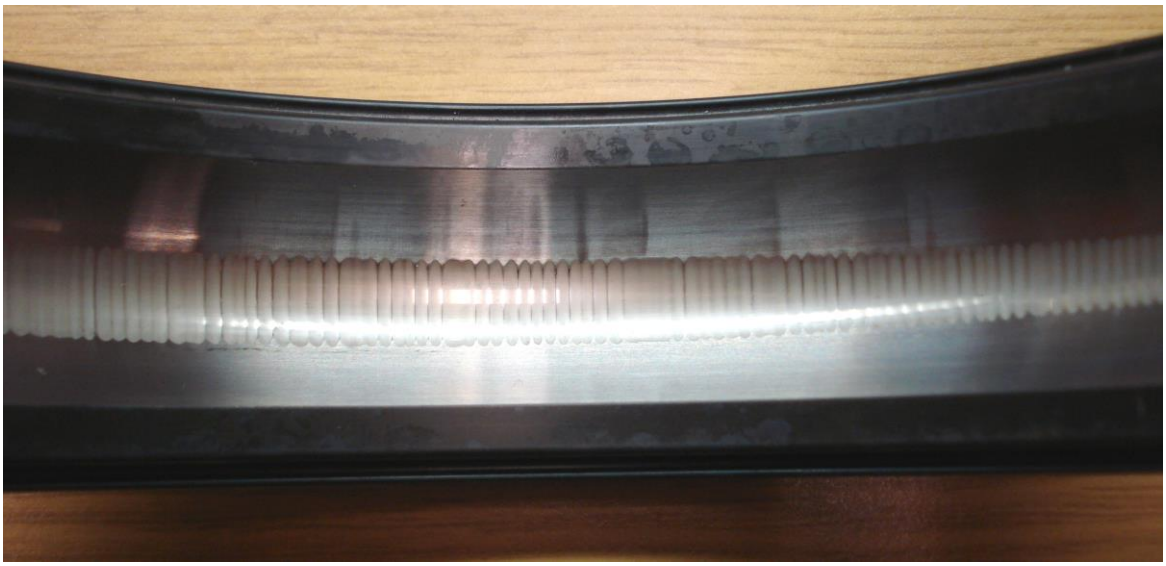
Bearing Fluting

Bearing Fluting is a term to describe early deterioration of bearings due to an electrical current passing across the grease film in the normal wear path of the bearing. Tiny pits created during each electrical discharge form a wash-board like pattern of parallel oval marks around the wear path. In the early 1900's this condition was typicallty caused by magnetism, shaft eddy currents, or assymetrical currents in a motor. However, today this same deterioration can be caused by variable speed drives (VSDs).



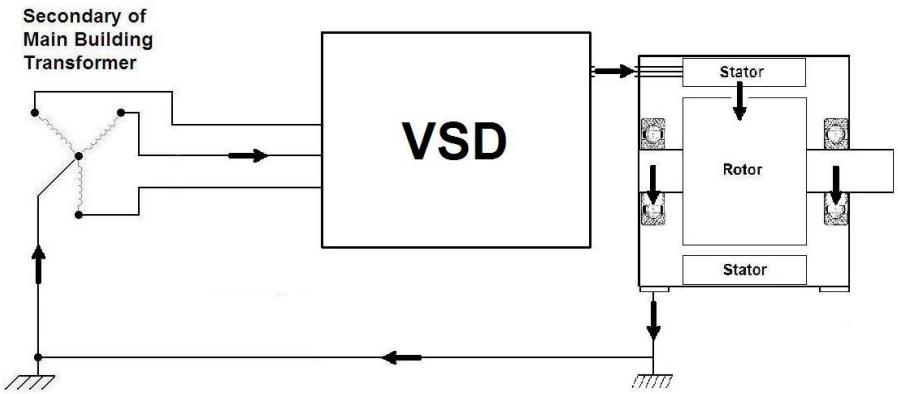
Fluted Bearing

York has always strived to design our chiller VSDs to minimize adverse effects such as bearing fluting, and most chiller VSDs shipped over the past three decades have never experienced this issue. However, in recent years we have discovered some locations where bearing fluting has occurred. The odds of having bearing fluting occur on a York centrifugal chiller are about 1%-2%, based on well over 10,000 of our present VSD designs being sold since 1995. We have found the factors which deterime whether fluting occurs at one site verses another site are largely due to impedance of the power source, degree of harmonic distortion present on the distribution, integrity of the building grounding system, and the size of the VSD.

Early efforts to correct this problem using a grounding brush, or grounding ring, on the motor shaft did not work. In fact, we also tried applying these grounding rings on both ends of the motor rotor, and this failed as well. Later we tried special bearings with a non-conductive coating on the outer ring of the bearing. This just created another capacitor in the electrical path, and did not solve the problem either.

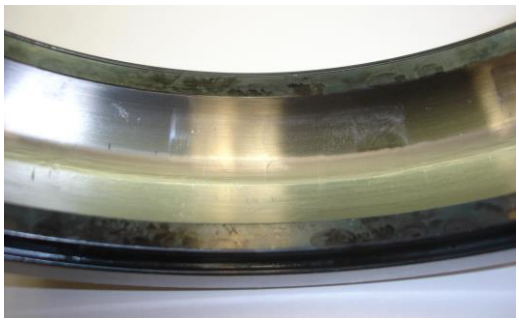
Research in 2008 found that when fluting occurs, currents circulate from the VSD, to the motor, across the bearings to ground, and back through the building electrical system to the VSD. We also found that these currents can be eliminated by placing an impedance in series with this circuit path. This could be accomplished by adding three-phase line inductors in front of the VSD, or after the VSD – or, by placing inductors on both sides of the VSD's DC bus. Our 790HP and 1100HP VSDs did not have inductors on both sides of the DC bus, and only 790HP and 1100HP VSDs had been found to sometimes experience fluting, so we created kits to retrofit existing DC bus inductors to place ½ of the inductance on the

positive side of the bus and the other ½ on the negative side. This has proven to eliminate bearing fluting in most cases, and has now become standard in all new 790HP and 1100HP VSDs shipped since December of 2009.



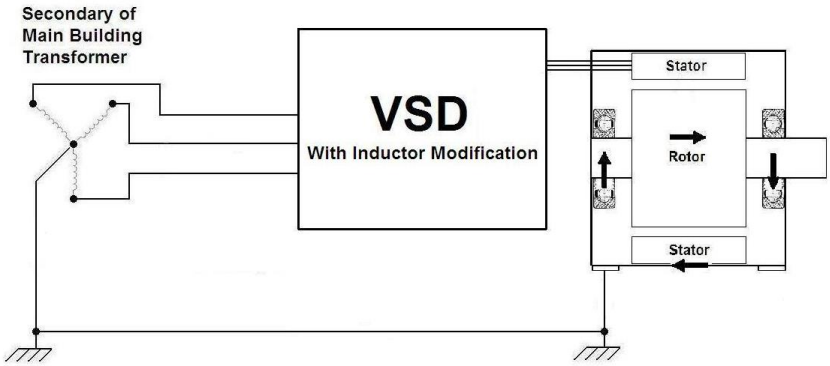
Current Circulating from VSD to Motor, to Ground, and back to the VSD

Although our inductor modification proved to correct bearing fluting in most of the isolated cases that developed, some of those locations were later found to be so severe that a mild frosting of the bearing surface continued to occur.



Frosted Bearing

Further research in 2009 found this frosting to be caused by additional currents which circulate from the motor-rotor, across one bearing, to the frame, and back across the other bearing to the rotor. This circulating current occurs entirely within the motor, and is the same current path that exists when parts of the motor become magnetized. The only means of stopping this current is to break the circuit path by replacing one of the bearings with a non-conductive bearing. Special bearings are now being made with non-conductive balls made of silicon nitride material, which is harder, and higher-rated, than standard steel. These special bearings are now available through the York Parts Distribution Center.



Current Circulating within the Motor

Additional testing of motors using this non-conductive bearing has proven it eliminates the circulating currents which cause frosting in the wear path. Although these currents are stopped, and bearings no longer deteriorate, we also discovered that the voltage on the shaft with respect to ground actually becomes higher! So, to prevent the higher shaft voltage from causing any other problems, we have elected to apply the shaft grounding rings to any motors that have been modifided with a non-conductive bearing. This keeps the shaft voltage as low as would be expected with standard bearings.

Shaft Grounding Ring

Although we plan to continue to use shaft grounding rings in combination with non-conductive bearings, keep in mind that testing has proven that grounding rings alone do not eliminate fluting. Even if grounding rings would be applied after modification of the VSD inductor, this will not eliminate the frosting that can occur. Grounding rings are applied solely to maintain a lower shaft voltage after the addition of a non-conductive bearing.

In summary, very few York VSD chillers have ever been found to experience bearing fluting. Only a small percentage of 790HP and 1100HP units have been afected, and most of these have been corrected by the addition of a DC bus inductor modification within the VSD. In some extreme cases we have seen a frosting condition continue to occur, and this we have proven can be addressed by changing the motor non-drive end bearing to a non-conductive bearing, with the addition of a shaft grounding ring to keep the shaft voltage to a normal level. Furthermore, the inductor modification has now been incorporated into standard production, and is now present on all York VSDs shipped after December 2009.