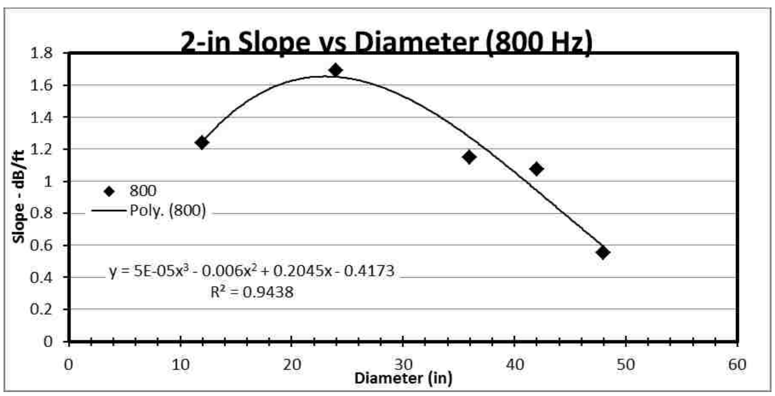

Figure F.43: 2-in Slope vs Diameter at 800 Hz

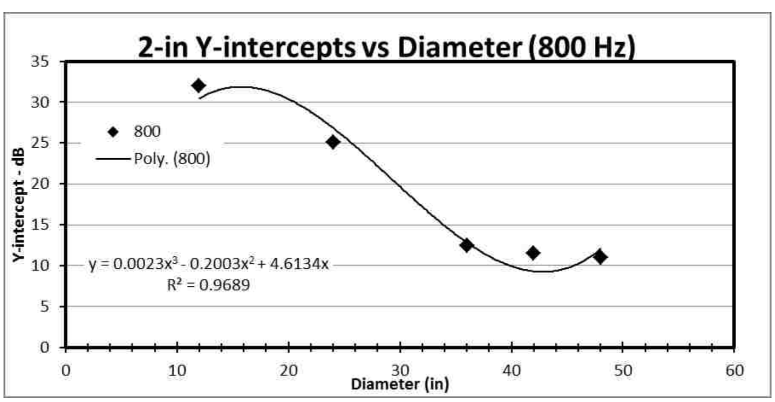

Figure F.44: 2-in Y-intercepts vs Diameter at 800 Hz

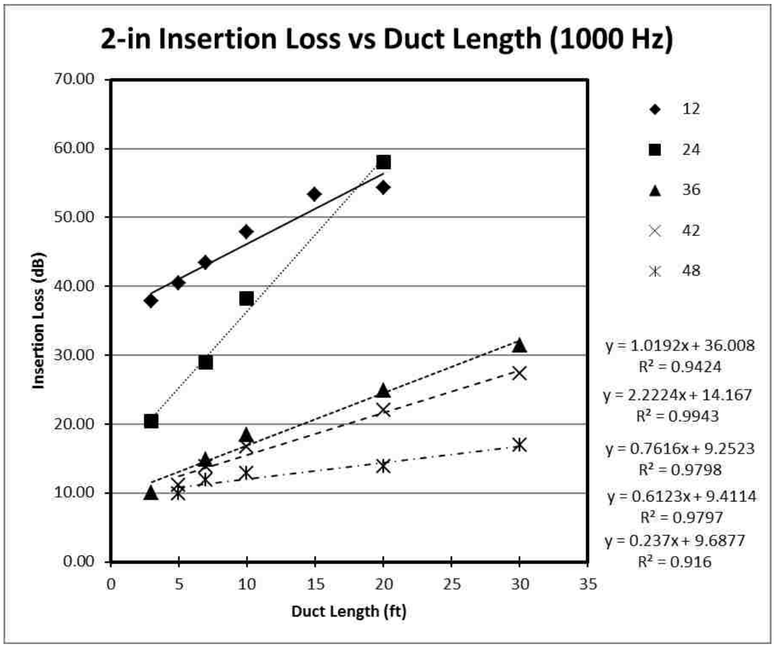

Figure F.45: 2-in Insertion Loss vs Duct Length at 1000 Hz

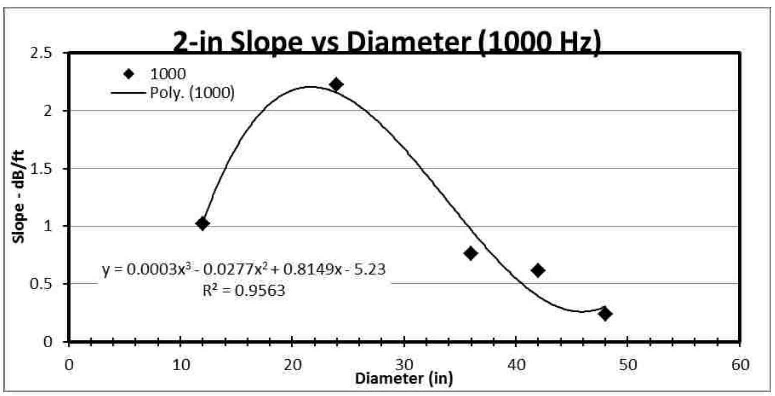

Figure F.46: 2-in Slope vs Diameter at 1000 Hz

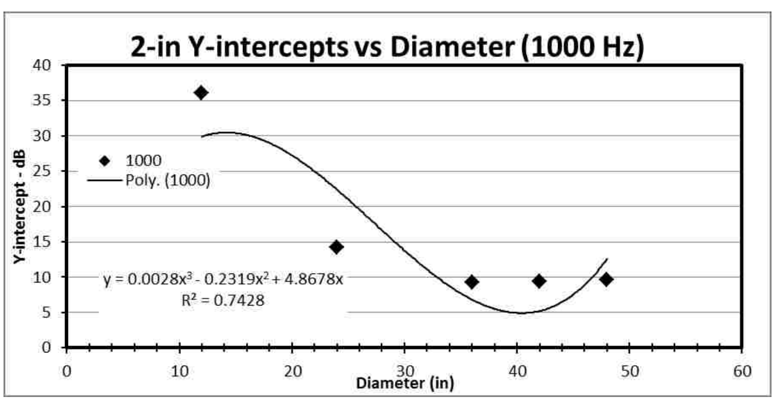

Figure F.47: 2-in Y-intercepts vs Diameter at 1000 Hz

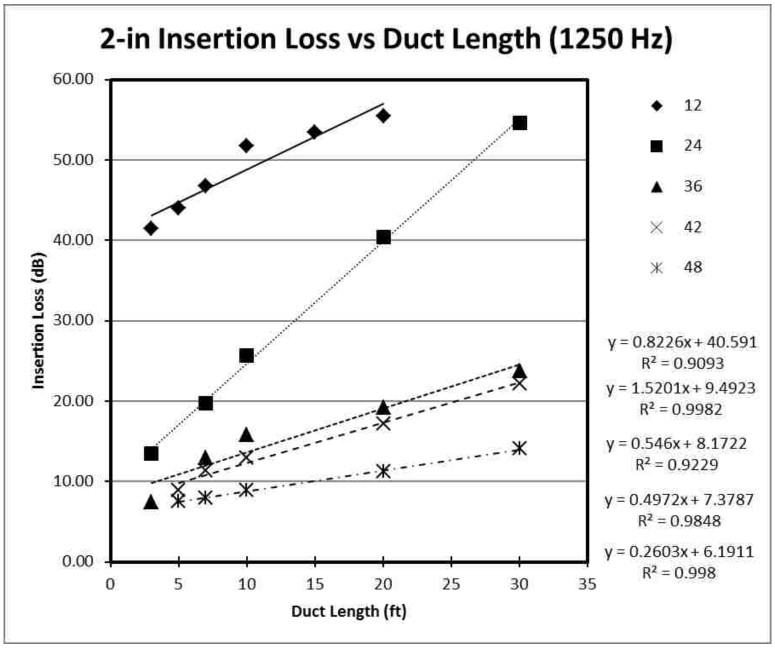

Figure F.48: 2-in Insertion Loss vs Duct Length at 1250 Hz

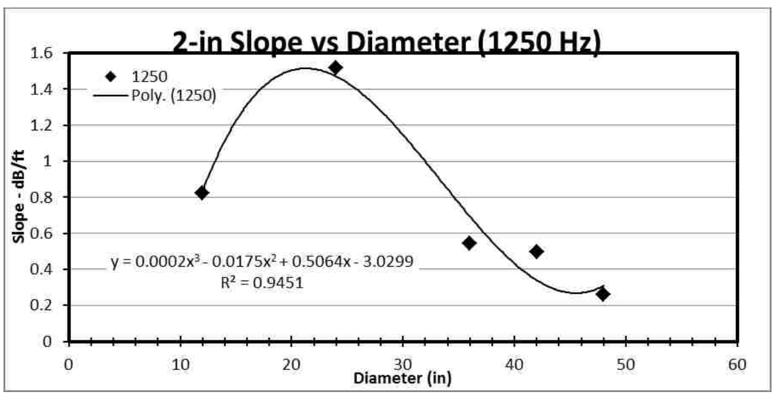

Figure F.49: 2-in Slope vs Diameter at 1250 Hz

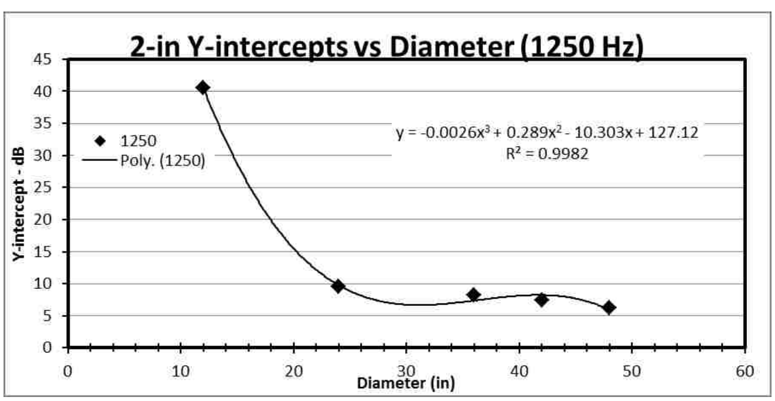

Figure F.50: 2-in Y-intercepts vs Diameter at 1250 Hz

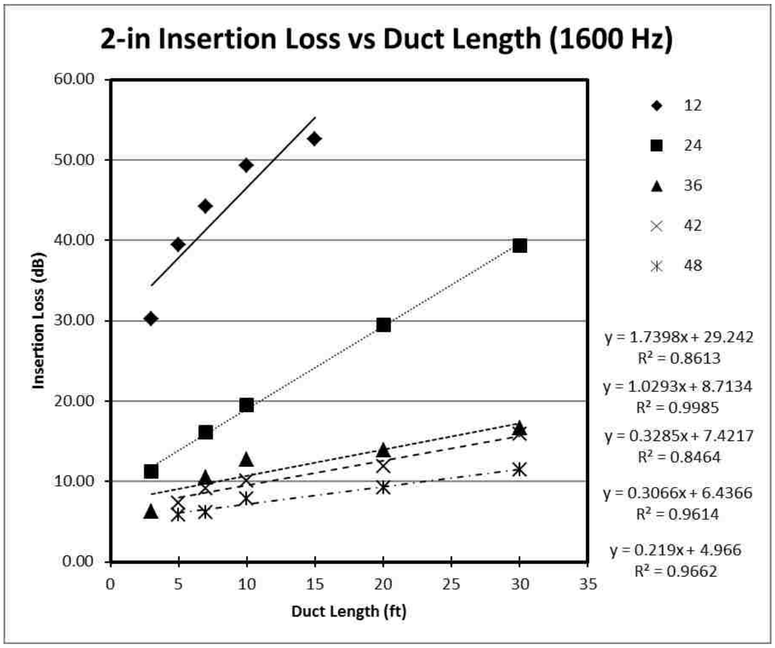

Figure F.51: 2-in Insertion Loss vs Duct Length at 1600 Hz

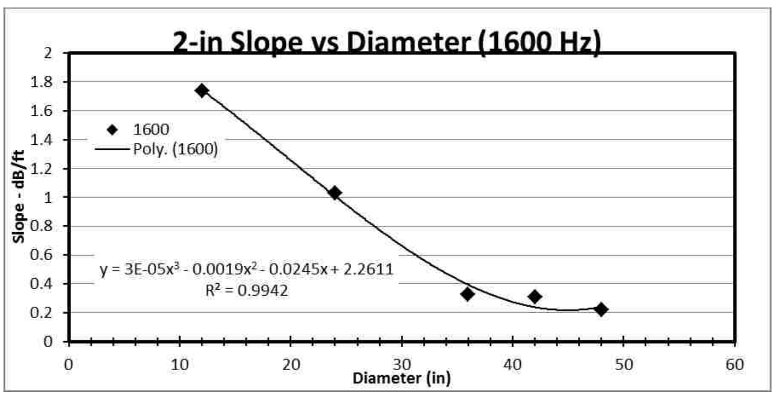

Figure F.52: 2-in Slope vs Diameter at 1600 Hz

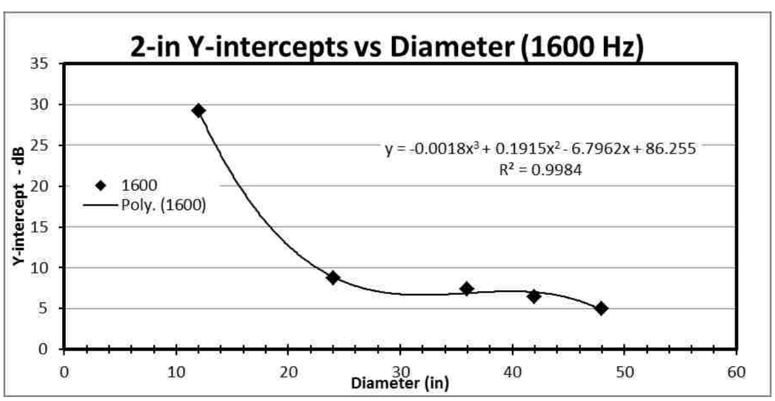

Figure F.53: 2-in Y-intercepts vs Diameter at 1600 Hz

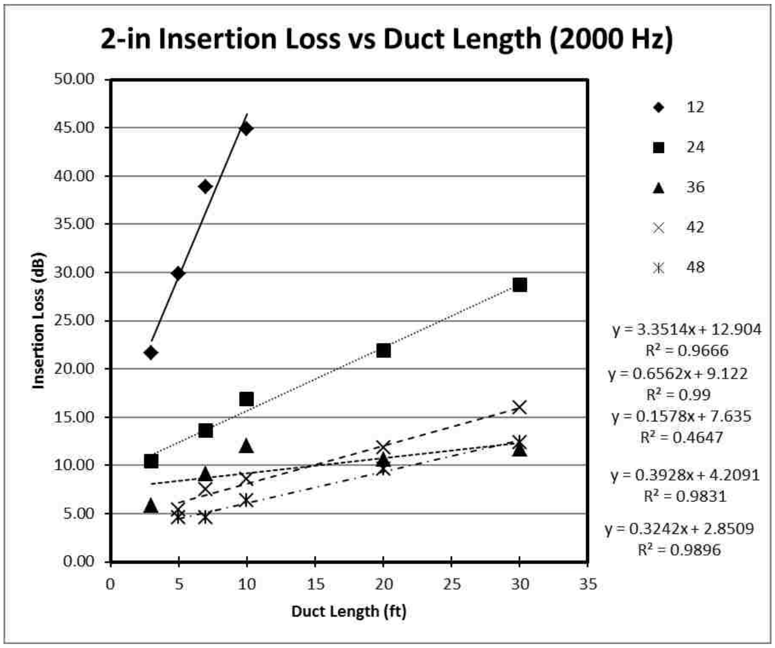

Figure F.54: 2-in Insertion Loss vs Duct Length at 2000 Hz

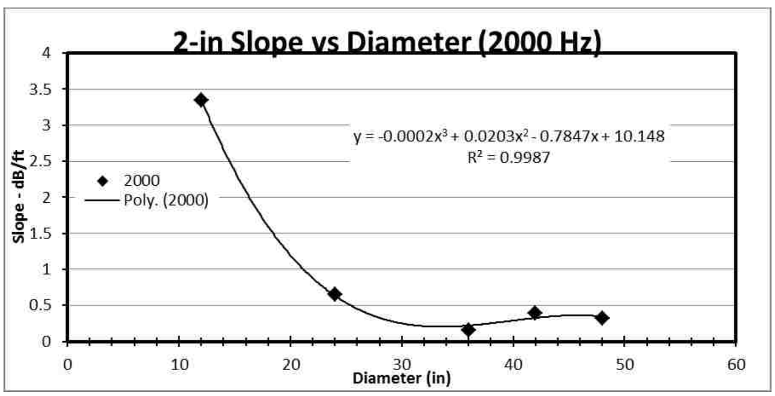

Figure F.55: 2-in Slope vs Diameter at 2000 Hz

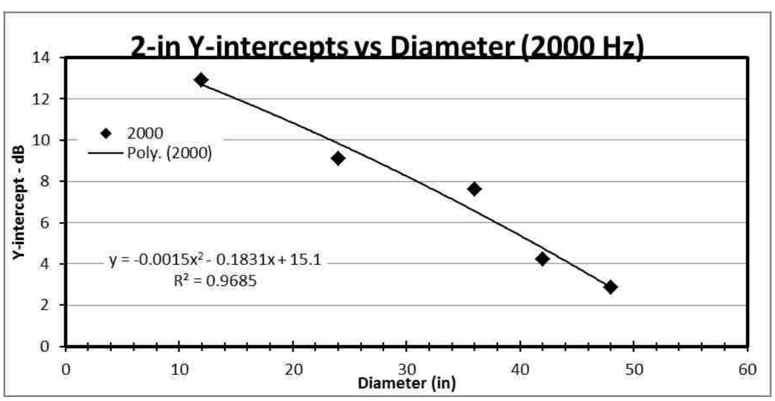

Figure F.56: 2-in Y-intercepts vs Diameter at 2000 Hz

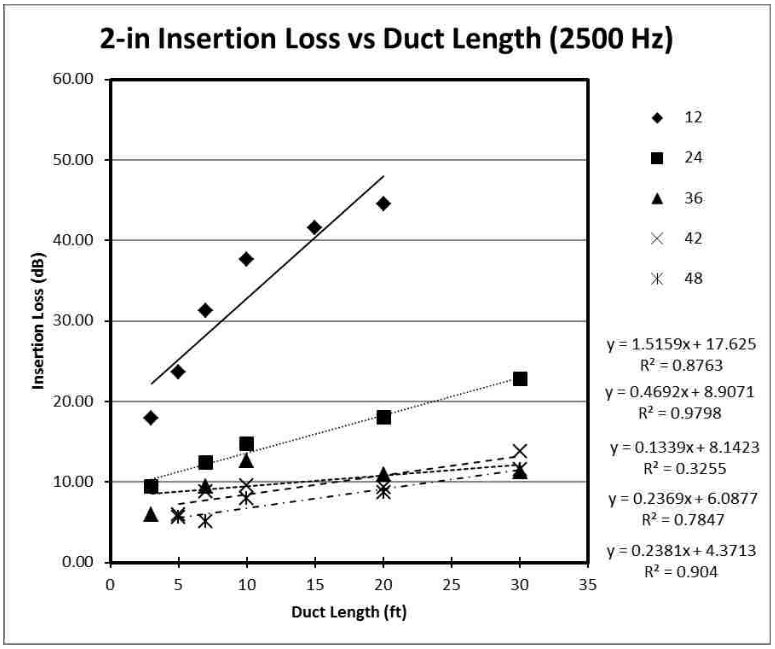

Figure F.57: 2-in Insertion Loss vs Duct Length at 2500 Hz

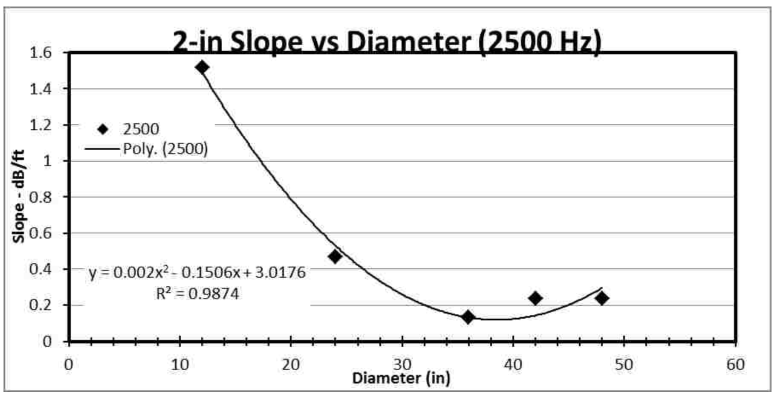

Figure F.58: 2-in Slope vs Diameter at 2500 Hz

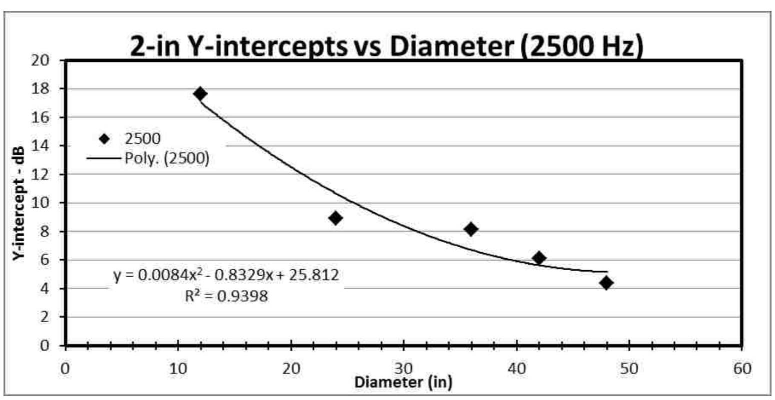

Figure F.59: 2-in Y-intercepts vs Diameter at 2500 Hz

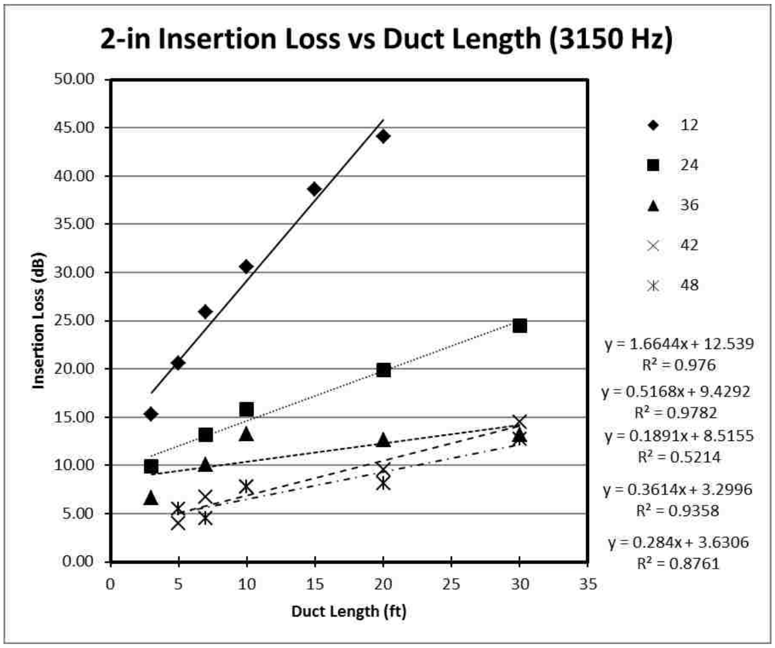

Figure F.60: 2-in Insertion Loss vs Duct Length at 3150 Hz

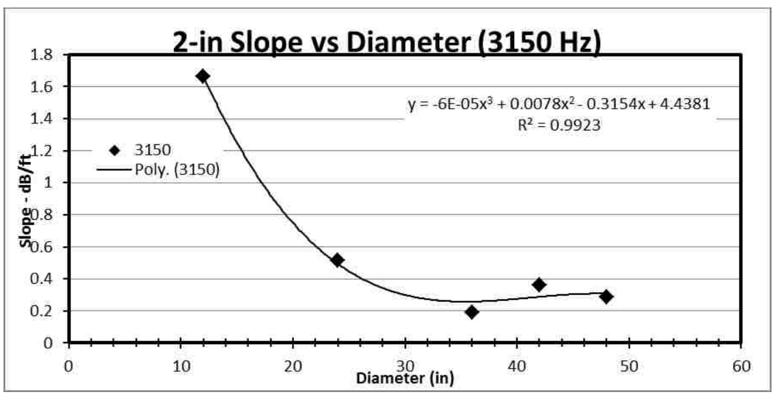

Figure F.61: 2-in Slope vs Diameter at 3150 Hz

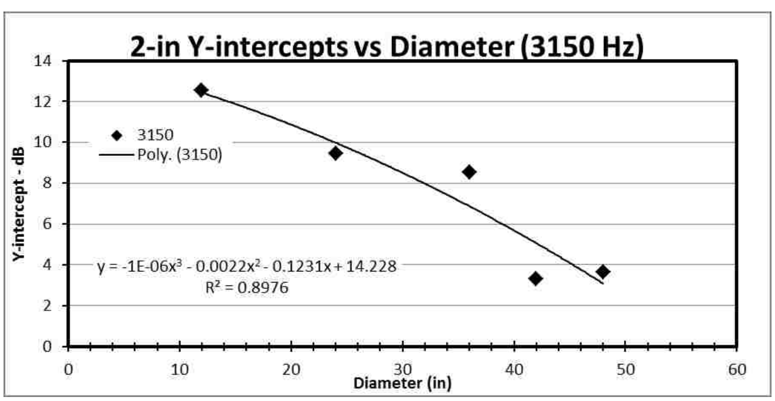

Figure F.62: 2-in Y-intercepts vs Diameter at 3150 Hz

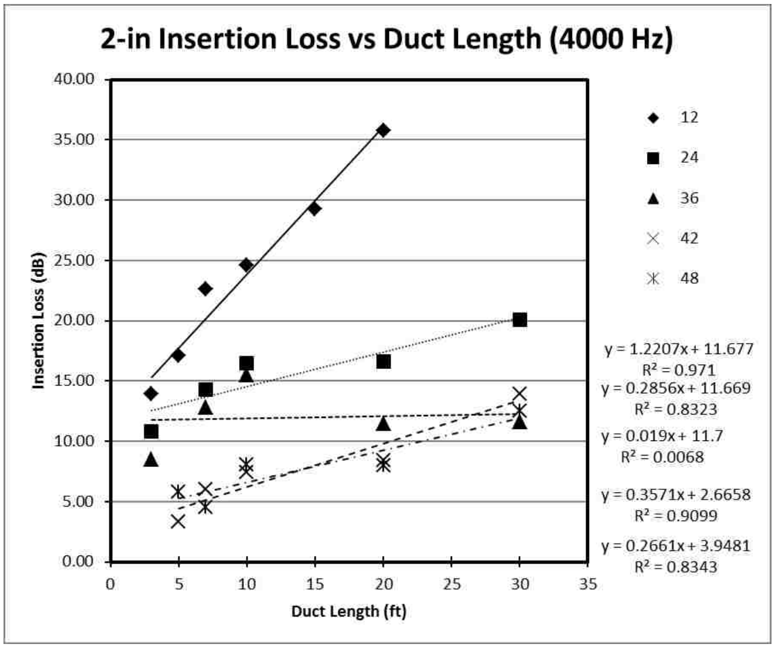

Figure F.63: 2-in Insertion Loss vs Duct Length at 4000 Hz

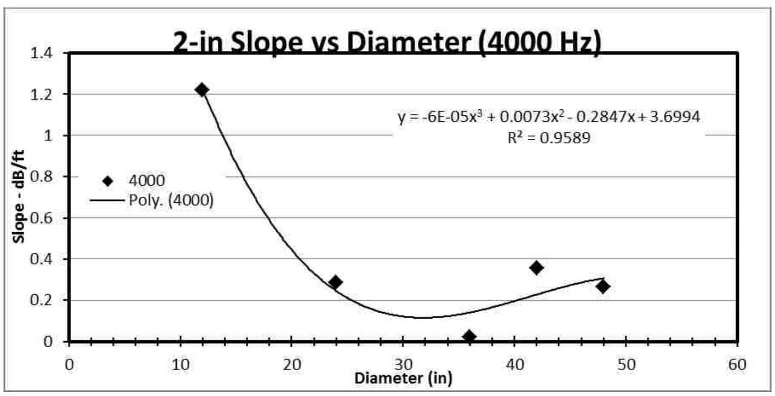

Figure F.64: 2-in Slope vs Diameter at 4000 Hz

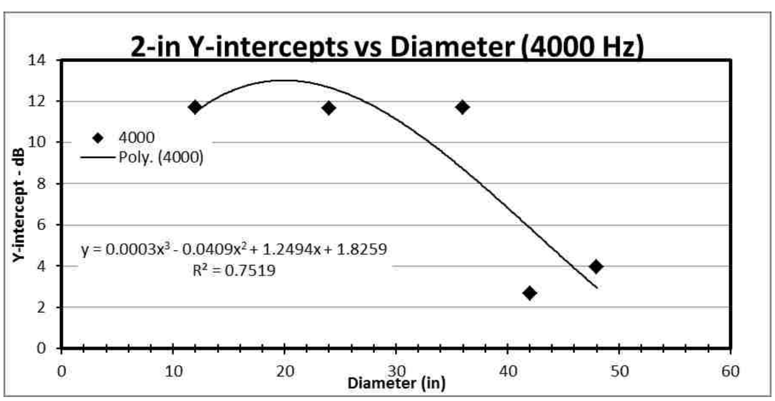

Figure F.65: 2-in Y-intercepts vs Diameter at 4000 Hz

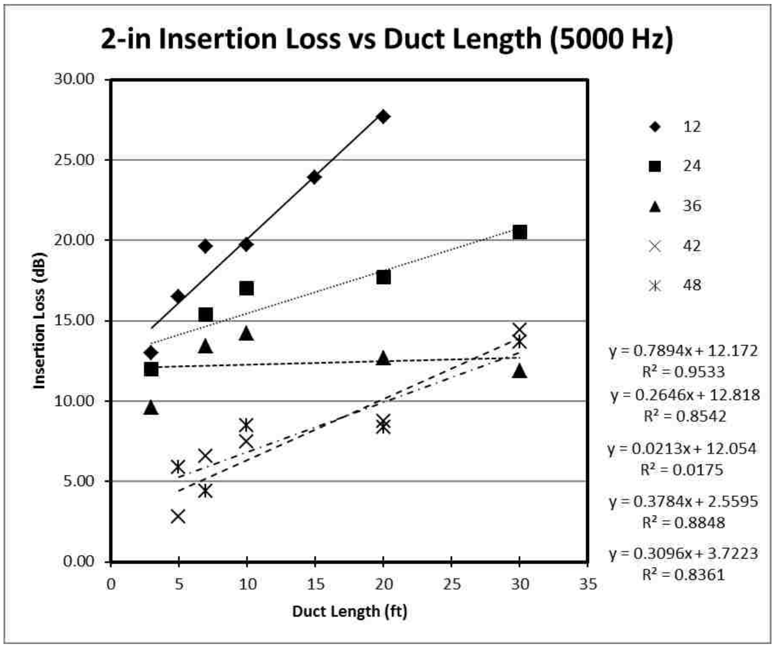

Figure F.66: 2-in Insertion Loss vs Duct Length at 5000 Hz

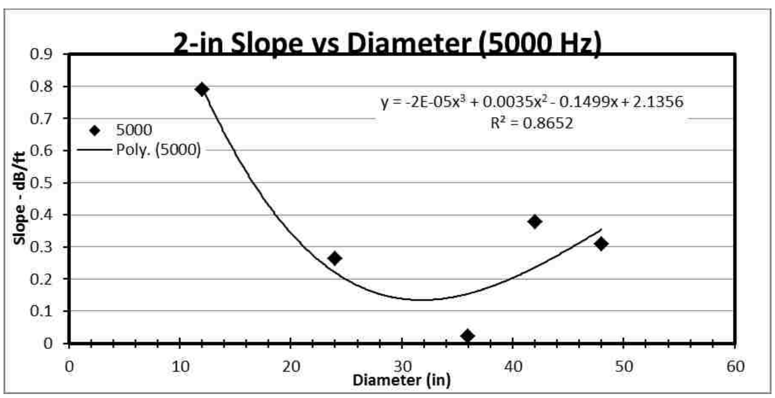

Figure F.67: 2-in Slope vs Diameter at 5000 Hz

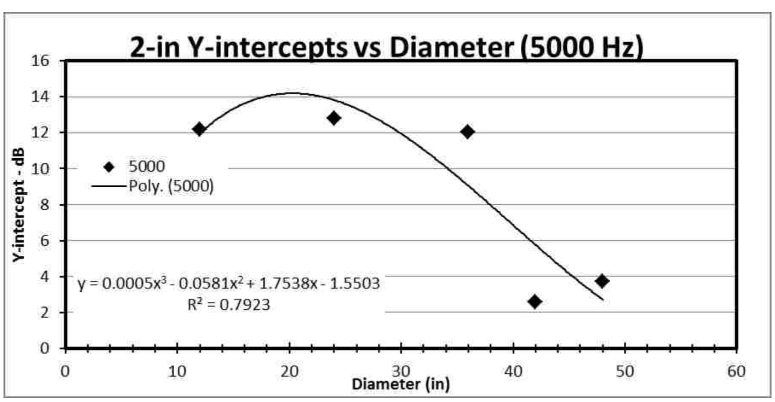

Figure F.68: 2-in Y-intercepts vs Diameter at 5000 Hz

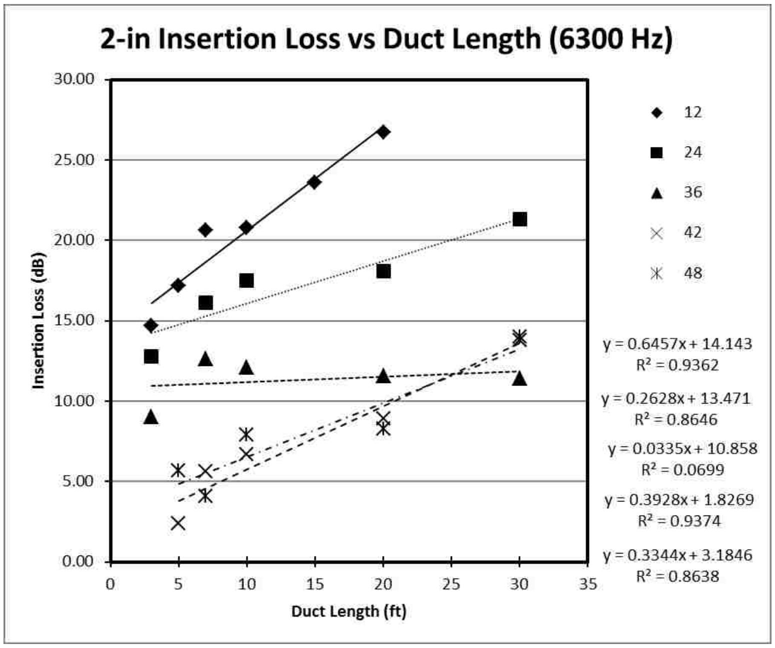

Figure F.69: 2-in Insertion Loss vs Duct Length at 6300 Hz

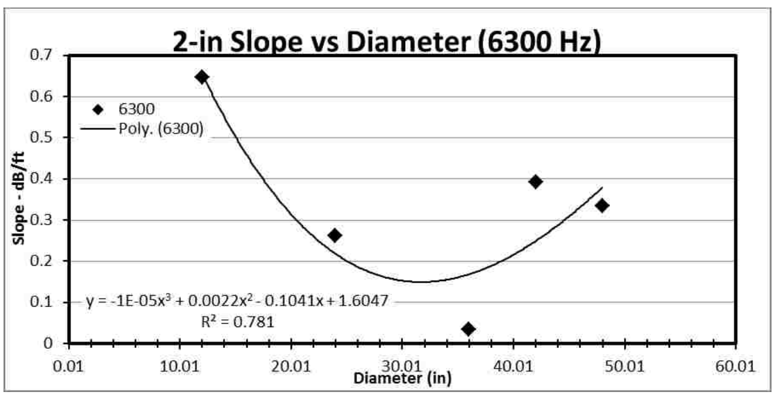

Figure F.70: 2-in Slope vs Diameter at 6300 Hz

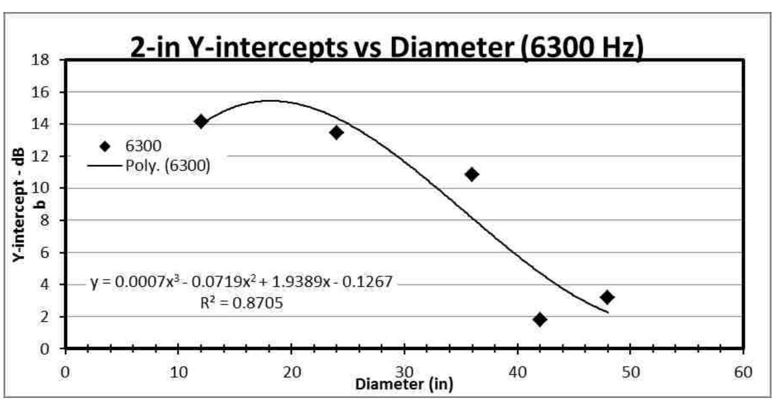

Figure F.71: 2-in Y-intercepts vs Diameter at 6300 Hz

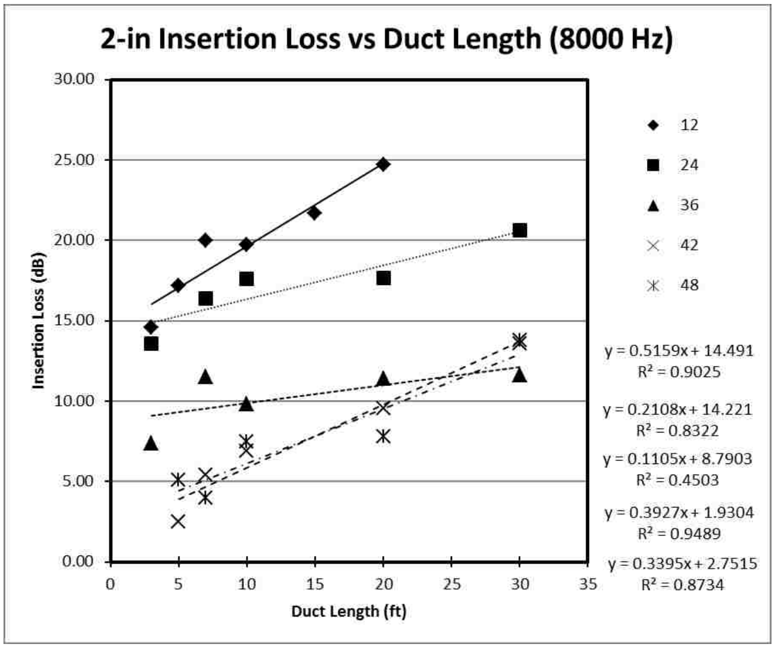

Figure F.72: 2-in Insertion Loss vs Duct Length at 8000 Hz

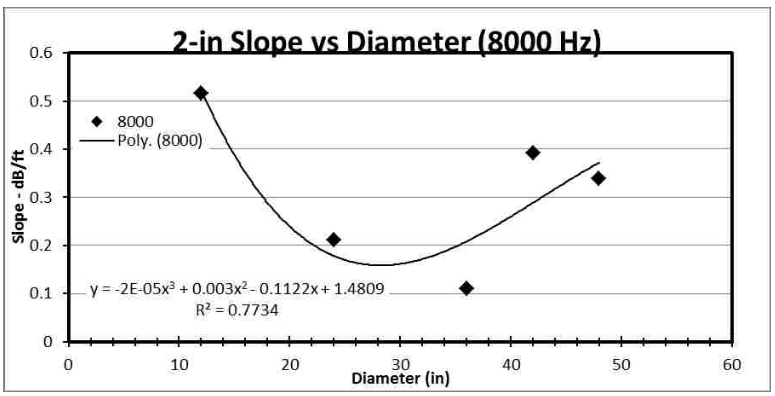

Figure F.73: 2-in Slope vs Diameter at 8000 Hz

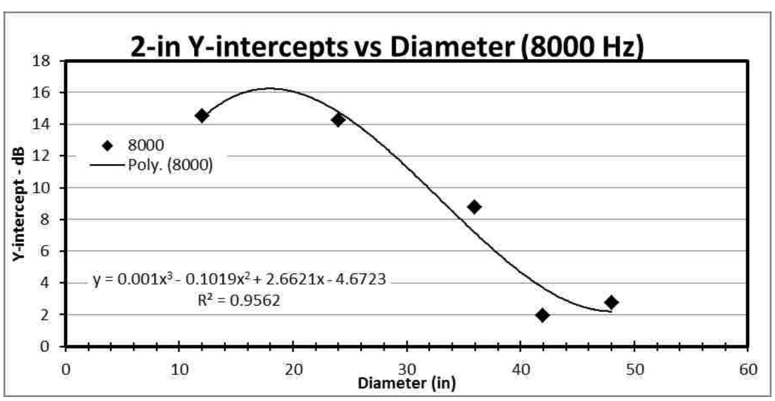

Figure F.74: 2-in Y-intercepts vs Diameter at 8000 Hz

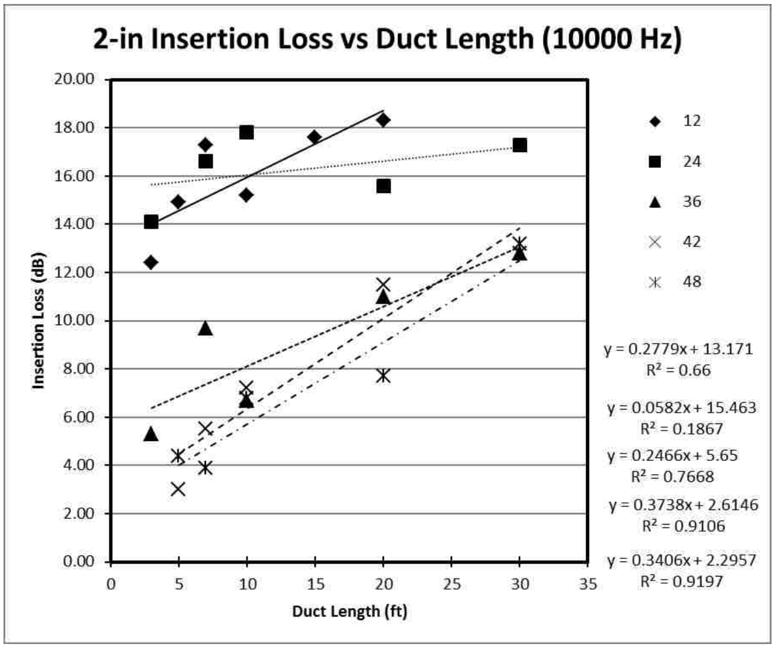

Figure F.75: 2-in Insertion Loss vs Duct Length at 10000 Hz

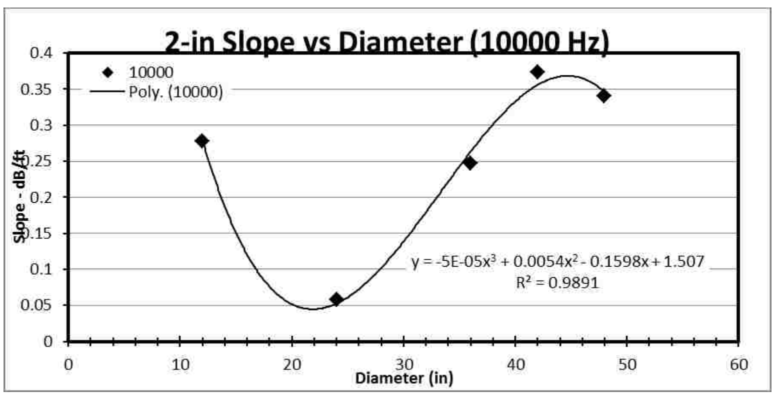

Figure F.76: 2-in Slope vs Diameter at 10000 Hz

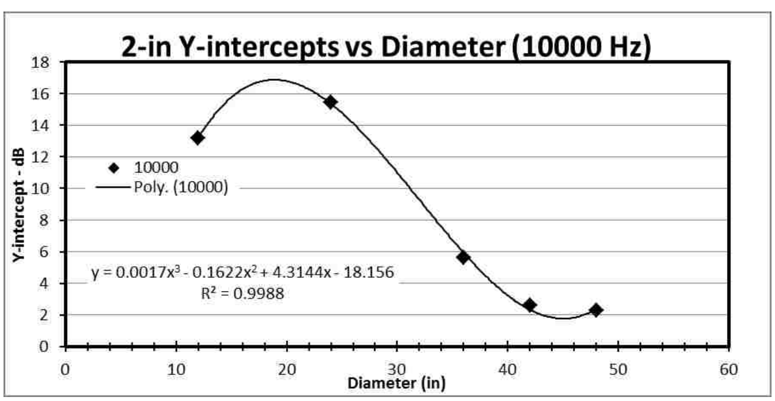

Figure F.77: 2-in Y-intercepts vs Diameter at 10000 Hz

Diameter - in		12	24	36	12	42	48	12	24	36	42	48	12	24	36	42	48	12	12	24	36	42	48	24	36	42	48			
Length -ft		3	3	3	5	5	5	7	7	7	7	7	10	10	10	10	10	15	20	20	20	20	20	30	30	30	30	AVG	STD	Freq
meas	50	0.5	1.1	0.1	2.8	0.7	2.0	6.3	1.9	0.5	1.1	1.7	6.0	0.4	0.9	1.1	3.0	3.7	3.3	1.3	0.0	1.8	3.0	1.6	0.8	2.3	3.3			50
regres	50	3.3	1.1	0.3	3.4	0.8	2.1	3.6	1.2	0.4	0.9	2.2	3.8	1.2	0.5	1.1	2.4	4.1	4.5	1.3	0.7	1.5	3.0	1.4	1.0	1.9	3.6			50
DIFF AVG		-2.8	0.0	-0.2	-0.6	-0.1	-0.1	2.7	0.7	0.1	0.2	-0.5	2.2	-0.8	0.4	0.0	0.6	-0.4	-1.2	0.1	-0.7	0.3	0.0	0.2	-0.2	0.4	-0.3	0.00	1.00	
meas	63	-1.4	1.4	2.2	0.0	0.0	1.0	3.6	2.8	1.0	-0.2	0.6	3.7	1.8	1.6	0.0	0.7	1.5	2.2	2.0	1.0	0.9	0.9	2.9	2.6	1.8	2.0			63
regres	63	0.6	2.0	0.8	0.9	0.4	0.4	1.2	2.1	1.0	0.5	0.5	1.6	2.2	1.1	0.7	0.7	2.3	3.0	2.5	1.5	1.2	1.2	2.7	2.0	1.8	1.7			63
DIFF AVG		-2.0	-0.6	1.4	-0.9	-0.4	0.6	2.4	0.7	0.0	-0.7	0.1	2.1	-0.4	0.5	-0.7	0.0	-0.8	-0.8	-0.5	-0.5	-0.4	-0.3	0.2	0.6	0.0	0.3	0.00	0.94	
meas	80	1.4	1.1	0.0	2.5	0.7	1.0	3.9	1.6	0.3	0.8	1.1	6.3	1.2	0.5	1.5	1.1	4.2	6.8	3.7	1.7	1.6	1.1	4.8	3.4	3.2	3.0			80
regres	80	2.4	0.8	0.1	2.9	0.4	0.9	3.4	1.4	0.5	0.6	1.0	4.2	1.8	0.9	0.9	1.2	5.5	6.8	3.3	2.1	1.9	1.9	4.8	3.2	2.9	2.6			80
DIFF AVG		-1.0	0.3	-0.1	-0.4	0.3	0.1	0.5	0.2	-0.2	0.2	0.1	2.1	-0.6	-0.4	0.6	-0.1	-1.3	0.0	0.4	-0.4	-0.4	-0.8	0.0	0.2	0.3	0.4	0.00	0.64	
meas	100	2.1	1.9	-0.1	2.7	1.5	0.7	3.8	2.4	0.4	1.6	0.7	5.9	2.1	1.2	2.7	1.5	7.3	9.6	5.0	2.7	3.7	3.6	7.2	4.6	5.2	3.5			100
regres	100	2.2	1.2	0.6	3.0	0.8	1.0	3.9	2.0	1.2	1.1	1.3	5.3	2.7	1.7	1.6	1.6	7.5	9.7	4.8	3.4	3.2	2.9	6.9	5.0	4.7	4.2			100
DIFF AVG		-0.1	0.7	-0.7	-0.3	0.7	-0.3	-0.1	0.4	-0.8	0.5	-0.6	0.6	-0.6	-0.5	1.1	-0.1	-0.2	-0.1	0.2	-0.6	0.5	0.7	0.3	-0.4	0.5	-0.7	0.00	0.54	
meas	125	2.8	1.8	0.0	5.2	1.4	0.9	6.1	2.7	0.8	1.7	1.2	8.2	3.5	1.3	2.9	2.0	10.2	13.2	7.0	3.6	4.7	3.7	10.2	6.2	6.7	5.4			125
regres	125	3.6	1.3	0.4	4.8	0.9	1.1	5.9	2.6	1.4	1.3	1.5	7.7	3.6	2.0	1.9	2.0	10.5	13.4	6.7	4.4	4.0	3.9	9.9	6.7	6.1	5.7			125
DIFF AVG		-0.8	0.5	-0.4	0.4	0.5	-0.2	0.2	0.1	-0.6	0.4	-0.3	0.5	-0.1	-0.7	1.0	0.0	-0.3	-0.2	0.2	-0.8	0.7	-0.2	0.3	-0.5	0.6	-0.3	0.00	0.49	
meas	160	3.1	1.8	0.7	5.2	2.0	1.4	7.5	3.9	1.8	2.4	2.3	10.5	5.0	3.1	3.7	3.2	13.8	18.7	10.1	6.5	6.5	5.1	15.0	10.0	9.4	8.0			160
regres	160	3.6	1.7	1.0	5.4	1.6	1.8	7.1	3.6	2.3	2.2	2.3	9.8	5.1	3.4	3.1	3.0	14.3	18.8	10.0	6.8	6.1	5.5	14.9	10.2	9.2	8.0			160
DIFF AVG		-0.5	0.1	-0.3	-0.2	0.4	-0.4	0.4	0.3	-0.5	0.2	0.0	0.7	-0.1	-0.3	0.6	0.2	-0.5	-0.1	0.1	-0.3	0.3	-0.4	0.1	-0.2	0.2	0.0	0.00	0.33	
meas	200	4.8	2.4	1.6	7.4	2.6	2.1	10.2	5.1	3.1	3.2	3.0	14.4	7.1	4.6	4.9	4.1	20.1	26.5	14.7	9.3	8.8	8.0	21.2	14.2	13.3	11.8			200
regres	200	5.0	2.3	1.5	7.6	2.4	2.2	10.1	5.1	3.4	3.2	3.0	13.9	7.2	4.9	4.5	4.2	20.3	26.6	14.2	9.6	8.7	8.0	21.3	14.3	13.0	11.9			200
DIFF AVG		-0.2	0.1	0.1	-0.2	0.2	-0.1	0.1	0.0	-0.3	0.0	0.0	0.5	-0.1	-0.3	0.4	-0.1	-0.2	-0.1	0.4	-0.3	0.0	0.0	-0.1	-0.1	0.3	-0.1	0.00	0.22	
meas	250	5.9	3.3	1.9	9.9	3.4	3.3	13.2	7.1	4.5	5.0	4.9	18.8	10.1	6.9	7.5	6.6	27.0	35.4	19.5	13.6	14.6	13.6	28.4	19.7	20.3	19.5			250
regres	250	6.3	3.4	2.3	9.8	3.5	3.6	13.2	7.1	5.0	4.8	4.9	18.4	9.8	7.0	6.8	6.8	27.0	35.6	19.1	13.8	13.4	13.4	28.3	20.6	20.0	19.9			250
DIFF AVG		-0.4	-0.1	-0.4	0.1	-0.1	-0.3	0.0	0.0	-0.5	0.2	0.0	0.4	0.3	-0.1	0.7	-0.2	0.0	-0.2	0.4	-0.2	1.2	0.2	0.1	-0.9	0.3	-0.4	0.00	0.42	
meas	315	8.2	4.9	4.0	13.1	6.6	6.7	17.9	10.7	8.8	9.0	9.3	25.9	14.2	13.1	12.7	13.0	37.7	50.9	31.1	26.2	26.2	24.6	43.8	38.4	38.6	36.9			315
regres	315	8.1	4.8	3.9	13.1	6.6	6.8	18.1	10.7	9.0	9.1	9.2	25.6	15.1	12.9	13.0	12.8	38.1	50.7	29.8	25.8	25.8	24.8	44.4	38.7	38.7	36.8			315
DIFF AVG		0.1	0.1	0.1	0.0	0.0	-0.1	-0.2	0.0	-0.2	-0.1	0.1	0.3	-0.9	0.2	-0.3	0.2	-0.4	0.2	1.4	0.4	0.3	-0.2	-0.6	-0.3	-0.1	0.1	0.00	0.41	
meas	400	12.9	10.5	7.8	20.6	13.3	14.3	27.9	22.4	19.7	18.3	18.7	37.7	32.2	26.1	25.1	26.1	44.7	48.8	46.8	40.2	37.8	37.9	54.9	50.1	49.9	49.6			400
regres	400	17.5	15.8	12.7	21.7	15.2	16.6	25.9	22.2	18.6	18.1	19.3	32.1	26.9	23.0	22.4	23.4	42.6	53.0	42.9	37.7	36.8	37.0	55.0	52.5	51.2	50.6			400
DIFF AVG		-4.6	-5.3	-4.9	-1.1	-1.9	-2.3	2.0	0.2	1.1	0.2	-0.6	5.6	5.3	3.1	2.7	2.7	2.1	-4.2	3.9	2.4	1.0	0.9	-0.1	-2.4	-1.3	-1.0	0.14	3.00	
meas	500	15.9	13.4	11.1	25.4	16.7	18.7	32.3	26.7	24.8	21.8	24.6	43.9	37.8	32.4	30.7	31.7	47.0	48.4	52.8	48.8	42.8	45.6	53.4	48.9	48.7	51.6			500
regres	500	22.6	21.1	18.1	26.2	20.6	22.3	29.9	26.9	23.4	23.2	24.8	35.5	31.2	27.4	27.1	28.6	44.7	53.9	45.7	40.5	40.0	41.4	55.0	53.7	53.0	54.1			500
DIFF AVG		-6.7	-7.7	-7.0	-0.8	-3.9	-3.6	2.4	-0.2	1.4	-1.4	-0.2	8.4	6.6	5.0	3.6	3.1	2.3	-5.5	7.1	8.3	2.8	4.2	-1.6	-4.8	-4.3	-2.5	0.20	4.83	
meas	630	23.6	21.2	17.0	36.7	23.1	15.3	43.2	36.9	32.8	28.8	19.5	46.7	44.0	37.0	36.6	24.8	45.8	47.5	51.3	57.4	51.4	38.6	55.5	56.9	57.4	46.5			630
regres	630	27.3	26.6	25.9	33.7	25.2	17.7	40.0	33.1	31.5	28.0	20.2	49.5	37.9	35.7	32.2	23.9	55.0	55.0	54.2	49.8	46.1	36.2	55.0	55.0	55.0	48.5			630
DIFF AVG		-3.7	-5.4	-8.9	3.0	-2.1	-2.4	3.2	3.8	1.3	0.8	-0.7	-2.8	6.1	1.3	4.4	0.9	-9.2	-7.5	-2.8	7.6	5.3	2.4	0.5	1.9	2.4	-2.0	-0.10	4.43	
meas	800	29.7	26.6	14.1	40.2	14.9	11.5	43.8	40.0	21.7	18.7	15.7	47.5	44.1	24.9	24.7	17.8	50.0	54.8	57.4	35.2	33.6	22.7	58.4	46.5	42.9	26.7			800
REGRESS	800	35.8	29.7	17.3	38.2	15.1	14.2	40.7	36.3	22.4	17.0	15.4	44.5	41.3	26.2	19.8	17.2	50.7	55.0	55.0	38.9	29.2	23.1	55.0	51.7	38.6	29.1			800
DIFF AVG		-6.1	-3.1	-3.2	2.0	-0.2	-2.7	3.1	3.7	-0.7	1.7	0.3	3.0	2.8	-1.3	4.9	0.6	-0.7	-0.2	2.4	-3.7	4.4	-0.4	3.4	-5.2	4.3	-2.4	0.26	3.08	
meas	1000	37.9	20.4	10.0	40.4	11.2	9.9	43.4	28.9	14.8	13.9	11.9	47.9	38.2	18.5	16.7	12.9	53.3	54.3	58.1	24.9	22.0	13.9	59.0	31.4	27.3	16.9			1000
regres	1000	39.1	20.6	12.1	41.2	11.4	11.2	43.2	29.3	16.0	12.2	11.8	46.3	35.7	18.9	13.4	12.7	51.5	55.0	57.3	28.5	17.3	15.8	55.0	38.2	21.3	18.8			1000
DIFF AVG		-1.2	-0.2	-2.1	-0.8	-0.2	-1.3	0.2	-0.4	-1.2	1.7	0.1	1.6	2.5	-0.4	3.3	0.2	1.8	-0.7	0.8	-3.7	4.7	-1.9	4.0	-6.8	6.0	-1.9	0.16	2.67	
meas	1250	41.5	13.5	7.4	44.0	8.9	7.5	46.8	19.7	12.9	11.4	8.0	51.7	25.7	15.8	13.0	8.9	53.4	55.5	40.4	19.2	17.2	11.2	54.6	23.8	22.2	14.1			1250
regres	1200	43.0	14.2	9.4	44.7	9.9	7.5	46.4	20.1	12.2	10.6	8.1	48.9	24.5	14.3	11.6	9.0	53.0	55.0	39.2	21.2	15.0	12.1	53.9	28.2	18.4	15.2			1200
DIFF AVG		-1.5	-0.7	-2.0	-0.7	-1.0	0.0	0.4	-0.4	0.7	0.8	-0.1	2.8	1.2	1.5	1.4	-0.1	0.4	0.5	1.2	-2.1	2.2	-0.9	0.7	-4.4	3.8	-1.1	0.10	1.67	
meas	1600	30.2	11.2	6.3	39.5	7.3	5.8	44.2	16.1	10.5	9.1	6.2	49.3	19.5	12.7	10.1	7.9	52.6	53.4	29.5	13.9	11.9	9.2	39.3	16.7	15.9	11.5			1600
regres	1600	34.4	11.9	8.1	37.9	8.2	6.0	41.4	15.9	9.6	8.7	6.5	46.6	19.0	10.8	9.4	7.2	55.0	55.0	29.0	14.8	11.8	9.6	39.1	18.7	14.1	12.0			1600
DIFF AVG		-4.2	-0.7	-1.8	1.6	-0.9	-0.2	2.8	0.2	0.9	0.4	-0.3	2.7	0.5	1.9	0.7	0.7	-2.4	-1.6	0.5	-0.8	0.1	-0.4	0.2	-2.0	1.8	-0.5	-0.04	1.58	
meas	2000	21.7	10.4	5.8	29.9	5.4	4.6	38.9	13.6	9.1	7.5	4.6	44.9	16.9	12.0	8.6	6.4	44.7	46.5	21.9	10.6	11.8	9.6	28.7	11.7	16.0	12.4			2000
regres	2000	22.9	11.3	7.5	29.6	6.7	4.3	36.3	13.8	8.4	7.4	5.0	46.4	15.7	9.0	8.3	6.0	55.0	55.0	22.1	11.2	11.6	9.5	28.5	13.4	14.8	12.9			2000
DIFF AVG		-1.2	-0.9	-1.7	0.3	-1.3	0.3	2.6	-0.2	0.7	0.1	-0.4	-1.5	1.2	3.0	0.3	0.4	-10.3	-8.5	-0.2	-0.6	0.2	0.1	0.2	-1.7	1.2	-0.5	-0.71	2.81	
meas	2500	17.9	9.4	5.9	23.7	6.0	5.6	31.3	12.4	9.4	8.8	5.1	37.7	14.7	12.6	9.6	8.0	41.6	44.5	18.1	11.0	9.3	8.7	22.8	11.2	13.8	11.6			2500
regres	2500	22.1	10.5	8.1	25.2	7.7	5.4	28.2	12.3	8.8	8.0	5.9	32.8	13.7	9.3	8.6	6.7	40.4	48.0	18.2	11.1	10.6	9.2	22.8	12.8	12.5	11.7			2500
DIFF AVG		-4.2	-1.1	-2.2	-1.5	-1.7	0.2	3.1	0.1	0.6	0.8	-0.8	4.9	1.0	3.3	1.0	1.3	1.2	-3.5	-0.1	-0.1	-1.3	-0.5	0.0	-1.6	1.3	-0.1	0.00	1.98	
meas	3150	15.3	9.9	6.6	20.6	4.0	5.5	25.9	13.2	10.1	6.7	4.5	30.6	15.8	13.3	7.8	7.8	38.6	44.1	19.9	12.6	9.5	8.1	24.5	13.2	14.5	12.7			3150
regres	3150	17.4	11.5	7.6	20.8	6.5	4.6	24.1	13.4	8.7	7.1	5.2	29.1	14.9	9.4	7.9	6.2	37.5	45.8	19.9	12.0	10.8	9.2	24.8	14.6	13.7	12.3			3150
DIFF AVG		-2.1	-1.6	-1.0	-0.2	-2.5	0.9	1.8	-0.2	1.4	-0.4	-0.7	1.5	0.9	3.9	-0.1	1.6	1.1	-1.7	0.1	0.6	-1.3	-1.1	-0.3	-1.4	0.8	0.4	0.01	1.44	
meas	4000	13.9	10.8	8.5	17.1	3.3	5.8	22.6	14.3	12.8	6.0	4.5	24.6	16.5	15.5	7.4	8.1	29.3	35.8	16.6	11.4	8.4	8.0	20.1	11.6	13.9	12.5			4000
regres	4000	15.2	13.4	9.1	17.6	7.0	4.5	20.1	14.4	9.7	7.4	5.1	23.8	15.1	10.1	8.1	6.0	29.9	36.1	17.6	11.5	10.4	9.1	20.0	12.9	12.7	12.1			4000
DIFF AVG		-1.3	-2.6	-0.6	-0.5	-3.7	1.3	2.5	-0.1	3.1	-1.4	-0.6	0.8	1.4	5.4	-0.7	2.1	-0.6	-0.3	-0.9	-0.1	-2.0	-1.1	0.1	-1.3	1.2	0.4	0.02	1.89	
meas	5000	13.0	12.0	9.6	16.5	2.8	5.9	19.6	15.4	13.4	6.6	4.4	19.7	17.0	14.2	7.5	8.5	23.9	27.7	17.7	12.7	8.7	8.4	20.5	11.9	14.4	13.7			5000
regres	5000	14.4	14.5	9.5	16.0	6.9	4.5	17.6	15.4	10.1	7.4	5.2	20.0	16.0	10.6	8.1	6.3	23.9	27.9	18.2	12.1	10.5	9.8	20.4	13.7	12.9	13.3			5000
DIFF AVG		-1.4	-2.5	0.1	0.5	-4.1	1.4	2.0	0.0	3.3	-0.8	-0.8	-0.3	1.0	3.6	-0.6	2.2	0.0	-0.2	-0.5	0.5	-1.7	-1.4	0.1	-1.8	1.5	0.4	0.02	1.72	
meas	6300	14.7	12.8	9.0	17.2	2.4	5.7	20.6	16.1	12.6	5.6	4.1	20.8	17.5	12.1	6.7	7.9	23.6	26.7	18.1	11.5	8.9	8.3	21.3	11.4	13.8	14.0			6300
regres	6300	15.9	15.0	8.6	17.2	6.0	4.2	18.5	15.9	9.3	6.5	4.9	20.5	16.6	9.8	7.2	6.1	23.8	27.1	18.7	11.5	9.7	9.9	20.9	13.2	12.2	13.7			6300
DIFF AVG		-1.2	-2.2	0.4	0.0	-3.6	1.5	2.1	0.2	3.3	-0.9	-0.8	0.3	0.9	2.3	-0.5	1.8	-0.2	-0.4	-0.7	0.0	-0.8	-1.6	0.4	-1.8	1.6	0.3	0.02	1.52	
meas	8000	14.6	13.6	7.4	17.2	2.5	5.1	20.0	16.4	11.5	5.4	4.0	19.7	17.6	9.8	6.9	7.5	21.7	24.7	17.7	11.4	9.5	7.8	20.6	11.6	13.6	13.8			8000
regres	8000	15.9	15.3	7.8	17.0	5.1	4.1	18.0	16.0	8.6	5.7	4.8	19.6	16.5	9.2	6.6	5.9	22.2	24.8	18.3	11.3	9.4	9.6	20.1	13.4	12.3	13.4			8000
DIFF AVG		-1.3	-1.7	-0.4	0.2	-2.6	1.0	2.0	0.4	2.9	-0.3	-0.8	0.1	1.1	0.6	0.3	1.6	-0.5	-0.1	-0.7	0.1	0.1	-1.8	0.5	-1.8	1.3	0.4	0.01	1.25	
meas	10000	12.4	14.1	5.3	14.9	3.0	4.4	17.3	16.6	9.7	5.5	3.9	15.2	17.8	6.7	7.2	6.8	17.6	18.3	15.6	11.0	11.5	7.7	17.3	12.8	12.8	13.2			10000
regres	10000	14.0	15.5	6.7	14.6	4.1	4.1	15.1	15.7	7.8	4.8	4.8	16.0	15.9	8.6	5.9	5.8	17.4	18.8	16.4	11.2	9.4	9.3	17.0	13.8	13.0	12.8			10000
DIFF AVG		-1.6	-1.4	-1.4	0.3	-1.1	0.3	2.2	0.9	1.9	0.7	-0.9	-0.8	1.9	-1.9	1.3	1.0	0.2	-0.5	-0.8	-0.2	2.0	-1.6	0.3	-1.0	-0.2	0.4	0.00	1.23	

(shaded cell) Flanking Insertion Loss Reached

meas - Measured IL Values

Regress - Calculated IL Values from Regression Equations

DIF AVG - Calculation of the average of the differneces between measured and calculated IL values

STD - Calculation of the standard deviation relative to the DIFF AVG

Figure F.78: Data Comparison for 2-in Round Ducts

BIBLIOGRAPHY

[1] Fojas, R. R. (2012). *Upgrading UNLV's ASTM E477 Test Facility to Meet the Current Requirements of ASTM E477.* Las Vegas.

[2] *2011 ASHRAE Handbook HVAC Applications.* (2011). Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

[3] *Acoustic Glossary*. (n.d.). Retrieved August 5, 2015, from Sound Isolation Company Web Site: http://www.soundisolationcompany.com/education/soundproofing-101-3/acoustic-glossary/

[4] *AM7215/95 High Power 2-Way Loudspeaker with 1 x 15" LF & Rotatable Horn.* (2010). Northridge, California: JBL Professional.

[5] *JBL ASB7128 Ultra Long Excursion High Power Dual 18" Subwoofer.* (2009). Northridge, California: JBL Professional.

[6] *JBL Selenium Pro Driver Titanium D4400Ti.* (2006). Redondo Beach: JBL Selenium USA.

[7] *Product Data: Multifunction Acoustic Calibrator - Type 4226.* (n.d.). Nærum, Denmark: Brüel & Kjær.

[8] Reynolds, D. D. (2010). *Engineering Principles of Acoustics & Noise Control.* Las Vegas: DDR, Inc.

[9] (2013). *Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.* West Conshohocken: ASTM International.

[10] *Svan 958 Four Channels Sound and Vibration Level Meter & Analyser User's Manual.* (2008). Warsaw: Svantek.

[11] *UltraCurve Pro DEQ2496 User's Manual.* (2003). Behringer.

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