TRANE®

General
Service Bulletin

Vibration Analysis for CVHE, CVHF & CVHG

Order Number: CTV-SVB29A-EN DATE: August 2006

NOTICE: Warnings and Cautions appear at appropriate sections throughout this literature. Read these carefully.

⚠ WARNING: Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION: Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

CAUTION: Indicates a situation that may result in equipment or property-damage only accidents.

Introduction

This service bulletin outlines the proper method for checking vibration levels on model CVHE, CVHF, CVHG, CDHF, and CDHG compressors, and also discusses the interpretation of vibration levels or signatures that may be encountered.

Discussion

This bulletin describes typical routine vibration analysis processes that can be performed to evaluate thrust bearing condition, or to determine if a rotational imbalance is present.

This bulletin does not directly address the determination of inboard or sleeve bearing condition in centrifugal chillers, as this is best done by an oil analysis program. This bulletin also does not address vibration or noise caused by aerodynamic, aero-acoustic, or structural resonance issues within the chiller, and it does not address the use of current analysis to determine motor or bearing faults.

Thrust Bearing Condition Analysis

While it is not a requirement for the proper routine maintenance of a CenTraVac chiller, vibration analysis is recommended as a valuable non-destructive method of determining the condition of the compressors bearings and for detecting any imbalance of the rotating components. Vibration analysis is often incorporated into the chiller's periodic maintenance program or "service contract" terms.

The thrust (or "outboard") bearing used in CVHE/F/G and CDHF/G chiller compressors is an anti-friction type, "duplex" ball bearing. As a result of this bearing's properties, the classic oil analysis program - successfully used to evaluate the condition of the babbitted inboard bearing - does NOT reliably indicate the condition of the thrust bearing.

"AUDIO" CHECK. The simplest and least expensive method of checking for thrust bearing failure is to listen to the bearing during operation and coastdown. A failed bearing will "howl" while the unit is running and "click" during coastdown. While the howling noise is readily apparent, the best way to listen for "clicking" during coastdown is to place a stethoscope against the thrust bearing inspection cover; the "clicking" sound will be most noticeable just before the rotor stops turning.

Mechanics stethoscopes for listening to machine noises are commonly available from automotive supply stores. If necessary, a screwdriver can be used in lieu of a stethoscope; simply place the tip of the screwdriver against the inspection cover, then press your ear lightly against the handle.

If the "audio" method of bearing evaluation indicates that the thrust bearing is bad, but unit vibration is not severe, the bearing will usually continue to be operable for several months before failing.

VIBRATION ANALYSIS. Another method to determine thrust bearing condition is by the use of a "vibration analyzer". There are several popular makes of analyzer equipment, and this discussion will try to remain general in nature in order to provide the best coverage.

Important!: While vibration analysis results indicating high vibration levels <u>may</u> be symptomatic of a potential bearing problem, it may not be necessary to change out the thrust bearing <u>unless the audible symptoms described above are also present</u>. View Figure 1, for example, a chiller with bearing vibration in the yellow caution range may continue to provide valuable service life if it does not also have audible symptoms.

It is sometimes difficult to define "good" or "bad" readings for a vibration analysis, since bearings of identical quality in similar units may well show different levels of vibration output. Most commonly, vibration analysis is used to monitor changes in the bearings quality over its entire life.

To correctly monitor a thrust bearing, it is important to record vibration levels when the chiller is fairly new; this establishes a "baseline" vibration level that can be used for comparison with future vibration level checks. It is also recommended that vibrations readings be taken with the chiller operating as fully loaded as is possible. Readings taken on a lightly loaded chiller (running less than 50% of capacity) can be misleading. Always check at higher loads if possible.

Note that it is important for the unit to be operating at similar conditions each time the bearing condition is checked. For this reason it is advisable to record vibration level readings at various operating load points.

Once the "baseline" is established, vibration analysis can be used to periodically check for bearing deterioration.

For units equipped with variable speed motor drives, it is recommended to manually override the motor speed command to 60Hz during the recording of vibration data. Readings taken at the same speed will be easier to use for trending, and will allow for the easier interpretation of data.

Equipment Recommendations

The vibration recording equipment used should be capable of recording or plotting vibration data or signatures, on single or on multiple channels. Equipment with the ability to plot “spectrums” and “waveforms” to allow the easiest review of data is highly desirable. NOTE: There is a great range of vibration analysis equipment available for purchase on the market, some with greater ability than others. Equipment should be selected based on the results expected, the amount of investment required, and the amount of expertise needed to operate it and to understand the result. Simpler less expensive equipment may be acceptable in many cases.

Any equipment used should, at a minimum, be capable of:

- Recording data in the frequency ranges of 0-3,000 Hz.
- Be capable of recording and displaying data at a minimum resolution of 1600 lines.
- Recording and plotting (as a spectrum) velocity in in/sec and mm/sec, in the range listed above.
- Recording and plotting (as a waveform) acceleration in g’s.

La Crosse CenTraVac Product Support presently uses CSI vibration equipment.

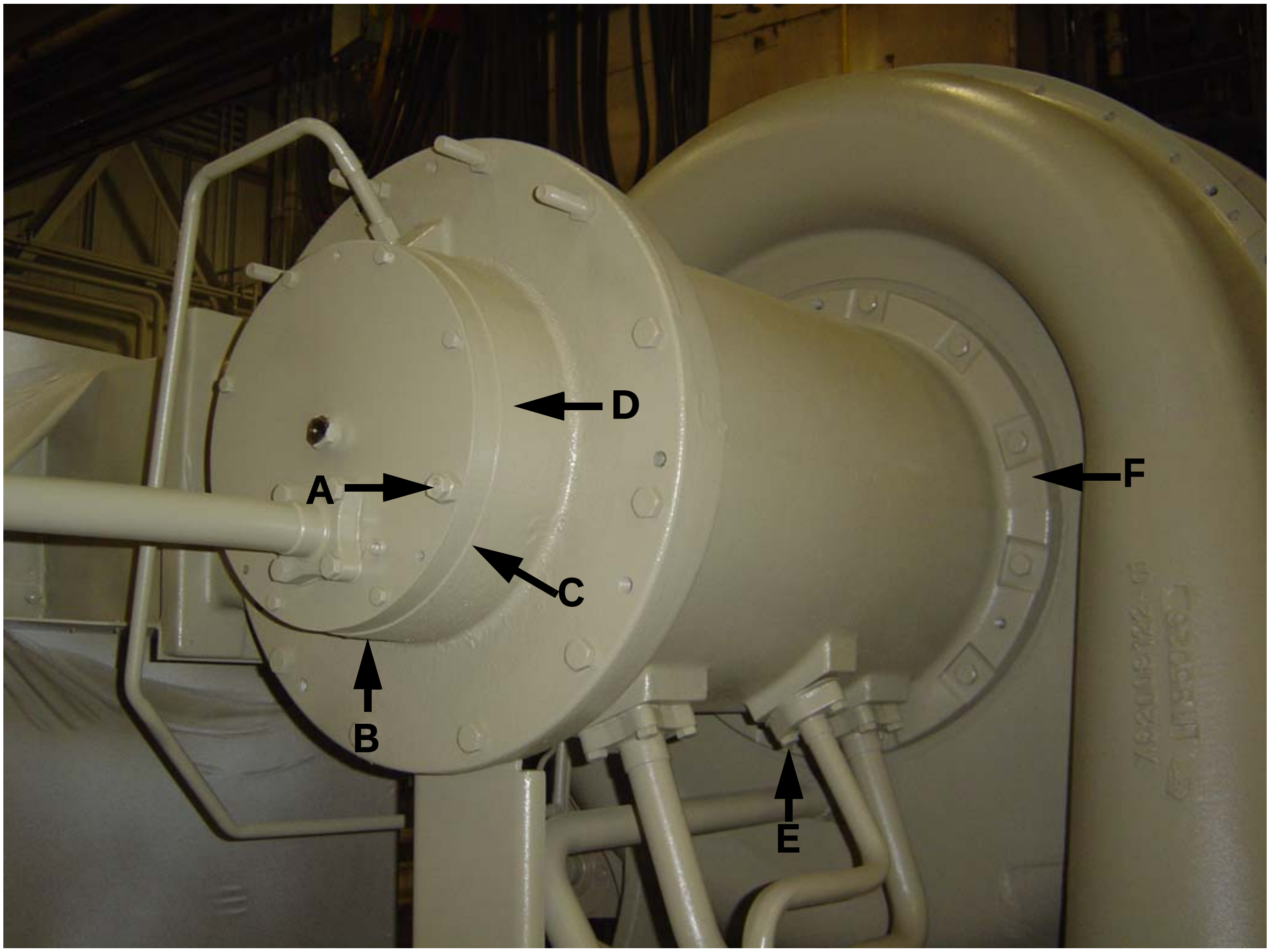
Data Collection Points

Data should be collected from the appropriate transducers placed on the equipment in the locations described below. The transducers may be magnetic mounted if desired, though a more securely mounted (bolted, epoxied, etc.) transducer may provide better results for bearing analysis. Be aware that transducers are generally very limited in accuracy at the higher frequency ranges, and some higher frequency results can be misleading if care is not taken.

Collect data from:

- Axial - Point A on Figure 1. Thrust bearing end of the compressor motor. Axial data can be very helpful in the determination of thrust bearing issues. Because bearing fault frequencies may be very high it is recommended that magnetically mounted transducers be avoided when taking axial readings. If possible, use the transducer mounting stud that is present on most bearing inspection cover bolting systems. Also, do not take axial readings near the center of the bearing inspection cover since it can act as a “drum head” and provide erroneous readings.
- Vertical Motor End - Point B on Figure 1. Place the transducer on the motor cover at the 6 o’clock position, close to the bearing inspection cover. May indicate thrust bearing condition or rotational imbalance.
- Radial Motor End – Point C on Figure 1. Place the transducer on the motor cover at the 4:30 o’clock position, close to the bearing inspection cover. May indicate thrust bearing condition or rotational imbalance.
- Horizontal Motor End - Point D on Figure 1. Place the transducer on the motor cover at the 3:00 o’clock position, close to the bearing inspection cover. May indicate thrust bearing condition or rotational imbalance.
- Vertical Compressor End - Point E on Figure 1. Optional. Generally used to determine rotational imbalance rather than thrust bearing issues. Readings affected by electrical noise.
- Horizontal Compressor End - Point F on Figure 1. Optional. Generally used to determine rotational imbalance rather than thrust bearing issues. Readings affected by electrical noise.

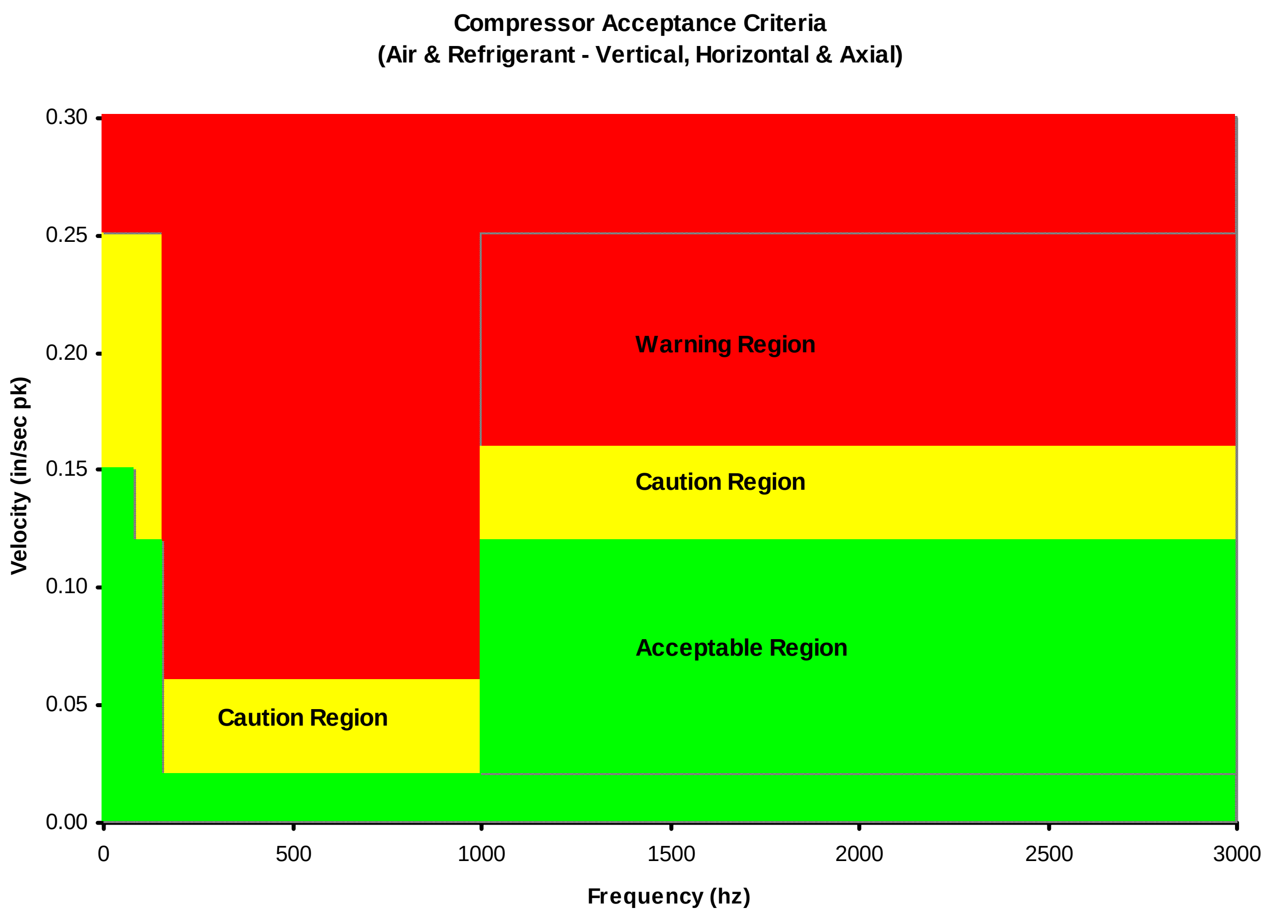
Figure 1. Recommended Vibration Data Collection Points



Thrust Bearing Acceptance Criteria - Velocity

While it is difficult to define pass/fail criteria for rolling element bearings, operation of any centrifugal chiller with a vibration level in excess of 0.25 in/sec (6.35 mm/sec) peak at rotational speed (50 or 60 Hz) is not recommended. The chiller should be secured and the cause of the vibration determined and corrected. For vibration limits at other frequencies refer to figure 2 & figure 3.

Figure 2. Recommended Limits

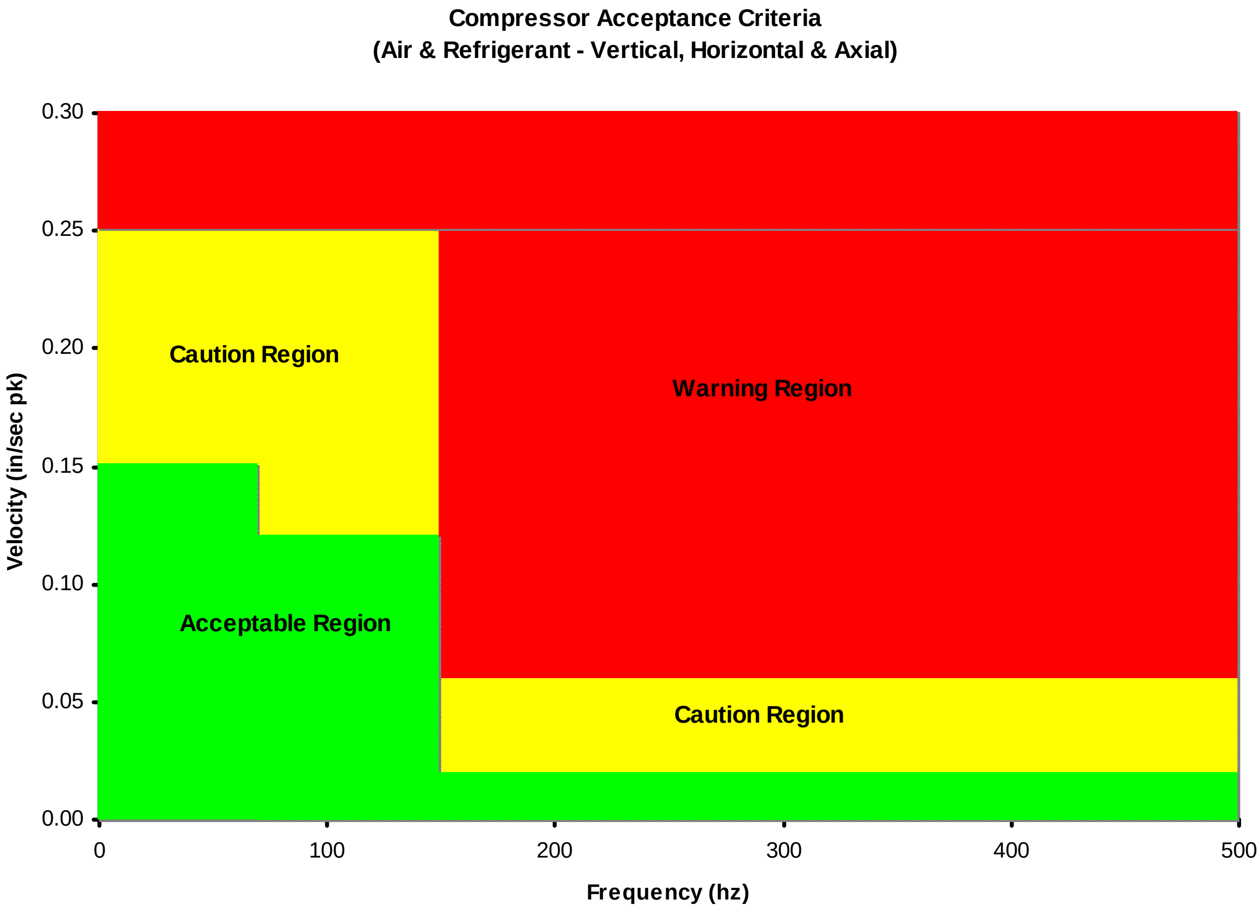


Green – acceptable vibration levels, no action recommended

Yellow – caution, closer monitoring of trends recommended

Red – warning, a bearing failure or rotational imbalance may be present

Figure 3. Recommended Limits



Green – acceptable vibration levels, no action recommended

Yellow – caution, closer monitoring of trends recommended

Red – warning, a bearing failure or rotational imbalance may be present

Thrust Bearing Characteristics

The data below is intended to assist a vibration analyst when identifying sources of thrust bearing vibration energy. Refer to tables 1 and 2.

Table 1. Ball Bearing Geometry

Bearing	Pitch Dia.(In)	# Of Balls	Ball Dia.(In)	Alpha (Contact Angle Deg)
BRG00913 BRG00609 BRG01209 BRG01507 BRG01583 BRG01585	3.4488	11	0.8437	40

Table 1. Ball Bearing Geometry

Bearing	Pitch Dia.(In)	# Of Balls	Ball Dia.(In)	Alpha (Contact Angle Deg)
BRG00914 BRG00610 BRG01210 BRG01508 BRG01584 BRG01586	5.5118	12	1.25	40
BRG01258	5.8071	12	1.3125	40

Table 2. Common Ball Pass/fault Frequencies
As orders of shaft turning frequency.

Bearing	Cage	Inner Race	Outer Race	Roller Spin	Roller Defect
BRG00913 BRG00609 BRG01209 BRG01507 BRG01583 BRG01585	0.4063	6.5307	4.4693	1.9721	3.9442
BRG00914 BRG00610 BRG01210 BRG01508 BRG01584 BRG01586	0.4131	7.0424	4.9576	2.1382	4.2764
BRG01258	0.4131	7.0424	4.9576	2.1382	4.2764
*values are approximate					

Common Fault Indications

The CenTraVac product line has a lot of variation, the guidelines provided in this discussion are of a general nature and should be applied with caution

Loss of Thrust Bearing Preload - High radial vibrations at 1x operating speed. Loss of pre-load can reduce the 1st natural frequency of the shaft to running speed, resulting in excitation of the critical speed and very large shaft orbits.

Bearing Misalignment – May see high axial indications at 2x operating speed.

Electrical or line issues, may see indications at 2 x line frequency, if increasing over time consider electrical testing.

Thrust Bearing Damage - High axial vibrations at the ball pass frequencies and their multiples may be an indication of possible internal bearing damage.

Outer race clamping or distortion, may see indications or mounding at 500-600 Hz?

Motor eccentricity – High vertical and horizontal indications at 1x or 2x operating speed.

Open Rotor – Indications sometimes seen at ~44x (will vary due to rotor configuration or # of bars) operating speed. Sidebands may appear at 1x line frequency plus/minus 2x slip. To determine possible rotor bar defects using a vibration analyzer it will be necessary to set the analyzer for an 80Hz maximum scale and with a minimum of 1600 lines of resolution and preferably 3200 lines, to properly observe for the sideband frequencies around rotor shaft turning speed. Current analysis is a better indicator of rotor bar issues. Also be observant for other indicators of rotor issues (fluctuating oil pressure, fluctuating amps, noise, longer acceleration times, more slip, etc.). Refer to CTV-SB-48 (latest revision)

Operating Imbalance – High vertical and horizontal indications at 1x operating speed.

Compressor Component Rub – 1/2x

Copper Plating - Indicated by higher frequency faults at all reading points. High g's overall. High energy at 8-12 kHz. May see an indication appear at the cage fault frequencies.

Definitions

Acceleration. the rate of change of velocity of a mechanical system. Commonly measured in units of "g" in English units. 1g = 386.4 in/s squared.

CPM. Cycles Per Minute. 60 cycles per minute = 1 cycle per second = 1 hertz.

Displacement. The distance that an object moves when vibrating.

Frequency. the number of times that an event repeats itself in a unit of time. Units commonly used are hertz (cycles per second) and CPM (cycles per minute).

Fundamental Frequency. the first frequency in a series of harmonic frequencies. Shaft turning speed is generally used as the fundamental frequency for bearing analysis.

Harmonic. an integer multiple of a fundamental frequency.

Hertz, or Hz. a unit of frequency equal to cycles per second.
1Hz = 1 cycle per second = 60 cycles per minute.

Mil(s). a unit of displacement equal to 1/1000 of an inch.

Order. a multiple of the shaft turning frequency.

Resolution. the number of lines displayed in a spectrum, for a given frequency range.

Spectrum. The frequency domain representation of a signal. Generally represented as magnitude against frequency, over a defined frequency range.

Velocity. the rate of change of displacement of a mechanical system. Typical units are inches per second.

Waveform. analog or digital representation of a signal displayed as a plot of level against time.

Questions

For general questions contact the CTV Technical Service department in La Crosse at 608-787-3943 or e-mail at *TechService@trane.com*.

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