Attachment #10

Prepared For: **HiAxiom, Inc.**

Point of Contact: **Walter Bonola**

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50 Myrock Avenue
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Subject: **Nine Fuel Cells**
Airborne Noise Assessment
At 35 North Main Street
Ansonia, CT 06401

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Summary

This document makes a positive acoustic assessment that should assist in meeting any acoustic noise concerns during the operation of nine HiAxiom 460 KW fuel cells at the down town Ansonia site at 35 North Main Street in Ansonia, CT. An acoustic assessment plan was developed and executed to acquire airborne acoustic information useful in explaining and mitigating the potential airborne noise issues during operation of the nine 460 KW fuel cells. It is important to show that the airborne noise generated by the fuel cells will not significantly impact the facility's neighbors.

The airborne noise levels expected to be generated by the HiAxiom fuel cells operating at the Ansonia site were simulated by exciting a Soundboks speaker at two of the fuel cell Cooling Module positions. (The Cooling Module is the dominant noise source.) The Soundboks speaker produced an overall airborne noise level that was 14 to 17 dB higher than the levels measured for a single HiAxiom fuel cell installed at Montville, CT. One-third octave band analysis showed the speakers' level to be near the Montville fuel cell airborne noise levels at low frequencies where the airborne noise levels were low and to exceed the fuel cell signature by 10 to 15 dB at higher frequencies where the fuel cell signature was higher in noise level.

Airborne noise levels with the speakers operating were measured at distances from 5 to 185 meters from the proposed fuel cell location on North Main Street. The speaker produced overall A-weighted sound pressure levels of approximately 86 to 88 dBA at 5 meters and 79 to 82 dBA at 10 meters (reference 20 microPascals) at the proposed fuel cell locations. The airborne noise levels from the speakers received at nearby properties on site were measured at noise levels of 40 to 60 dBA. Residential measurement locations to the west were too far away to be able to measure the airborne noise with the speaker on. Analysis of the speaker data indicated propagation losses of at least 18 to 41dB from the fuel cells' location to the nearby properties. The source level at 10 meters from the operation of a HiAxiom fuel cell at Montville, CT was then used as a basis for making the Ansonia fuel cell airborne noise estimates.

Operation of the nine HiAxiom fuel cells will have no significant acoustic impact at all but one of the nearby properties adjacent to the HiAxiom fuel cell site on North Main Street. The adjacent property on 61 Cliff Street is open land between a Church and a garage on a hill about 50 feet above North Main Street. The first 20 meters of this property abutting North Main Street is a steep hill that no one normally occupies. The location of the cooling modules at 15 meters from the wall results in a 53 dBA noise level at position 2 and a 56.3 dBA level at position 3. The location of the cooling modules at 3 meters from the wall results in a 50.7 dBA noise level at position 2 and a 54 dBA level at position 3. The wall provides additional noise attenuation so it is recommended to move the cooling modules as close as possible to the wall on North Main Street. This can be done by moving the power modules away from the wall. (The fans at one end of the power module produce about 4 dB less noise than the cooling module and can still be kept closer to the wall than the cooling module at 15 meters.)

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 cells 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 HiAxiom site permitting process with an assessment of potential acoustic issues associated with fuel cell airborne noise reaching the properties adjacent to the Farrel Corporation site at 35 North Main Street in Ansonia, CT. Responding to a request from Walter Bonola, a site visit was made on October 3, 2023. During the visit, a survey of the airborne noise levels produced by a Soundboks speaker simulating the airborne noise produced by a HiAxiom 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 speaker off. This document provides an acoustic assessment to assist in meeting acoustic noise concerns during the permitting process for the siting of nine HiAxiom fuel cells at the 35 North Main Street site.

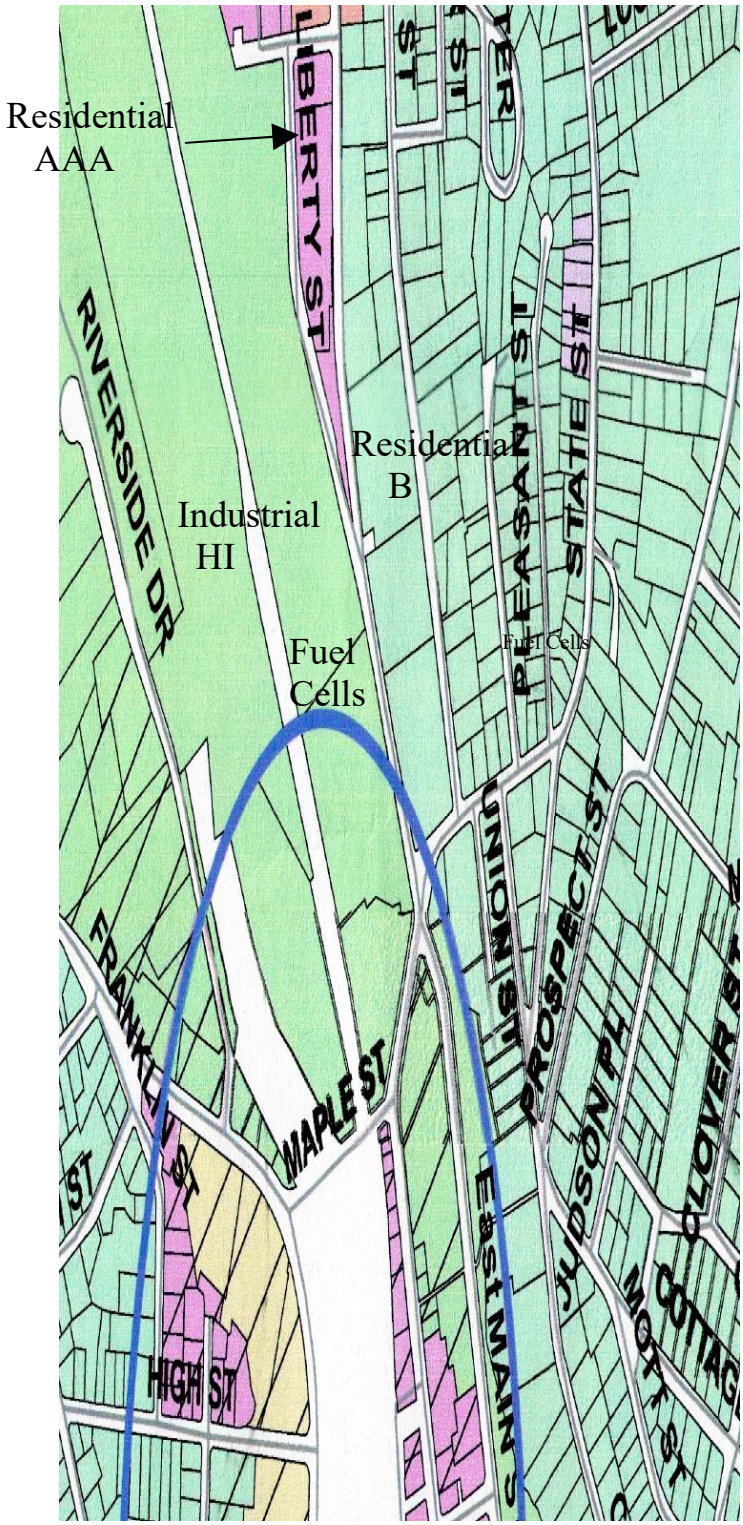
Development of the Acoustic Assessment Plan

The purpose of this effort is to acquire acoustic information useful in explaining the potential airborne noise issues associated with the operation of nine HiAxiom 460 KW fuel cells at the Farrel Corporation site on North Main Street. The proposed site at 35 North Main Street is located in a Heavy Industrial (HI) Zone. This Industrial Zone is surrounded by Residential AAA and B Zones to the north, east and south with the Naugatuck River to the west. The westerly direction is blocked by tall buildings and no sound propagation to the west is anticipated. (If the buildings were removed, the property on the other side of the river is more than 280 meters away and would not be affected by the fuel cell noise. Figure 1 shows a section of the Ansonia zoning map. It is important to determine whether the airborne noise generated by the nine HiAxiom fuel cells will impact these neighbors.

The acoustic impact is assessed in the following way. The fuel cells are 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 HiAxiom 460 KW fuel cell are available (Reference 3). Using this data, a Soundboks speaker has been programmed through a set of filters to generate a noise spectrum similar to that of the 460 KW fuel cell. (It is assumed that the Cooling and Power Module noise in the existing measured 460 KW fuel cell are similar to the new units.) This spectrum will then be played through an audio amplifier to create the electrical voltage necessary to drive the Soundboks speaker. In order to overcome the potentially high background noise at the Ansonia site the speaker output will be increased to a level more than 15 dB higher than the overall dBA noise level measured on a 460 KW fuel cell at a distance of 10 meters. With the speaker on, this approach then follows the traditional “What is the airborne noise level at the neighbor’s property line?”. The speaker will be run and airborne measurements made near the proposed fuel cell locations and at several of the nearest neighbor’s properties. This measured site data can also be used to estimate noise levels at other neighbor’s property lines. The State of Connecticut’s Noise Ordinance[1] and the City of Ansonia Noise Ordinance[2] will then be consulted to assess the impact of the measured and estimated acoustic levels. Because of the closeness of the proposed fuel cell site to the nearest properties noise mitigation may be

recommended if the airborne noise estimated for nine fuel cells comes near or exceeds the noise requirements at the neighbors' property lines.

Figure 1. Center of the Ansonia Zoning Map Showing the Area near the Nine Fuel Cells



Acoustic Measurement Program

The acoustic data necessary to assess the impact of nine 460 KW HiAxiom Fuel Cells are described below: Airborne sound pressure measurements were conducted at the 35 North Main Street site on October 3, 2023 during the morning hours. This testing established both background airborne noise levels and simulated airborne noise levels with the speaker operating. The overall A-weighted airborne noise measurements were made with an ExTech model 407780A Digital Sound Level Meter (s/n 140401544) that had been calibrated prior to and just 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. All measurements were made with the microphone at a height above ground between five and six feet. The sound pressure data reported herein are all given in dB reference 20 microPascals.

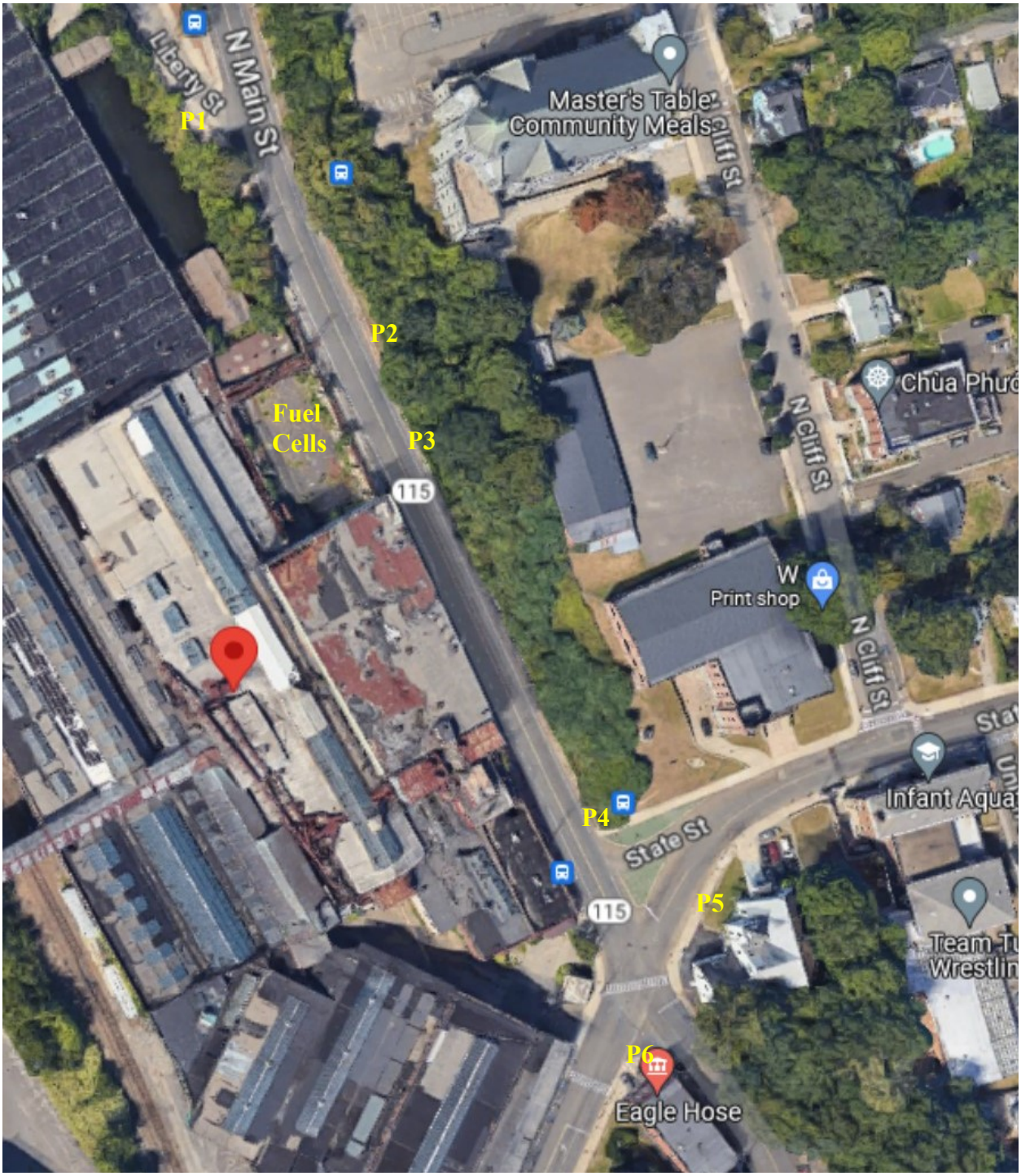
In Ansonia "speaker on" and background airborne noise measurements were taken at 5 and 10 meters from the proposed 460 KW fuel cell site and at the following six nearby properties.

Location	**Business**	**Distance**	**Zone**	**Type**
1 – Fuel Cell North End	HiAxiom	5 meters	HI	Industrial
2 – Fuel Cell North End	HiAxiom	10 meters	HI	Industrial
3 – Fuel Cell South End	HiAxiom	5 meters	HI	Industrial
4 – Fuel Cell South End	HiAxiom	10 meters	HI	Industrial
P1 – 10 Liberty Street	Corner	104 meters	AAA	Residential
P2– 61 North Cliff Street	Church	25 meters	B	Residential
P3 – 31 North Cliff Street	Church	25 meters	B	Residential
P4 – 5 State Street	Church	100 meters	B	Residential
P5 – 10 State Street	Church	137 meters	B	Residential
P6 – 1 Main Street	Fire House	165 meters	HI	Industrial

See the Google satellite map in Figure 2 for the approximate measurement locations. Measurements were made near the proposed north and south Cooling Module units. Sound pressure data were taken with the ExTech sound level meter. Figures 3 and 4 provide photographs of the speaker location for the North position and the measurement location across the street, respectively. At these locations, a one-minute record of the acoustic noise was analyzed for the speakers in the "on" condition. One minute of background noise data was also analyzed at 5 and 10 meters with the same speaker positions and at the six nearby property lines.

Airborne noise measurements taken outside are corrupted by rain and wind so a day was selected when the winds were expected to be 10 miles per hour or less. Table 1 provides the weather data in Ansonia for the acoustic measurements on October 3, 2022. Measurements were taken over the period from 10:00 am until 2:00 pm. Table 1 shows the temperature and wind speeds in hourly intervals. Wind conditions were very good during all the testing. Also, there was no rain during the testing. Vehicle traffic along Main Street was heavy and many of the measurements had to be delayed until all visible traffic was absent.

Figure 2. Google Map Showing Measurement Positions P1 through P6



Because of the distant traffic noise, background noise levels at all of the property line measurement positions were high with levels from 44 to 57 dBA. At all of the measurement locations it was possible to audibly hear the airborne noise from the speaker over the background noise. Airborne noise loss versus range was determined at all these locations.

The highest airborne noise levels were obtained directly across North Main Street from the two speaker locations. These transfer functions were then applied to the 460 KW data from Montville[3] in order to estimate the received levels for the new 460 KW fuel cells in Ansonia. Nine fuel cells could make as much as 9.5 dB more noise than one fuel cell if they were all in one place. Since they are spread out the highest level across the street would be across from the middle of the nine units. Reasonable estimates for this and the other locations were calculated by looking at the relative distances to the property line for each of the nine fuel cells. For properties to the east the nine cooling modules are side by side so the distance to the property is slightly different for each fuel cell. Each cooling module will be modeled at a 10-meter source level of 65 dBA while each power module will be modeled at a 10-meter source level of 61 dBA.[3]

Figure 3. HiAxiom North Cooling Module Location Looking East at North Main Street

The east direction requires a combination of cooling module and power module noise. This direction will produce the highest property line noise levels since the property lines are closest (about 30 meters). The north and south property lines are more than 100 meters away and should have noise levels at least 10 dB lower. The airborne noise at the closest property line on North Main Street is calculated by combining nine power modules and nine cooling modules. The cooling module and power module noise is adjusted a bit according to the different distances

from each module to the property line. Calculations are made on North Main Street for the middle and each end of the fuel cell locations (P2 and P3) as well as the other locations.

Figure 4. HiAxiom P2 Location Looking South at North Main Street across from the Speaker

Table 1. Weather Data near Ansonia on October 3, 2023
https://www.wunderground.com/history/daily/us/ct/east-haven/KHVN/date/2023-10-3

Time (EST)	Temp. (°F)	Humidity (%)	Dew Point (°F)	Barometer (in HG)	Wind Speed (mph)	Wind Direction	Condition
8:53 AM	63 °F	84 %	58 °F	30.18 in	0 mph	CALM	Fair
9:53 AM	67 °F	79 %	60 °F	30.17 in	3 mph	VAR	Fair
10:53 AM	72 °F	68 %	61 °F	30.16 in	6 mph	SSW	Fair
11:53 AM	72 °F	76 %	64 °F	30.15 in	7 mph	S	Fair
12:53 PM	73 °F	76 %	65 °F	30.15 in	7 mph	SSW	Fair
1:53 PM	74 °F	71 %	64 °F	30.13 in	7 mph	SW	Fair
2:53 PM	75 °F	69 %	64 °F	30.11 in	10 mph	SSW	Fair
3:53 PM	77 °F	62 %	63 °F	30.10 in	12 mph	WSW	Fair
4:53 PM	77 °F	62 %	63 °F	30.10 in	9 mph	WSW	Fair

Data Analysis

This section analyzes the airborne noise levels measured at the Ansonia site and then estimates the received level and transmission loss to nearby properties expected during actual fuel cell operation. These estimated levels will be compared to the noise limits in the Connecticut and Ansonia noise ordinances. Speaker operating noise levels at the Ansonia site are reported in Table 2. Background noise levels at the Ansonia site are reported in Table 3. The background data are used to correct the speaker levels providing estimates in Table 4 of only the speaker noise contribution at each location. Table 4 also reports the transfer functions and the operating noise levels estimated for the nine new 460 KW fuel cells.

Figure 5. Proposed Layout of Four Fuel Cells to Be Expanded to Nine in Ansonia

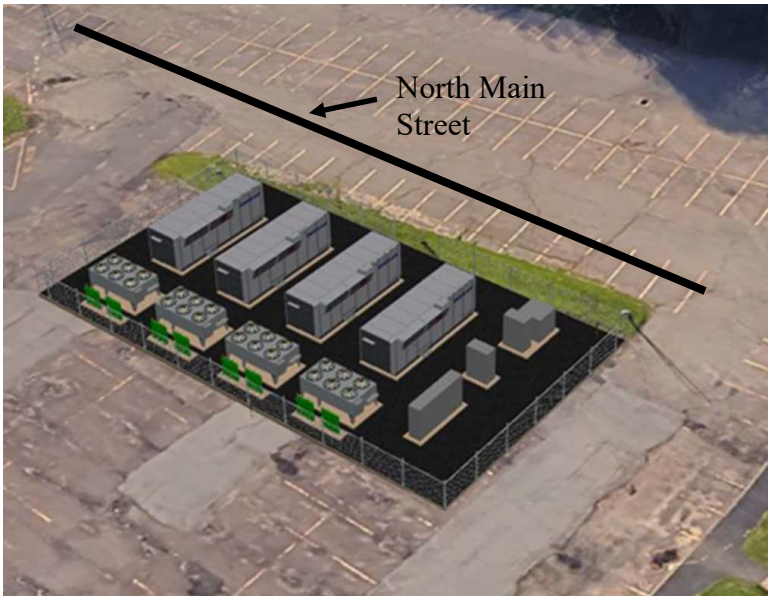


Figure 5 illustrates how the nine fuel cell cooling and power modules will be located along North Main Street. The power modules will block some of the airborne noise directed towards North Main Street. A Noise Tools Model[4] is used to account for the wall along North Main Street and blocking by the power modules. See Figures 6 and 7 for sample calculations. This configuration exceeds the night time noise limit so a calculation with the cooling modules next to the wall proved better by about 3 to 4 dB.

Table 2. Measured Overall Sound Pressure Levels in dBA ref. 20 microPascals with **Speaker On**

Location	Range in Meters	Location	Leq	Max	Min	L10	L90
Speaker On	5	North	87.7	88.0	87.3	87.8	**87.6**
Speaker On	10	North	82.0	82.7	81.6	82.5	**81.8**
Speaker On	5	South	86.4	86.8	86.2	86.6	**86.4**
Speaker On	10	South	79.0	80.6	75.5	80.2	**76.7**
North Speaker							
10 Liberty	104	North	52.4	76.5	47.2	55.3	**47.9**
61 North Cliff	30	East	60.6	85.4	59.7	61.3	**59.9**
31 North Cliff	50	East	57.7	81.7	53.2	61.1	**54.1**
5 State Street	125	South East	57.6	82.3	50.8	60	**52.7**
10 State Street	160	South East	55.0	89.8	49.6	57.3	**50.7**
1 Main Street	185	South	59.4	83.3	57.1	59.9	**57.4**
South Speaker							
61 North Cliff	50	East	54.2	81.0	51.5	56.7	**51.8**
31 North Cliff	30	East	60.0	80.9	59.3	60.8	**59.6**
5 State Street	100	South East	56.7	82.2	50.5	60.4	**50.7**
10 State Street	137	South East	54.9	57.6	52.6	56.5	**53.2**
1 Main Street	165	South	58.5	77.6	49.9	59.6	**50.2**

Leq: Equivalent continuous sound level over the measurement period. – **this is normally the level to be identified as the value to be compared with the steady state overall noise requirement. Because of the heavy traffic noise, the L90 value is used instead.**

SPL MAX: Maximum one-second sound level observed during the measurement period.
SPL MIN: Minimum one-second sound level observed during the measurement period.
L10 - 10% percentile sound level –L10 is the noise level that is exceeded only 10% of the time.
L90: - 90% percentile sound level –L90 is the level that is exceeded 90% of the time.
The CT State Noise Ordinance[1] identifies the L90 acoustic calculation as useful in determining background airborne noise. **This value will also be used as the background noise level.**

The overall airborne noise levels are 14 dB to 17 dB higher for the speakers as compared to what was measured from the HiAxiom 460 KW cooling module at Montville, CT. These 14 to 17 dB differences in level were subtracted from the Ansonia measured levels to estimate the expected fuel cell acoustic signature for one fuel cell. Column 4 of Table 4 provides the background corrected data for the speaker. The transfer function to each property line is shown in column 5 and the estimated level for nine fuel cells in shown in column 6. The 10-meter Montville airborne noise levels were used with the Ansonia transmission loss data to estimate the expected nine fuel cell airborne noise at the six nearby neighbors. Only the locations closest to the fuel cells on North Main Street are near or above the night time 51 dBA noise limit.

Table 3 Measured Overall Sound Pressure Levels in dBA ref. 20 microPascals with **Speaker Off**

Location	Range in Meters	Direction	Leq	Max	Min	L10	L90
Speaker Off	5	North	55.9	58.3	52.2	57.6	**53.4**
Speaker Off	10	North	53.7	57.5	41.3	56.5	**42.5**
Speaker Off	5	South	53.9	57.9	47.1	56.5	**48.6**
Speaker Off	10	South	55.3	67.7	47.8	56.1	**49.1**
North Speaker							
10 Liberty	104	North	65.6	74.8	45.6	70.6	**46.3**
61 North Cliff	30	East	54.7	80.4	43.4	58.2	**43.9**
31 North Cliff	50	East	70.1	78.3	49.2	75.0	**51.9**
5 State Street	125	South East	67.2	76.0	57.0	71.0	**59.6**
10 State Street	160	South East	57.8	71.8	51.1	59.9	**52.2**
1 Main Street	185	South	61.9	80.1	56.0	63.3	**59.6**

Table 4 Background Corrected L90 Sound Pressure Levels in dBA ref. 20 microPascals

Location	Range in Meters	Location	L90 Estimate	Transfer Function	Property Line	Night Spec	Over Spec
North Speaker			In dBA	In dB	dBA	dBA	dBA
10 Liberty	104	North	**45.6**	36.2	36.5	51	
61 North Cliff	30	East	**59.8**	22	50.7	51	
31 North Cliff	50	East	**52.1**	29.7	43	51	
5 State Street	125	South East	**44.7**	37.1	35.6	51	
10 State Street	160	South East	**42.7**	39.1	33.6	51	
1 Main Street	185	South	**41**	40.8	31.9	70	
South Speaker							
61 North Cliff	50	East	**51.1**	25.6	46.2	51	
31 North Cliff	30	East	**58.9**	17.8	**54**	51	3 dB
5 State Street	100	South East	**42.7**	34	37.8	51	
10 State Street	137	South East	**42.7**	34	37.8	51	
1 Main Street	165	South	**40.2**	36.5	35.3	70	

The South transfer function appears to be about 4 dB stronger than the North transfer function causing the closest property line to exceed the 51 dBA night time noise limit by 3 dB at the very closest location. This calculation was done with the cooling modules 3 meters from the wall rather than 15 meters, a change that lowers the noise levels across the street by about 4 dB. Locations further than 30 meters from the cooling modules will meet all the requirements.

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Figure 6. Noise Tool Model of Noise Speaker Location with P2 Measurement of 59.8 dBA

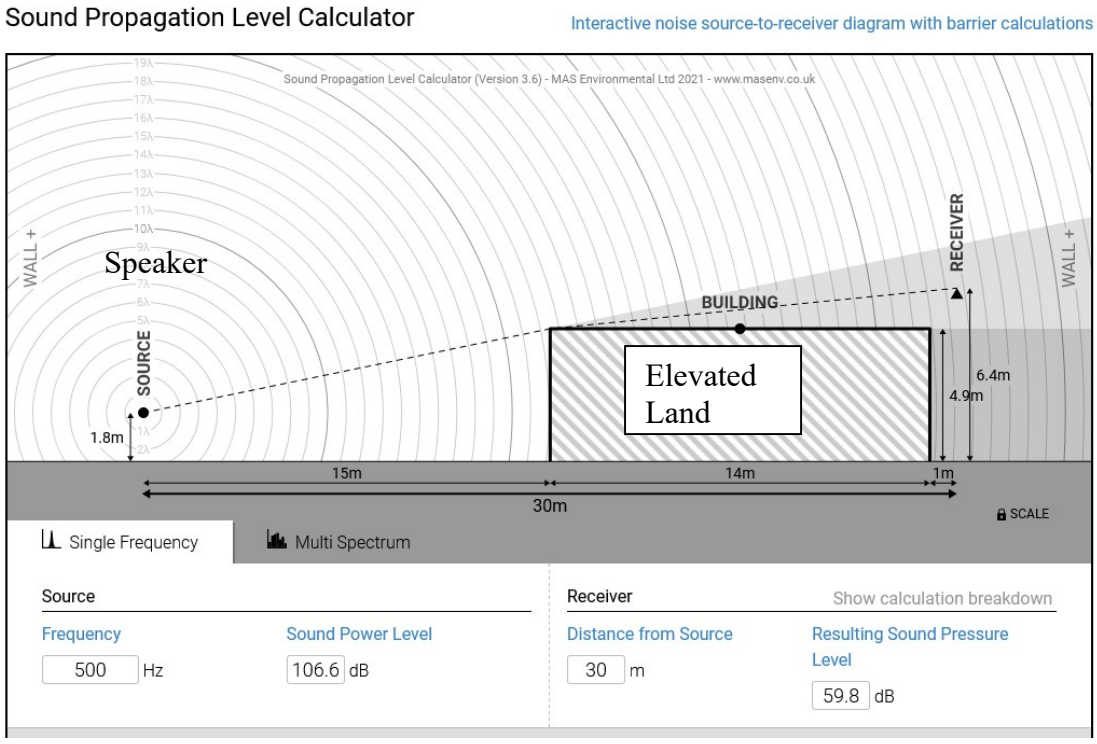


Figure 7. Noise Tool Model of Expected Noise from One Cooling Module at 30 Meters

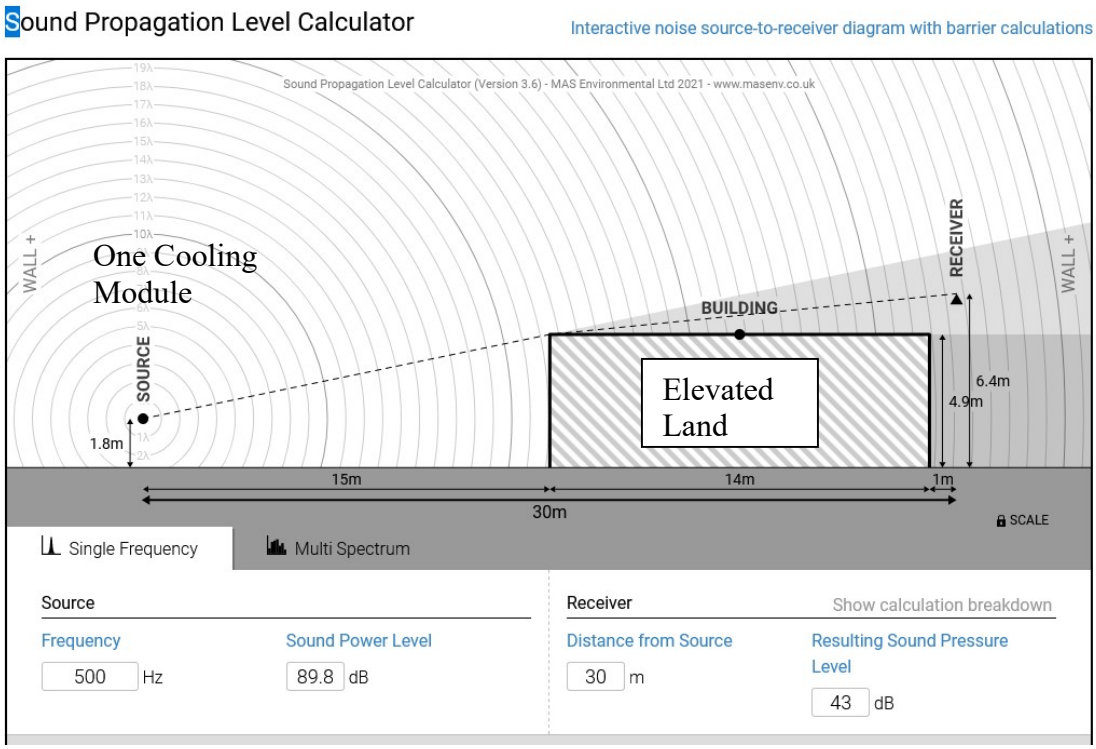
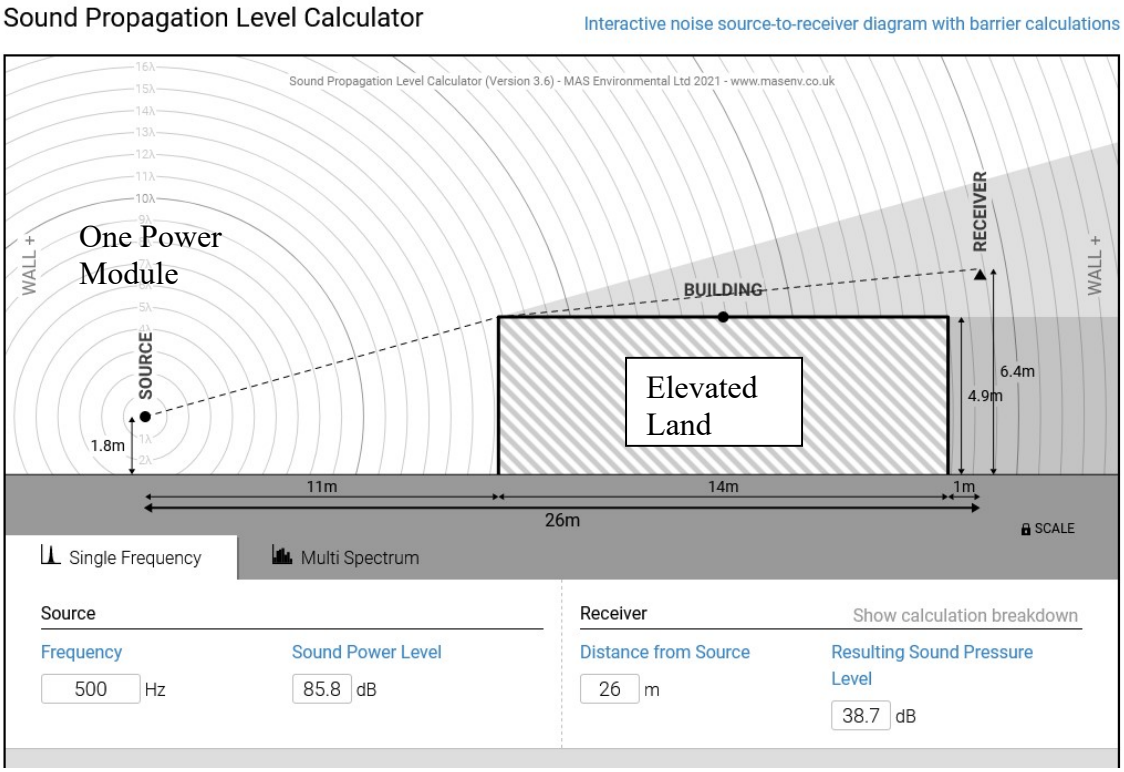


Figure 8. Noise Tool Model of Expected Noise from One Power Module at 26 Meters



The airborne noise levels to be produced by the HiAxiom fuel cells are shown in Table 4. For each of the six locations the Ansonia measurements are corrected to account for the higher speaker levels. The fuel cell noise correction for the Cooling Module is estimated to be 17dB for the North location because the speaker levels are that much higher than the Montville Cooling Module levels. The speaker at the South location was estimated to be 14 dB higher than the Montville Power Module levels.

The measurements at Ansonia were taken at various distances from the speakers and then corrected to estimate the expected noise from nine fuel cells. Except for the closest location at 30 meters, the airborne noise levels are all below 47 dBA, 4 dB below the lowest residential night time noise limit. The other properties not on North Main Street are expected to be below 38 dBA depending on how close the locations are to the fuel cells.

Allowable Noise Levels

Connecticut's regulation for the control of noise provides in *CT section 22a-69*-3[1] the requirements for noise emission in Connecticut. *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 CT ordinance will be used to evaluate the noise generated by the HiAxiom 460 KW Fuel Cells. (The Ansonia noise ordinance has the same noise limits.) Following sections discuss each type of noise using the results obtained from the October 3, 2023 speaker measurements in Ansonia and the HiAxiom 460 KW fuel cell test in Montville, CT reported on July 13, 2020.

As stated above, the Ansonia site is located in an Industrial Zone on North Main Street and is surrounded by Residential Zones. The closest residential zone is only 30 meters away. Based on the analysis resulting in Table 4 the airborne noise from the nine new fuel cells should be below the 51 dBA noise limit at distances greater than 30 meters. A 100-meter-long stretch of North Main Street opposite the fuel cells will see airborne noise levels slightly above 51 dBA. All other nearby residential properties at greater distances are expected to be well below the day time and night time Residential Zone noise limits for an emitter in an Industrial zone.

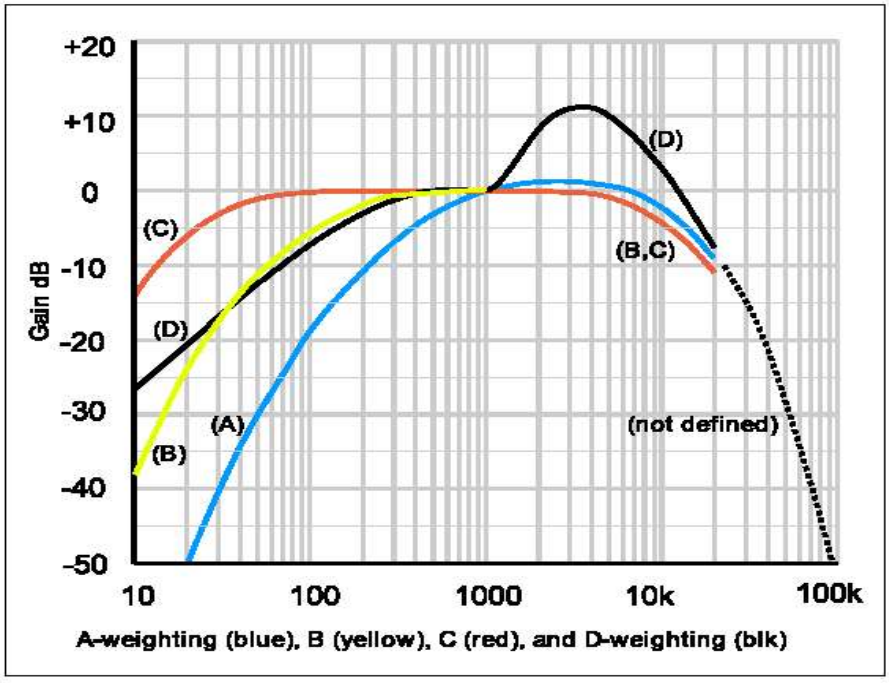
Because of the traffic noise on North Main Street, experience suggests a noise level less than 5 dB above the requirement would not be objectionable since the fuel cells generate mostly random noise. Nine fuel cells will probably be heard at low level along North Main Street.

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 night time to any class A Noise Zone. Night time is 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 Ansonia noise ordinance sets the same limits for Impulse Noise.

Figure 9. Acoustic Airborne Noise Weighting Curves

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



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Impulse noise in excess of 80 dBA was not observed during any of the ten property line measurements of the Doosan 460 KW fuel cell made at the Montville site on 7 July, 2020[3]. The maximum level measured was 79.7 dBA at location P2 using the ExTech sound level meter. This and the other levels above 70 dBA were caused by vehicle traffic and not by the fuel cell. Unweighted impulse noise levels were determined using a Hewlett Packard HP3561A spectrum analyzer. (The maximum level ten meters from the fuel cell was 77 dBA.) The closest Ansonia property showed 18 dB of transmission loss so the highest expected level would be below 60 dB. Given the steady state nature of the fuel cell's noise signature there should be no acoustic issues with the State of Connecticut's or the City of Ansonia'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 9 above 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. The fuel cell measurements show the unweighted overall levels to be about 9 dB higher than the A-weighted noise levels. Adding 9 dB to the Montville measured levels brings the peak impulse up to about 69 dB reference 20 microPascals. The impulse noise levels on North Main Street should be no higher than 69 dB reference 20 microPascals, well below the 100 dB limit.

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 CT Regulations establish different noise limits for different land use zones. Residential (homes and condominiums) and hotel uses are in Class A. Schools, business, parks, recreational activities and government services are in Class B. Forestry and related services are in Class C. By my reading of the regulations the Ansonia is a Class C emitter in an Industrial Zone. The noise zone standards in *CT section 22a-69-3.5* state that a Class C emitter cannot exceed the following overall sound pressure levels:

To Class C 70 dBA To Class B 66 dBA To Class A 61 dBA (day) 51 dBA (night)

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

To Class C 65 dBA To Class B 61 dBA To Class A 56 dBA (day) 46 dBA (night)

The Ansonia noise ordinance does not discuss discrete tones so the CT Noise Ordinance will be used. To address the discrete tone issue, we use measured spectral data from the Reference 3 Montville testing. The data is the maximum level received in 1/30 octave bands for frequencies from 0.32 to 100,000 Hz. Figure 10 plots the airborne noise measured 10 meters from the Cooling and Power Modules in 1-30th octave bands. This figure shows some discrete tones in the middle frequencies produced by the HiAxiom Fuel Cell Cooling and Power Modules. The

eight largest tones are given in Table 5. The highest is 55.1 dB reference 20 microPascals at 302 Hz. The second highest tone is at 213.8 Hz at a level of 54.3 dB reference 20 microPascals. All the remaining tones are below 53 dBA. The A-weighted discrete tone corrections are given in the 4th row of Table 5. Incorporating the transmission loss to the properties gives the A-weighted levels in the last three rows of Table 5 after the 9.5 dB correction for nine units is added. (The 9.5 dB correction for 9 units over estimates by about 1.5 dB the combination of nine fuel cells spaced 10 meters apart.) All the frequencies at the nearest residences on North Main Street have levels that are below the 46 dBA requirement in a Residential Zone by at least 3 dB. All the nearby residential properties should meet all the discrete tone requirements. There should be no acoustic issue with the CT discrete tone noise requirements at any of the nearby properties.

Figure 10. Montville Tones 460 KW Fuel Cell Cooling & Power Modules in 1-30th octave bands

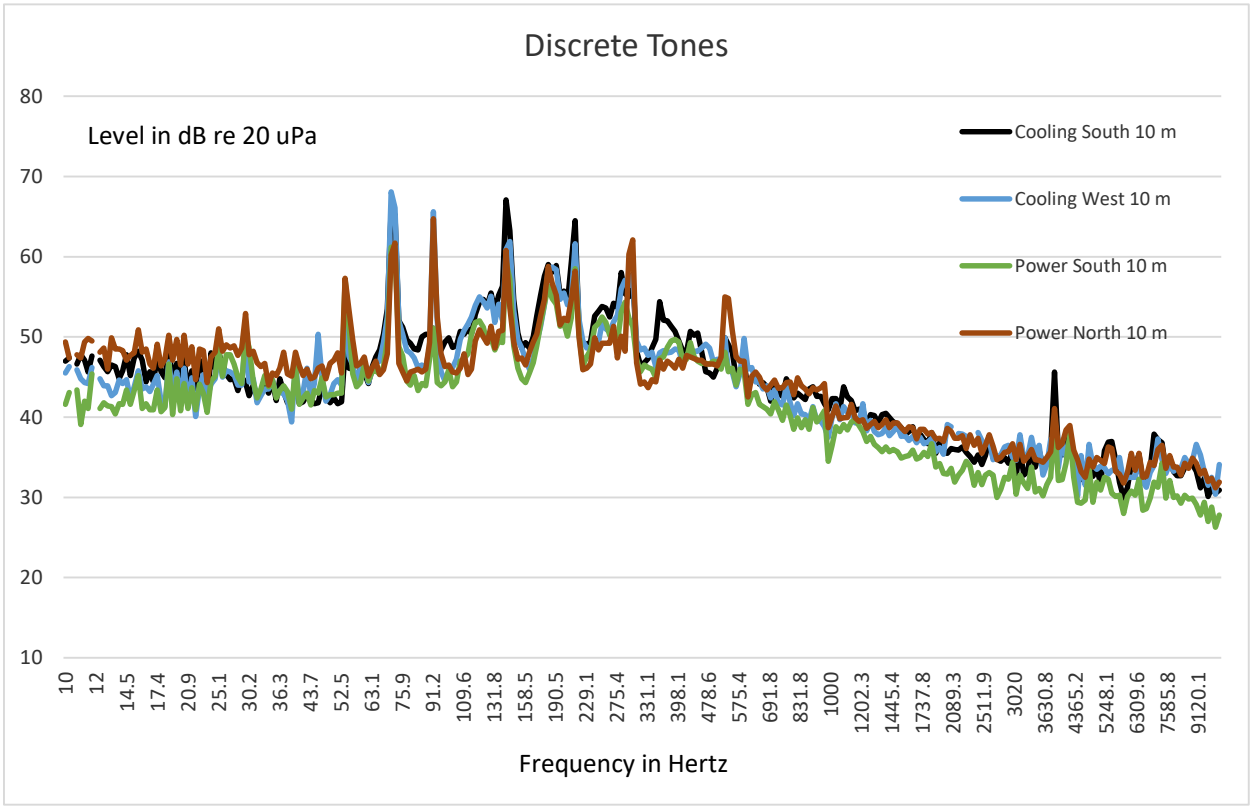


Table 5. Peak Discrete Sound Pressure Level Estimates in dB ref. 20 microPascals

Location	Range Meters	53.7 Hz	70.8 Hz	91.2 Hz	141.3 Hz	213.8 Hz	302 Hz	3801 Hz	4169 Hz
Allowed Level		**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**
Montville	10	57.3	68.1	65.6	67.1	64.5	62.1	45.6	39
A Weighting		-29.0	-24.3	-20.5	-14.7	-10.2	-7.0	1.0	0.9
Ansonia 1 unit	10	28.3	43.8	45.1	52.4	54.3	55.1	46.6	39.9
9 Fuel Cells	10	37.8	53.3	54.6	61.9	63.8	64.6	56.1	49.4
P1– 10 Liberty	104	1.6	17.1	18.4	25.7	27.6	28.4	19.9	13.2
P2– 61 NMain	30	15.8	31.3	32.6	39.9	41.8	42.6	34.1	27.4
P3– 31 NMain	50	8.1	23.6	24.9	32.2	34.1	34.9	26.4	19.7
P4– 10 State	125	0.7	16.2	17.5	24.8	26.7	27.5	19.0	12.3

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. There is no mention in the Ansonia Noise Ordinance that limits infrasonic or ultrasonic noise so the State of CT Noise Ordinance will be used.

Narrow bandwidth sound pressure spectrums in dB reference 20 microPascals made at the Montville western 10-meter Cooling Module location can be used to compare with the infrasonic and ultrasonic noise requirements. The Montville airborne noise data were processed in the 0 to 200 Hertz and 0 to 100,000 Hertz frequency ranges. The bandwidth of each data point is 0.75 Hertz for the 200 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 11 for the 460 KW unit at Montville[3]. The maximum level at 10 meters is 48 dB reference 20 microPascals. The entire 20 Hertz band can be power summed and never exceeds 70 dB reference 20 microPascals at 10 meters in Montville. After subtracting 17.8 dB for the maximum transfer function correction at Point P3, the closest site, and adding the gain of 9.5 dB for nine units, the 61.7 dB level is well below the Infrasonic requirement of 100 dB for the Ansonia site. The noise levels at all the other nearby residential neighbors will be lower. There should be no issue with the infrasonic noise requirement at any of the neighboring residential properties.

The ultrasonic noise for frequencies up to 100 KiloHertz is given in Figure 12. The Montville data uses a microphone with flat high frequency performance and provides a good estimate for the 460 KW fuel cell. The entire 80 KiloHertz band from 20 to 100 kiloHertz has been power summed and never exceeds a noise level of 62 dB reference 20 microPascals 10 meters from the

fuel cell at Montville. After subtracting 17.8 dB for the maximum transfer function correction at Point P3, the closest site, and adding the gain of 9.5 dB for nine units, the ultrasonic level of about 53.7 dB is well below the requirement of 100 dB for the Ansonia site. The noise levels at all the other nearby residential neighbors will be lower and there should be no issue with ultrasonic noise at any of the neighboring properties.

Figure 11. Infrasonic Noise from Montville Fuel Cell Cooling Modules in 1-30th octave bands

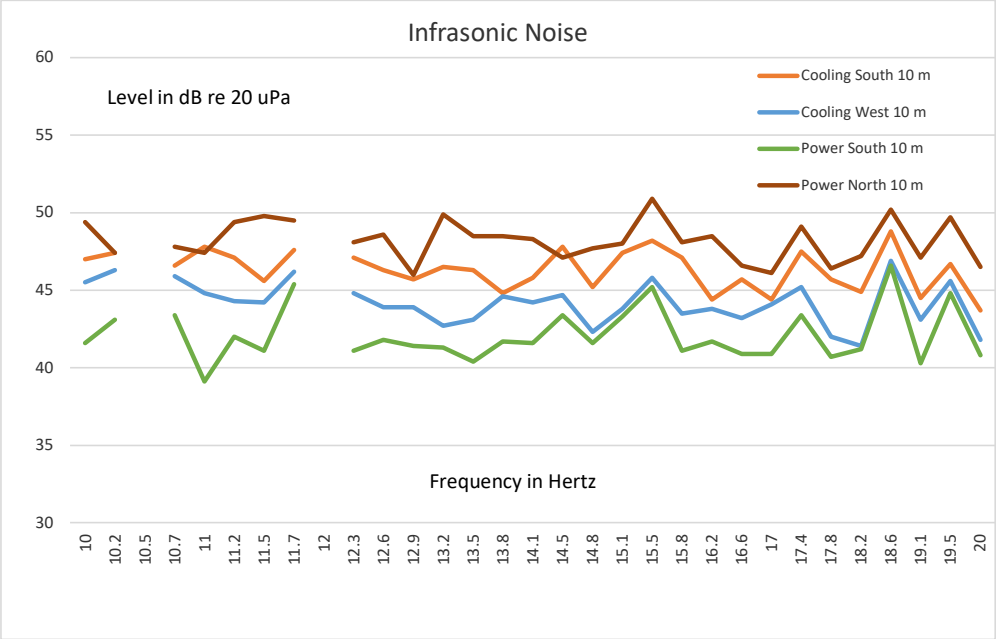
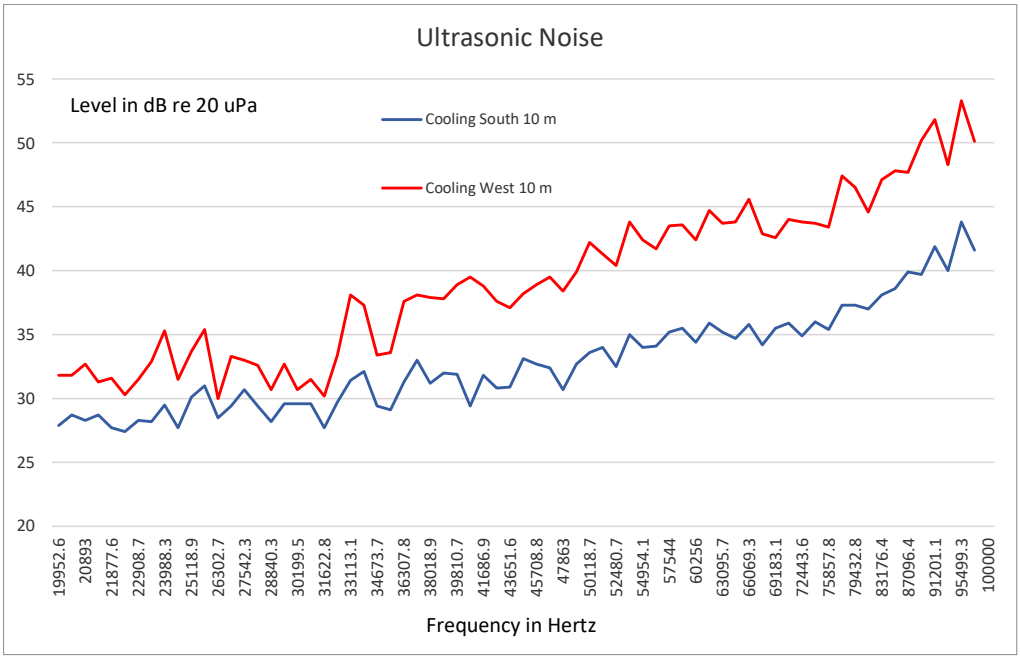


Figure 12. Ultrasonic Noise from Montville Fuel Cell Cooling Modules in 1-30th octave bands



Overall Sound Pressure Levels

The Connecticut regulations for the control of noise state that
(a) No person in a Class C Noise Zone shall emit noise exceeding the levels below:

To Class C 70 dBA To Class B 66 dBA To Class A 61 dBA (day) 51 dBA (night)

The Ansonia site is in an Industrial Zone that has surrounding Residential Zones. The nearby neighbors in AAA and B residential zones have airborne noise limits of 61 dBA during the day and 51 dBA at night. The Industrial Zone limit is 70 dBA.

The estimated overall A-weighted sound pressure levels for nine fuel cells in dBA reference 20 microPascals are given in column 6 of Table 4 above using the background corrected measurements made on October 3, 2022. The second column gives the approximate distance from the fuel cells to the measurement location, with locations identified by a P number in Figure 2. Column 3 gives the direction from the fuel cell to the property. The airborne noise values given in column 4 are the estimated received level for one speaker. The transfer functions in column 7 provide the loss in sound level from the fuel cells to the property lines. The values in column 6 provide the estimated airborne noise levels at the property lines with nine fuel cells operating. The values are all below the industrial zone noise limit and below the residential noise limits except for position P3 which is across the street from the fuel cells. The increasing loss with distance to the surrounding residential properties means all should be lower than 51 dBA.

Operation of the nine HiAxiom fuel cells will have no significant acoustic impact at all but one of the nearby properties adjacent to the HiAxiom fuel cell site on North Main Street. The adjacent property at 61 Cliff Street is open land between a Church and a garage on a hill about 50 feet above North Main Street. The first 20 meters of this property abutting North Main Street is a steep hill that no one normally occupies. The location of the cooling modules at 15 meters from the wall results in a 53 dBA noise level at position 2 and a 56.3 dBA level at position 3. The location of the cooling modules at 3 meters from the wall results in a 50.7 dBA noise level at position 2 and a 54 dBA level at position 3. It is recommended to move the cooling modules as close as possible to the wall on North Main Street.

The other properties close to the fuel cells should see overall airborne noise levels from the fuel cells below the 51 dBA airborne noise requirement. Some of these properties may be able to hear the fuel cells at noise levels below the background noise below 51 dBA when no traffic is present. Residential properties not on North Main Street in the Industrial and Residential Zones are not expected to hear the fuel cells. All of the nearby residential and industrial properties should not be affected by the operation of the nine fuel cells.

Conclusions

The purpose of this effort is to evaluate the acoustical environment at the Ansonia sire during operation of the nine HiAxiom 460 KW fuel cells. This effort has been accomplished and the results show that the operation of the nine HiAxiom 460 KW fuel cells will meet all of the State of Connecticut and City of Ansonia airborne noise requirements at all the nearby properties

except for one property across the street. Other residences in all directions are expected to meet all the noise requirements because they are far enough away from the new fuel cells and have airborne noise levels below 51 dBA. Locations at distances greater than 150 meters should not hear the operating 460 KW fuel cells.

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) Ansonia Noise Ordinance, http://portal.ct.gov/AnsoniaNoiseOrdinancepdf.pdf

3) Town of Montville Water Pollution Control Authority Airborne Noise Test

   At 83 Pink Row, Acoustical Technologies Inc., July 13, 2020

4) https://noisetools.net/barriercalculator was used in the sound pressure calculations