



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

February 24, 2017

**RE: PETITION NO. 1268- Response to Interrogatories;  
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 460-kilowatt customer-side fuel cell facility to be located at the Unilever Research and Development Center building, 20 Merritt Boulevard, Trumbull, Connecticut**

Dear Siting Council,

Please find attached the responses to Council Interrogatories - (along with corresponding exhibits), requisitioned on 12/05/2016 for PE 1268 by the CT Siting Council.

Additional questions may be addressed to:

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

Thank you for your consideration and time.

Sincerely,

Doosan Fuel Cell America, Inc.

A handwritten signature in black ink that reads "Dawn Mahoney". The signature is fluid and cursive, with the first name "Dawn" being more prominent than the last name "Mahoney".

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

**VIA ELECTRONIC MAIL**

December 5, 2016

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

RE: **PETITION NO. 1268** - 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 460-kilowatt customer-side combined heat and power fuel cell facility to be located at the Unilever Research and Development Center building, 20 Merritt Boulevard, Trumbull, Connecticut.

Dear Attorney Mahoney:

The Connecticut Siting Council (Council) requests your responses to the enclosed questions no later than December 23, 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/CW

c: Council Members

**Petition No. 1268**  
**Doosan Fuel Cell America, Inc.**  
**Unilever – 20 Merritt Blvd, Trumbull, CT**

**Interrogatories**

1. Please provide a detailed, scaled site plan for the proposed facility including but not limited to, the dimensions and location of the proposed fuel cell facility, cooling module, concrete pads, fencing and/or other protection, and utility connections. If a fence is proposed, indicate if it would have anti-climb features. If bollards are not proposed, is the facility at risk from vehicle impact?
  - R1. Please see attached Unilever -1 Detailed Scaled Site Plan.
  9. Please provide additional noise analysis data to supplement the determination (Petition p. 5) that noise levels comply with DEEP criteria at the property boundaries.
  - R9. Please see attached Unilever -2 Detailed Site Specific Noise Analysis Report.
- .

***UNILEVER -1***

***DETAILED SITE PLAN***

E

D

C

B

A

E

D

C

B

A



PureCell® Model 400

PROPRIETARY STATEMENT: COPYRIGHT © DOOSAN FUEL CELL AMERICA, INC. THIS DOCUMENT CONTAINS INFORMATION THAT IS CONFIDENTIAL AND PROPRIETARY TO DOOSAN FUEL CELL AMERICA, INC (DOOSAN). THIS DOCUMENT IS FURNISHED ON THE UNDERSTANDING THAT THE DOCUMENT AND THE INFORMATION THAT IT CONTAINS WILL NOT BE COPIED OR DISCLOSED TO OTHERS OR USED FOR ANY OTHER PURPOSE THAN CONDUCTING BUSINESS WITH DOOSAN AND WILL BE RETURNED AND ALL FURTHER USE DISCONTINUED.

THESE DRAWINGS ARE PROVIDED BY DOOSAN FOR REFERENCE ONLY AND ARE SUBJECT TO CHANGE WITHOUT NOTICE.

CONTACT DOOSAN FOR THE LATEST REVISIONS BEFORE USING THESE DRAWINGS FOR DESIGN PURPOSES.

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.

A		
MARK	DATE	DESCRIPTION
ISSUE:		

ORIGINAL RELEASE:		
DRAWING NO:		
DRAWING SCALE: 1/8" = 1'-0"		
DRAWING REVISION: A		
CAGE CODE:		
DRAWN BY: T. BLISS		
CHECKED BY: XX		

SHEET TITLE  
SITE PROPOSAL  
UNILEVER  
TRUMBULL, CT

P1  
SHEET 1 OF 1

- ELECTRICAL:  
300kVa TRANSFORMER  
480V  
METER E22822
- NATURAL GAS:  
NG SERVICE
- HEATING RUN:  
OUTDOOR BOILER  
BUILDING HEAT

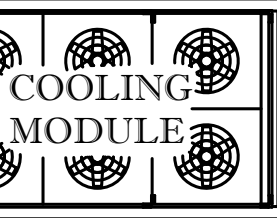
HG Interconnection  
Reheat Loop

Unilever

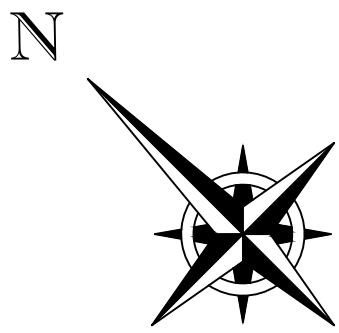
Natural  
Gas Supply

LV Electrical  
Interconnection

POWER  
MODULE



Pavement



***UNILEVER - 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: Unilever  
Airborne Noise Assessment**

**Author: Carl Cascio**

**Date: February 5, 2017**

**Revision: 0**

## Table of Contents

	Page
Summary	3
Introduction	4
Development of the Acoustic Assessment Plan	4
Acoustic Measurement Program	5
Data Analysis	8
Allowable Noise Levels	12
Impulse Noise	13
Prominent Discrete Tones	13
Infrasonic and Ultrasonic Noise	14
Overall Sound Pressure Levels	16
Conclusions	17
References	18



## 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 Unilever Facility in Trumbull, 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 Unilever Facility in Trumbull 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 about 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 noise levels at frequencies below 250 Hertz where the A-weighted 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 225 meters from the fuel cell location. The speakers produced overall A-weighted sound pressure levels of 93 dBA at 5 meters and 87 to 88 dBA at 10 meters (reference 20 microPascals) at the proposed fuel cell locations. The airborne noise levels at nearby property lines could be measured only at the closest property line at a level of 62 dBA with the speakers on. The three other locations were background limited at values from 54 to 56 dBA. Analysis of the speaker data indicated propagation losses from 26 to 48 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 used as a basis for the Trumbull fuel cell 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 property lines. (The Commercial Zone noise limits are used because of the more restrictive wording of the Town of Trumbull's Noise Ordinance.) The highest expected level of 44 dBA will be at the 20-30 Nutmeg Drive property line 57 meters from the fuel cell. The next closest neighbor property lines are much further away with expected airborne noise levels of 22 to 29 dBA with the fuel cell on. The nearest residential zone outside the I-L2 Industrial Zone is more than 170 meters from the fuel cell location. The nearest residence within the Industrial I-L2 Zone is at 370 meters. The airborne noise levels are expected to be well below both the commercial and residential noise limits. There are no acoustic issues expected with operation of the fuel cell at the Unilever site.

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 Unilever Facility in Trumbull, CT. Responding to a request from Claudio Borea, a site visit was made on January 25, 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 20 Merritt Blvd. on the Unilever property.

## **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 Unilever site in Trumbull, CT. The Unilever building at 20 Merritt Blvd. is located in an Industrial Zone near CT Route 8. The Industrial Zone (I-L2) is surrounded by Residential Zone (AA) where the closest residential location is St John Hall at 170 meters to the west across CT Route 8. The next closest residential zone (A) is more than 500 meters to the east. 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 will be 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 18 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 Town of Trumbull Noise Ordinance and the State of Connecticut Noise Code have 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 town and 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 Unilever property on and near 20 Merritt Blvd. during the afternoon hours of January 25, 2017. 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 a 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 Unilever site “source on,, and background airborne noise measurements were taken at the following four nearby property lines all in the I-L2 Industrial District:

- P1 - 45 Commerce Drive
- P2 - 50 Commerce Drive
- P3 - 1-35 Nutmeg Drive
- P4 - 20-30 Nutmeg Drive
- P5 – 100 St Johns Drive, listed to show distance from fuel cell
- P6 – 55 Twin Circle Drive, listed to show distance from fuel cell

See the Google satellite map in Figure 1 for the approximate measurement locations. (Figure 5 below shows individual Google Map pictures at each property line.) Measurements near the proposed operating fuel cell sites at position L and M were simultaneously taken with the ExTech sound level meter and two microphones recording on the digital tape recorder. Figure 2 provides a Doosan sketch of the site location for the fuel cell. Figure 3 below shows a photograph of the speakers used at the two source positions. The two source locations were chosen because L represents the side of the power module closest to the neighbors to the east and M represents the center of the cooling module facing the neighbors to the west. At locations L and M, three minute records of the acoustic noise were stored for the speakers in the “on,, condition, respectively. Three minutes of background airborne noise data were also recorded at position M. (Background at position L was assumed to be the same as data from position M.) The source levels are high enough that the background level 20 meters from the source causes only 0.1 dB correction to the source level while the 5 and 10 meter locations need no correction.

Figure 1. Unilever Site Map from Google Maps

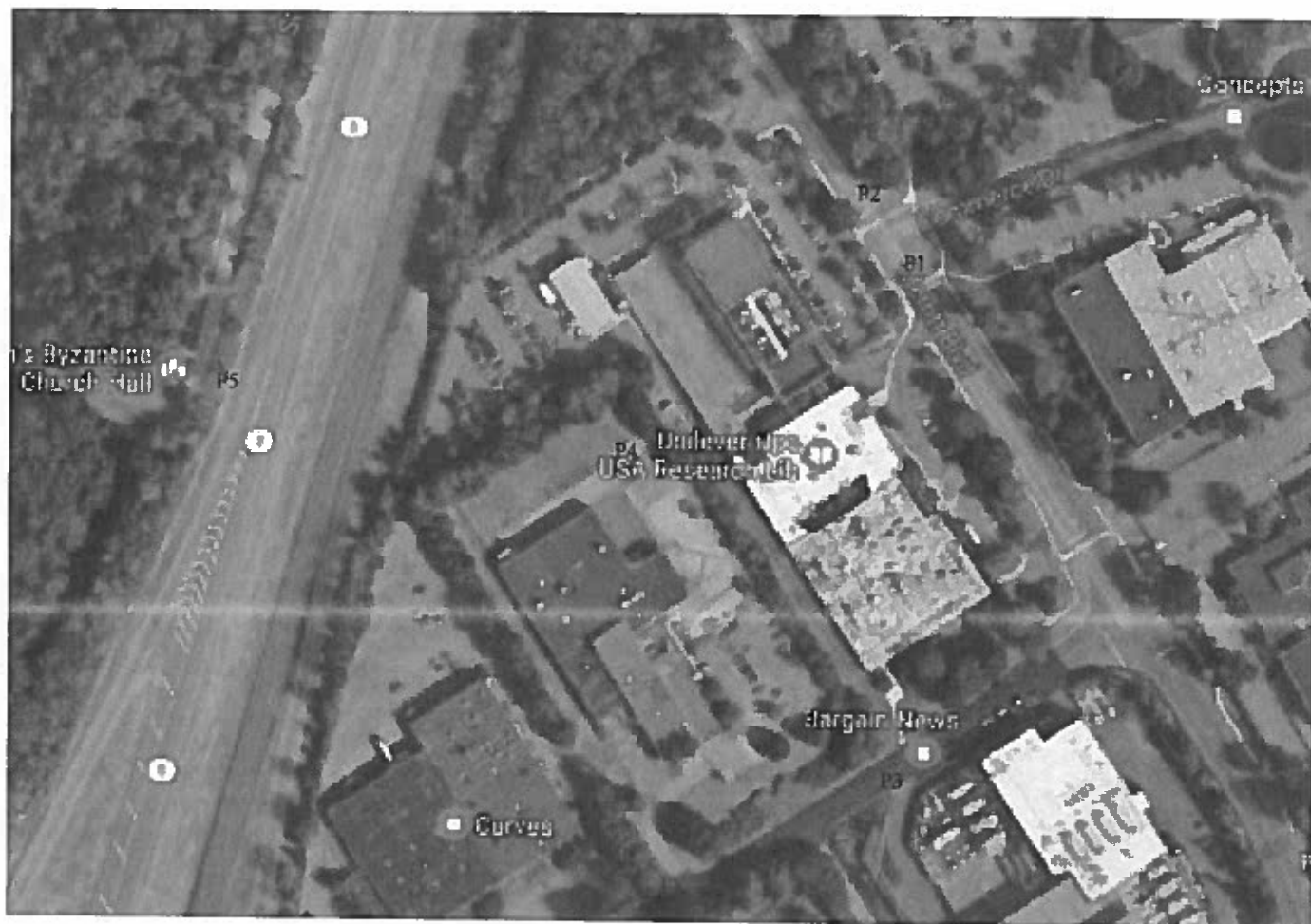
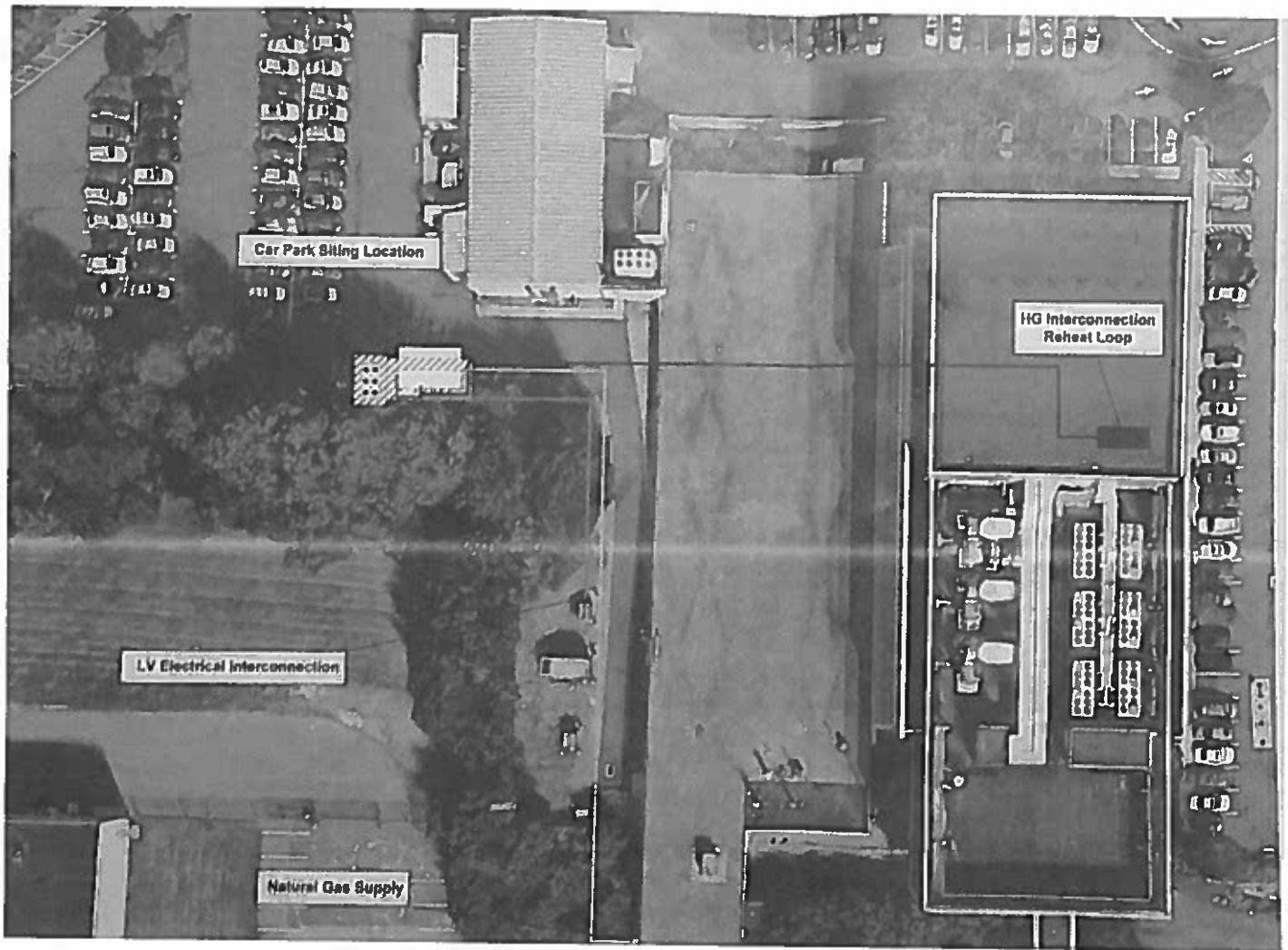


Table 1. Trumbull Weather on January 25, 2017 from [www.LocalConditions.com](http://www.LocalConditions.com)

Time (EST)	Temp. (°f)	Humidity (%)	Dew Point (°f)	Barometer (in HG)	Wind Speed (mph)	Wind Direction
7:00 PM	44.6	56.72	30.2	29.66	5	wnw
6:30 PM	44.6	56.72	30.2	29.66	6	nw
6:00 PM	44.6	56.72	30.2	29.66	9	wnw
5:30 PM	44.6	56.72	30.2	29.67	9	w
5:00 PM	44.6	56.72	30.2	29.65	12	w
4:30 PM	46.4	52.98	30.2	29.63	11	w
4:00 PM	48.2	49.51	30.2	29.64	11	w
3:30 PM	48.2	49.51	30.2	29.63	10	w
3:00 PM	50	46.29	30.2	29.64	10	w
2:30 PM	48.2	49.51	30.2	29.62	15	w
2:00 PM	46.4	56.99	32	29.61	-	-
1:30 PM	44.6	61.02	32	29.61	7	s
1:00 PM	46.4	52.98	30.2	29.6	8	w
12:30 PM	44.6	56.72	30.2	29.61	6	w
12:00 PM	42.8	60.77	30.2	29.61	7	wnw
11:30 AM	42.8	60.77	30.2	29.64	9	wnw
11:00 AM	42.8	56.46	28.4	29.63	11	wnw

Figure 2. Doosan Fuel Cell Installation Sketch for the Unilever Site



Airborne noise measurements taken outside are corrupted by rain and wind so a day was selected when the weather was dry and the winds were 12 miles per hour or less. Table 1 provides the weather data in Trumbull for the measurements on January 25, 2017. Measurements were taken over the period from 3 pm until 4:45 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 no rain. Motor traffic was moderate and it was possible to wait for periods of time when no traffic was seen or heard at the nearby measurement locations. Operation of the facility fans and continuous traffic noise from CT Route 8 did cause high background noise levels on the west side of the facility. (Airborne noise levels near the location of the two source positions varied from 59 to 63 dBA.)

Figure 3. Speakers Used as a Simulated Source



## Data Analysis

This section analyzes the airborne noise levels measured at the Trumbull 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 and Town of Trumbull noise ordinances. Both background noise levels at the Unilever site and estimated Doosan Fuel Cell equipment operating noise levels will be reported. Comparing these Unilever measurements with the state and town noise requirements will identify which nearby locations are quiet and meet the requirements and which locations are not quiet enough. 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. The CT noise requirement is 70 dBA in an Industrial Zone. The Town of Trumbull modifies the requirement by using the type of use to select the noise limits. This interpretation drops the allowable level to 62 dBA. Figure 4 is a map showing the Trumbull zoning in the Unilever 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. Figure 5 provides the position vector at each location. With the picture comes an estimate of the range in meters.

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 Unilever 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 overall airborne noise levels are 17.5 and 18.5 dB higher for the speakers at positions L and M, respectively, compared to what is expected from the Doosan 460 KW fuel cell that was measured in Hartford, CT.

Table 2. Overall Sound Pressure Levels in dBA ref. 20 microPascals at the Unilever Site

Location	Range in Meters	Speakers On L	Background	Bkgd Corrected	Speakers On M	Background	Bkgd Corrected
Pos. R Ch 1	5	93	61	93			
Pos. R Ch 2	10	87	63	87			
Pos. R Ch 3	20	80	64	79.9			
Pos. S Ch 1	5				93		93
Pos. S Ch 2	10				88		88
Pos. S Ch 3	20				80	64	79.9
P 1 – 45 Commerce	155/160 m	53	55	< 50	54	55	< 50
P 2 – 50 Commerce	149/154 m	53	54	< 50	54	54	< 50
P 3 – 1-35 Nutmeg	228/229 m	56	56	< 50	56.5	56	< 50
P 4 - 20-30 Nutmeg	56/ 58 m	62	55	61	61.8	55	60.8

P5 is located at St John Hall (170 m) and P6 is the closest home at 55 Twin Circle Drive (370 m)

Figure 4. Trumbull Zoning Map Showing Speaker Location at Position L

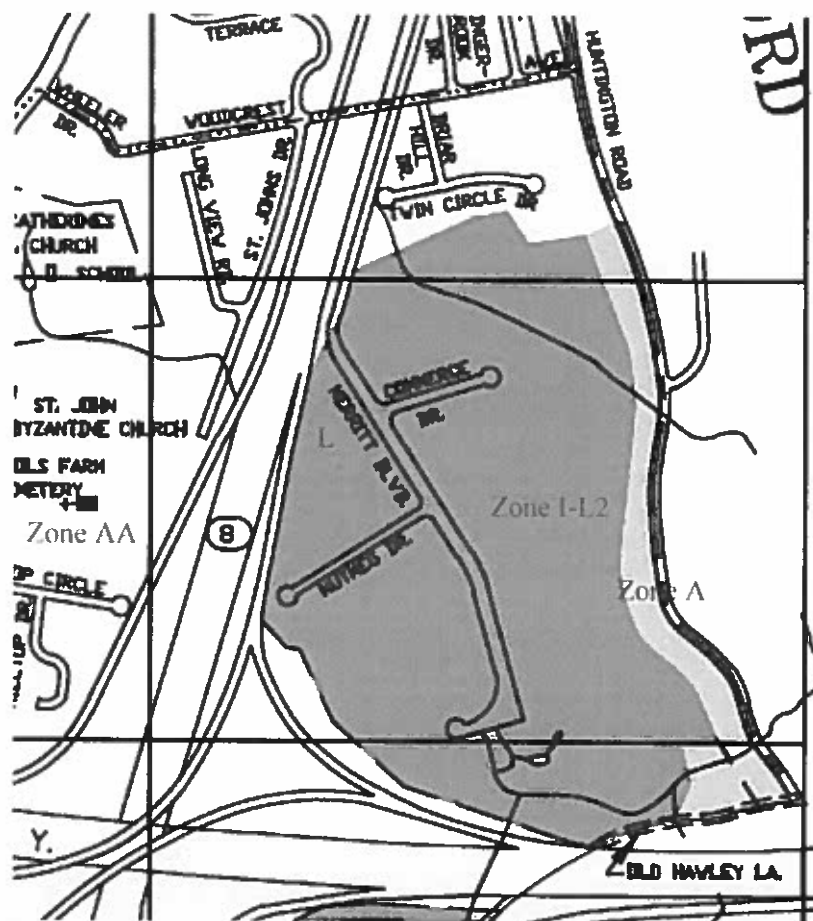


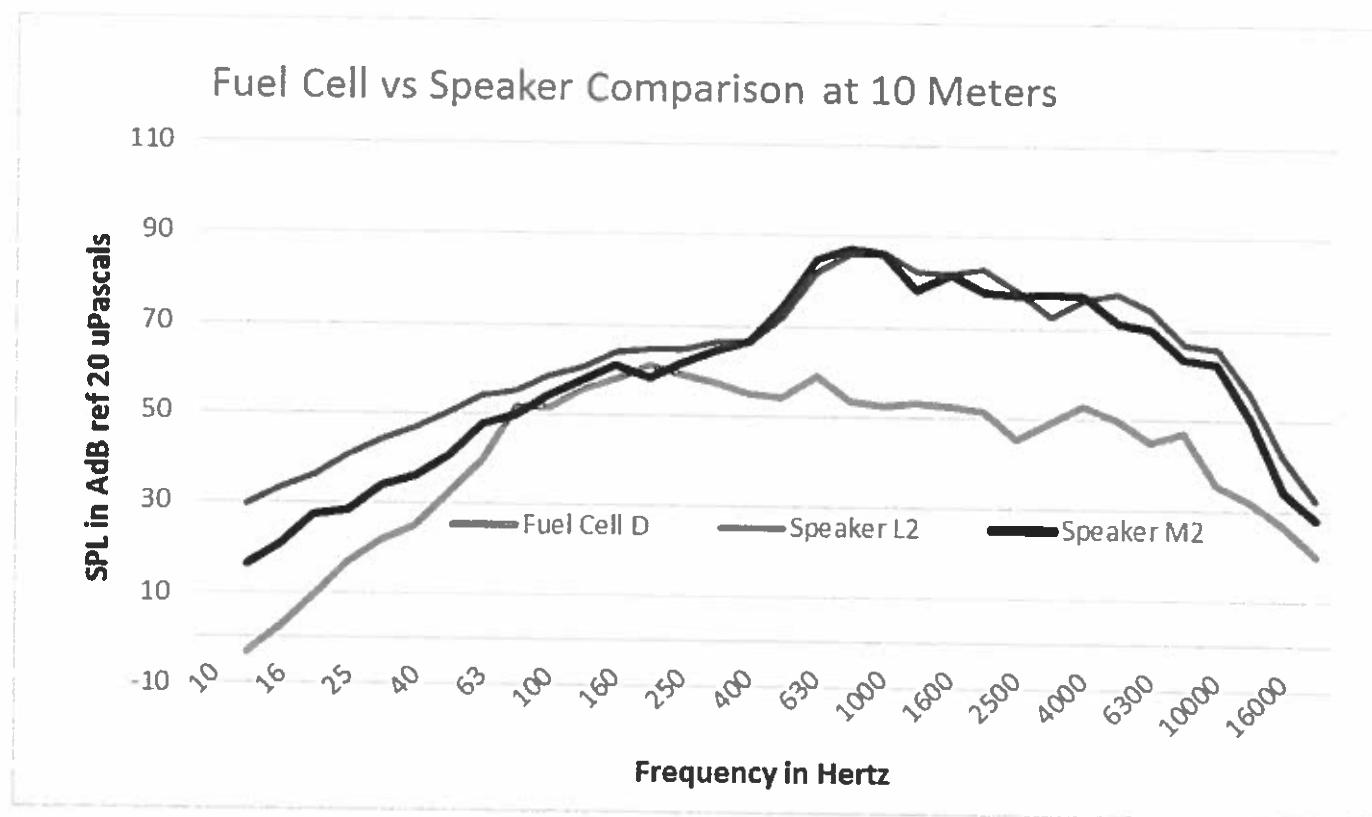


Figure 5. Measurement Locations Showing Range Vectors to the Source at Position M





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. The Trumbull Noise Ordinance (Ref. 2) uses the same noise levels in the pertinent sections of the CT Noise Code basically changing only the definition of nighttime hours and the type of use. The CT Code and Trumbull Noise Ordinance 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 measurements at the Unilever site.

The southern part of the Trumbull zoning map is given in Figure 4. Unilever is in the I-L2 Industrial Zone District. The other nearby businesses are also in the I-L2 Industrial Zone District. The homes in the residential zones AA and A are too far away (more than 160 meters for AA to the west and 500 meters for A to the east) to hear the speakers and by comparison the operation of the fuel cell. (The closest home to the north is 370 meters on Twin Circle Drive in Zone AA.) The Mount Sinai Hospital report (Ref. 3) 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. Using the Trumbull speaker measurements, the airborne noise level expected at a distance of 56 meters at the 20-30 Nutmeg property line should be about 44 dBA. The additional 100 plus yards to these other residential zones would reduce the fuel cell noise well below the required residential level of 45 dBA for an emitter in a residential or 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.

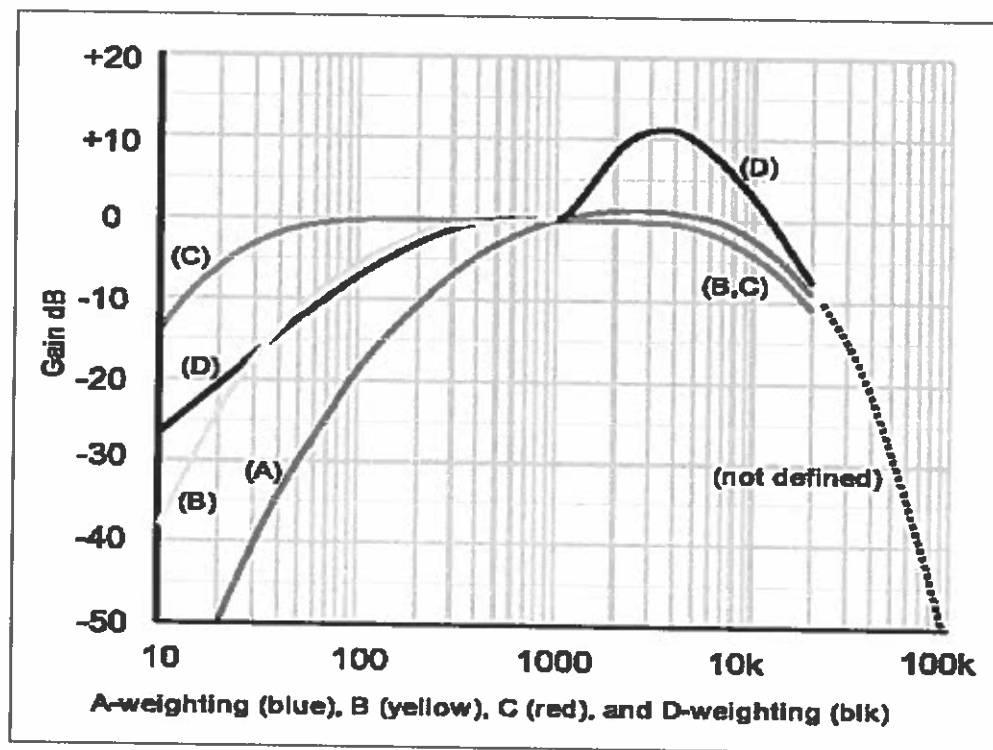
Nighttime hours are defined as 10 pm to 7 am. *CT section 22a-69-3.2 (part b) Impulse Noise* states that no person shall cause or allow the emission of impulse noise in excess of 100 dB peak sound pressure level at any time to any Noise Zone. The Trumbull Noise Ordinance adopts the state's impulse noise requirements but changes the nighttime hours starting at 9 pm instead of 10.

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 Trumbull. Given the steady state nature of the fuel cell's noise signature there should be no acoustic issues with either the State of Connecticut's or the Town of Trumbull'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](http://upload.wikimedia.org/wikipedia/commons/3/39/Acoustic_weighting_curves_(1).svg)



## 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 Unilever is a Class B emitter in an Industrial 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)

Trumbull's noise ordinance does not mention prominent discrete tones noise so the state ordinance shall be used.

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. 3) 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 transmission loss to the nearest Trumbull property line is at least 26 dB so the maximum possible discrete tone would be about 28 dBA at the 20-30 Nutmeg Drive 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. Trumbull's noise ordinance does not mention either infrasonic or ultrasonic noise so the state ordinance shall be used.

Narrow bandwidth sound pressure spectrums in dB reference 20 microPascals at the 10 meter Cooling Module location given in Reference 3 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 20-30 Nutmeg Drive property line will be at least 26 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)

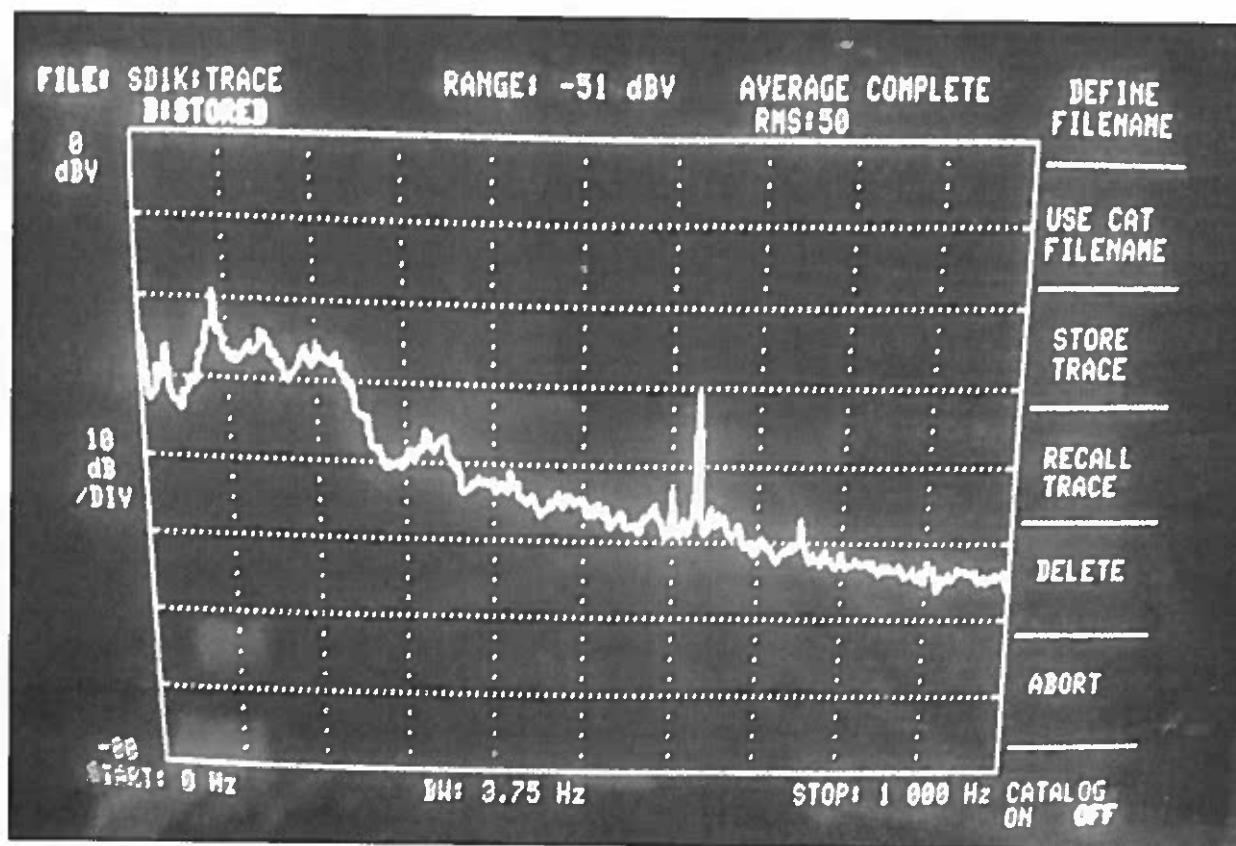


Figure 9. Infrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20 $\mu$ Pa)

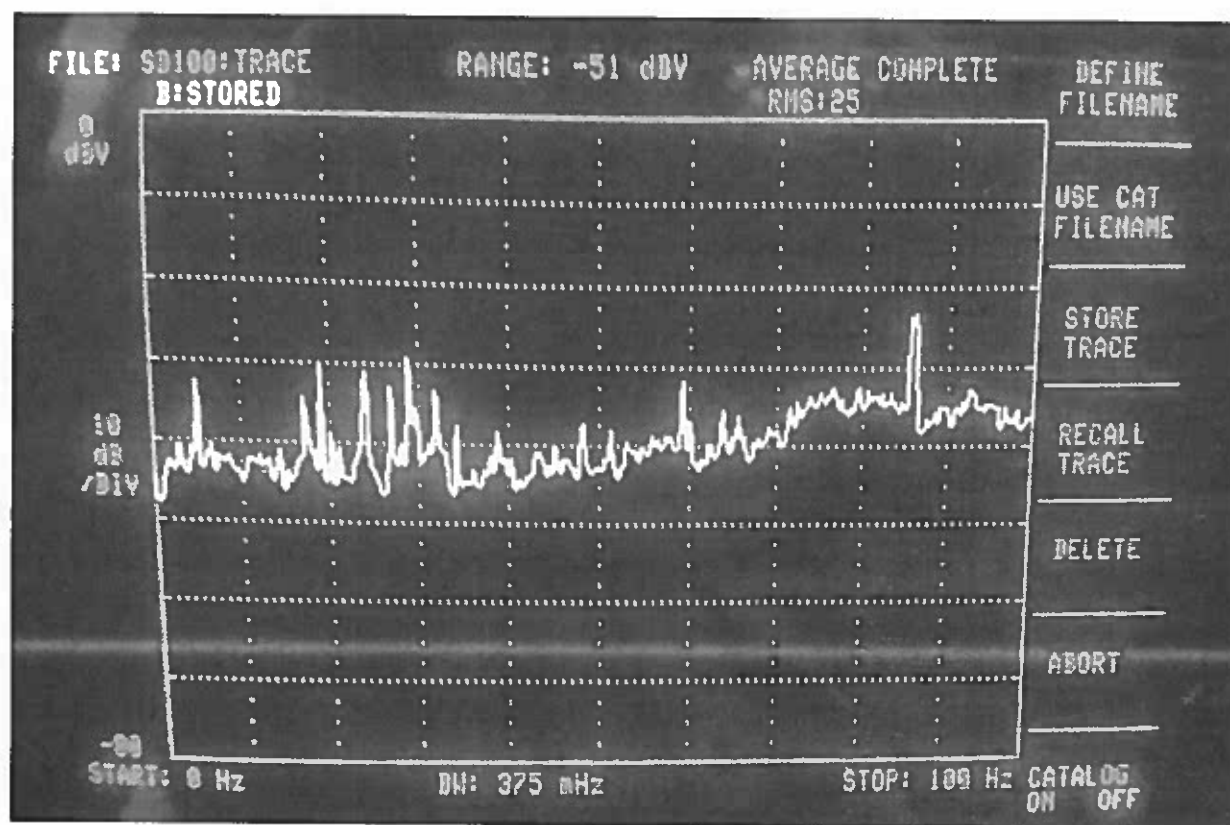
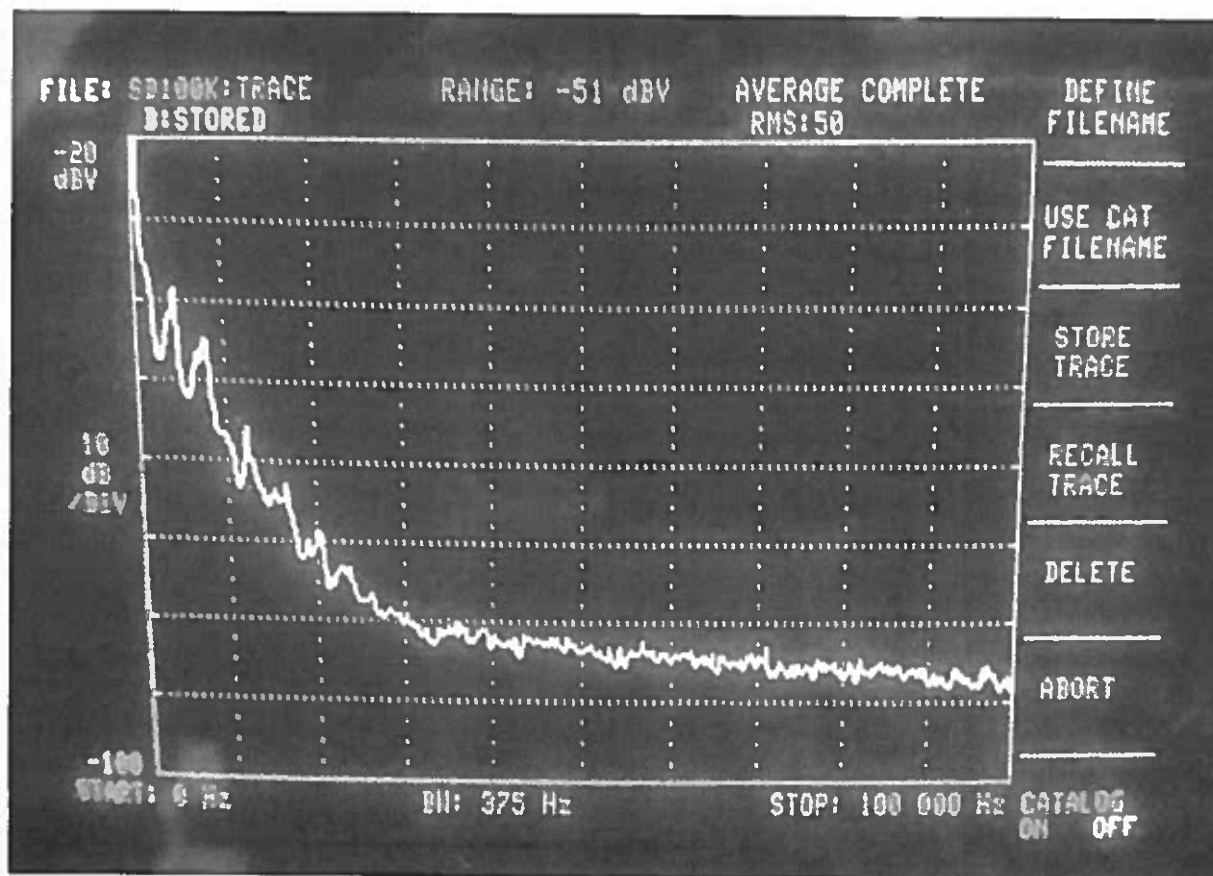


Figure 10. Ultrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20 $\mu$ Pa)



## 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 C Noise Zone shall emit noise exceeding the levels below:*

*Class C emitter to      C 70 dBA      B 66 dBA      A/day 61 dBA      A/night 51 dBA*

### **CT Sec. 22a-69-2.2. Multiple uses**

*Where multiple uses exist within a given Noise Zone, the least restrictive land use category for the Emitter and Receptor shall apply regarding the noise standards specified in Section 3 of these Regulations. This section implies that we should use the Class C levels even though Unilever is a Class B emitter.*

The Trumbull noise ordinance uses the same airborne noise levels but states in Section 13.50.4 that *"Any use that is non-conforming shall be deemed to be in the zone which corresponds to the actual use.,* As a result, the Unilever site falls into Class B both as a zone and as an emitter. Please see the Trumbull Noise ordinance (Ref. 2). This changes the noise limits to:

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

The nearby neighbors can then be classified as either industrial or commercial with either noise limit at 62 dBA. The closest property lines in the residential zones are too far away (more than 160 meters) to hear the speakers or the operation of the fuel cell. The Doosan fuel cell has a noise level of 62 dBA at about 30 meters from the fuel cell, still within the Unilever property.

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 25. 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 "L,, position while the second number is the distance to the "M,, position. Column 3 gives the noise levels measured with the speakers "on,, at position "L,, 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 "M,,. In this case the background was taken after the speakers at position "M,, were turned off

The following table compares the Unilever 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 from 5 to 6 dB, very close to the 6 dB expected. At 5 meters the speakers generate airborne noise levels 19.7 dB higher than the operation of the fuel cell. At 10 meters the speakers generate airborne noise levels about 18 dB higher than the operation of one fuel cell. The 10 meter Mount Sinai airborne noise levels are used with the Unilever data to estimate the expected fuel cell airborne noise at the Unilever property lines.

Table 3. Measured Airborne Noise Levels in dBA (20  $\mu$ Pascals) 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
"L,,	93	87	← 6	19.7	
"M,,	93	88	← 5	5 meters →	73.3
Speaker Avg	93	87.5		18	
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 61.8 dBA at 20-30 Nutmeg Drive. The 20-30 Nutmeg Drive property line should see airborne noise levels no higher than 44 dBA with the fuel cell operating. Because of the increasing loss with distance to the remaining property lines it was not possible to distinguish the speaker noise from the background noise. Measurements showed background levels from 54 to 56 dBA which is below the 62 dBA commercial noise limit with the speakers operating at levels about 18 dB higher than the levels expected from the fuel cell. All the expected maximum values (worse case between locations L and M) are shown in Table 4 below. All of the property line estimates meet the 62 dBA commercial and 45 dBA residential limits.

Table 4. Expected Airborne Noise Levels from Operating the Doosan Fuel Cell (ref. 20  $\mu$ PA)

P1	P2	P3	P4	P5	P6
28 dBA	29 dBA	22 dBA	44 dBA	26 dBA	10 dBA

Operation of the Doosan fuel cell will have no significant acoustic impact at the Unilever site and to the nearby neighbors.

## Conclusions

The purpose of this effort is to evaluate the acoustical environment at the proposed Unilever fuel cell site in Trumbull, 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 and Town of Trumbull airborne noise requirements.

## 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) Town of Trumbull Noise Ordinance  
[www.ct.gov/dep/lib/dep/air/noise/ordinances/Trumbullnoise\\_ordinance.pdf](http://www.ct.gov/dep/lib/dep/air/noise/ordinances/Trumbullnoise_ordinance.pdf)
- 3) Mount Sinai Rehabilitation Hospital Airborne Noise Assessment, Carl A. Cascio,  
Acoustical Technologies Inc., January 26, 2017