



PRINCETON UNIVERSITY

SITE
ACOUSTIC REPORT

**ENERGY PLANT CONVERSION AND
EXPANSION PROJECT - TIGER**

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1 INTRODUCTION

ZGF is currently designing a new TIGER building for Princeton University. The new facility will house mechanical equipment associated with a central utility plant such as chillers, pumps, a generator, and exhaust fans. The following report details the predicted noise levels surrounding the site based on this new equipment as well as the ambient noise levels that are currently present. The ambient noise levels are based on a noise survey that was performed on January 19, 2020.

2 EXECUTIVE SUMMARY

This report summarizes our review of the mechanical systems associated with the proposed TIGER building at Princeton University. It includes both current ambient noise levels measured at the site as well as predicted noise levels at identified locations around the site once the building is operational.

Existing noise levels were measured on January 19, 2020 from 12:30 PM to 4:00 PM. Noise levels were captured without any activities taking place, ambient noise levels, as well as discrete events such as car pass bys and helicopter fly overs. The ambient measurements showed that noise levels on site were in the range of 45-50 dBA with no activities taking place and that discrete events could increase those noise levels into the 60-65 dBA range with some noise as high as 70 dBA for louder events such as the helicopter fly over. These noise levels are typical for a residential/campus site.

Predicted noise levels were also calculated based on the basis of design equipment for the new TIGER building. This included equipment such as chillers, pumps, a generator, and exhaust fans. Factors such as barrier effects due to the TES Tanks as well as the building itself were considered as well as distance from the measurement locations. Predicted noise levels for all of the equipment together, except the generator as this will only operate every once in a while for testing or in an emergency situation, were at or below the New Jersey noise code of 50 dBA during the hours of 10:00 PM to 7:00 AM for all locations except Location 1 which is closest to the TIGER building. Location 1 meets the daytime noise levels presented in the New Jersey noise code of 65 dBA between the hours of 7:00 AM to 10:00 PM.

Recommendations to achieve the established acoustical criteria included an upgrade to the acoustical louvers providing airflow to the Chiller Room in order to better control noise levels from the pumps and the chillers. Recommendations also included incorporation of appropriate vibration isolation for each piece of equipment in order to limit the propagation of vibration to spaces within the TIGER / Athletic Ops building as well as to adjacent properties.

3 ACOUSTICAL STANDARDS

The recommendations presented in this report are consistent with the criteria and design standards listed below.

3.1 2019 ASHRAE APPLICATIONS HANDBOOK

Chapter 49 "Noise and Vibration Control" from the 2019 ASHRAE Applications Handbook is the industry standard for mechanical, electrical, and plumbing noise control related to building HVAC systems. Mechanical system treatments and design guidelines presented in this report are primarily based upon this document. Wherever possible, the mechanical system design should follow this standard, which is the most current version of the document.

3.2 PRINCETON NOISE CODE

The Princeton Noise Code Chapter 21 'Loud, Continuous or Excessive Noise' states the following with regards to property line noise:

Sec. 21-1. Loud, continuous or excessive noise.

It shall be unlawful for any person to make, continue or cause to be made or continued any loud, continuous or excessive noise or any noise which endangers the health, safety or welfare of the community, or which annoys, disturbs, injures or endangers the comfort, repose, health, peace or safety of others within Princeton. (Ord. No. 2014-35)

This type of noise code is very difficult to enforce as what is considered excessive or annoying to one resident may not be considered so by another resident. We therefore recommend that the project follow the State of New Jersey noise code noted below.

3.3 NEW JERSEY NOISE CODE

The state of New Jersey noise code Chapter 29 'Noise Control' states the following with regards to property line noise:

7:29-1.2 Industrial, commercial, or community service facilities

- a) *No person shall cause, suffer, allow, or permit sound from any industrial, commercial, or community service facility that, when measured at any residential property line of any affected person, is in excess of any of the following:*

- 1. *From 7:00 AM to 10:00 PM*

- i. *Continuous airborne sound which has a sound level in excess of 65 dBA; or*
- ii. *Continuous airborne sound which has an octave band sound pressure level in decibels which exceeds the values listed below in one or more octave bands*

Frequency (Hz)	31.5	63	125	250	500	1000	2000	4000	8000
Sound Pressure Level (dB)	96	82	74	67	63	60	57	55	53

- iii. *Impulsive sound in air which has a maximum sound level in excess of 80 dBA*

- 2. *From 10:00 PM to 7:00 AM*

- i. *Continuous or airborne sound which has a sound level in excess of 50 dBA; or*
- ii. *Continuous airborne sound which has an octave band sound pressure level in decibels which exceeds the values listed below in one or more octave bands*

Frequency (Hz)	31.5	63	125	250	500	1000	2000	4000	8000
Sound Pressure Level (dB)	86	71	61	53	48	45	42	40	38

iii. Impulsive sound in air which has a maximum sound level in excess of 80 dBA and such impulse sound shall not be repeated more than four times in any hour. Impulsive sound which repeats more than four times in any hour shall not exceed 50 dBA.

4 ACOUSTIC SITE VISIT

On January 19, 2020, The Sextant Group performed a site survey of the proposed location for the new TIGER building. The survey was conducted between 12:30 PM and 4 PM and encompassed both the proposed site of the new building as well as mechanical equipment at the existing Central Utility Plant (CUP). Measurements were recorded of ambient conditions on site as well as any discrete events (such as car pass bys, helicopters, etc) that were noted while on site.

4.1 MEASUREMENT LOCATIONS AND EQUIPMENT

Measurements were recorded using a NTI 'XL2' sound level meter. The diagram below shows the measurement locations. These locations were selected by the client to represent the boundaries of the property as well as some of the more acoustically sensitive areas surrounding the property.



4.2 MEASUREMENT RESULTS

The table below shows the ambient noise levels at each location during the time of our survey.

Measurement Location	Ambient Noise Level (dBA)
1	45-50
2	45-50
3	45-50
4	45-50
5	45-50

The measurements above represent the noise level when there was very little activity on the site and no cars passing by. The following table shows the increase in noise levels due to discrete events.

Event	Noise Level (dBA)
Car Pass by	60-65
Helicopter Fly Over	65-70
Truck Pass by	60-65

Measurements were also recorded in the existing Central Utility Plant. These were of limited use as most of the equipment was not operational due to it being winter. One measurement that was useful was the measurement directly adjacent to an existing chilled water pump. This helped us to gain a better understanding of the frequency spectrum of the noise emanating from these pumps which helped our calculations, described below, be more accurate.

4.3 CONCLUSIONS

The noise levels measured on site are typical for a residential/campus environment. If the New Jersey noise code is implemented for the project, noise levels from the plant will likely be audible at the property line although we would not anticipate that they will be disruptive and will be less than discrete events such as car pass bys and helicopter fly overs.

5 MECHANICAL EQUIPMENT SUMMARY

This report will discuss multiple types of mechanical equipment located in various locations in and around the TIGER building. These include the following:

- Chillers located in the Chiller Room
- Pumps located in the Chiller Room
- Exhaust Fans located on the roof
- Generator located adjacent to the building

Calculations consider noise data provided by the mechanical engineer as well as any structural items, such as the tanks or the building itself, that might provide some reduction of the noise. Calculations were performed for all locations noted in the site survey section above and conclusions have been drawn regarding the relationship between the predicted noise levels and the measured ambient noise levels. A summary at the end discusses the overall noise impact on the surrounding area that is predicted based on operational noise generated by all of the different mechanical equipment.

5.1 CHILLERS

There will be four chillers located in the chiller room in the TIGER building. The sound pressure level at 3 feet for each unit is shown in the table below.

Chiller Noise Levels at 3 feet								
Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Sound Pressure Level at 3 feet	81	85	83	80	80	82	77	70

The chiller room is located at the south end of the building. The building façade will be comprised of 1" IGU glass and CMU with metal panels. There will also be louvers, similar to Greenheck 'AHJ-801' that will be used to allow air flow into the chiller room. The glass and the louvers will be the weak points of the construction. The currently selected louvers have the following insertion losses

Louver Insertion Loss							
Frequency (Hz)	125	250	500	1000	2000	4000	8000
Insertion Loss (dB)	5	5	7	7	13	22	14

Noise levels have been calculated at each ambient measurement location. Locations 1-4 will not have any obstructions between them and the building whereas at location 5 the noise path will be partially blocked by the TES Tank. We would expect noise levels due to the chillers to be the following assuming a worst-case scenario of the louvers.

- Location 1: 60-65 dBA
- Location 2: 45-50 dBA
- Location 3: 45-50 dBA
- Location 4: 45-50 dBA
- Location 5: 25-30 dBA

As can be seen from the noise information above, these levels will be at or slightly above ambient noise levels. With the exception of Location 1, they should all meet the NJ noise code for nighttime. These noise levels could be reduced by using an upgraded louver similar to a VibroAcoustics 'ALV LV 18' in lieu of the currently specified Greenheck AHJ Louver.

5.2 PUMPS

There will be a number of pumps located in the chiller room that will also generate noise. Octave band sound power data was not available for these units, however; the following single number ratings were provided by the mechanical engineer.

- TGR-CHW-1PMP: 4 pumps, 80 dBA at 3 feet
- TGR-CHW-2PMP: 4 pumps, 96 dBA at 3 feet
- TGR-HW-1PMP: 4 pumps, 78 dBA at 3 feet
- TGR-HW-2PMP: 4 pumps, 96 dBA at 3 feet
- TGR-GEO-PMP: 4 pumps, 89 dBA at 3 feet
- TGR-HW-TES-PMP: 4 pumps, 85 dBA at 3 feet

During our site survey on January 19, 2020, we were able to measure an existing pump located in the Central Utility Plant on campus. This pump was CHW Pump 7 Chilled Water and the client indicated that it would be similar in nature to the pumps that will be included in the TIGER building. From this data we can take the spectrum of noise from the measured pump and calibrate it to the sound levels noted above. This will provide us with a more accurate calculation.

As with the chillers noted above, the weak point in the façade construction will be the louvers that allow airflow into the chiller room. Locations 1-4 will not have any obstructions between them and the building whereas at location 5 the noise path will be partially blocked by the TES Tank. We would expect noise levels due to the chillers to be the following assuming a worst-case scenario of the louvers.

- Location 1: 65-70 dBA
- Location 2: 50-55 dBA
- Location 3: 50-55 dBA
- Location 4: 50-55 dBA
- Location 5: 30-35 dBA

If a better acoustical louver is provided, such as VibroAcoustics 'ALV LV 18', the predicated noise levels could be reduced to the following:

- Location 1: 55-60 dBA
- Location 2: 45-50 dBA
- Location 3: 45-50 dBA
- Location 4: 40-45 dBA
- Location 5: 20-25 dBA

An upgraded louver is recommended as it would then reduce the noise levels below those required by the New Jersey noise code in all locations except location 1.

5.3 EXHAUST FANS

Based on the current mechanical plans, there will be 5 exhaust fans located on the roof of the building. These fans will sit on 24" curbs and will be surrounded by a 42" tall parapet. Sound power levels provided by the mechanical engineer are shown in the table below.

Exhaust Fan Sound Power Level (dB re: 10 ⁻¹² W)								
Fan	Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
HVAC EF 4303, 4, 5	91	89	80	73	71	66	59	53
HVAC EF 4301	78	82	85	79	74	41	67	62
HVAC EF 4302	81	83	75	73	68	64	64	61

Based on the above noted sound power levels and the distances to the various measurement locations we would expect the following noise levels for all exhaust fans assuming they run continuously.

- Location 1: 40-45 dBA
- Location 2: 30-35 dBA
- Location 3: 30-35 dBA
- Location 4: 30-35 dBA
- Location 5: 20-25 dBA

These units should be below the ambient noise levels on site and are certainly below the noise code goals for the project.

5.4 GENERATOR

The generator for the project will be located exterior to the building between the TES Tanks. This is beneficial as the Tanks will provide some attenuation to the more sensitive residential property lines to the east of the proposed building. The generator currently selected for the project has a noise rate enclosure that provides a noise level of 70 dBA at 23 feet.

Based on the above noted sound power levels and considering any barrier effects from the proposed building and the TES Tanks, the predicted noise levels at the various measurement locations are as follows:

- Location 1: 25-30 dBA
- Location 2: 40-45 dBA
- Location 3: 45-50 dBA
- Location 4: 25-30 dBA
- Location 5: 55-60 dBA

The State of New Jersey noise code does permit the following as it relates to emergency generators:

Section 7:29-1.5 Exceptions

14. Emergency electricity generators at an industrial, commercial, or community service facility in use during an electrical outage

The generator at the TIGER facility would likely be included in this category, however; there is no provision that excludes the generator while it is being routinely tested. This should be scheduled for a time when it is least disruptive such as during the day on a weekday.

5.5 CUMALATIVE NOISE LEVELS

The following map indicates the cumulative predicted noise levels at each of the measurement locations around the site. These noise levels assume that an upgraded acoustical louver can be incorporated at the chiller room and that all units are operating simultaneously, i.e. there are no redundant chillers, pumps or fans. The numbers in green indicate the current ambient noise levels and the numbers in blue indicate the noise levels due to the proposed mechanical equipment running.

Since the generator will only run while it is being tested or during an emergency when it is exempted, it has not been included in this diagram.



The following map indicates the predicted noise levels with the generator running. Again, this would be exempted during an emergency.



Please note that in areas where mechanical equipment noise is below ambient noise, ambient noise levels will dominate in this location. We do not anticipate a decrease in ambient noise levels.

6 VIBRATION ISOLATION

Vibration due to the mechanical equipment has also been discussed as a concern for the client. Typically, if a piece of equipment is isolated per ASHRAE guidelines, vibration transmitted into the surrounding area will be minimal. The table below provides our recommended vibration isolation for each piece of equipment discussed in this report.

Equipment	Recommended Isolation
Chillers	Rubber mounts with a 0.25" static deflection
Pumps	Spring isolators with a 1.5" static deflection
HVAC EF 4301, 4302	Structural steel base with spring isolators with a 1.5" static deflection
HVAC EF 4303, 4304, 4305	Structural steel base with spring isolators with a 2.5" static deflection
Generator	Spring isolators with a 0.75" static deflection

This concludes our review of the mechanical equipment currently proposed for the new TIGER building. If you have any questions related to this report, please do not hesitate to contact us at jfischer@thesextantgroup.com or 202.753.5564.

Best regards,



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