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An Examination of the OITC Metric for Building Facade Design in New York City

Benjamin H. Sachwald[a)]
Christian P. H. Thompson[b)]
AKRF, Inc.
440 Park Avenue South
7th Floor
New York, NY 10016

The Department of City Planning in New York issued an updated City Environmental Quality Review (CEQR) Technical Manual in May of 2010. While most City Agencies have gradually made the transition from the STC metric to the OITC metric for building façade design evaluation, Chapter 19, "Noise" of the 2010 CEQR Technical Manual represents the first time this design requirement has been officially prescribed. While most acoustical consultants will typically perform 1/3 octave band transmission loss calculations based on site-specific noise survey data and the ASTM E90 laboratory test data of façade elements, having a simplified single number metric, such as OITC, provides City Agencies (ex: DOB, OER, DEP, etc.) the ability to certify compliance in an expeditious manner. While OITC is arguably the most appropriate single number metric for building façade design, this paper explores the intricacies associated with using the OITC metric in New York City. Specifically, using actual noise survey data of roadway, railway, and aircraft activity for specific development sites, interior noise levels were calculated and compared using two approaches: 1) the OITC metric, and 2) 1/3 octave band transmission loss calculations.

1 INTRODUCTION

In the New York City urban environment, noise pollution comes from a wide variety of sources: vehicular traffic (autos, trucks, busses), commuter rail and above-ground subway lines, aircraft (rotorcraft and fixed-wing), and stationary sources such as manufacturing and industrial facilities. Some sources are activities essential to the health, safety, and welfare of a city's inhabitants (e.g., noise from emergency vehicle sirens, garbage collection operations, construction and maintenance equipment). Other sources, such as vehicular, rail and aircraft traffic, are essential to the viability of a city as a place to live and do business. Although these and other noise-producing activities are necessary to a city, the noise they produce is undesirable. New York City's high population density and wide variety of land uses (e.g. residential, commercial, transportation, manufacturing and industrial) exist in close proximity and it is common for a noise-sensitive building (i.e., residential, school, hospital, high-end office space, etc.) to be located in an area with ambient noise levels considered undesirable for development. Since developers have no control of environmental noise sources, such as an elevated subway

[a)] Email: bsachwald@akrf.com
[b)] Email: cthompson@akrf.com

adjacent to a development site, in order to avoid a finished building with interior noise levels unsuitable for tenant use, a proposed development's façade should be designed and constructed to adequately block the intrusion of exterior environmental noise. Accordingly, the City of New York prescribes minimum window/wall attenuation requirements for projects: 1) requiring discretionary approvals, 2) on a tax Block/Lot with an (E) designation or Restrictive Declaration, or 3) in a Special Mixed Use District. To demonstrate compliance with the City's minimum window/wall attenuation requirement, the single number Outdoor Indoor Transmission Class[1] (OITC) metric is used. While most acoustical consultants typically perform 1/3 octave band transmission loss calculations based on site-specific noise survey data and the ASTM E90[2] laboratory test data of façade elements, having a simplified single number metric, such as OITC, provides City Agencies (ex: Department of Buildings [DOB], Office of Environmental Remediation [OER], Department of Environmental Protection [DEP], etc.) the ability to certify compliance in an expeditious manner. While OITC is arguably the most appropriate single number metric for building façade design, this paper explores the intricacies associated with using the OITC metric in New York City.

2 2010 CEQR ATTENUATION REQUIREMENTS

In May of 2010, the Mayor's Office of Environmental Coordination released an updated City Environmental Quality Review (CEQR) Technical Manual (previous CEQR Technical Manual update was October 2001). The CEQR Technical Manual defines minimum attenuation requirements for buildings based on exterior noise level (see Table 1). The minimum noise attenuation values for buildings are designed to maintain interior noise levels of 45 dBA (approx. NC 40) or lower for residential, school, hospital, etc. uses and interior noise levels of 50 dBA (approx. NC 45) or lower for office, retail, etc. uses and are most often determined based on exterior L_{10}[c] noise levels. These interior noise level design goals account for the intrusion of exterior environmental noise (i.e., roadway, railway, aircraft, etc.) only (i.e., independent of building mechanical, plumbing, etc. systems).

When comparing the 2010 publication to the 2001 publication of the CEQR Technical Manual, the two most significant revisions are as follows:

- While the CEQR interior noise level criteria [i.e., 45 or 50 dB(A) L_{10} or less, depending on use] have not changed, the 2010 CEQR Technical Manual's noise attenuation requirement increments are smaller [1 to 3 dB(A)] compared to those in the 2001 CEQR Technical Manual [5 dB(A)], and
- While most City Agencies have gradually made the transition from the STC metric to the OITC metric for building façade design evaluation prior to its release, the 2010 CEQR Technical Manual represents the first time this design requirement has been officially prescribed.

3 NEW YORK CITY - COMMON ENVIRONMENTAL NOISE SOURCES

As previously discussed, the noise pollution in New York City is a result of a wide variety of sources: vehicular, rail and aircraft traffic; manufacturing and industrial uses; outdoor mechanical equipment; business and commercial uses, nightclubs, etc. The New York City

[c] Depending on site-specific conditions, the daily L_{dn} (for rail) and yearly L_{dn} (for aircraft) must be examined in lieu of the peak hour L_{10} value for noise attenuation requirements.

Zoning Resolution Performance Standards for Manufacturing Districts prescribes noise limits for areas zoned manufacturing and the New York City Noise Control Code sets stringent limits on specific noise sources such as outdoor mechanical equipment, business and commercial uses, and amplified music associated with nightclubs, etc. Consequently, this study focuses on the environmental noise sources discussed below that are not regulated by City codes.

3.1 Roadway

The following common roadway categories that occur in New York City and their associated characteristics are outlined below.

- *At-Grade, Elevated and In-Cut Highways*: large volume of vehicles that can include a high volume of trucks (ex: Brooklyn Queens Expressway), traffic traveling at speeds in excess of 35 miles per hour (MPH), and little-to-no stop lights or other traffic control measures. Examples include the Bruckner Expressway, Long Island Expressway, and Franklin D. Roosevelt Drive.
- *Major Avenues/Streets*: large volume of vehicles that can include a high volume of trucks and/or busses, traffic traveling at speeds of 35 MPH or less, stop lights or other traffic control measures at each intersection. Examples include Second Avenue, East 34th Street, and Flatbush Avenue.
- *Minor Streets*: moderate to low volume of vehicles with typically little-to-no trucks or busses, traffic traveling at speeds of 35 MPH or less, stop lights or other traffic control measures at each intersection, and some locations with irregular roadway surfaces such as cobblestone (ex: Water Street in Brooklyn). Examples include East 2nd Street, Bedford Street, and Sterling Place.
- *Bridges*: large volume of vehicles that can include a high volume of trucks (ex: George Washington Bridge), traffic traveling at speeds in excess of 35 MPH, and little-to-no stop lights or other traffic control measures. Examples include the Brooklyn Bridge, Robert F. Kennedy Bridge, and Ed Koch Queensboro Bridge.

3.2 Railway

The following common railway categories that occur in New York City and their associated characteristics are discussed below.

- *Elevated Rail*: while there are locations in Manhattan with elevated rail (ex: 1 and A Trains, Metro North Railroad) these are more common in outer boroughs (i.e., Brooklyn, Queens and the Bronx), elevated subway trains (i.e., electric, local [more frequent stops] and express [less frequent stops], typically slower speeds than commuter trains) and commuter trains (i.e., electric, fewer stops, wide range in speed). A significant source of non-vehicle noise is a result of structure-borne noise caused by the metal railway structures and wheel-to-rail curve-squeal at curve locations. Examples include F, B and 3 Trains.
- *At-Grade Rail*: typically electric commuter trains, fewer stops, and wide range in speed. Examples include the Long Island Rail Road.
- *In-Cut Rail*: less common, subway (i.e., electric, local [more frequent stops] and express [less frequent stops] trains) with typically slower speeds than commuter trains, and regional rail. Examples include the Q train and AMTRAK.

3.3 Aircraft

The two common aircraft categories that occur in New York City and their associated characteristics are discussed below.

- *Fixed-Wing*: Aircraft take-offs, landings, and flyovers associated with John F. Kennedy, LaGuardia, and Newark Airports.
- *Rotorcraft*: Helicopter idling, hovering, take-offs, landings, and flyovers associated with hospitals, City of New York Police Department, East 34th Street Heliport, etc.

4 METHODOLOGY

To examine potential caveats associated with using the OITC metric in New York City, an investigation was performed in accordance with the methodology outlined below.

- Actual noise survey data for specific development sites was assembled and divided into categories (i.e., roadway, railway, and aircraft) based on the dominant source of noise.
- The 1/3 octave band L_{10} values (in dB) and broadband L_{10} values (in dBA) for each measurement were collected.
- The spectral shape of the measured L_{10} 1/3 octave band values were compared to the spectral shape of the ASTM E1332-10a reference spectrum and any significant differences were noted.
- To minimize the number of variables in the investigation, the theoretical building façade was assumed to be a 1-inch insulated glass unit (IGU) of ¼" glass – ½" airspace – ¼" glass. From our experience, this glass assembly is very typical for windows, window/wall systems, and curtain walls of new development projects in New York City. This IGU has been tested at several NVLAP certified acoustical test facilities and has an OITC rating of 30.
- Interior noise levels, due to the intrusion of exterior environmental noise, were calculated and compared using two approaches: 1) measured broadband L_{10} value (in dBA) minus the OITC metric, and 2) measured 1/3 octave band L_{10} values (in dB) minus the ASTM E90 1/3 octave band transmission loss values.

The results of the investigation are presented below.

5 INVESTIGATION RESULTS

This section discusses and compares the results of the investigation between using the OITC metric and 1/3 octave band analysis to predict interior noise levels based on the intrusion of exterior environmental noise. The difference between the two calculation approaches was recorded and a standard deviation was found for each noise source category (i.e., roadway, railway, and aircraft). Unless the difference was within one standard deviation, when the "measured broadband L_{10} value (in dBA) minus the OITC metric" method resulted in a lower interior noise level than the "measured 1/3 octave band L_{10} values (in dB) minus the ASTM E90 1/3 octave band transmission loss values" method, the spectral shape of the measured L_{10} 1/3 octave band values were compared to the spectral shape of the ASTM E1332-10a reference spectrum and any significant differences were noted.

The delta between using the OITC metric versus a 1/3 octave band analysis was determined. If use of the OITC metric resulted in a higher predicted interior noise level (when compared to the predicted interior noise level using the 1/3 octave band analysis), the delta was a positive number; if use of the OITC metric resulted in a lower predicted interior noise level (when compared to the predicted interior noise level using the 1/3 octave band analysis), the delta was a negative number (and if the OITC metric and 1/3 octave band analysis resulted in the same predicted interior noise level, the delta was zero). Since the CEQR Technical Manual uses the OITC metric (and subsequently, this is what New York City Agencies such as DOB, OER, DEP, etc. enforce), a delta greater than zero indicates that use of the OITC metric would be conservative and result in adequate interior noise levels when used for building façade design acoustical specifications. If the delta was a negative number, this indicates that use of the OITC metric is likely to result in interior noise levels greater than what was predicted by subtracting the OITC rating from the measured L_{10} value in dBA (and consequently, use of the OITC metric for building façade design acoustical specifications should be used with caution). The results of the investigation are shown in Table 2. A summary is as follows:

- Use of the OITC metric was conservative for 208 of the 248 (i.e., 83.8%) cases examined for this investigation.
- For 37 of the 248 (i.e., 14.9%) cases examined, use of the OITC metric resulted in interior noise levels lower than what was calculated using the 1/3 octave band method.
- For 3 of the 248 (i.e., 1.2%) cases examined, the OITC metric and 1/3 octave band method predicted identical interior noise levels

The standard deviation was determined for each noise source category: ±1.54, ±1.76, and ±1.38 for roadway, railway, and aircraft, respectively. All noise survey data was divided into their respective categories based on dominant noise source (i.e., roadway, railway, and aircraft) and plotted against their respective standard deviations (see Figures 1, 2 and 3). Several data points with a negative delta fit inside of these standard deviations. When excluding these values within one standard deviation, only 13 of the 248 (i.e., 5.2%) cases examined remained.

For data points with a negative delta, the spectral shape of the OITC reference spectrum was compared to that of the site-specific noise survey data. Whether it was a mid-spectrum peak associated with wheel-to-rail curve-squeal, high levels of low frequency (i.e., below 125 Hz) noise associated with heavy truck and bus traffic, or locations not immediately adjacent to a busy roadway (or other noise source[s]), in these cases it was apparent that the measured spectrum shape notably deviated from the OITC reference spectrum (see Figure 4 for an example).

6 CONCLUSIONS

While the most accurate method to predict interior noise levels due to the intrusion of exterior environmental noise is to perform 1/3 octave band transmission loss calculations based on site-specific noise survey data and ASTM E90 laboratory test data of façade elements, building codes and city regulations are commonly based on single number metrics (such as OITC). As this investigation demonstrates, developing a building façade design acoustical specification based on the OITC metric in New York City is a conservative approach for more than 80% of the cases examined. Considering the number of variables involved and the investigation's standard deviations, use of the OITC metric in New York City was determined to be a successful approach for approximately 95% of the cases examined. Despite this rate of success, it is strongly recommended to always compare a noise survey's measured 1/3 octave band spectral shape to that of the OITC reference spectrum to determine any notable deviations. If notable deviations between these two spectra are identified, 1/3 octave band calculations are recommended. Since the DOB, OER, and DEP use the OITC metric to certify compliance, the results of 1/3 octave band calculations can be used to make necessary adjustments to the project specifications such that both the City Agencies and the project interior noise level criteria are achieved.

7 REFERENCES

1. ASTM E1332-10a, "Standard Classification for Rating Outdoor-Indoor Sound Attenuation"

2. ASTM E90-09, "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements"

Table 1– May 2010 CEQR Attenuation Requirements

Peak Hour Noise Level in dB(A)	Attenuation
$70 < L_{10} \leq 73$	28 dB(A)
$73 < L_{10} \leq 76$	31 dB(A)
$76 < L_{10} \leq 78$	33 dB(A)
$78 < L_{10} \leq 80$	35 dB(A)
$80 < L_{10}$	$36 + (L_{10} – 80)$ dB(A)

Table 2– Summary of Investigation Results

Noise Source Category	Number of Instances where 1/3 Octave Band TL Resulted in Lower Interior Noise Level	Number of Instances where OITC Resulted in Lower Interior Noise Level	Standard Deviation	Range of Differences Between Two Methods, in dB(A)
Roadway	171	28	±1.54	-3.5 to 5.1
Railway	19	5	±1.76	-2.6 to 2.9
Aircraft	18	4	±1.38	-1.8 to 3.1

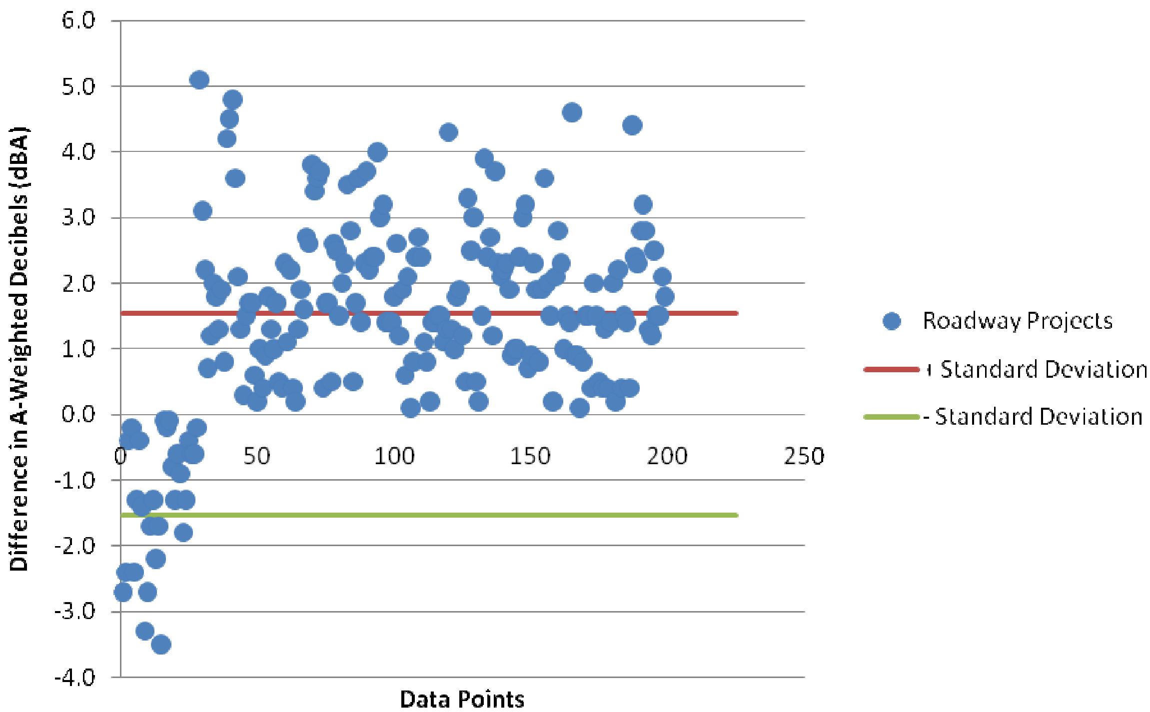

Fig. 1 – Roadway Traffic Comparison

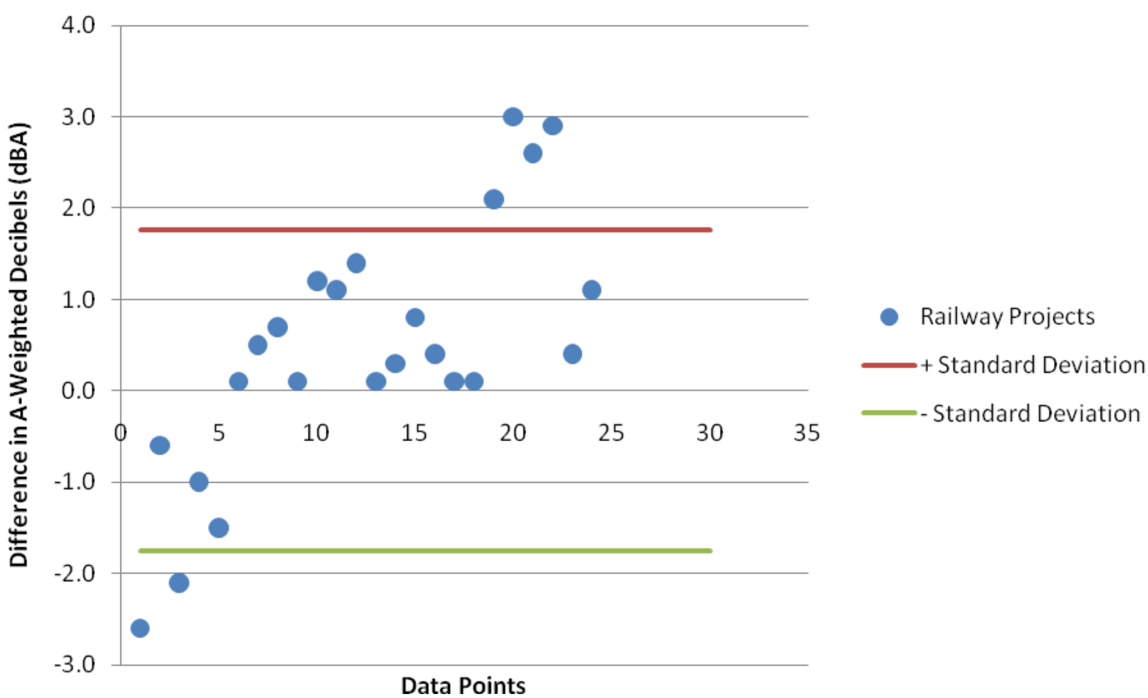

Fig. 2 – Railway Traffic Comparison

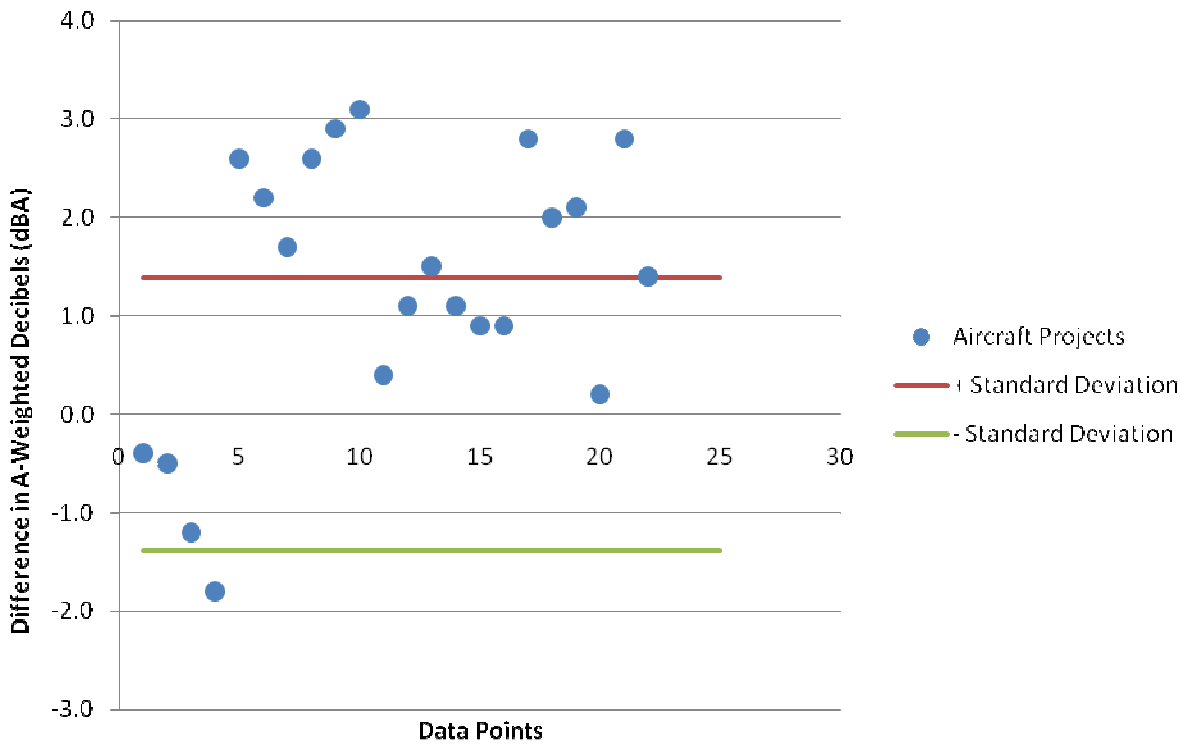

Fig. 3 – Aircraft Traffic Comparison

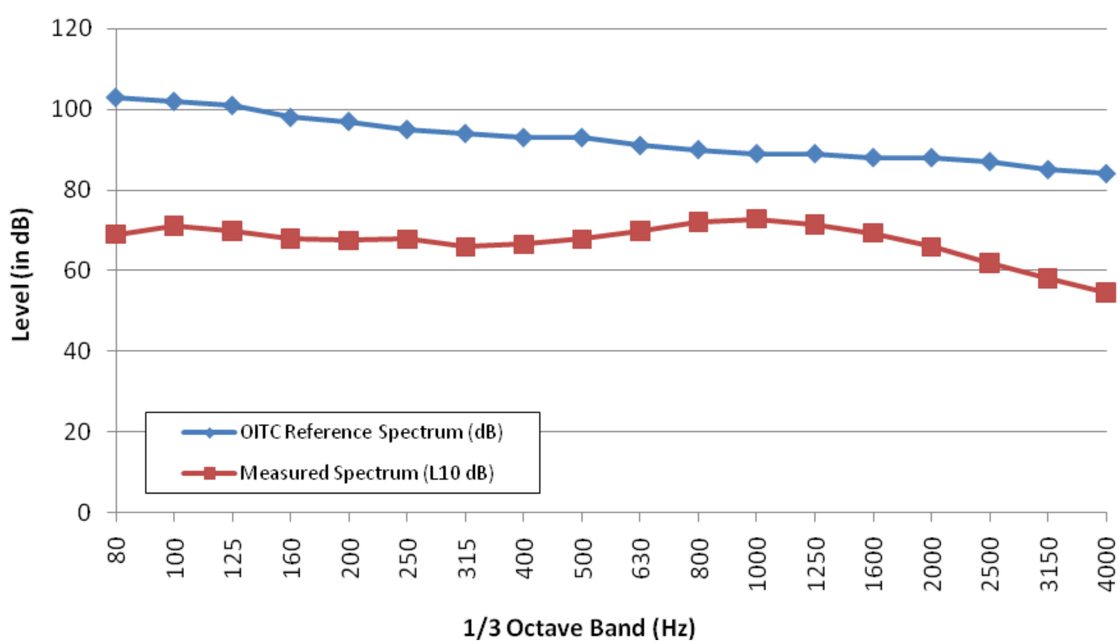

Fig. 4 – Measured vs. OITC Reference Spectrum