Doosan Fuel Cell America, Inc.
195 Governor's Highway
South Windsor, CT 06074
T - 860 727 2200

February 24, 2017

Responses to PE 1265-(11/23/16 Notice) Interrogatories – Set Two

RE: PETITION NO. 1265 - Doosan Fuel Cell America, Inc. petition for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required for the construction, maintenance, and operation of a customer-side 460-kilowatt fuel cell facility to be located at the Norwich Inn and Spa, 607 West Thames Street, Norwich, Connecticut

Dear Siting Council:

Please see the attached responses to the interrogatories with exhibits to the questions posed by the Connecticut Siting Council on 12/28/16 for PE 1265 – Set Two.

Please address additional questions to:

Claudio Borea
195 Governor's Highway
South Windsor, CT 06074
(860) 727-2076
Claudio.Borea@doosan.com

Thank you for your time and consideration.

Sincerely,

Doosan Fuel Cell America, Inc.

Dawn Mahoney

Dawn Mahoney, Esq.
General Counsel
Doosan Fuel Cell America, Inc.

VIA ELECTRONIC MAIL

December 28, 2016

Dawn Mahoney, Esq.
General Counsel
Doosan Fuel Cell America Inc.
195 Governor's Highway
South Windsor, CT 06074

RE: **PETITION NO. 1265** - Doosan Fuel Cell America, Inc. petition for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required for the construction, operation and maintenance of a customer-side 460-kilowatt fuel cell facility to be located at the Norwich Inn and Spa, 607 West Thames Street, Norwich, Connecticut.

Dear Attorney Mahoney:

The Connecticut Siting Council (Council) requests your responses to the enclosed questions no later than January 11, 2016. To help expedite the Council's review, please file individual responses as soon as they are available.

Please forward an original and 15 copies to this office, as well as send a copy via electronic mail. In accordance with the State Solid Waste Management Plan and in accordance with Section 16-50j-12 of the Regulations of Connecticut State Agencies the Council is requesting that all filings be submitted on recyclable paper, primarily regular weight white office paper. Please avoid using heavy stock paper, colored paper, and metal or plastic binders and separators. Fewer copies of bulk material may be provided as appropriate.

Any request for an extension of time to submit responses to interrogatories shall be submitted to the Council in writing pursuant to §16-50j-22a of the Regulations of Connecticut State Agencies.

Yours very truly,

Melanie Bachman
Acting Executive Director

MB/MP

c: Council Members

Petition No. 1265
Doosan Fuel Cell America, Inc.
607 West Thames Street
Norwich, CT
Interrogatories — Set Two

32. As the Council previously requested in Council interrogatory number 3, please provide a detailed site plan with a scale for the proposed facility, including but not limited to, the dimensions and location of the proposed fuel cell facility cooling module, concrete pads, fence design and bollards (if applicable) and utility connections.

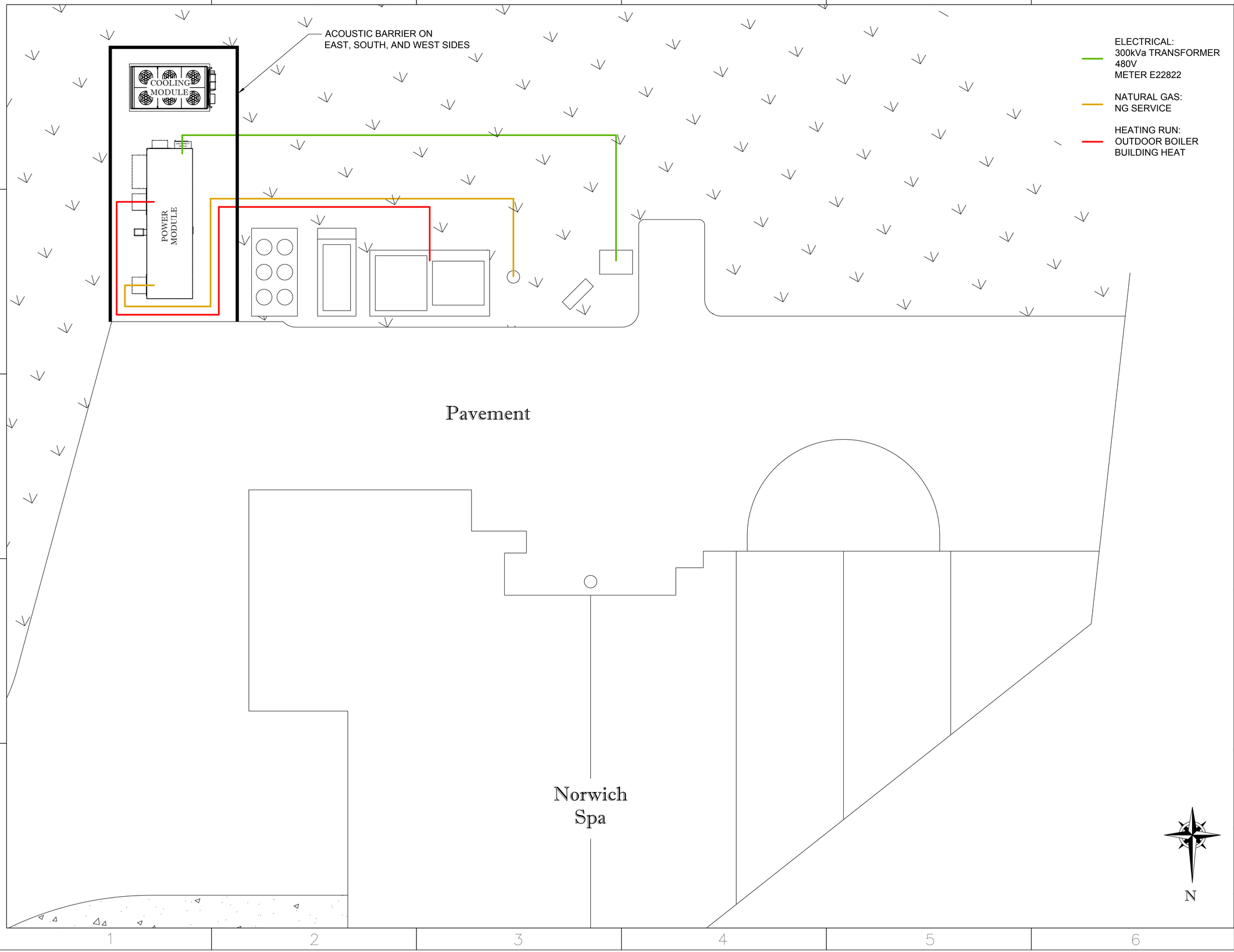
R32. Please see attached Norwich -1 Detailed Site plan.

33. In response to Council interrogatory number 10, Doosan did not provide a noise analysis report for the proposed fuel cell facility; however, Doosan states it will perform site specific noise studies at host property boundaries to confirm compliance. Please provide such noise analysis report of the proposed fuel cell unit at the host property boundaries.

R33. Please see attached Norwich -2 Detailed Noise Report. Noise barriers will be installed in accordance with the recommendations of the acoustical engineer to ensure compliance with nighttime limits.

NORWICH -1

DETAILED SITE PLAN



DOOSAN

PureCell® Model 400

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SITE-SPECIFIC CONSTRUCTION DRAWINGS MUST BE PREPARED BY THE ENGINEER OF RECORD. DOOSAN IS NOT RESPONSIBLE FOR THE ACCURACY OF CONSTRUCTION DRAWINGS, INCLUDING, BUT NOT LIMITED TO, THE DESIGN OF THE SYSTEMS THAT INTERFACE WITH DOOSAN'S EQUIPMENT.

NOT FOR CONSTRUCTION

REPRESENTATION OF MATERIAL ON THIS DRAWING DOES NOT INDICATE A RESPONSIBILITY OF DOOSAN TO SUPPLY THE EQUIPMENT. DOOSAN SCOPE OF SUPPLY IS DEFINED IN CUSTOMER CONTRACT DOCUMENTS.

MARK	DATE	DESCRIPTION
A		

ISSUE:

ORIGINAL RELEASE:

DRAWING NO.:

DRAWING SCALE: 1/8" = 1'-0"

DRAWING REVISION: A

CAGE CODE:

DRAWN BY: T. BLISS

CHECKED BY:

SHEET TITLE:

SITE PROPOSAL
NORWICH SPA
NORWICH, CT

P1

SHEET 1 OF 1

NORWICH-2

SITE SPECIFIC NOISE REPORT

Prepared For: Doosan Fuel Cell America Inc.

Point of Contact: Claudio Borea

Prepared by: Acoustical Technologies Inc.
50 Myrock Avenue
Waterford, CT 06385-3008

Subject: Norwich Inn and Spa
Airborne Noise Assessment

Author: Carl Cascio

Date: February 7, 2017

Revision: 0

Table of Contents

Summary

This document makes a positive acoustic assessment that should assist in meeting any acoustic noise concerns during the operation of a Doosan 460 KW fuel cell at the Norwich Inn and Spa in Norwich, CT. An acoustic assessment plan was developed and executed to acquire airborne acoustic information useful in explaining and mitigating the potential airborne noise issues associated with operation of the Doosan 460 KW fuel cell. It is important to show that the airborne noise generated by the fuel cell will not significantly impact the facility's neighbors.

The airborne noise levels expected to be generated by the Doosan fuel cell operating at the Norwich Inn and Spa were simulated by exciting a set of four co-located speakers at the fuel cell power and cooling module positions. The cooling modules are the dominant noise source. The four speakers produced an overall airborne noise level that was 16 to 18 dB higher than the levels measured for a similar Doosan fuel cell installed at Mount Sinai Hospital in Hartford, CT. One-third octave band analysis showed the speakers to match or slightly exceed the fuel cell airborne noise levels at frequencies up to 250 Hertz where the airborne noise levels were low and to exceed the fuel cell signature by about 20 dB at higher frequencies where the fuel cell signature was higher.

Airborne noise levels were measured at distances from 5 to 213 meters from the fuel cell location. The speakers produced average overall A-weighted sound pressure levels of 92 dBA at 5 meters and 87 dBA at 10 meters (reference 20 microPascals) at the proposed fuel cell power module and cooling module locations. The airborne noise levels from the speakers at nearby property lines were measured at levels from 34 to 68 dBA. Measurement locations to the northwest and north were very quiet with levels below 45 dBA even with the speakers on. Measurement locations to the southeast and east were high because of the short distance to the speaker H location that overlooked West Thames Street. Analysis of the speaker data indicated propagation losses from 19 to 53 dB from the fuel cell location to the nearby property lines. The source levels at 10 meters from the operation of a Doosan fuel cell at Mount Sinai Hospital in Hartford, CT were then used as a basis for the Norwich fuel cell airborne noise estimates.

Operation of the fuel cell should produce noise levels below the Commercial Zone noise limit of 62 dBA at all of the nearby commercial property lines. The highest expected level of 51 dBA will be at the 2 Trading Cove Road property line 91 meters from the fuel cell cooling module. Two nearby neighbor property lines are also above the nighttime residential noise limit with expected airborne noise levels of 46 and to 50 dBA with the fuel cell on. Other residences further away on West Thames Street are expected to be below the 45 dBA limit. All the residences are expected to be below the 55 dBA daytime noise limit. There is a minor acoustic issue with the three homes on West Thames Street during operation of the fuel cell at the Norwich Inn and Spa. An 8 foot high acoustic barrier lining the west, south and east sides of the fuel cell enclosure is recommended to eliminate this nighttime noise issue for the residences on West Thames Street. With this noise barrier in place there should be no acoustic issues with operation of the fuel cell.

The Connecticut's Noise Code (Reference 1) also calls for review of acoustic issues associated with impulse noise, prominent discrete tones, infrasonic and ultrasonic noise. Operation of the fuel cell is expected to meet all of these requirements at all of the nearby property lines.

Introduction

Acoustical Technologies Inc. was tasked as part of a Doosan site permitting process with an assessment of potential acoustic issues associated with fuel cell airborne noise reaching the properties adjacent to the Norwich Inn and Spa in Norwich, CT. Responding to a request from Claudio Borea, a site visit was made on January 31, 2017. During the visit a survey of the airborne noise levels produced by a set of speakers simulating the airborne noise produced by a Doosan Fuel Cell was made in order to identify potential airborne noise issues. Airborne noise measurements were taken to quantify the propagation of the simulated fuel cell airborne noise to the adjacent properties. Background airborne noise levels were also made with the speakers off. This document provides an acoustic assessment to assist in meeting acoustic noise concerns during the permitting process for the siting of a Doosan fuel cell at 607 West Thames Street.

Development of the Acoustic Assessment Plan

The purpose of this effort is to acquire acoustic information useful in explaining the potential airborne noise issues associated with the operation of a Doosan 460 KW fuel cell at the Norwich Inn and Spa site in Norwich, CT. The Norwich Inn and Spa at 607 West Thames Street is located in a Planned Commercial Zone near the Thames River. This Commercial Zone (PC) is adjacent to MultiFamily (MF) and R-20 Residential Zones (AA) to the east and General Commercial Zones (GC) to the north and south. To the west is a golf course in a Recreational Open Space Zone (ROS). It is important to determine whether the airborne noise generated by the Doosan fuel cell will impact these neighbors.

The acoustic impact is assessed in the following way. The fuel cell is yet to be installed so there is no way to measure fuel cell operating airborne noise levels at the new site. The fuel cell airborne noise has been measured at other sites and both overall and one-third octave band airborne noise data of a typical Doosan 400 KW fuel cell are available for reference. Using this data, a set of four speakers have been programmed through a set of two octave band filters to generate a noise spectrum similar to that of the fuel cell. This spectrum will then be played through an audio amplifier to create the electrical voltage necessary to drive the four symmetrical speakers. In order to overcome the high background noise at the site the speaker output will be increased to a level at least 16 dB higher than the overall dBA level measured on a fuel cell at a distance of 10 meters. With the speakers on, this approach then follows the traditional "What is the airborne noise level at the neighbor's property line?„. The four speakers were run and airborne measurements made near the proposed fuel cell location and at several of the neighbor's property lines. This measured site data can also be used to estimate noise levels at other neighbor's property lines. The City of Norwich does not have a Noise Ordinance so the State of Connecticut's Noise Code has been consulted to assess the impact of the measured and estimated acoustic levels. Noise mitigation may be recommended if the airborne noise estimated for the fuel cell exceeds the state noise requirements at the neighbor's property lines.

Acoustic Measurement Program

The acoustic data necessary to assess the impact of the 460 KW Doosan Fuel Cell are described below: Airborne sound pressure measurements and audio tape recordings were conducted at the Norwich Inn and Spa on and near 607 West Thames Street on January 31, 2017 during the afternoon hours. This testing established both background airborne noise levels and simulated airborne noise levels with the speakers operating. The overall A-weighted airborne noise measurements were made with an ExTech model 407750 Digital Sound Level Meter (s/n 3072577) that had been calibrated just prior to and after the test with a Quest model QC-10 Calibrator (s/n Q19080194). Measurements were taken with A-weighting (frequency filtering that corresponds to human hearing) and with the sound level meter in a Slow response mode. For reference, a noise level increase of 1 dB is equal to an airborne sound pressure increase of 12.2 per cent. The audio tape recordings were conducted with a Sony Digital Audio Tape Recorder (model TCD-D8 s/n 579588 on channels 1 and 2). Two PCB microphones (model 130C10 s/n 11283 and 130C10 s/n 10641) were powered by two Wilcoxon P702B power supply/amplifiers (s/n 1992 and 1995 respectively). The PCB microphones were also calibrated just prior to and after the test with the Quest model QC-10 Calibrator (s/n Q19080194). All measurements were made with the microphones at a height between four and five feet. A Hewlett Packard model HP3561A Dynamic Signal Analyzer, s/n 2338A00659, was used to perform A-weighted spectral analysis on the tape-recorded data. The tape-recorded data was also used to verify the ExTech sound level meter overall dBA readings.

At the Norwich Inn and Spa site "source on„ and background airborne noise measurements were taken at the following nine nearby property lines in the Commercial and Residential Zones:

	Zone	Type
P1 - 17th Tee Norwich Golf Course	ROS	Residential
P2 - 698 New London Turnpike (Condominium nearest 17th Tee)	PC	Commercial
P3 - Northeast Corner of Norwich Inn & Spa property	PC	Commercial
P4, P5, P6 - 612, 630, 656 West Thames Street, homes	MF	Residential
P7 – 665 West Thames Street, home	PC	Commercial
P8 – 671 West Thames Street, Joy's Restaurant	PC	Commercial
P9 - 2 Trading Cove Road, home	R20	Residential

See the Google satellite map in Figure 1 for the approximate measurement locations. (Figure 5a and 5b below show individual Google Map pictures at each property line.) Measurements near the proposed operating fuel cell sites at position G were simultaneously taken with the ExTech sound level meter and two microphones recording on the digital tape recorder. Figure 2 provides a photograph of the site location for the fuel cell. The power module is to be located where the dumpster is shown with the cooling module behind it. Figure 3 below shows a photograph of the speakers located at position G. The two source locations were chosen because G represents the side of the power module closest to the Norwich Inn and H represents the center of the cooling module facing the neighbors to the east and south. At location G an eight minute record of the acoustic noise was stored for the speakers in the "on„ condition. Four minutes of background airborne noise data were also recorded at position G. (Background and source levels at position H were assumed to be the same as data from position G.)

Figure 1. Norwich Inn and Spa Site Map from Google Maps

Figure 2. Doosan Fuel Cell Location for the Norwich Inn and Spa Site

Airborne noise measurements taken outside are corrupted by rain and wind so a day was selected when the winds were 10 miles per hour or less. Unfortunately, some snow flurries were present but did not interfere with the acoustic testing. Table 1 provides the weather data in Norwich for the measurements on January 31, 2017. Measurements were taken over the period from 1:15 pm until 6:15 pm. The table below shows the temperature and wind speeds in half hourly intervals. Wind conditions were good and the wind did not affect the operating and background airborne noise measurements. There was a small amount of snow that diminished as the afternoon progressed. Motor traffic was heavy and the measurements on West Thames Street were delayed until after 5pm when the traffic abated. It was then possible to wait for periods of time when no traffic was seen or heard at the nearby measurement locations. Airborne noise levels near the location of the two source positions were high due to the operation of an existing cooling system. Levels of 74 and 77 dBA at 5 and 10 meters from position G are similar to the levels expected from the Doosan cooling system and were heard in the backgrounds along West Thames Street.

Table 1. Norwich Weather on January 31, 2017 from **www.LocalConditions.com**

Time (EST)	Temp. (ºf)	Humidity (%)	Dew Point (ºf)	Barometer (in HG)	Wind Speed (mph)	Wind Direction	SnowTotal (in.)
8:00 PM	26.6	86.04	23	29.84	9	ne	-
7:30 PM	26.6	86.04	23	29.84	8	ne	-
7:00 PM	26.6	86.04	23	29.84	6	nne	-
6:30 PM	26.6	86.04	23	29.83	8	nne	-
6:05 PM	26.6	92.79	24.8	29.82	8	nne	-
5:30 PM	26.6	86.04	23	29.82	9	nne	-
5:00 PM	26.6	86.04	23	29.81	10	ne	-
4:30 PM	26.6	86.04	23	29.81	9	ne	-
4:00 PM	26.6	86.04	23	29.8	10	ne	-
3:30 PM	26.6	86.04	23	29.81	10	ne	0.01
3:00 PM	26.6	86.04	23	29.82	9	ene	-
2:30 PM	26.6	86.04	23	29.84	9	ene	0.02
2:05 PM	26.6	86.04	23	29.85	7	ene	-
1:30 PM	26.6	92.79	24.8	29.87	7	ene	0.02
1:00 PM	26.6	92.79	24.8	29.89	6	e	-
12:35 PM	26.6	86.04	23	29.91	6	e	0.03
12:00 PM	26.6	79.74	21.2	29.94	5	ese	-
11:40 AM	26.6	73.84	19.4	29.95	7	ese	-
10:56 AM	28.04	52.48	12.92	29.99	3	-	-

Data Analysis

This section analyzes the airborne noise levels measured at the Norwich site and then estimates the transmission loss to nearby property lines expected during fuel cell operation. These levels will be compared to the limits in the Connecticut noise ordinance. Both background noise levels at the Norwich Inn and Spa and estimated Doosan Fuel Cell equipment operating noise levels will be reported. Comparing these Norwich estimates with the state noise limits will identify which nearby locations do or do not meet the airborne noise requirements.

Figure 3. Speakers Used as a Simulated Airborne Noise Source at Position G

The complete set of overall A-weighted airborne noise levels that were measured are in Table 2 for the conditions with the speakers on and off. Figure 4 is a map showing the Norwich zoning districts in the Norwich Inn and Spa area. The position locations were calculated using the Pocket Ranger GPS App from the CT State Parks & Forests. The indicated GPS accuracy was about 10 meters. The GPS range results were calculated with an application found at http://www.movable-type.co.uk/scripts/latlong.html and then checked with Google Maps. Figures 5a and 5b provide the position vector at each location. With the picture comes an estimate of the range in meters that is given in Table 2.

Table 2. Overall Sound Pressure Levels in dBA ref. 20 microPascals at the Norwich Inn and Spa

Location	Range in Meters	Speakers On L	Background	Bkgd Corrected	Speakers On M	Background	Bkgd Corrected
Pos. G Ch 1	5	95.5,88.5,93	77	95.5,87.6,93			
Pos. G Ch 2	10	90.5,85,87	74	90.5,84.6,86.2			
P1 – 17th Tee - Golf	145/147 m	42.6	42	34			
P 2 – Closest Condo	194/196 m	43.5	42	38			
P3 – Inn at Northeast Corner	210/213 m	44	44	39		Used Pos. G Bkgd. below	
P4 - 612 West Thames	158/160 m	46.5	47	< 45	48.5		46.6
P5 - 630 West Thames	88/90 m	52			53.5		52.5
P6 - 656 West Thames	58/ 55 m	57	55	52.8	68		67.8
P7 - 665 West Thames	87/84 m	54		51	64		63.4
P8 - 671 West Thames	113/110 m	51	48	47.9	55		54
P9 - Trading Cove #2	94/91 m	55	53	50.8	68.5		68.4

Figure 4. Norwich Zoning Map Showing Speaker Location at Position G

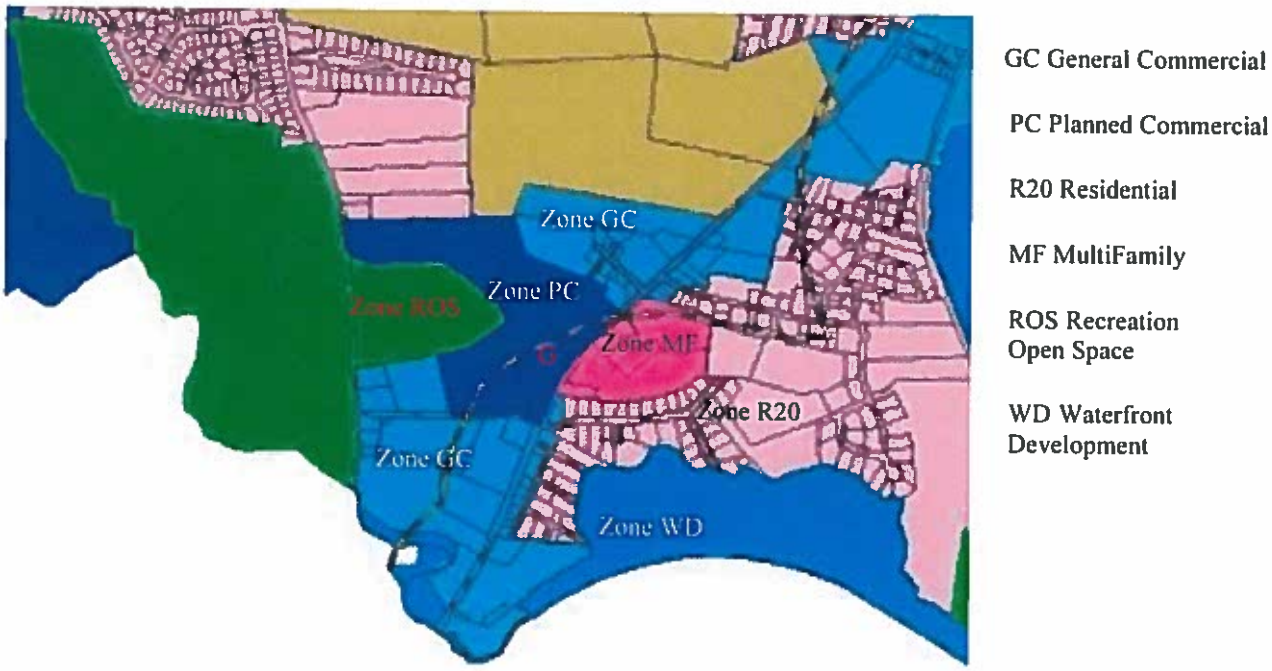
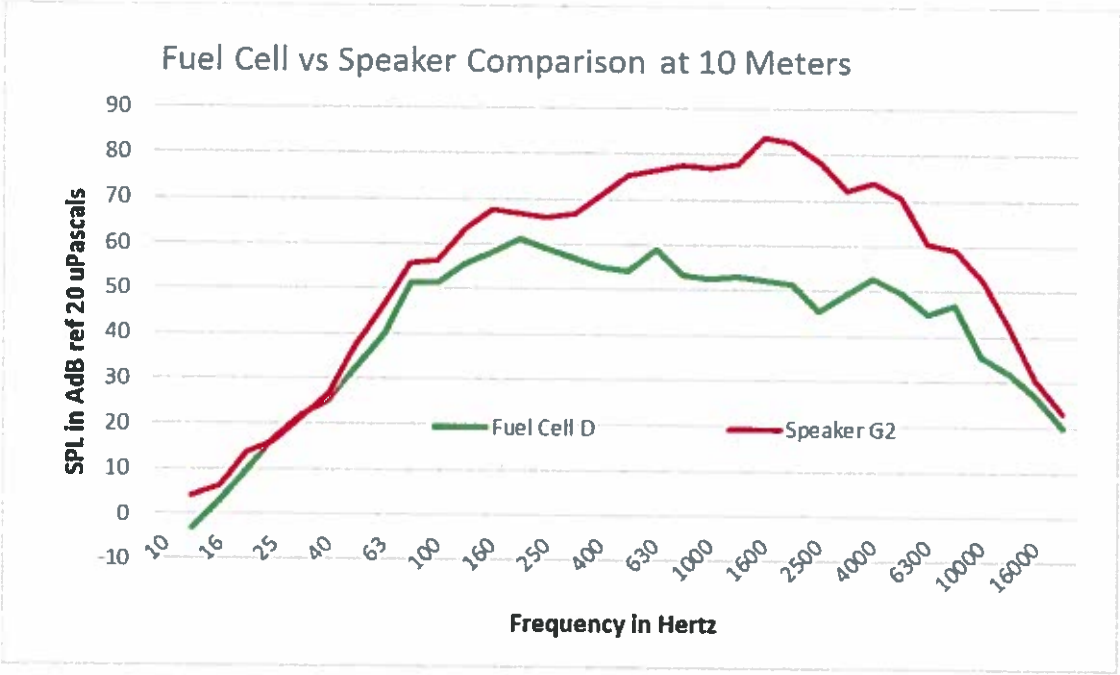


Figure 5a. Measurement Locations Showing Range Vectors (P1-P5) to the Source at Position G

Figure 5b. Measurement Locations Showing Range Vectors (P6-P9) to the Source at Position G

A comparison of the airborne noise produced at 10 meters by the Doosan fuel cell on the Mount Sinai Hospital site with the airborne noise produced by the speakers at the Norwich Inn and Spa site is shown in Figure 6. The speakers match the fuel cell airborne noise for frequencies below 250 Hertz and greatly exceed the fuel cell airborne noise at higher frequencies. The average overall airborne noise levels are 17.6 dB higher for the speakers at positions G and H compared to what is expected from the Doosan 460 KW fuel cell that was measured at Mount Sinai Hospital in Hartford, CT.

Figure 6 The Four Speakers Generate Airborne Noise Well Above That of a Single Fuel Cell



Allowable Noise Levels

The Connecticut regulation for the control of noise provides in *CT section 22a-69-3* (Ref. 1) the requirements for noise emission in Connecticut. *CT section 22a-69-3.1* states that no person shall cause or allow the emission of excessive noise beyond the boundaries of his/her Noise Zone so as to violate any provisions of these Regulations. Since the City of Norwich doesn't have a noise regulation the CT Code will be used to evaluate the noise generated by the Doosan Fuel Cell. Following sections discuss each type of noise using the results obtained from the airborne noise measurements at the Norwich Inn and Spa.

The southern part of the Norwich zoning map is given in Figure 4. As stated above the Norwich Inn and Spa at 607 West Thames Street is located in a Planned Commercial Zone. This Commercial Zone is adjacent to MultiFamily (MF) and R-20 Residential Zones to the east and General Commercial Zones to the north and south. To the west is a golf course in a Recreational Open Space Zone. The closest home to the east is 55 meters away at 656 West Thames in the MF residential zone. The Mount Sinai Hospital report (Ref. 2) showed that its single fuel cell's airborne noise was estimated to be below the 45 dBA Hartford residential noise limit at about 75 meters from the fuel cell. The shorter 55 meter distance to the cooling module will put the 656 West Thames Street property line above the 45 dBA nighttime noise limit. Using the Norwich speaker measurements, the airborne noise level expected at a distance of 55 meters at the 656 West Thames Street property line should be about 50 dBA. Two other nearby properties are also expected to be above the nighttime residential noise limit of 45 dBA for an emitter in a commercial zone.

Impulse Noise

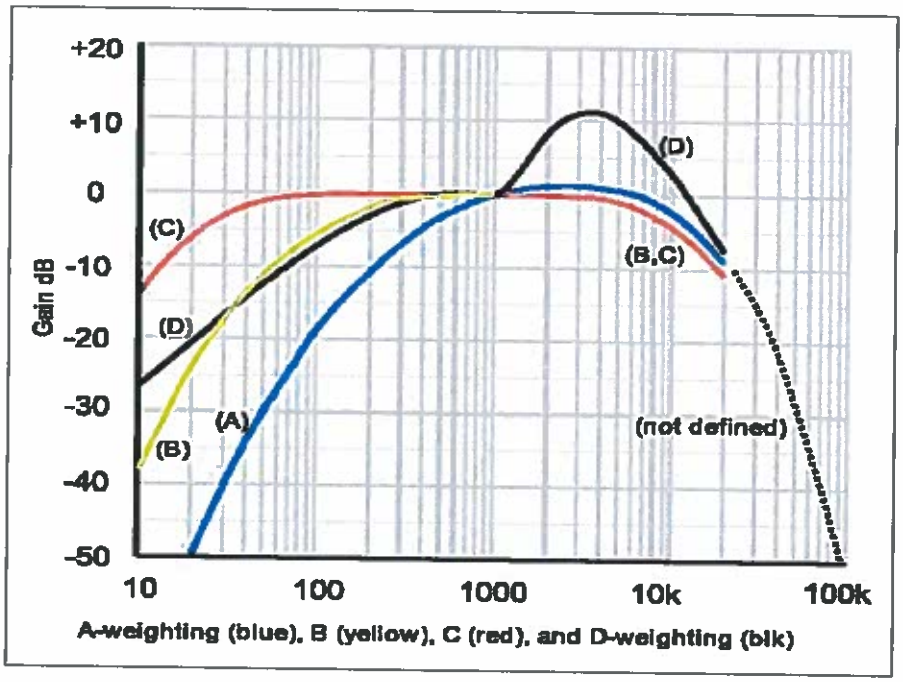
The Connecticut noise code states in *CT section 22a-69-3.2* (part a) *Impulse Noise* that no person shall cause or allow the emission of impulse noise in excess of 80 dB peak sound pressure level during the nighttime to any class A Noise Zone. Class A Noise Zones are residential. Nighttime hours are defined as 10 pm to 7 am. *CT section 22a-69-3.2 (part b) Impulse Noise* states that no person shall cause or allow the emission of impulse noise in excess of 100 dB peak sound pressure level at any time to any Noise Zone.

Impulse noise in excess of 80 dB was not observed on the tape-recorded data during any of the measurements of the Doosan 400 KW fuel cell made at the Mount Sinai Rehabilitation Hospital on 18 January, 2017. This fuel cell design is similar to the unit that will be installed in Norwich. Given the steady state nature of the fuel cell's noise signature there should be no acoustic issues with the State of Connecticut's impulse noise requirements.

A few words are in order to discuss the difference between A-weighted and un-weighted impulse noise. A-weighting emphasizes the middle and higher frequencies while reducing the influence of the low frequencies. Figure 7 plots the A-weighting curve versus frequency in blue. Below a frequency of 1 kiloHertz the acoustic level is attenuated by increasing amounts. The reduction is about 10 dB at 200 Hertz, 20 dB at 90 Hertz and 30 dB at 50 Hertz. It also reduces the level at very high frequency being down in level by 10 dB at 20 kiloHertz.

Figure 7. Acoustic Weighting Curves

http://upload.wikimedia.org/wikipedia/commons/3/39/Acoustic_weighting_curves_(1).svg



1 of 1

1/25/2013 9:35 PM

Prominent Discrete Tones

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.3 Prominent discrete tones:* Continuous noise measured beyond the boundary of the Noise Zone of the noise emitter in any other Noise Zone which possesses one or more audible discrete tones shall be considered excessive noise when a level of 5 dBA below the levels specified in section 3 of these Regulations is exceeded. The Regulations establish different noise limits for different land use zones. Residential (homes and condominiums) and hotel uses are in Class A. Schools, parks, recreational activities and services are in Class B. Forestry and related services are in Class C. By my reading of the regulations Norwich Inn and Spa is a Class B emitter in a Commercial Zone. The noise zone standards in *CT section 22a-69-3.5* state that a Class B emitter cannot exceed the following overall sound pressure levels:

To Class C 62 dBA To Class B 62 dBA To Class A 55 dBA (day) 45 dBA (night)

The discrete tones limits are 5 dBA lower so that no tone may be higher than the following:

To Class C 57 dBA To Class B 57 dBA To Class A 50 dBA (day) 40dBA (night)

To address the discrete tone issue we use measured data from the January 18 testing of a similar Doosan fuel cell. This data does not have A-weighting. The photo in figure 8 plots the airborne noise measured 10 meters from the Mount Sinai Cooling Module (Ref. 2) for frequencies from 0 to 1000 Hertz. This curve shows the two largest discrete tones produced by the Doosan Fuel Cell Cooling Module. The first tone is at 86 Hertz at a level of 65 dB reference 20 microPascals. The second tone is at 630 Hertz at a level of 56 dB reference 20 microPascals. The A-weighting corrections are -21.5 dB at 86 Hertz and -1.9 dB at 630 Hertz. Incorporating these corrections gives A-weighted levels of 44 dBA at 86 Hertz and 54 dBA at 630 Hertz both at a distance 10 meters from the Cooling Module. The minimum transmission loss to the property lines on West Thames Street is at least 18 dB so the maximum possible discrete tone would be about 36 dBA at the 2 Trading Cove property line. This level is below the 40 dBA nighttime requirement in a Residential Zone and well below the 50 dBA Commercial Zone limit. Operating the Doosan fuel cell should produce airborne noise levels well below the CT discrete tone requirement at all the property lines. There should be no acoustic issue with the CT discrete tone noise requirements.

Infrasonic and Ultrasonic Noise

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.4 Infrasonic and Ultrasonic* that no person shall emit beyond his/her property infrasonic or ultrasonic sound in excess of 100 dB at any time. 100 dB with respect to the reference of 20 microPascals is a sound pressure of 2 Pascals or 0.00029 psi. Infrasonic sounds are sound pressure fluctuations below a frequency of 20 Hertz. Ultrasonic sounds are sound pressure fluctuations at frequencies above 20,000 Hertz.

Narrow bandwidth sound pressure spectrums in dB reference 20 microPascals at the 10 meter Cooling Module location given in Reference 2 can be used to compare with these Infrasonic and Ultrasonic noise requirements. Mount Sinai Hospital airborne noise data were processed in the

0 to 100 Hertz and 0 to 100,000 Hertz frequency ranges. The bandwidth of each data point is 0.375 Hertz for the 100 Hertz range and 375 Hertz for the 100,000 Hertz frequency range. The infrasonic noise for frequencies up to 20 Hertz is shown in Figure 9. The maximum level at 10 meters is 57 dB reference 20 microPascals. The entire 20 Hertz band can be power summed and equals a value of 66 dB reference 20 microPascals, well below the requirement at 10 meters. The ultrasonic noise for frequencies up to 100 KiloHertz is given in Figure 10. The maximum level at 10 meters is 20dB reference 20 microPascals. The entire 80 KiloHertz band from 20 to 100 kiloHertz has been power summed and equals a value of 31 dB ref. 20 microPascals. Both levels fall well below the 100 dB limit at a distance 10 meters from the Cooling Module. The airborne noise level at the Thames Street property lines will be at least 18 dB lower. The noise levels at the other neighbors will be even lower based on the analysis in the previous section and there should be no issue with either infrasonic or ultrasonic noise at any of the neighboring properties.

It should be noted that while the spectrum analysis covers frequencies up to 100 kiloHertz, the microphone sensors lose some sensitivity above 25 kiloHertz. The flat response below a frequency of 25 kiloHertz changes to a gradual roll off that reduces the amplitudes at higher frequencies. Fortunately, the measured noise levels are very low at 20 kiloHertz and decrease with higher frequencies and thus, no ultrasonic acoustic issues are expected above 25 kiloHertz.

Figure 8. Discrete Tones Produced by the Fuel Cell Cooling Module (0 dBV = 88.6 dB re20μPa)

Figure 9. Infrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20μPa)

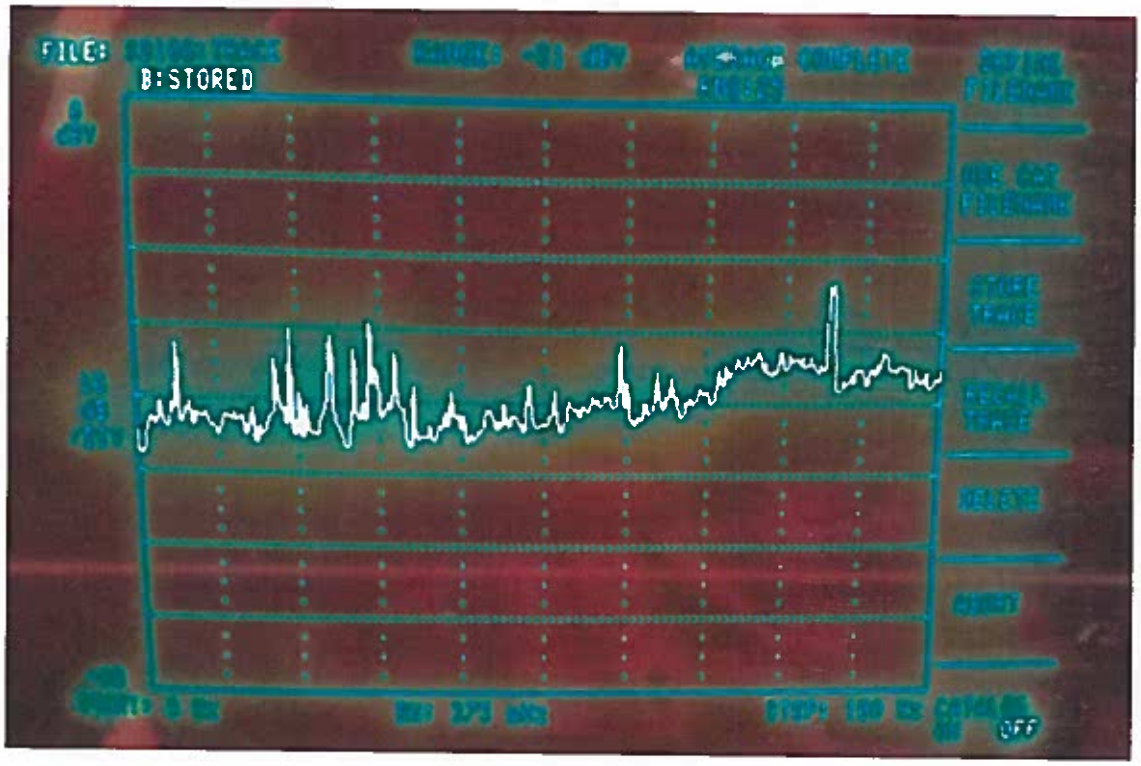
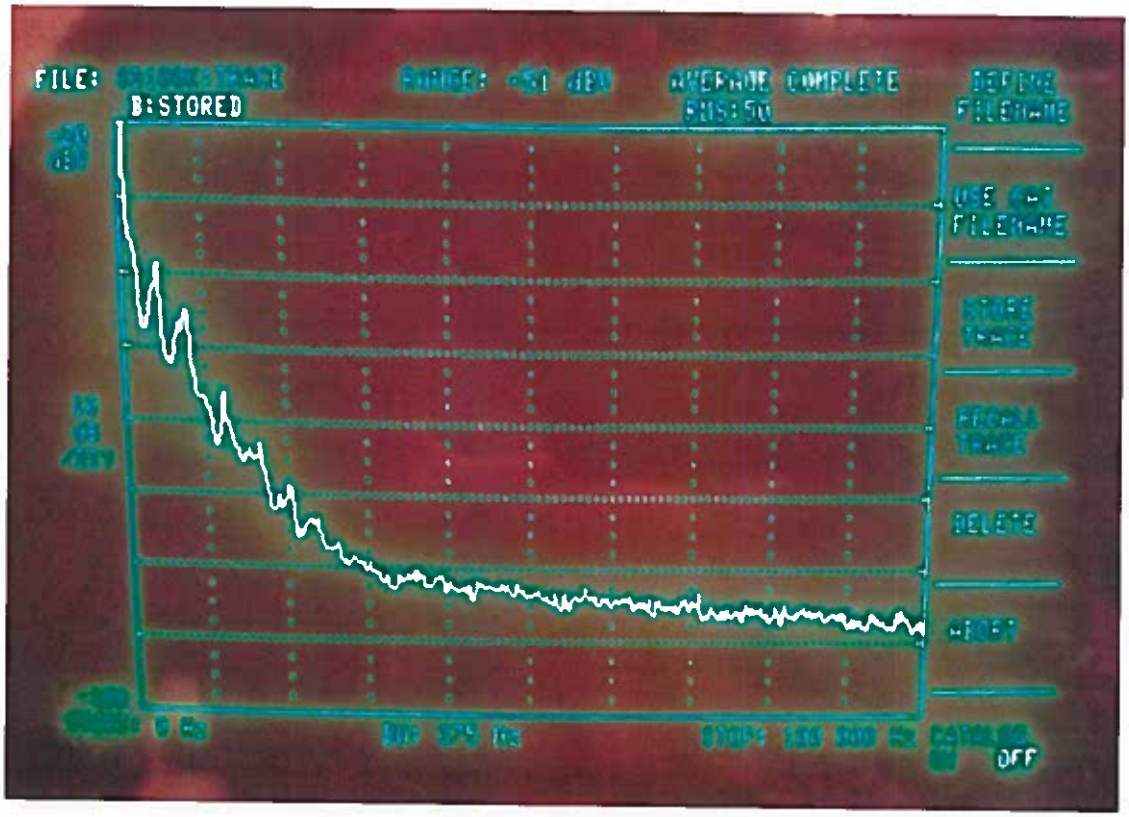


Figure 10. Ultrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20μPa)



Overall Sound Pressure Levels

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.5 Noise zone standards (a) No person in a Class B Noise Zone shall emit noise exceeding the levels below:*

Class B emitter to C 62 dBA B 62 dBA A/day 55 dBA A/night 45 dBA

The nearby neighbors are classified as either residential or commercial with the commercial noise limit at 62 dBA and the residential noise limit at 55 dBA during the day and 45 dBA at night. The east side of West Thames Street is residential and the west side is commercial.

The overall A-weighted sound pressure level measurements in dBA reference 20 microPascals are given in Table 2 above for the measurements made on January 31. The second column gives the approximate distance from the speakers to the measurement location, identified by a P number in Figure 1. The first number is the distance to the speaker at the "G„ position while the second number is the distance to the "H„ position. Column 3 gives the noise levels measured with the speakers "on„ at position "G„ while column 4 gives the background levels before the speakers were turned on. Background corrections are applied to column 3 and the background corrected speaker noise is given in column 5. The column 5 levels with the background noise removed are estimates of the contribution provided only by the speakers at each location. Columns 6, 7 and 8 repeat this same information for the case with the speakers at position "H„.

The following table compares the Norwich Inn and Spa speaker data with the Mount Sinai Hospital fuel cell measurements. Averages are calculated for the two speaker positions and the three 5 and 10 meter locations measured at the Mount Sinai Hospital. Doubling the measurement distance from 5 to 10 meters shows a drop in level of about 5 dB, close to the 6 dB expected. At 5 meters the speakers generate airborne noise levels 18.7 dB higher than the operation of the fuel cell. At 10 meters the speakers generate airborne noise levels about 17.6 dB higher than the operation of one fuel cell. The 10 meter Mount Sinai airborne noise levels are used with the Norwich Inn and Spa transmission loss data to estimate the expected fuel cell airborne noise at the Norwich Inn and Spa property lines.

Table 3. Measured Airborne Noise Levels in dBA (20 μPascals) Corrected for Background

Source	5 meters dBA	10 meters dBA	Range Difference In dB	Level Difference In dB	Expected dBA Level For the Fuel Cell
"G„	92	87.1	← 4.9		
"H„	92	87.1	← 4.9	5 meters →	73.3
Speaker Avg	92	87.1			
Fuel Cell Avg	73.3	69.5	← 4.5	10 meters →	69.5
Mt Sinai "A„	74	69.9			
Mt Sinai "B„	74.3	70.3			
Mt Sinai "C„	71.5	68.3			

Reviewing Table 2 it is clear that the airborne noise levels drop significantly in propagating to the nearby properties as the range increases. The highest property line background corrected level was measured at 68.4 dBA at 2 Trading Cove Road. This property line should see airborne noise levels no higher than 51 dBA with the fuel cell operating. One other residential property and one commercial property line on West Thames Street showed levels above 45 dBA for homes numbers 656 and 665. Because of the increasing loss with distance to the remaining property lines the expected fuel cell noise levels fell below 45 dBA. All the expected maximum values (worse case between locations G and H) are shown in Table 4 below. All of the property line estimates will meet the 62 dBA commercial and 55 dBA daytime residential noise limits.

Table 4. Expected Airborne Noise Levels from Operating the Doosan Fuel Cell (ref. 20 μPA)

P1	P2	P3	P4	P5	P6	P7	P8	P9
17 dBA	21 dBA	22 dBA	29 dBA	35 dBA	50 dBA	46 dBA	36 dBA	51 dBA

Operation of the Doosan fuel cell will have a minor acoustic impact at three homes adjacent to the cooling module on West Thames Street. Property lines further away on West Thames street and all the other surrounding property lines will not be affected by the operation of the fuel cell.

Conclusions

The purpose of this effort is to evaluate the acoustical environment at the proposed Norwich Inn and Spa fuel cell site in Norwich, CT. This has been accomplished and the results show that the operation of a Doosan 460 KW fuel cell will meet all of the State of Connecticut airborne noise requirements on property lines to the southwest through northeast quadrants. Residences to the east through south along west Thames Street are expected to meet the commercial and daytime noise limits but be as much as 6 dB above the nighttime noise limit. An acoustic barrier lining the west, south and east sides of the fuel cell enclosure is recommended to eliminate this minor nighttime noise issue along West Thames Street.

References

1) CT DE&EP *Noise Control Regulation RCSA Section 22a-69-*1 to 22a-69-7.4 http://www.ct.gov/dep/lib/dep/regulations/22a/22a-69-1through7.pdf

2) Mount Sinai Rehabilitation Hospital Airborne Noise Assessment, Carl A. Cascio, Acoustical Technologies Inc., January 26, 2017