VSD Modification to Inhibit Motor Bearing Fluting

(revised April 2009)

Background:

"Bearing Fluting" is a term used to describe deterioration in a motor bearing due to electrical currents passing through the bearing, causing electrical discharge on the wear path of the bearing. This phenomenon creates a characteristic washboard appearance in the bearing wear path and is evidenced by higher than normal vibration and a rumbling sound, especially noticeable during coast down.

This phenomenon was first encountered by York in the early 1980's when air hander drives migrated to pulse width modulation (PWM) at higher carrier frequencies. Our present chiller VSD, introduced in 1995, utilizes a low carrier frequency and includes an output filter designed to minimize the potential for motor problems such as bearing fluting. With more than 10,000 of these chiller VSDs operating in the field, to date less than 100 of those chillers have been found to experience fluted bearings.

Traditional solutions for bearing fluting have been applied in several of these cases, however none of these solutions has been found to be a perfect solution. This includes replacement with insulated bearings, and/or addition of shaft grounding brushes. More recently JCI determined to identify why this phenomena occurs at some locations, but not with the majority of identical chillers and drives. We found that differences in the building electrical system greatly influence this situation. We also noted that installations with conventional series line-inductors, located at the input to the VSD have never experienced an occurrence of fluted bearings. Input inductors eliminate the problem because electrical currents passing across the bearing to ground must have a circuit path back to the source, and the York VSD power circuits are not referenced to earth, therefore the circuit path must be back through the building ground, to the main transformer's ground reference, and through the power feeder, back to the input of the VSD. The addition of impedance (inductance) in series with the drive input breaks this circuit path.

How to Determine if Bearing Fluting has Occurred:

With York VSDs, fluting can only occur on the 790 HP and 1100 HP models, but does not occur on every installation. To determine if motor bearings have been fluted, first examine the condition of the bearing grease. Do this by removing the grease relief port pipe-plug, and inserting a white nylon wire-tie up into the relief port. Whip the wire-tie around to get a sample of grease on the end, and then withdraw the wire-tie to examine the condition of the grease. Bearings that have been fluted will exhibit blackened grease having normal grease consistency, looking wet and shiny, although black in color. This appearance differs from grease that is just worn out, which looks blackened - but gritty and dry, like charcoal.

Another test is to listen to the bearing as the rotor is spinning just a few RPM. This can be done by hand-rolling the rotor, or listening toward the end of a coast down. There are fancy devices designed for listening, but listening with a screwdriver against the bearing housing and having its handle held up to your ear works fine. With a fluted bearing it will sound like the balls are rolling over cobblestones. Normal bearings emit a smooth, continuous, whistling type sound.

If you have the ability to take vibration readings, we have found fluted bearings produce one of several distinct vibration signatures. This is a lengthy subject. You are welcome to forward vibration data to us for evaluation and we can advise if the data represents a fluted bearing.

Solution:

Having stated that input inductors eliminate bearing fluting on York 790 HP and 1100 HP VSDs, the obvious solution would be to add three-phase series line inductors at the input to any chiller VSD that is affected. Unfortunately, this can be very costly, and often there is no physical space to accommodate the enclosure for such a device.

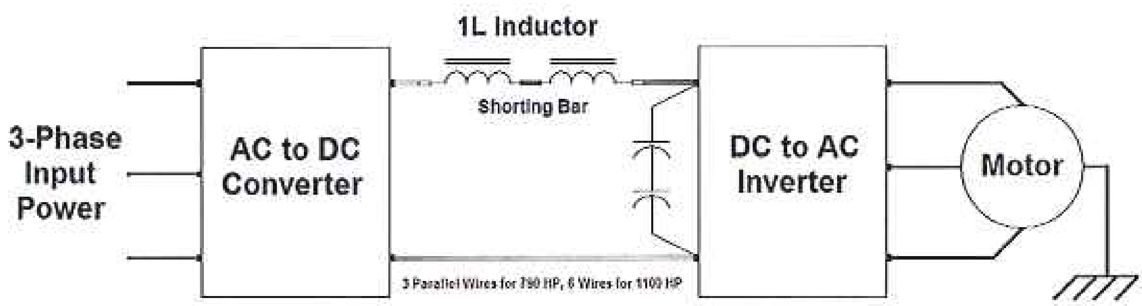
The designs of the present York 351 HP and 503 HP VSDs actually include three-phase series inductors on the input side of the drive, located internally. We have NEVER seen a case of fluted bearings on any chiller with these two models of York VSD. We also produced two previous models of VSDs having line inductors on BOTH sides of the DC bus, but NO inductors at the input. We have never seen any case of fluting with this configuration either! This led us to find that we can create the same benefit as series line-inductors provide, by placing impedance on BOTH sides of the DC link in the VSD. This bulletin addresses how to modify a 790 HP or 1100 HP VSD to provide impedance on both sides of the DC link, in order to eliminate an existing, confirmed case of fluted bearings. Please keep in mind that the majority of these VSDs do not suffer from bearing fluting, and there is no need to modify every 790 HP and 1100 HP

VSD that exists in the field. Only chillers with confirmed cases of fluted bearings should be addressed.

Over the past year we have performed this modification on over 20 chillers having confirmed cases of bearing fluting. Several of these modified chillers have now been operating for over a year, and several have logged over 5000 hours since being modified. None of the modified VSDs have experienced a repeat of bearing fluting. In fact, we have monitored vibration on several of these chillers, comparing the data to recordings made immediately after new bearings were installed, and we have seen no degradation at all in the bearings or in the vibration data.

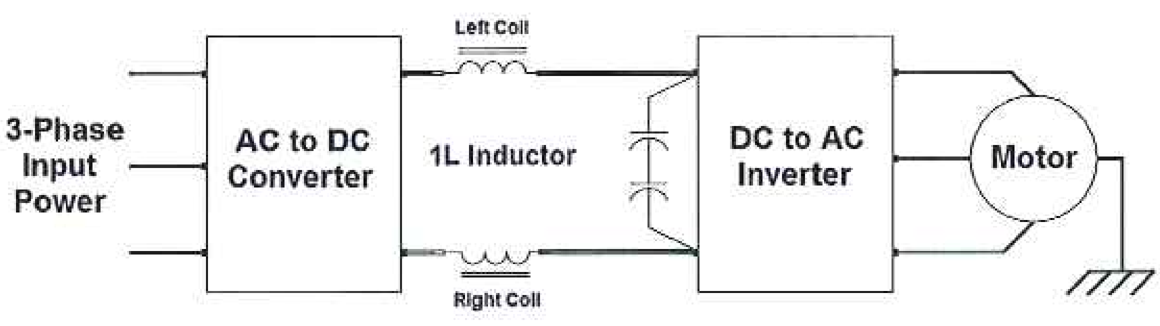
Overview:

The standard 790 HP and 1100 HP York VSDs contain a DC series inductor only on the positive side of the DC link. This device, along with electrolytic capacitors, serves to filter the ripple from the DC supply that feeds the output inverter. This series inductor has two coils which are bussed together to form the full inductance on the positive side of the DC link.



Above is the Standard 790 HP VSD Configuration

The modification separates the two sides of this inductor, and places ½ of the inductor in the negative side of the DC link, with the other ½ of the inductor remaining in the positive side. This requires removing the inductor 1L from the VSD cabinet, and cutting away the shorting bar which ties the two coils together across the bottom of the inductor. It also requires re-routing some power cables, and the addition of new power cables for the negative side of the DC link. The whole process can be completed in one day.



Above is the 790 HP VSD with Inductor Modification

Tools Required:

Socket and End-Wrenches
Come-A-Long
Sling/s
Metal Cutting Saw
3/8 x 1.5" bolts, nuts, washers
3/8 x 2" bolts, nuts, washers
Alcoa EJC#2 Joint Compound or Equiv
Grinder or Metal File
Drill with 3/8" clearance bit
Large Plastic Garbage Bag
Duct Tape
Modification Kit of New Power Wires:
790 HP Wiring Kit = 571-01749-211
1100 HP Wiring Kit = 571-02461-211

Procedure:

Note – This procedure is written around modification of the 790 HP VSD. The procedure for the 1100 HP VSD is exactly the same, except that there are six wires per connection instead of three wires per connection.

1- Follow all standard safety procedures to shutdown the chiller and VSD, lockout and tagout the drive, wait 15 minutes to assure electrical discharge, and check to assure absence of voltage before beginning work.

2- Remove all wires (wires 208 B/C/D and 236 A/B/C) from the two lugs at the top of 1L inductor inside the VSD cabinet. Keep all hardware for re-use.

3- Remove the bolts holding 1L to the cabinet.

4- If the VSD contains the optional IEEE-519 filter, remove the adjacent wires (517, 518, 519) from the 3L inductor and temporarily move these wires back, out of the way. Also, temporarily remove the 20 kHZ trap filter located to the right side of the 1L inductor.

5- Slide the 1L inductor toward the cabinet opening between 3L (if supplied) and the center door post.

6- Fasten a sling around the 1L inductor and rig a come-a-long or other suitable device to assist in removing the 1L inductor from the cabinet and lowering it to the floor.

7- Position the 1L inductor on the floor with the shorting bar pointed upward. Cut a slit in the large plastic bag, and place this slit down over the bus bars, using tape to seal the slit against the bus bars. This will prevent metal filings from getting down into the coils of the inductor.

8- Use a metal cutting saw such as a hack-saw to cut out the middle section of the shorting bar. The double-thickness of bar on either side can be left as is.

9- Use a grinder or sanding disc to remove all varnish from the top and bottom surfaces of the lower bus bars on both coils.

10- Use a drill and 3/8" clearance bit to place holes in the lower bus bars, with spacing identical to the hole pattern in the upper bus bars.

Plastic Bag and Tape keeps dirt out of Inductor

11- Clean up the surface to remove any burrs or sharp edges using a file or suitable tool.

12- Carefully remove the duct tape and plastic bag, making certain none of the metal filings drop down into the coils of the inductor.

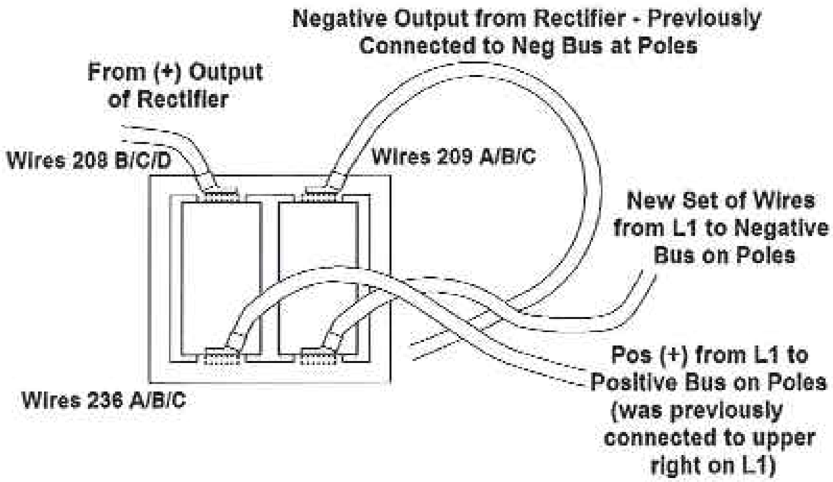
13- Re-install the 1L inductor into the VSD cabinet using the sling and come-a-long.

14- Position the 1L inductor with the bus bars facing the rear of the cabinet as before. Do not fasten the inductor to the cabinet floor at this time, so that the inductor can be moved slightly to help with access to the lugs.

15- Connect existing wires 208 B/C/D from the positive side of the rectifiers to the upper left bus bar (viewed from open cabinet door). This is the same bus bar as originally connected to these wires.

Modified 1L Inductor is Moved into Position

16- Connect the existing wires 236 A/B/C to the lower left bus bar so that the left coil is now feeding + DC to the positive side of the pole assemblies. Use Alcoa EJC#2 or equivalent joint compound on this bus bar since the surface is un-plated aluminum. Use flat washers on both sides, similar to the bolt arrangement used for the top bus bar. Longer bolt length is necessary due to the double thickness of bus bar.



Simplified Diagram Showing only One Wire per Connection (viewed from open doors, looking through the inductor)

17- Remove the negative bus wires 209 A/B/C from the laminated bus on the pole assemblies. Bend these wires back toward the 1L inductor. The two bottom wires will be the correct length to reach the upper right lug on 1L. The third wire from the laminated bus will be about 24" longer. Just loop this wire back and attach together with the other two to the same lug at the upper right side of 1L. (The third wire in the photo below was cut back and re-lugged)

18- Install three new wires (no wire number) from the lower right bus bar of 1L to the negative side of the laminated bus on the inverter poles. Use Alcoa EJC#2 again as with the other lower lug. The two shorter wires go to the bottom laminated bus connection, the single longer wire goes to the upper connection on the laminated bus.

New Wires are added between 1L and DC bus

19- Position the 1L inductor so that the mounting feet align with the holes in the cabinet floor and re-install the mounting hardware.

20- If the unit includes the IEEE-519 filter option, at this time re-connect wires 517, 518, and 519. Also, reinstall the 20 kHZ trap assembly. Make certain the wires from the 1L inductor to the laminated bus are not pierced or cut by any hardware along the bottom of the 20 kHZ trap. Use wire ties to secure the power conductors.

The 20 kHZ Trap is re-installed into the VSD

This completes the modification to the 790 HP / 1100 HP VSD.

D. Saylor 4-23-2009