TRANE™

General Service Bulletin

CVHE-SB-18

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Subject: CVHE Vibration Analysis and Trim Balance Procedures

Introduction:

This service bulletin outlines the proper method for checking vibration levels on Model CVHE CenTraVacs, and also describes the appropriate corrective action to take if vibration levels are excessive.

Discussion:

The information presented in this bulletin is divided into 3 sections; a brief summary of the topics covered in each of these sections is provided below:

Section 1: Routine Vibration Analysis
This section describes 2 types of vibration analysis that can be performed routinely to evaluate (1) thrust bearing condition, and (2) rotational imbalance. It also outlines the procedures and types of equipment to use when conducting these vibration checks.

Section 2: Checking Vibration After Unit Disassembly or Compressor Rework
Outlined here are procedures for checking vibration levels following: (1) suction elbow removal; (2) removal of the entire compressor/motor assembly; and, (3) disassembly of any portion of the compressor's rotating assembly.

Section 3: Trim Balancing
Included in this section is a brief summary of how the trim balancing process is used to reduce excessive compressor vibration.

While excessive vibration levels can be caused by worn bearings—or when components in the compressor's rotating assembly are out of alignment, it most often results if the additive imbalance of the individual, prebalanced components exceeds the allowable imbalance for the entire rotating assembly. This is evidenced by the fact that approximately 10% of all CVHE compressors built today require trim balancing before leaving the factory. (All CVHE compressors are factory-analyzed for vibration.)

Section 1:
Routine Vibration Analysis

Though not required for proper, routine unit maintenance, 2 types of vibration analysis can be performed on CVHE-style compressors; one type of analysis is used to ascertain the condition of the thrust (outboard) bearing, while the other checks for rotational imbalance. Both types of vibration analysis (described below) can be incorporated into the chiller's periodic maintenance program or "service contract" terms.

Analyzing Thrust Bearing Condition

The thrust (or "outboard") bearing used in CVHE compressors is an antifriction-type, "duplex" ball bearing. As a result, the classic oil analysis program—successfully used to evaluate the condition of the babbitted inboard bearing—does not indicate the condition of the thrust bearing.

"Audio" Check. The simplest, 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.

Note: Stethoscopes for listening to machine noise 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 a thrust bearing is bad, the bearing will usually continue to be operable for several months before failing.

* * * * *

"Mechanical" Check. An alternative method for determining thrust bearing quality is to monitor bearing condition with a "bearing-gear" analyzer. We tested several popular makes of this type of vibration analyzer on good bearings as well as on bearings with "manufactured" defects. Though none of the analyzer makes tested provided an obvious signal of a failed bearing in all cases, the "SWAN-1 Bearing/Gear Analyzer" yielded the best results and is considered acceptable for use as a routine diagnostic tool.

Important! While vibration analyzer readings indicating high vibration levels (i.e., over 40,000 SWE on a SWAN analyzer) may be symptomatic of a potential bearing problem, do not change out the thrust bearing unless the audible symptoms described above are also present!

SWAN-1 Bearing/Gear Analyzer

During our evaluation of the SWAN analyzer, we obtained vibration readings from a variety of locations on the motor. Based on this experience, the optimum location for monitoring thrust bearing condition is on the outboard bearing inspection cover in the radial direction. See Figure 1. (Though this location yields the best results with the SWAN analyzer, be sure to follow the instructions provided by the manufacturer for the bearing-gear analyzer you are using.)

It is difficult to specifically define "good" and "bad" readings for bearing/gear analyzers like the SWAN; bearings of identical quality in similar units may well show different levels of "stress wave" output. Most commonly, this type of analyzer is used to monitor the change in a bearing's quality over its entire life.

To correctly monitor a thrust bearing, it is important to record a vibration reading while the bearing is fairly new; this establishes a "base line" vibration level that can be used for comparison with future vibration level checks. Note that it is important for the unit to be operating at similar conditions each time bearing condition is checked; for this reason, it is advisable to record vibration level readings at various operating load points.

Once the "base line" is established, use a bearing/gear analyzer to periodically check bearing deterioration.

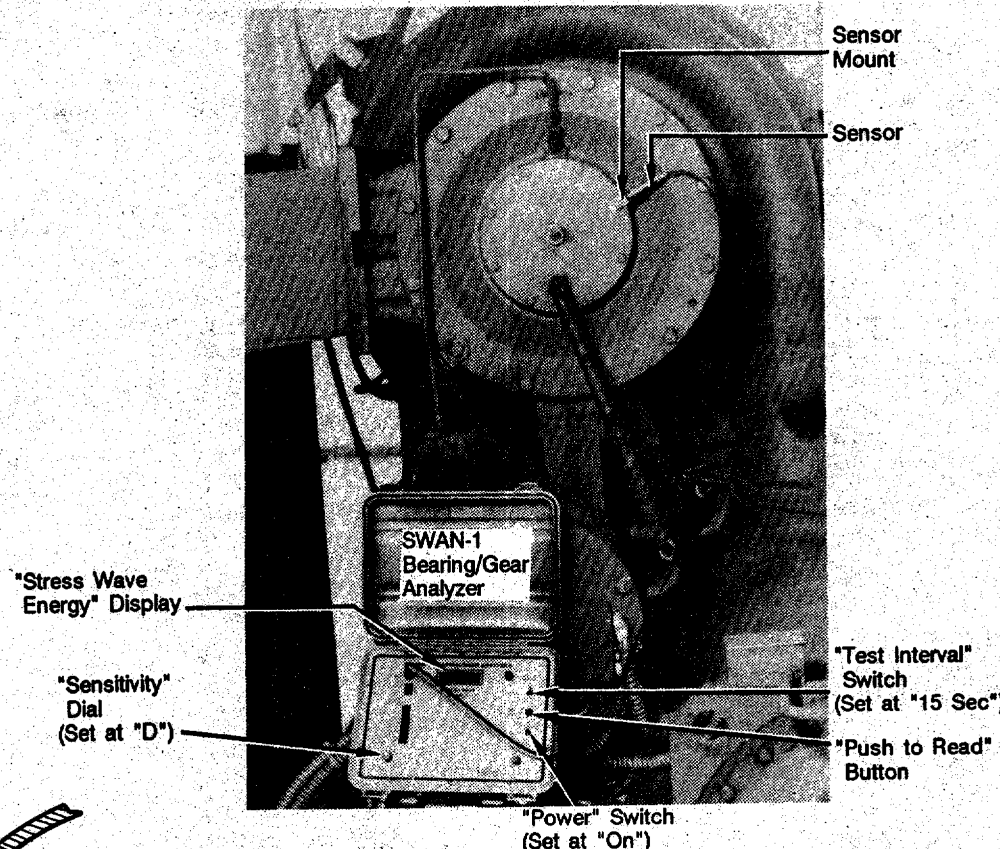
Note: While there are undoubtedly other types of vibration analyzers that can be used to indicate thrust bearing degradation, the SWAN analyzer yielded the best results in our laboratory tests. For more information about the "SWAN-1 Bearing/Gear Analyzer", phone or write to this address:

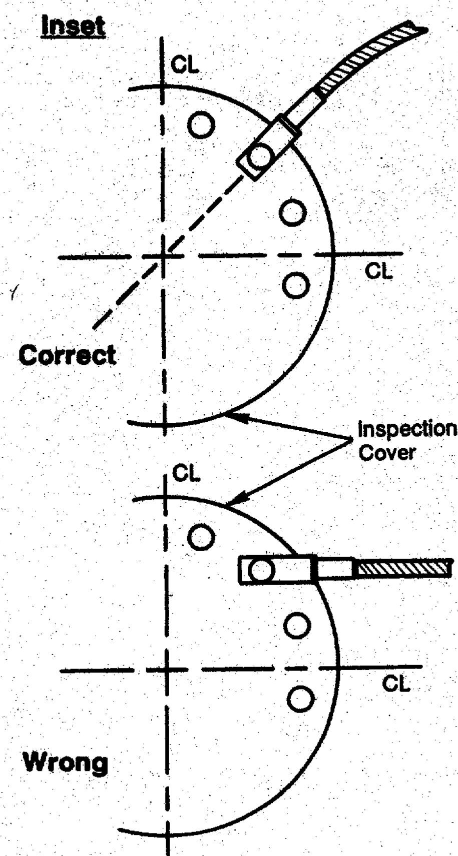
DIAGNOSTIC EQUIPMENT DEVELOPMENT, INC.
6699 N.E. 7th Avenue
Boca Raton, Florida 33431

Phone: (305) 994-1543

The Trane Company
La Crosse, Wisconsin 54601-7599
Printed in U.S.A.

Figure 1
Checking Thrust Bearing Quality with a SWAN-1 Bearing/Gear Analyzer





Instructions:

1. Drill a 13/32"-diameter clearance hole in the sensor mount (i.e., to accommodate the 3/8" bolt on the thrust bearing inspection cover).

2. Clean the following to ensure that they are free of dust, paint and metal chips:
(a) the sensor base and the threads of its 10-32 mounting screw; and,
(b) the sensor mount's surface and its 10-32 tapped hole.

3. With the brass washer in place, screw the sensor onto the sensor mount and hand-tighten.

4. Tighten the sensor to 30-35 inch-pounds (1.8-2.0 nm) using a torque wrench and a 5/8"-deep well socket.

5. Loosen the bolt at the 2 o'clock position on the thrust bearing inspection cover; then slide the sensor mount into place. Make sure that the sensor is positioned perpendicular to the center line of the shaft (see inset). Retighten the bolt to its normal torque.

6. Plug the end of the sensor cable into the input jack on the SWAN-1 analyzer.

7. Ensure that the "Test Interval" toggle switch is set at "15 Sec", and that the "Sensitivity" dial is set at "D".

8. Flip the "Power" toggle switch to "On"; then press the "Push to Read" button to activate the digital display. Note that the numbers appearing on the display will stop changing after 15 seconds; this is the cumulative "Stress Wave Energy" (SWE) value. The analyzer will continue to update the SWE value at 15-second intervals.

9. Record at least 10 consecutive SWE readings. If the recorded values consistently increase or decrease, continue to log SWE readings until the trend reverses or disappears.

10. To arrive at a final SWE value, compute the average of all the recorded readings; then round off the result to 2 significant figures. Compare the final SWE value against the general guidelines below; keep in mind that the ranges indicated are necessarily broad because of the variance between base line SWE values from one chiller to the next.

0 to 20,000 SWE ("D" sensitivity):	Typical at Initial Start-Up
20,000 to 40,000 SWE ("D" sensitivity):	"Normal" Thrust Bearing Wear
Over 40,000 SWE ("D" sensitivity):	*Thrust Bearing Replacement May Be Indicated*

Analyzing Rotational Imbalance

Measurements associated with this check not only verify that alignment of the compressor's rotating assembly did not shift during shipment and installation, but also establish "base line" readings that can be used for comparison with future rotational imbalance measurements. The best time to begin vibration analysis for trend logging purposes is at initial start-up.

Normally, rotational imbalance does not change once the unit is in operation; however, compressor rework can change the level of imbalance, just as worn motor bearings can sometimes magnify rotational imbalance.

Equipment Requirements. Our factory uses a "Scientific Atlanta Model 2521 Tracking Vibration Recorder" to analyze compressor rotation imbalance, though any one of a number of popular vibration analyzers can be used for this purpose. Just make sure that the analyzer you elect to use includes these features:

a. Battery-Powered Operation. Battery-powered meter operation is convenient for those job sites where building power is inaccessible. More importantly, though, this feature eliminates the erroneous vibration measurements that can be produced if an electrical ground loop exists.

An "electrical ground loop" is an undesirable current flow that results when the ground potentials of 2 circuits differ. For example, an electrical ground loop may occur if the ground potential of a vibration analyzer plugged into a 115 VAC power supply differs from that of the chiller.

b. Analyzer Pickup Probe. To obtain consistent vibration readings in velocity ("in/sec peak") at high frequencies (over 1000 Hz), the meter must include an accelerometer with a magnetized base.

c. Scale. Make sure that the analyzer selected has a full-scale deflection sensitivity of 0.0 to 0.2 in/sec peak, minimum. To eliminate over-range plots and allow the user to monitor 2 frequency ranges (0-150 Hz and 0-1500 Hz), the meter scale and frequency ranges must be field-selectable, too.

Note: If an analyzer with the features described in "C" is not available, use an instrument that measures displacement (mils) and includes a tuneable filter (allowing the operator to adjust the meter to a specific frequency).

d. Output. To simplify measurement recording and analysis, the vibration meter used should produce a hard-copy, X-Y plot of velocity (in/sec) versus frequency (Hz).

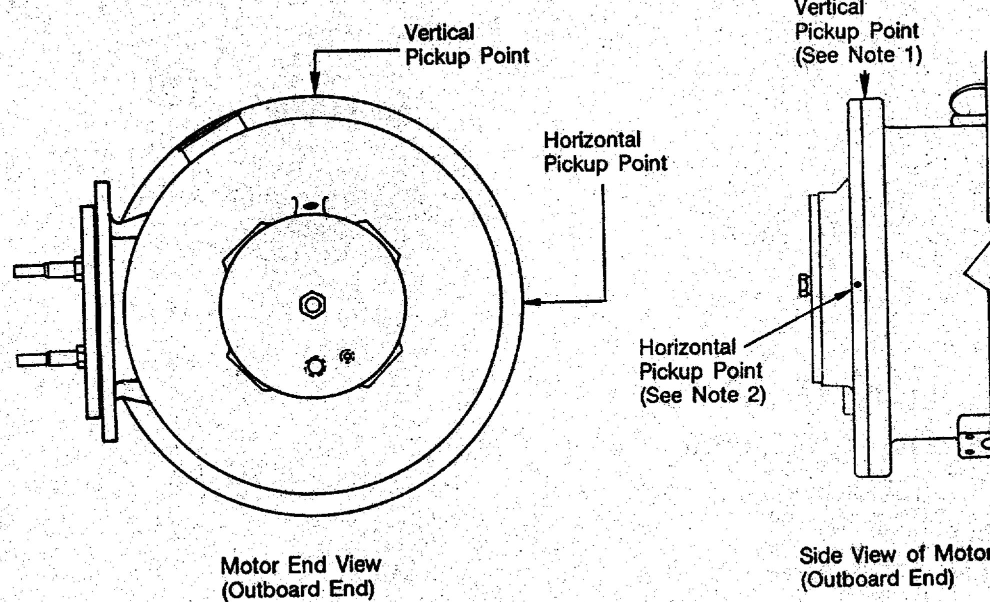
* * * * *

Vibration Pickup Points. Rotational imbalance is indicated by the degree of horizontal and vertical vibration, and is always measured at the outboard end of the motor. Specific locations or "pickup points" for accelerometer placement are illustrated in Figure 2.

Before placing the accelerometer on the motor, remove all insulation, glue and excess paint from the surface of the bearing bracket at each "pickup point". To assure accelerometer stability and reading accuracy: (1) make sure that the surfaces of the vibration "pickup points" are smooth and clean; and, (2) position the accelerometer so that its magnetized legs are parallel to the rotor shaft.

When measuring horizontal and vertical vibration, tune the analyzer to the vibration peak at running speed (60 Hz) and at twice running speed (120 Hz). If the vibration analyzer generates a hard-copy report, use the low frequency scale (or the scale that covers the 0-150 Hz range) for these readings.

Figure 2
Measuring Vertical and Horizontal Vibration
(Scientific Atlanta Model 2521 Tracking Vibration Recorder)



Notes:

1. Vertical Vibration Measurement. Place the vibration analyzer pickup probe on the vertical axis of the outboard bearing bracket. Be sure to position the magnetized legs of the probe parallel to the rotor shaft to prevent rocking during vibration measurement.
2. Horizontal Vibration Measurement. Place the vibration analyzer pickup probe on the horizontal axis of the outboard bearing bracket. Be sure to position the magnetized legs of the probe parallel to the rotor shaft to prevent rocking during vibration measurement.

To determine whether or not compressor rotational imbalance falls within acceptable limits, compare the actual horizontal and vertical measurements obtained with the values shown in Table 1. Notice that this table indicates the maximum allowable horizontal/vertical vibration levels for 3 different unit configurations: (1) an air-run compressor (without the elbow); (2) an air-run unit (complete chiller without refrigerant); and, (3) a Freon-run unit (complete chiller with refrigerant). While the same pickup points are used for each of these variations, notice that the allowable vibration limits change from one configuration to the next.

* * * * *

For additional information about the "Scientific Atlanta Model 2521 Tracking Vibration Recorder", phone or write to this address:

SCIENTIFIC ATLANTA,
DYMAC Division
P.O. Box 23575
San Diego, California 92123-0575

(619) 268-7113

Table 1
Maximum Allowable Horizontal and Vertical Vibration Levels at 60 Hz

Unit "Configuration"	Horizontal or Vertical Velocity at 60 Hz (Filtered)
Air-Run Compressor (w/o Suction Elbow)	0.10 in/sec peak
Air-Run Chiller (complete unit w/o refrigerant)	0.15 in/sec peak
Freon-Run Chiller (complete unit w/refrigerant)	0.25 in/sec peak

Section 2:
Checking Vibration After Unit Disassembly or Compressor Rework

Check the vibration level of the chiller when it is restarted following:

a. suction elbow removal;
b. removal of the entire motor/compressor assembly; or,
c. disassembly of any portion of the compressor's rotating assembly.

In all cases (where it is easy to do so), check the unit's vibration level before teardown. This provides a "base line" measurement that can be compared to the vibration level recorded after rework is completed.

Suction Elbow Removal

For those teardowns that require removal of the suction elbow—but the compressor is neither removed nor rebuilt, use the procedure outlined below to reinstall the elbow.

1. Set the elbow on the evaporator flange; then align it with the suction cover without using guide pins.

2. Insert 2 bolts through the suction cover flange at the 3 o'clock and 9 o'clock positions. Tighten both bolts enough to draw the elbow flush with the suction cover.

3. Install the evaporator flange bolts. Do not use pry bars or guide pins to align the bolt holes!

4. Using the appropriate bolt-tightening sequence, tighten the evaporator flange bolts to the specified torque.

5. Loosen the 2 bolts installed in the suction cover in Step 2, and watch for compressor-to-suction-elbow movement. Normally, the compressor will lift slightly when these bolts are loosened.

Inspect the gap between the suction elbow and suction cover. The width of this gap should be the same around the entire circumference of the joint. If the gap is uneven, note where the widest and narrowest widths are located.

Note: If the vibration levels recorded when the assembled unit is air-run exceed the maximum levels allowable (Table 1), it may be necessary to equalize this gap by realigning the elbow (where possible).

6. Install the bolts in the suction cover flange and tighten them to the specified torque; be sure to follow the appropriate bolt-tightening sequence.

7. Air-run the assembled unit; to do this, complete Steps 7a through 7f.

Caution: To prevent possible equipment damage when the compressor is air-run (with or without the suction elbow), exercise these precautions:
[ ] Lock the inlet guide vanes in the closed position.
[ ] Disable the transition circuit so that the starter cannot transition.
[ ] Isolate the water flows through the chiller to prevent condensate from forming on the tubes.
[ ] Do not start the compressor motor more than 5 times (3 times for across-the-line starters) without refrigerant cooling. After the 5th start (3rd start for across-the-line starters), allow the motor to cool down for at least 24 hours.

a. Lock the inlet guide vanes in the closed position.

b. Isolate the chilled water and condenser water flows so that condensation does not form on the tubes. (To enable the unit to run, the "proof-of-flow" circuits must be jumpered.)

c. Units w/Reduced-Voltage Starters Only. Disable the transition circuit to prevent the unit from running in the delta formation. The steps required to do this on "A"- through "J"-design CVHEs with classic control panels are shown in Figure 3; for "K"- and later-design CVHEs with UCP695 control panels, see Figure 4.

d. Start the chiller and run it for 10 minutes before recording any vibration readings. During this "warm-up" period, monitor the unit's vibration level with a vibration analyzer set up for running speed (i.e., 60 Hz or 3600 rpm).

If the vibration level is excessive (i.e., exceeds 0.25 in/sec peak), shut down the compressor and prepare it for trim balancing.

e. Once the 10-minute "warm-up" period expires, take a complete set of vibration readings.

Note: If the vertical vibration is high—but all other readings are acceptable, loosen the motor support bracket (Figure 5) and retake both the vertical and horizontal vibration measurements. If the new vibration levels registered are higher than before, retighten the motor support bracket bolts; if the new measurements are lower, discard these bolts.

f. Shut down the compressor; then compare the horizontal and vertical vibration readings obtained with the allowable vibration levels shown in Table 1 for an air-run chiller.

If the actual vibration levels recorded are acceptable, evacuate the unit and charge it with refrigerant. However, if unit vibration exceeds the values shown in Table 1, realign the suction elbow.

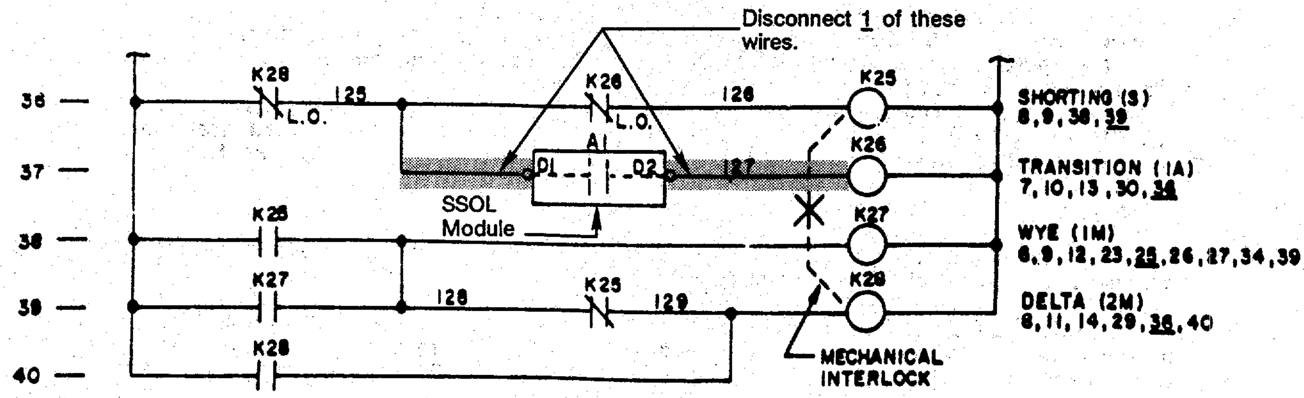
Removal of the Entire Motor/Compressor Assembly

Occasionally, limited access at a job site makes it necessary to remove the entire motor/compressor assembly from the chiller before the unit can be installed. In this situation, it is important to dowel the motor/compressor assembly before it is removed from the shells to prevent the compressor components from shifting during the rigging process.

Normally, the "compressor removal for unit installation" requirement is known before the unit is ordered, making it possible to specify optional factory-dowelling. However, if field-dowelling is necessary, be sure to review the compressor dowelling instructions described in Trane General Service Bulletin CVHE-SB-10.

When the chiller is reassembled (i.e., the motor/compressor assembly is set on the shells), careful alignment of the discharge flange and compressor foot is of critical importance since it determines suction elbow alignment, as well. (Follow the elbow alignment procedure described under "Suction Elbow Removal" in Section 2 of this bulletin.)

Figure 3
Air-Running a CVHE w/"Classic" Control Panel in the "Wye" Configuration

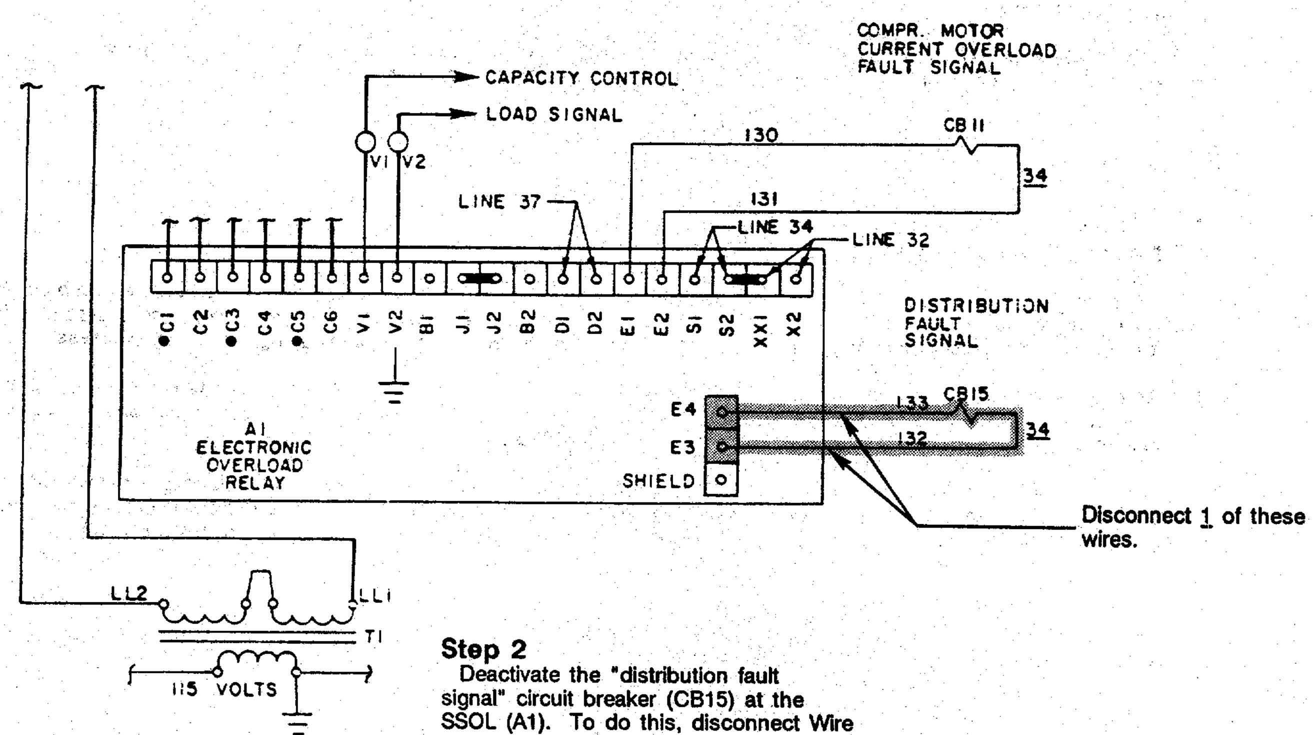


WARNING!
Disconnect electrical power supply to prevent injury or death due to electrical shock.

Step 1

Deactivate the starter panel's "transition" circuit. To do this, locate SSOL module A1 in the starter panel and remove Wire No. 125 from Terminal D1 (or remove Wire No.127 from Terminal D2).

Insulate the end of the disconnected wire with black electrician's tape.



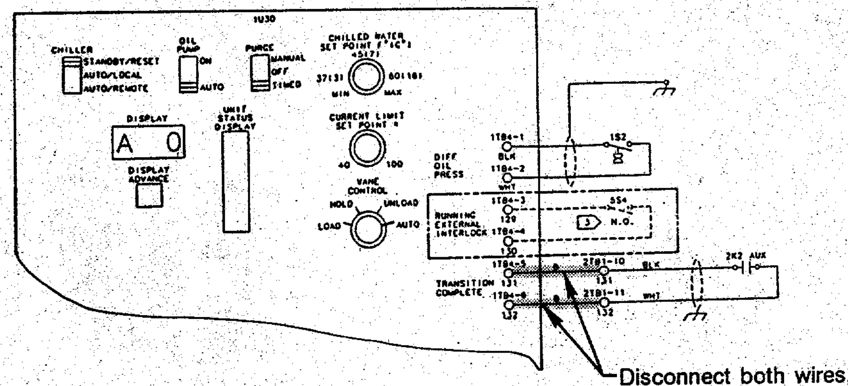
Step 2

Deactivate the "distribution fault signal" circuit breaker (CB15) at the SSOL (A1). To do this, disconnect Wire No. 133 from Terminal E4 (or remove Wire No. 132 from Terminal E3).

Insulate the end of the disconnected wire with black electrician's tape.

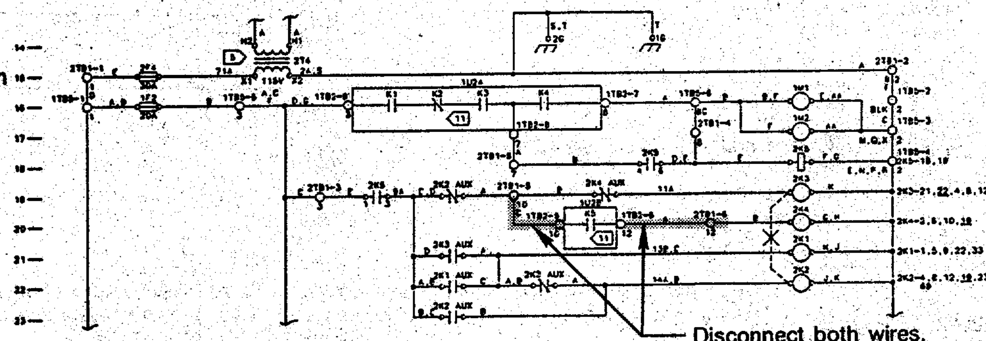
Figure 4
Air-Running a CVHE w/UCP695 Control Panel in the "Wye" Configuration

Step 1
Disconnect Wires 131B and 132B from micro module Terminals 1TB4-5 and -6, respectively. Wrap the exposed end of each lead with electrician's tape



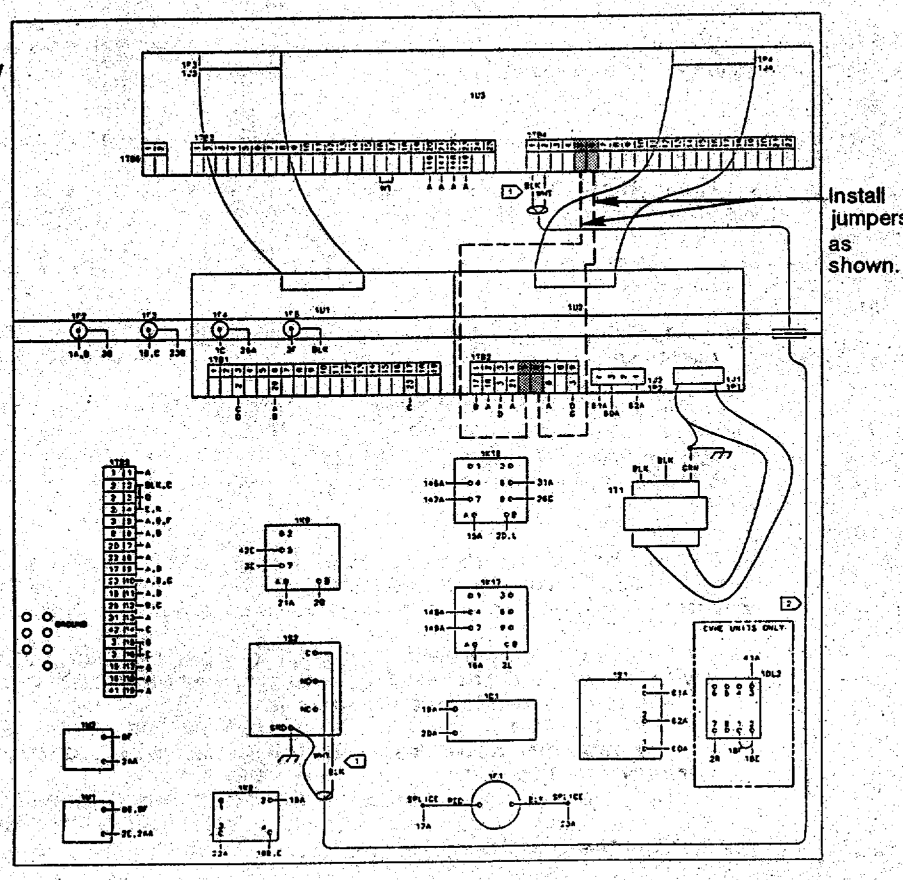
WARNING!
Disconnect electrical power supply to prevent injury or death due to electrical shock.

Step 2
Disconnect Wires 10C and 12A from Terminals 1TB2-5 and -6 in the UCP. Insulate the free end of each wire with electrician's tape.



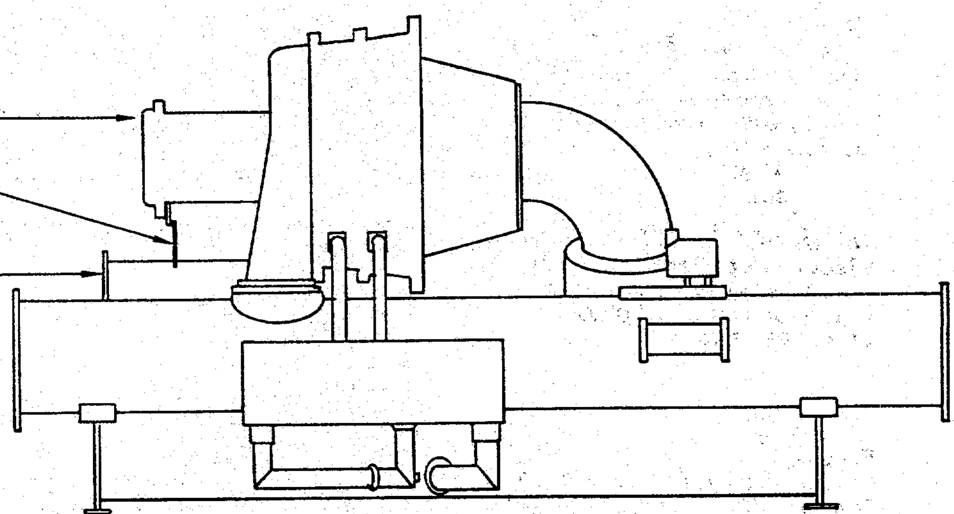
Step 3
Connect Terminals 1TB4-5 to 1TB2-5, and 1TB4-6 to 1TB2-6. Use #14 AWG, 600V copper wire.

Note: These connections prevent the starter from "transitioning" the compressor motor into the "delta" configuration.



Caution!
Exercise extreme care when connecting the 1TB4 terminals in the low-voltage (<30V) section of the UCP to the 1TB2 terminals in the 115V section. Improper connections in these temporary circuits can result in fatal damage to micro module 1U3.

Figure 5
Motor Support Bracket Location
(Back View of Unit)



Compressor Disassembly

Whenever the compressor must be disassembled for any reason, be sure to comply with the recommendations outlined below.

1. After removing the suction elbow and inlet guide vanes, examine the nut on the end of the compressor shaft. If the nut is a "trim balance" nut (see Figure 6), record the locations of the balance weights with respect to the keyway before removing the nut.

2. Complete the compressor teardown. During the teardown process, be sure to mark each component to indicate its relative position on the shaft.

3. Reassemble the compressor; follow the standard procedures described in the CVHE service guide (CTV-SG-2).

Important! As you install each impeller on the shaft, make sure that the keyway is facing up; this is especially important when the first-stage impeller is installed. The keyway must face up when the shaft nut is tightened.

Note: If the shaft nut is actually a "trim balance" nut, a couple of additional steps must be performed as the compressor is reassembled:

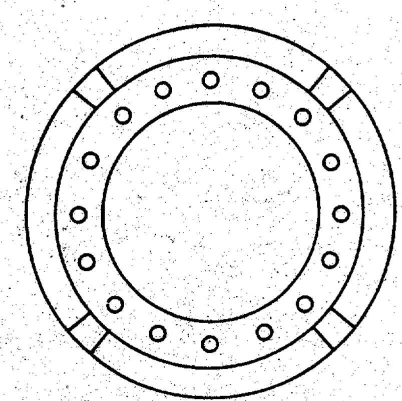
a. If none of the rotating assembly components were replaced, reinstall the trim balance nut so that the balancing weights are in their original positions (before the nut was removed) with respect to the keyway.

b. If any of the rotating assembly components were replaced, record the locations of the balancing weights in the nut; also, label each weight so that it can be replaced if necessary. Then, remove the balancing weights from the trim balance nut before reinstalling it on the shaft. (Imbalance problems are likely to occur if weights are added to the trim balance nut at this time.) Note that a standard, nonbalancing nut can be substituted for the trim balance nut in this situation.

4. Continue the standard rebuild procedure, including reinstallation of the inlet guide vanes. After the vanes are installed, air-run the compressor and monitor its vibration levels before reinstalling the suction elbow. (To air-run the compressor, see Step 7 of "Suction Elbow Removal" in Section 2 of this bulletin.)

Caution: To prevent possible equipment damage when the compressor is air-run (with or without the suction elbow), exercise these precautions:
[ ] Lock the inlet guide vanes in the closed position.
[ ] Disable the transition circuit so that the starter cannot transition.
[ ] Isolate the water flows through the chiller to prevent condensate from forming on the tubes.
[ ] Do not start the compressor motor more than 5 times (3 times for across-the-line starters) without refrigerant cooling. After the 5th start (3rd start for across-the-line starters), allow the motor to cool down for at least 24 hours.

Figure 6
Typical Trim Balance Nut
(Face of Nut Shown)



Note: The holes around the face of the trim balance nut are threaded. Several balance weights (i.e., bolts and washers) are installed in each trim balance nut, as shipped.

5. Compare the horizontal and vertical vibration measurements obtained in Step 4 with the allowable vibration levels listed in Table 1 for an air-run compressor.

If the levels of vibration are acceptable, reinstall the suction elbow on the unit. (Follow the instructions provided under "Suction Elbow Removal" in Section 2 of this bulletin.)

If unit vibration is <u>not</u> acceptable—and the compressor does <u>not</u> have a trim balance nut, the unit must be trim balanced. (See "Section 3: Trim Balancing" in this bulletin.)

If the compressor vibration measurements observed in Step 4 are unacceptable—but the unit <u>does</u> include a trim balance nut, reinstall the balance weights (removed in Step 3) at their original positions in the trim nut. Air-run the compressor again and check the vibration levels. If vibration still exceeds the maximum levels allowable, the compressor must be trim balanced. (See "Section 3: Trim Balancing".)

Note: If the horizontal and vertical vibration levels recorded <u>following thrust bearing replacement</u> are excessive, do <u>not</u> schedule the unit for trim balancing without first redoing the bearing installation <u>and</u> checking the amount of vibration that results.

Section 3:
Trim Balancing

Whenever any of the recommended vibration analyses described in this bulletin indicate an excessive amount of vibration, the compressor's entire rotating assembly must be balanced. Trim balancing a unit in the field requires a substantial investment in expensive vibration analysis equipment. The portable vibration analyzers typically used for fan balancing are usually unsuitable for balancing a CVHE compressor; they are not designed to provide the shaft orbit measurements that are critical for proper compressor balancing.

La Crosse service personnel use a Bentley Nevada Model DVF2 (plus supporting equipment) to trim balance CVHEs since it provides the sensitivity and features necessary for proper trim balancing. To trim balance the compressor, phase angle and the orbit of the compressor rotor shaft are tracked by noncontact "proximity" probes during initial and trial weight runs. (Because the probes must monitor a smooth surface, the standard shaft nut is replaced with a special trim balance nut.) Data recorded during these runs is then fed into a single-plane balance program that determines the amount of weight required at specific locations to balance the assembly.

* * * * * *

Note: Occasionally, high compressor vibration levels can be reduced <u>without</u> trim balancing. If the rotational vibration analysis indicates a high level of <u>vertical</u> vibration, locate the shipping support bracket (Figure 5) mounted between the end of the motor and the oil sump; then loosen the 2 bolts that secure this bracket to the motor. <u>If the vibration level improves</u>, discard the 2 bolts.

A worn thrust bearing can also be responsible for excessive vibration. If no rework has been done on the unit to date and it goes out of balance after operating normally, try replacing the thrust bearing <u>before</u> scheduling the unit for trim balancing.

For further information on this product or other Trane products, refer to the "Trane Service Literature Catalog", ordering number IDX-IOM-1. This catalog contains listings and prices for all service literature sold by Trane. The catalog may be ordered by sending a $20.00 check to: The Trane Company, Service Literature Sales, 3600 Pammel Creek Road, La Crosse, WI 54601.

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