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Case Study: Air Cooled Chillers with Rotary Helical (Screw) Compressors at Hospital with Impact on Patient Rooms, Residential Neighborhoods, and Open Park

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Abstract

Air cooled chiller with rotary (helical) screw compressors installed at a new hospital were producing disturbing tonal noise in patient rooms, an adjacent open park, and neighborhoods five to nine blocks away. The hospital received numerous complaints, and retained JEAcoustics to provide noise mitigation recommendations. The chiller produced a distinct tone measured at 117 Hz.

The criterion developed was based upon perceived annoyance according to the Composite Noise Rating (CNR) analysis acceptability levels. It was determined that the tonality should be decreased by 5 to 8 dB in the 125 Hz third octave band within surrounding neighborhoods.

Mitigation recommendations included: (a) attenuate radiated compressor noise by wrapping the compressors with an insulated limp mass noise barrier jacket, (b) attenuate compressor discharge noise by inserting pulse diffusers in the compressor discharges, (c) control the intake noise by providing acoustic louvers, (d) control discharge noise of both the fans and the condensers by providing discharge attenuators, and (e) reduce reflected sound from building surfaces (f) provide laminated ½" windows in patient rooms facing the chillers.

The client elected to implement recommendations incrementally. After the implementation of the first two recommendations, noise complaints ceased. Sound level validation measurements were made. JEAcoustics found that ~ a 5 dB tonal reduction had been attained. The attenuation design, sound level measurements, and the effectiveness of the mitigation efforts will be discussed.

1. Introduction

A new hospital was built amongst residential single and multi-family homes and apartments, an open park, and commercial property, including an outdoor dining facility. Three air-cooled chillers with rotary helical (screw) compressors were installed on the first level roof of the hospital, near patient windows. The hospital received many complaints of disturbing noise levels coming from the hospital. Interestingly, the hospital did not receive complaints from its closest neighbors, but rather from receivers as far away as half a mile in the residential neighborhoods and in the nearby, open park. The new hospital was concerned with

its public relations, and retained JEAcoustics to provide sound mitigation recommendations for the chillers. This case study report accounts the experience.

JEAcoustics analyzed the noise sources, and provided environmental noise control recommendations. JEAcoustics made several recommendations to the hospital to mitigate the noise, some of which were implemented (as recommended or in variance), and some of which were not. The hospital chose to implement the recommendations incrementally. After the first two recommendations were implemented, noise complaints ceased, and JEAcoustics returned to the site to conduct validation measurements. Criteria, procedure, findings, and recommendations detailed in JEAcoustics report [1] are reported below. Results follow.

2. Criteria

The hospital's first concern was compliance with local ordinances and regulations, to which sound level measurements taken at the property lines complied. The hospital's second concern was public relations. The hospital wanted the noise complaints, and threats of legal action to cease. In order to quantify the public's reaction to the noise, and determine the amount of attenuation required, JEAcoustics employed the Composite Noise Rating (CNR) analysis acceptability levels [2]. Criteria enabled JEAcoustics to confirm that the chillers were in fact the source of annoyance.

An existing parapet wall around the chillers did not conceal the chillers from the ground level, so the hospital planned to increase the height of the wall. The hospital wanted additional design recommendations that could be implemented in phases. With patient rooms overlooking the mechanical yard housing the chillers, the hospital did not want to add to the size of the chiller assemblies, which could make them more of a visual nuisance and block light from patient room windows. Cost was also a design criterion.

The design criteria was to decrease the 117 Hz, narrow band tone by 5 to 8 dB in the surrounding neighborhoods, as discussed below.

3. Procedure

JEAcoustics reviewed the installation information for the chillers and their layouts in relation to the hospital structure. The three chillers are package screw type chillers with varying operating speeds due to variance in loading. During day time hours, JEAcoustics made observations and conducted integrated time averaged third octave and narrow band noise measurements near the equipment, above the parapet wall surrounding the equipment, and in patient rooms on the third floor with windows facing the roof top equipment. During the early nighttime hours, when the most complaints were made, JEAcoustics conducted measurements in the neighborhoods from which the complaints originated. Measurements were made with a Larson-Davis 2900 1/3 octave integrated spectrum analyzer [3][4], with an ANSI Type 1 precision ½" microphone and pre-amplifier.

Measurement results were analyzed and compared to the criteria. JEAcoustics determined the amount of noise attenuation required to meet criteria, and developed recommendations to provide the prescribed amount of mitigation to the chillers. JEAcoustics returned to the site to conduct observations and make validation measurements.

4. Findings

Two equipment elements, the compressors and the discharge fans, generate the noise produced by the chillers. JEAcoustics was not able to measure the noise sources separately.

- On the roof and above the parapet surrounding the chillers, JEAcoustics observed and measured a distinct “buzz” or “hum” at 117 Hz, using a 1.56 Hz bandwidth.
- In the Patient Rooms the measurements showed that the 125 Hz third octave band (containing the 117 Hz tone) exceeded the side band noise levels by 14 dB within the interior, near the window.
- Unlike the aforementioned measurements, the measurements in the Neighborhoods were conducted during the early nighttime hours, when the most complaints had been generated. JEAcoustics collected integrated time average third octave and narrow band (1.56 Hz bandwidth) measurements at 8 different locations. The 117 Hz narrow band tone was clearly audible and measured between 0 to 5 dB above the side bands at the 8 different locations.

JEAcoustics determined that the tonality of the chillers was the cause of complaint. Studies have shown that humans can detect pure tones several dB below the broadband ambient sound level [5], therefore JEAcoustics determined that the 117 Hz narrow band/ 125 Hz third octave band tone should be reduced 5 to 8 dB within the surrounding neighborhoods.

5. Recommendations

JEAcoustics recommended mitigation efforts at or near the source in order to maximize the attenuation efforts. The primary intent of the recommendations was to decrease the tonality of the chillers. Recommendations included the following, in order of priority:

- Attenuate radiated compressor noise by wrapping the compressors, including the underside, with a 1” thick fiberglass or closed cell foam, wrapped in an insulated limp mass noise barrier jacket with a nominal face weight of 0.5 to 1.0 lb/ ft^2, face weight. The barrier jacket openings should be limited, and should be constructed to permit removal and reinstallation for maintenance. Depending on the materials used, this suggestion could decrease the component radiated by the condensers by up to 10 dB.
- Attenuate casing radiated noise caused by vibration transfer from refrigerant piping by inserting pulse diffusers in the compressor discharges.
- Control the compressor and fan intake noise by providing 12” thick acoustic louvers with an insertion loss ≥ 9 dB @ 125 Hz, with a static pressure drop of < 0.1” in H_20.
- Control compressor noise and fan noise escaping through the fan discharge by providing attenuators with insertion losses of > 7dB @ 125 Hz, and < 0.1 in. H_20, with minimal, if any bearing weight on the compressors. To prevent discharge air re-circulation at the intakes, a septum should be placed within the units.
- Increase the height of the parapet wall as planned, furthermore, apply a ≥ 1” thick coat of an acoustically absorptive cementations spray-on material to the exterior of third floor walls facing the chillers, to reduce reflected sound from building surfaces, and reduce reverberant build-up. The implementation of this recommendation should decrease the sound level at the property line by 3 to 5 dB.
- For the adjacent patient rooms, replace existing windows with window fixtures with ½” thick laminated glass, and an STC rating of 36, and a transmission loss of 30 dB or greater in the 125 Hz band.

6. Results

The hospital elected to implement the first two recommendations, to enclose the compressors with an insulated sheet metal enclosure, and install pulse diffusers in the compressor piped high-pressure refrigerant discharge. Validation measurements indicated 5 dB of attenuation

was achieved in the targeted 117 Hz narrow band, as reported in JEAcoustics summary report [6]. The enclosures that the hospital installed around the compressors were sheet metal square box enclosures, rather than limp mass jackets recommended. JEAcoustics found the flat sides of the sheet metal enclosure re-radiated the compressor noise, as foretold by Ebbing and Blazier [7], and degraded the attenuation by 3 to 5 dB. The parapet wall height was increased, and provided as much as 9 dB of additional attenuation in the 117 Hz narrow band, in some locations in the adjacent open park. The attenuation provided by the increase in height was limited to receivers near the hospital. No attenuation was applied to the chiller fan noise source, as none of the fan recommendations were selected for implemented.

The noise complaints from the neighborhoods ceased, and the hospital had achieved its objective. The hospital did not elect to implement any more of the recommended measures or correct the compressor enclosures.

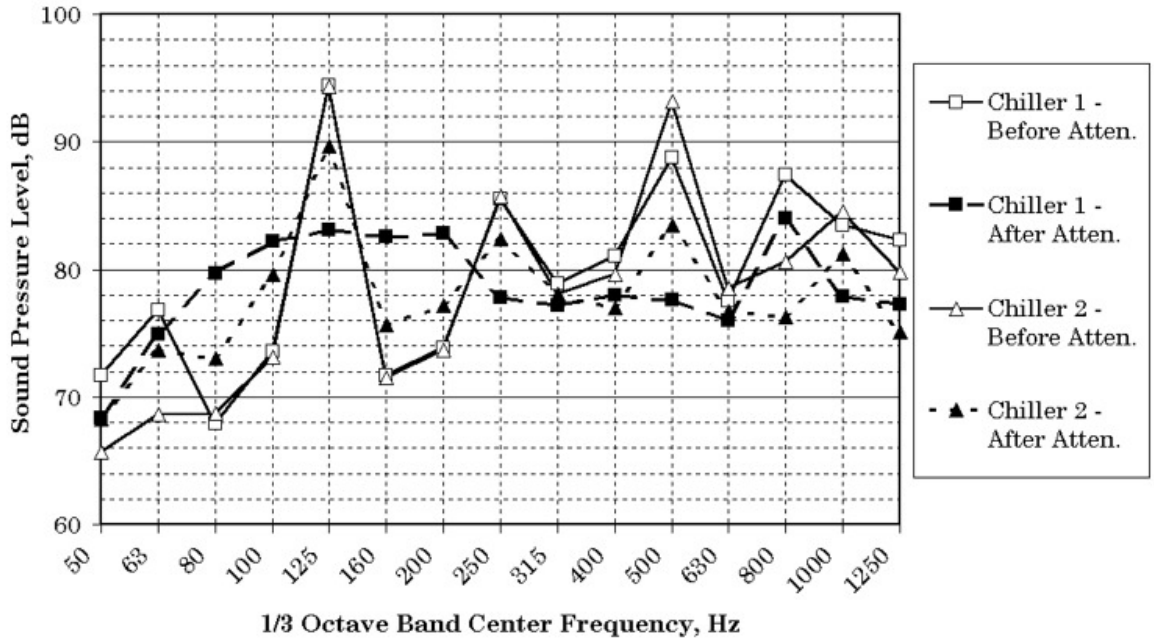

Figure 1: Air Cooled Chiller Compressor Noise; Helical Rotary (Screw Compressor, with Attenuation VS without; Measurements taken @ 1m.

7. References

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Noise from air conditioners at hospital upsets neighbors

■ City rules don't regulate high pitch from heart center

By Andy Alford
American-Statesman Staff

In the evening when the traffic has died down and the crickets are quiet, David Hefner is chased off his front porch and indoors by the noise from air conditioners at the Heart Hospital of Austin.

Though he lives about half a mile away in his Alta Vista neighborhood in Central Austin, he says he can hear the air conditioners — which drone in a high G pitch — even from his parlor.

"It is like a toothache," Hefner says, "or like tendinitis. It is a constant presence that you can hear underneath everything else."

The hospital, which opened in December at 911 W. 38th St., is in one of the busier commercial centers in Central Austin. It says its air conditioners meet city standards and are not excessively loud. But the noise has hit a sour note with neighboring homeowners in communities with roots planted in the late 1800s. Many of the people who live in the Hyde Park, Rosedale, Alta Vista and Heritage neighborhoods say the air conditioning units, which overlook a neighborhood park adjacent to Central Market, upset the area's ambience.

"They've transformed an extremely placid part of Austin. The air conditioners blare consistently. It sounds like an industrial factory," said Ross Baldick, a University of Texas engineering professor who lives in Hyde Park.

The city's noise ordinance was designed to regulate amplified noise, from outdoor concerts and in nightclubs, and doesn't specifically address this situation. The ordinance prohibits "any loud noise which is reasonably calculated to disturb others" between 10:30 p.m. and 7 a.m.

Heart Hospital President Michael Zucker said Austin's

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Air conditioners irk neighbors

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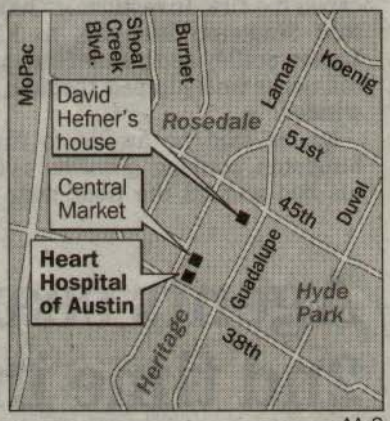
noise ordinance "doesn't apply to us. We're not a rock concert. We're just a building trying to do our job."

City officials say that if people call 911 to complain about excessive noise, Austin police will follow up by measuring noise levels at the property line of the noise's source. Measurements of noise over 70 decibels — the sound a lawn mower makes from a little more than 100 feet away — will prompt inspectors to write citations. Zucker said the hospital's units aren't that loud.

Some residents say that whether complaints stem from noisy air conditioners or traffic, friction between established neighborhoods and nearby businesses likely will become more common as Austin grows. The city's Smart Growth plans encourage denser residential and business development in Central Austin, and some say conflicts that will result require a forum so residents can resolve issues.



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Baldick and others say they want the hospital to make acoustic modifications to the building that would muffle the drone from the air conditioners.

Zucker said he's taking residents' concerns seriously and might muffle the air conditioning compressors if it doesn't cost too much. He wants first to measure the noise of the air conditioners from various points near the hospital to determine "whether this is a perceived noise issue" or whether there is a real problem.

Rosedale Neighborhood Association President Chris Allen said residents are "trying to be neighborly, but it's not working. We do need a place to go or a forum to clear up these issues. These issues will come up more and more as the city gets denser."

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