

update

A quiet compressor doesn't guarantee a quiet chiller

Centrifugal compressors that utilize magnetic bearings have a well-deserved reputation for low sound levels. Johnson Controls has offered magnetic-bearings compressors in our YORK® Titan™ centrifugal chillers since 1999, and our testing has confirmed the quiet operation of the bearings.

However, a quiet *compressor* does not automatically result in a quiet *chiller*. There are factors other than the compressor that impact chiller sound. And it is possible those other factors can make a magnetic-bearings chiller noisier than a similar chiller that utilizes traditional oil-lubricated bearings.

We believe this is the case with a line of centrifugal chillers offered by a major chiller manufacturer, which are equipped with magnetic bearings. Recent projects have been designed around these chillers, using sound data from the manufacturer's catalog. Unfortunately, that sound data is confusing at best, and misleading at worst. As a result, a building owner could pay a cost premium for a chiller that offers no sound improvement.

In this Update, we will examine these suspect sound ratings and, using other sound data in the manufacturer's catalog, demonstrate why we believe the ratings are in error.

Examining manufacturer claims

Figure 1 is a schedule of sound data that appeared in a recent specification for a 400-TR, water-cooled, centrifugal chiller with magnetic bearings. Below that is similar sound data for a 400-TR, water-cooled, YORK centrifugal chiller manufactured by Johnson Controls, which uses oil-lubricated bearings.

Based on this sound data, the manufacturer of the magnetic-bearings chiller claims that, because the majority of the sound-pressure values for their chiller are lower, their chiller is quieter overall. In fact, at 63 Hz, their chiller is over 32 dB quieter!

However, these claims are incorrect. A review of sound-rating basics and the manufacturer's own catalog will show why.

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Recent Spec for Chiller with Magnetic Bearings	42.6	52.0	59.8	65.6	71.0	71.9	74.8	69.3
Catalog Data for YORK Chiller with Oil-Lubricated Bearings	75.0	75.0	75.0	74.0	74.0	74.0	74.0	70.0

Figure 1: Sound-pressure levels (dB).



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Adjusting for sound-level perceptions

Within the acoustics industry, it is well-known that the human ear is more sensitive to sounds at certain frequencies than others, and it is most sensitive to 2000 Hz¹. As the frequency is increased or decreased, hearing sensitivity declines.

To account for this variation in auditory sensitivity, the acoustics industry developed a set of adjustments which can be applied to raw sound-pressure values (measured in dB) in order to convert them to sound ratings that are more representative of what the human ear perceives. The "A-weighting adjustment" is indicated as dBA.²

The A-weighting adjustments, shown in Figure 2, are added to the raw (aka linear) sound-pressure values to derive a dBA value that reflects the *perceived* sound-pressure level. The adjustments at the lower frequencies are negative because the human ear is less sensitive to those frequencies. At 2000 Hz, where the human ear is most sensitive, the adjustment is a positive number.

Confusion in published A-weighting ratings

Typically, a chiller catalog lists the linear sound-pressure levels for each frequency without the A-weighting applied. As a minimum, the catalog should note whether the ratings are in dB or dBA. Although the sound-ratings schedule in the project

specification in Figure 1 does not specifically state if the values are A-weighted, the manufacturer's catalog (which shows the same sound-pressure values) says that octave-band values are linear, not A-weighted.

The manufacturer's catalog also lists a Representative A-weighted Sound-Pressure Rating for each of its chillers. This rating is a one-number summation of the sound energy at all frequencies, weighted for human auditory perception. This is the number that mechanical engineers and contractors use most often to compare the overall sound levels of two pieces of machinery. Surprisingly, this rating did not appear in the project specification in Figure 1.

The Representative A-weighted Sound-Pressure Rating for the chiller in the project specification is listed in the manufacturer's catalog as 83.3 dBA. It is interesting to note that the Representative A-weighted Sound-Pressure Rating for the comparable YORK chiller is listed in its catalog as 80.0 dBA.

You may be asking yourself why the Representative A-weighted Sound-Pressure Rating for the magnetic-bearings chiller is higher when its ratings at the individual frequencies are (for the most part) lower. The answer lies in some additional sound data that can also be found in the manufacturer's catalog.

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Adjustments	-26	-16	-8.6	-3.2	+0	+1.2	+1	-1.1

Figure 2: A-weighting adjustments (dB).

Clearing up the confusion

In addition to the sound ratings for the full octave bands, the manufacturer’s catalog also contains sound ratings at one-third octave bands.

When the one-third octave-band ratings are converted to full-octave-band ratings, the A-weighting adjustments are applied, and the Representative A-weighted Rating is calculated, the result is close to the rating of 83.3 dBA listed in the catalog, as shown in Figure 3.

Now, if the sound data for the magnetic-bearings chiller is compared to the data for the chiller with oil-lubricated bearings, as is done in Figure 4, it is evident that the values are similar.

The reason the Representative A-weighted Rating for the chiller with oil-lubricated bearings is lower is because it has lower linear sound-pressure levels at the higher frequencies (2000, 4000, and 8000 Hz), where the human ear is more sensitive.

Summary

This Update examined a chiller manufacturer’s confusing claims about sound-pressure levels for its magnetic-bearings chiller.

Based on our analysis, it seems that the manufacturer calculated its Representative A-weighted Ratings correctly, but the Linear Octave-Band Ratings listed in the catalog are actually A-weighted Ratings, which is why the values are so low.

Once the sound ratings for the magnetic-bearings chiller are corrected for this error, and we compare its Representative A-weighted Rating to that of the YORK chiller using oil-lubricated bearings, the difference between the two is only 3.0 dBA. And a difference in sound pressures of 2 to 3 dB is recognized by the acoustics industry as barely perceptible.³

Because a magnetic-bearings chiller can cost as much as 40% more than chillers using oil-lubricated bearings, a decision based on erroneous information could cause a building owner to invest in a more expensive chiller that offers no significant sound reduction.

The best way to prevent such a mistake is to evaluate a chiller’s sound performance based on the Representative A-weighted Ratings provided in the manufacturer’s catalogs. And designers should recognize that a quiet compressor doesn’t guarantee a quiet chiller.

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000	Representative A-weighted Rating (dBA Calculated)
Chiller with Magnetic Bearings	72.0	72.0	72.0	72.0	74.0	76.0	80.0	74.0	83.6

Figure 3: Linear sound-pressure ratings based on one-third octave-band ratings (dB).

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000	Representative A-weighted Rating (dBA Calculated)
Chiller with Magnetic Bearings	72.0	72.0	72.0	72.0	74.0	76.0	80.0	74.0	83.6
Chiller with Oil-Lubricated Bearings	75.0	75.0	75.0	74.0	74.0	74.0	74.0	70.0	80.0

Figure 4: Corrected sound-pressure ratings.

1. Harvey Fletcher and W.A. Munson, "Loudness, Its Definition, Measurement and Calculation," J. Acoustic. Soc. Am., 5, pp. 82–108 (1933). The A-weighting filter was developed by Fletcher and Munson in 1933 to determine loudness level contours for various sound levels. These curves were then used in sound level meters developed by the Acoustical Society of America, making the A-weighted sound pressure level (dBA) the predominant measurement used in noise analysis for over 50 years.
2. Ibid.
3. Schaffer, Mark E., Practical Guide to Noise and Vibration Control, ASHRAE (2005).

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