TRANE™

October 1988/Vol. 17, No. 3

Engineers Newsletter

Sound Propagation From Air-Cooled Chillers

Air-cooled water chiller systems offer the designer a cost effective way of cooling buildings. The fact that the principal component, the water chilling-condensing section, is located outdoors, rentable floor space is freed within the building. In addition, once the roof steel is in place or the ground-level location is prepared, the chiller can be delivered and installed. These are but a few advantages offered by air-cooled water chilling equipment.

Since the principal system sound-producing components, condenser fans and compressors, are located outdoors, sound propagation problems within the building served by the chiller are not frequently encountered. However the occupants of neighboring buildings may be exposed to higher than acceptable sound levels. Higher than acceptable refers to the various standards that have been set by most localities for sound pressure readings taken at the property line. These standards provide the criteria for establishing target sound levels for outdoor installations.

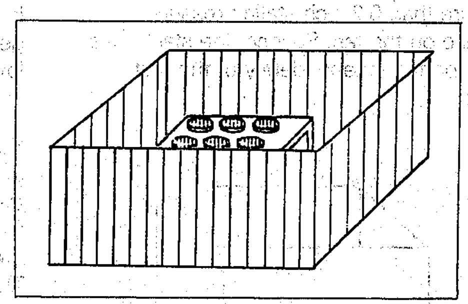
Excessive Property Line Sound Levels

Once the chiller has been installed, complaints of excessive property line sound should be cause for alarm for all parties involved for several reasons. First, it is always more costly to quiet installed equipment than it is to include quietness in the original system design. Second, the sound output by an air-cooled chiller is often a challenge to attenuate. The chiller requires open space for proper air flow, sometimes making the addition of sound absorbing structures and materials difficult.

Returning to the manufacturer for assistance may be a solution. However, the manufacturer's responsibility is limited to the verification of agreement of jobsite sound readings with the published test data. Occasionally, the manufacturer can offer sound attenuation options to be added in the field. However, these may or may not provide the attenuation needed to silence the complaints of neighboring building owners.

Quieting A Noisy Unit

The best course of action when resolving an existing noise problem is to contact an acoustical consulting firm. One solution commonly used by such firms is the construction of barrier walls to redirect the objectionable sound, Figure 1. This method is successful when done properly because it allows unrestricted air flow to the unit. However, barrier walls are not effective when the receiver (person) remains within the line-of-sight of the sound source, such as at a higher elevation in a neighboring building.



When barrier walls are unacceptable, attention turns to attenuating the two sound sources (compressors and fans) directly. This requires the construction of acoustically-lined enclosures around the compressors or wrapping them in acoustical blankets. When the compressors are located in a separate compartment, the addition of acoustical material is relatively simple. However, compressors are often located in the airflow path of the coils. When this is the case, the added acoustical material must not block air flow.

The condenser fans also generate a considerable amount of sound power. Two restrictions that must be recognized when attenuating a fan are

1
Attenuators must not block the airflow through the condensing coil or increase the static pressure on the fan by more than 0.2 inches of water.

2
Any attenuators added to the unit must **not** be supported by the unit.

Failure to comply with the first restriction will result in reduced chiller capacity or possibly fan failure. Reduction in airflow through the coil decreases its ability to condense refrigerant. This results in high head pressure and may result in a unit shutdown by the high pressure control. Fan failure is caused by excessive loading of the fan blades. Failure to comply with the second restriction may cause a problem since the unit is generally **not** designed to support additional weight.

Fan sound is attenuated frequently using a discharge air stack. The stack directs the sound upward and away from the surroundings, Figure 2. Both restrictions must be observed when applying such a stack. First, the area of the stack opening plus its length must be designed to produce no more than 0.2 inch static pressure increase on the fan. Second, the stack must be supported independently of the unit casing.

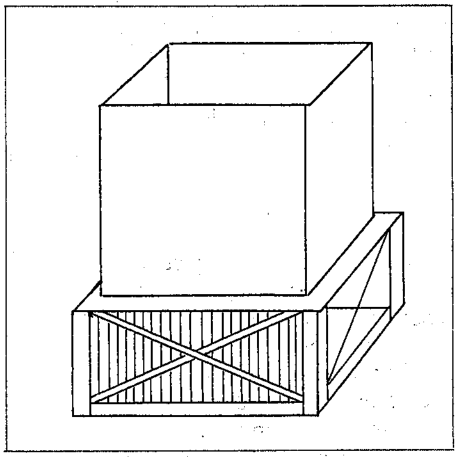


Figure 2

Prevention Is The Best Cure

From the previous discussion, it can be concluded that to prevent sound problems, it is more effective to be aware of local sound ordinances and to assure compliance by selecting equipment on the basis of an acoustical analysis.

To conduct an acoustical analysis, the following items are required:

1
Sound power or pressure output of the unit.

2
Plan and evaluation views of the unit surroundings, include heights of structures and location of the receiver (sound sensitive area).

3
Desired sound pressure level at the receiver.

Item 1 above can be provided by the equipment manufacturer once the unit has been selected. Item 2 requires some attention to detail. The more detailed the sketch, the better the analysis will be. Include any structures or elevation changes that place the receiver in the line-of- sight with the equipment. If the concern is annoyance of neighboring property owners, item 3 can be found in the local or state ordinance pertaining to sound pressure level at the property line. This value is generally around 55 dBA but may be as low as 45 dBA at night or if the sound is intermittent.

Sound data from the manufacturer can be provided in a variety of forms. To simplify the analysis, request that the data be given as a single number with the same weighting as the property line standard. The most common is the A weighting, denoted as "dBA."

Frequently the manufacturer's published sound data is in the form of sound pressure at a specified distance from the unit. Or, it may be in the form of sound power. When given in sound power, it can be converted to sound pressure. For this analysis, subtracting 21.5 dB (see footnote) from the sound power value will give the sound pressure at a 15-foot distance from the source.

Sound pressure (Lp) at a given distance from the source can be converted to sound pressure at the receiver using the following equation: $Lp1 = Lp2 + 10\ Log_{10}\ (R2/R1)^2$.

Where:
R2 = Distance from unit where sound pressure is known.
Lp2 = Known sound pressure at distance R2.
R1 = Distance from unit where sound pressure value is to be calculated.
Lp1 = Unknown sound pressure at a distance R1 from the unit.

This equation uses two important assumptions. First, the equation assumes that the unit can be treated as a point source. As the distance from the unit increases, this assumption becomes more valid. To avoid problems, R1 should always be larger than R2.

The second assumption is the unit is in a free field, Figure 3. Free field implies that the unit is located on a flat surface without obstructions to block or reflect the generated sound. Caution should be used whenever the unit is near a wall or other hard reflecting surface. In these cases, the sound pressure calculations for various distances can still be made but should be modified by the following "rules of thumb.'

- When the unit is located within 10 feet of a wall, as shown in Figure 4 (i.e. D1 is less than 10 feet), 3 dB should be added to the result of the equation.
- When the unit is located within 10 feet of two perpendicular walls, such as the inside corner of a building, as shown in Figure 5, 6 dB should be added to the result of the equation. This also holds true if the unit is located within 10 feet of a wall, Figure 4, that has a large overhang that extends out over the unit.

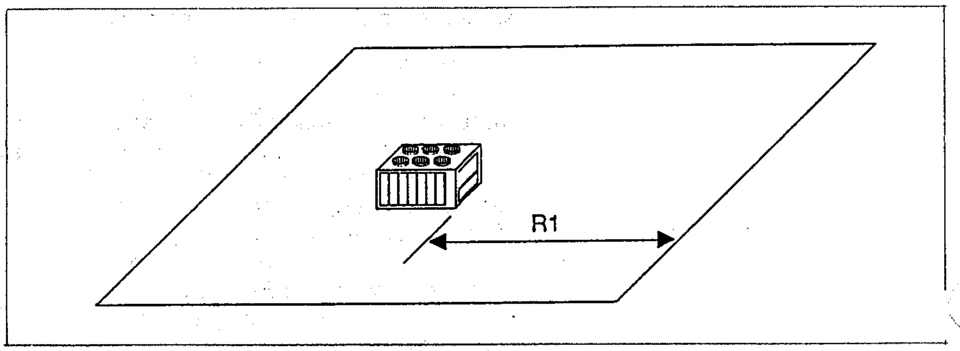


Figure 3

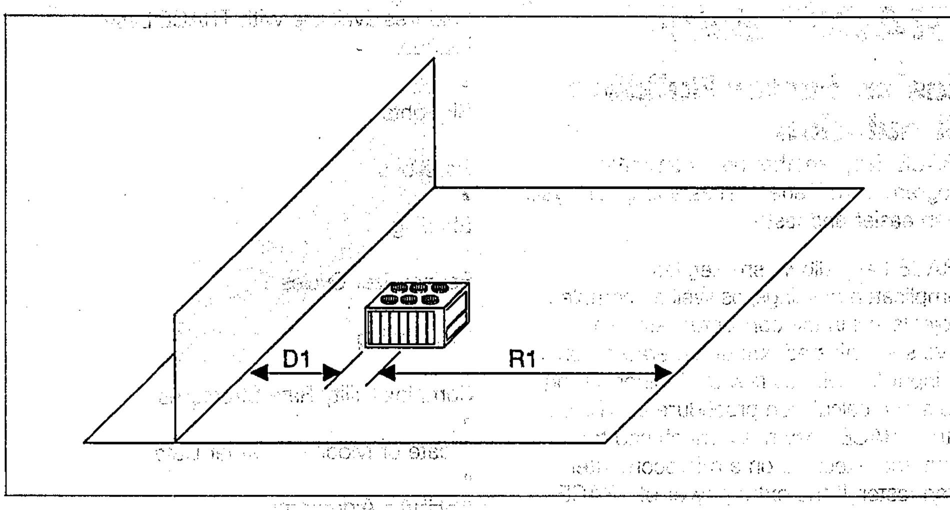


Figure 4

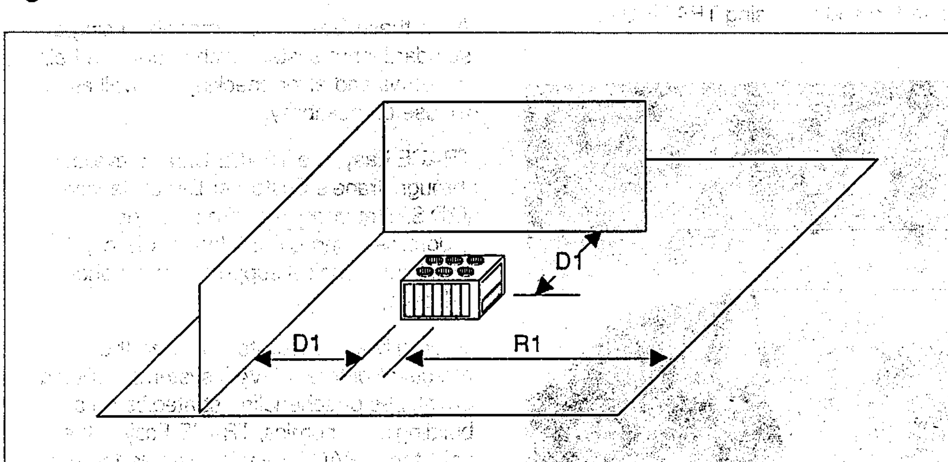


Figure 5

Some consideration should be given units that are close to a wall but beyond the 10-foot line. The calculation should be completed without the dB addition. However, if the calculated values are close to the maximum allowed, a closer analysis should be made by an acoustical consultant. As a result of the assumptions used above, the accuracy of this equation is plus or minus 5 dB.

When more than one unit is contributing to the sound level, the contribution of each unit is calculated separately and then summed to determine the total sound pressure. Since the decibel scale is logarithmic, sound pressure values cannot be added directly. Table 1 can be used in the addition of values, as follows:

Table 1

Difference	Add
0 to .5	3.0
1.0 to 1.5	2.5
2.0 to 3.0	2.0
3.5 to 5.0	1.5
5.5 to 7.0	1.0
More than 7.0	0.0

1
Determine the numerical difference between the largest and the next largest values.

2
Enter the left hand column of Table 1 to find the difference. Read across to the right hand column to find the amount to be added to the larger value.

3
Determine the difference between the combined value and the next largest value. Again, using the table, determine the amount to be added to the combined value. Repeat this step until each sound source has been accounted for.

Example: Add the values 45, 50 and 51 dB.

1
The difference between 50 and 51 equals 1 dB.

2
From the table, the value to be added is 2.5. Therefore, the combined value is 53.5 dB (51 plus 2.5).

3
The difference between the combined value and the next largest value equals 8.5 dB (53.5 minus 45). From the table, the amount to be added is 0. Therefore, the final total equals 53.5 dB.

Summary
These calculations are intended to provide a means to roughly approximate sound pressure levels at the property line. The resulting sound pressure levels can be divided into three categories, acceptable, marginal and excessive. Values within plus or minus 5 dB of the property line maximum are marginal.

In those cases where the sound pressure is excessive, attempt to move the equipment away from the sound receiver. If this is not possible, a more accurate analysis should be made by an acoustical consultant familiar with barrier calculations. Marginal cases also require additional analysis if the job is a sensitive one.

Marginal cases may be aided by the addition of line-of-sight barriers, even if the barriers do not provide substantial acoustical improvement (i.e. out of sight, out of mind). Finally, if the sound from the unit is directional (i.e. louder on the compressor end), rotating the loud end away from the receiver will generally produce an improvement.

Footnote: 21.5 is derived from the equation:

$$L_p = L_W + 10 \log \left(\frac{Q}{4\pi r^2} + \frac{4}{R}\right) + 10$$

Assuming the unit is on an extended flat plane, in a free field and the receiver is 15 feet away, this equation reduces to:

$L_p = L_W - 21.5$