Department of Mechanical Engineering
4505 S. Maryland Parkway
Box 454040
Las Vegas, NV 89154-4040

(702) 895-3807 FAX: (702) 895-4677

CENTER FOR MECHANICAL & ENVIRONMENTAL SYSTEMS TECHNOLOGY

Howard R. Hughes
College of Engineering

Insertion Loss Values Measured on Selected Round Duct Diameters For Acoustically Internally Lined Dual-Wall Round Ducts

Report No.
2350-254-5023ESM01

Report Prepared for:
Eastern Sheet Metal
8959 Blue Ash Road
Cincinnati, OH 45242

Submitted by:

Douglas D. Reynolds

Douglas D. Reynolds, Ph.D.
Director

December 30, 1999

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

INTRODUCTION

The Center for Mechanical & Environmental Systems Technology (CMEST) was requested by Eastern Sheet Metal to conduct insertion loss sound tests) on six different diameter round ducts. Each diameter duct was tested with a 1.0-in. and a 2.0-in. thick dual-wall internal acoustic round duct liner. The six duct diameters that were tested had internal diameters of 12 in., 20 in., 28 in., 36 in., 42 in., and 48 in. Insertion loss tables for both liner thickness were prepared from the test data for internal duct diameters from 12 in. to 72 in. in 2.-in. increments.

Insertion loss tests associated with the 1.0 in. and 2.0 in. thick dual wall acoustic round duct liners were conducted on six duct diameters: 12 in., 20 in., 28 in., 36 in., 42 in., and 48 in. A multivariable linear regression analysis was performed on the data to develop regression equations that were used to generate the data tables.

TESTS

Insertion loss tests were conducted on six duct diameters for 1.0 in. and 2.0 in. thick dual wall acoustic round duct liners. The blank duct diameters were 12 in., 20 in., 28 in., 36 in., 42 in., and 48 in. The inside duct diameters for the insertion loss tests on the 1.0 in. and 2.0 in. thick liner were: 12 in., 20 in., 28 in., 36 in., 42 in., and 48 in.

The forward flow duct system in CMEST LAB was modified to conduct the insertion loss tests. All of the tests were conducted without airflow. The system has a plenum chamber with the speaker system used to generate sound for the tests on one end, and the other end discharged into a 9,400-ft^3 -reverberation room. For the insertion loss tests:

1. An 11-ft long blank circular duct was placed in the duct system to be tested.

2. The sound source in the plenum chamber was turned on and the corresponding Third Octave Band sound pressure levels were measured in the reverberation room.

3. The 11-ft long blank circular duct was removed and replaced with a 11-ft long duct that was internally lined with a dual wall acoustic round duct liner. The length of the lined section of duct was 10-ft.

4. The sound source in the plenum chamber was turned on and the corresponding third octave band sound pressure levels were measured in the reverberation room.

5. The third octave band insertion loss values were obtained by subtracting the sound pressure levels measured in the reverberation room with the internally lined duct from the corresponding sound pressure levels measured with the blank duct. The Octave Band insertion loss values were calculated from the third octave band values.

The 9,400-ft^3 -reverberation room in CMEST has been qualified per ANSI Standard S12.31 for broad band sound tests. The sound pressure levels were measured with a microphone mounted on a rotating microphone boom that makes one revolution every 30s. A 30s average time was used for the sound pressure level measurements.

DISCUSSION OF RESULTS

A multi-variable non-linear regression analysis was conducted on the tests result to obtain regression equations for generating the insertion loss table 'or inside duct diameters from 18 in. to 72 in. Analysis was conducted on the test data for the octave band center frequencies for 63 Hz to 8,000 Hz. The test results for the six duct diameters that were tested for each liner thickness are listed in Appendix A. Tabulated regression results for the insertion loss values to two decimal places are listed in Appendix B. Tabulated regression results for the insertion loss values to three decimal places are listed in Appendix C.

The regression equation for calculating the tabulated results is:

$$IL = A + B \cdot dia + C \cdot dia^2 + D \cdot dia^3 + E \cdot th$$

Where:

dia = inside duct diameter (in.)

th = liner thickness (in.)

The values for the regression coefficients A, B, C, D, and E are:

Octave Band Center Frequency - Hz

Coeff.	63	125	250	500	1000	2000	4000	8000
A	0.036336	0.530986	1.122703	1.274094	5.791547	5.127838	2.633006	1.568627
B	-0.00371	-0.03827	-0.06972	-0.05279	-0.19741	-0.22739	-0.06049	0.012152
C	2.59E-05	0.000717	0.001132	0.00077	0.003025	0.004858	0.001197	-0.00069
D	0	-4.6E-06	-6.9E-06	-6.5E-06	-1.8E-05	-3.5E-05	-9.8E-06	4.13E-06
E	0.078749	0.175	0.5725	1.005001	0	0	0	0

Plots of the IL test data and the IL values predicted by the regression equations are shown in appendix D. IL data and regression values are plotted as a function of inside duct diameter. There is one plot for each of the octave band center frequencies from 63 Hz to 8000 Hz.

Plots of the IL values predicted by the regression equations as a function of octave band center frequency are shown in appendix E. There are two plots: one for the 1.0 in. liner and one for the 2 in. liner. Each plot contains curves for the following inside duct diameters: 12 in., 20 in., 28 in., 36 in., 42 in., and 48 in.

CONCLUSION

The results of the tests were very good. An examination of the plot, in Appendix D indicates the regression results agreed very well with the corresponding measured test data. Also, the regression tables in appendix B indicate the extrapolation of the test results to duct diameters over 48 in. appears to give null insertion loss values in the low frequencies and it extends to the middle range frequencies as the duct diameter increase.

LINER THICKNESS 1.00 in.

INSERTION LOSS - dB/ft

Diameter	Octave Band Center Frequency - Hz							
in.	63	125	250	500	1000	2000	4000	8000
12	0.074	0.342	1.010	1.745	3.828	3.038	2.063	1.622
14	0.068	0.298	0.922	1.673	3.572	2.800	1.994	1.615
16	0.062	0.258	0.841	1.605	3.335	2.589	1.932	1.604
18	0.057	0.223	0.767	1.541	3.115	2.403	1.875	1.588
20	0.051	0.191	0.698	1.480	2.912	2.241	1.824	1.569
22	0.046	0.162	0.636	1.422	2.724	2.101	1.777	1.547
24	0.041	0.137	0.579	1.366	2.552	1.981	1.735	1.521
26	0.036	0.115	0.527	1.313	2.393	1.880	1.697	1.492
28	0.031	0.096	0.479	1.263	2.248	1.795	1.663	1.460
30	0.027	0.079	0.436	1.214	2.114	1.726	1.631	1.425
32	0.023	0.065	0.397	1.166	1.993	1.670	1.602	1.388
34	0.019	0.053	0.362	1.120	1.882	1.626	1.575	1.348
36	0.015	0.044	0.331	1.074	1.780	1.592	1.550	1.306
38	0.011	0.036	0.302	1.030	1.688	1.567	1.525	1.263
40	0.008	0.029	0.277	0.985	1.604	1.548	1.502	1.217
42	0.005	0.024	0.253	0.940	1.526	1.534	1.478	1.170
44	0.002	0.020	0.232	0.895	1.456	1.524	1.454	1.122
46	0.000	0.017	0.213	0.850	1.391	1.515	1.430	1.072
48	0.000	0.014	0.195	0.803	1.330	1.506	1.404	1.022
50	0.000	0.012	0.178	0.755	1.273	1.496	1.377	0.971
52	0.000	0.011	0.162	0.705	1.219	1.482	1.347	0.919
54	0.000	0.009	0.147	0.654	1.168	1.463	1.315	0.867
56	0.000	0.007	0.131	0.600	1.117	1.437	1.279	0.815
58	0.000	0.005	0.116	0.543	1.068	1.402	1.240	0.762
60	0.000	0.002	0.100	0.484	1.017	1.358	1.197	0.711
62	0.000	0.000	0.083	0.422	0.966	1.301	1.149	0.659
64	0.000	0.000	0.065	0.356	0.912	1.231	1.097	0.608
66	0.000	0.000	0.045	0.286	0.855	1.145	1.039	0.558
68	0.000	0.000	0.024	0.212	0.795	1.043	0.975	0.509
70	0.000	0.000	0.000	0.134	0.729	0.922	0.904	0.461
72	0.000	0.000	0.000	0.051	0.659	0.780	0.827	0.415

LINER THICKNESS = 2.00 in.

INSERTION LOSS - dB/ft

Diameter	Octave Band Center Frequency – Hz							
In.	63	125	250	500	1000	2000	4000	8000
12	0.153	0.517	1.582	2.750	3.828	3.038	2.063	1.622
14	0.147	0.473	1.495	2.678	3.572	2.800	1.994	1.615
16	0.141	0.433	1.414	2.610	3.335	2.589	1.932	1.604
18	0.135	0.398	1.339	2.546	3.115	2.403	1.875	1.588
20	0.130	0.366	1.271	2.485	2.912	2.241	1.824	1.569
22	0.125	0.337	1.208	2.427	2.724	2.101	1.777	1.547
24	0.120	0.312	1.151	2.371	2.552	1.981	1.735	1.521
26	0.115	0.290	1.099	2.318	2.393	1.880	1.697	1.492
28	0.110	0.271	1.052	2.268	2.248	1.795	1.663	1.460
30	0.106	0.254	1.009	2.219	2.114	1.726	1.631	1.425
32	0.101	0.240	0.970	2.171	1.993	1.670	1.602	1.388
34	0.097	0.228	0.935	2.125	1.882	1.626	1.575	1.348
36	0.094	0.219	0.903	2.079	1.780	1.592	1.550	1.306
38	0.090	0.211	0.875	2.035	1.688	1.567	1.525	1.263
40	0.087	0.204	0.849	1.990	1.604	1.548	1.502	1.217
42	0.083	0.199	0.826	1.945	1.526	1.534	1.478	1.170
44	0.081	0.195	0.805	1.900	1.456	1.524	1.454	1.122
46	0.078	0.192	0.785	1.855	1.391	1.515	1.430	1.072
48	0.075	0.189	0.768	1.808	1.330	1.506	1.404	1.022
50	0.073	0.187	0.751	1.760	1.273	1.496	1.377	0.971
52	0.071	0.186	0.735	1.710	1.219	1.482	1.347	0.919
54	0.069	0.184	0.719	1.659	1.168	1.463	1.315	0.867
56	0.067	0.182	0.704	1.605	1.117	1.437	1.279	0.815
58	0.065	0.180	0.688	1.548	1.068	1.402	1.240	0.762
60	0.064	0.177	0.672	1.489	1.017	1.358	1.197	0.711
62	0.063	0.173	0.655	1.427	0.966	1.301	1.149	0.659
64	0.062	0.168	0.637	1.361	0.912	1.231	1.097	0.608
66	0.061	0.162	0.618	1.291	0.855	1.145	1.039	0.558
68	0.061	0.154	0.596	1.217	0.795	1.043	0.975	0.509
70	0.061	0.145	0.572	1.139	0.729	0.922	0.904	0.461
72	0.061	0.133	0.546	1.056	0.659	0.780	0.827	0.415