



## Technical Notes by Dr. Mel

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### *Solutions for over-heating and vibration, two common problems of existing installed Fluid Drives*

**Variable speed fluid drives** have been used for almost a century to provide variable speed power to pumps, fans, and compressors from constant speed sources. From the 1930s through 1965, they were the primary choice for variable speed power for boiler feed pumps (bfp), FD and ID Fans in the US. Most fluid drives were supplied by American Blower, and later American-Standard. By 1965, GE and Westinghouse were selling variable speed steam turbines to drive bfps as part of the T-G “package”. While this may have been commercially attractive at the time, it remains a fact - even today - that the most efficient bfp drive configuration is the main shaft driven bfp with a variable speed fluid drive between the turbine-generator and bfp.

In 1973, TRI began contributing to the solutions of certain reliability issues that some of the larger fluid drives were experiencing. Since 1985, TRI has manufactured new and/or upgraded Fluid Drives, to 30,000 hp, for bfp service, often using the original outer housing. They have proven to be very reliable.

Fluid Drive literature references are few. Consequently, they are not well understood (how they work, how to size the rotating element and how to determine cooling requirements). If the bfps/ fans are properly designed/selected, the maximum speed of the load speed exceeds 95% of the fluid drive input speed (<5% slip).

When problems occur, they usually fall into one of these categories: (1) Over-Heating, or (2) Rotor Vibration and Bearing Damage. Occasionally, vanes break, and this problem and associated solutions are discussed in other Technical Notes.

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**Over-Heating:** Almost all large U.S. fossil-fired power plants were built as “base load” units. Plant turn down below 50% of full load power was not considered in the original designs, even though many are now used in this manner. Turn downs below 50% cause more heating in fluid drives than was originally anticipated. Some bfps and fans are larger than they should be, so they and the fluid drives operate at low speed and produce more heat than they should. Also, most power plant personnel expect oil leaving coolers to be at or below 110 deg F. In many original fluid drive installations, coolers were sized for the oil cooler exit temperature to be 130 degrees F, not lower, so they seem “hot”, but are in spec.

**The solutions to most fluid drive over-heating problems** includes (a) larger oil coolers and/or higher oil flow rates, (b) resized bfp, fan and/or fluid drive. TRI Engineering can help in these cases. **TRI computer programs can evaluate fluid drives for proper sizing, calculating heat losses at various load points.**

**Vibration and Bearing Damage:** Two types of vibration appear in fluid drives: synchronous and non-synchronous, for each shaft, input or output. “Synchronous” vibration is vibration that has the same frequency as the rotational frequency of that shaft and usually results from unbalance of that shaft. The second is “non-synchronous” vibration, from two sources: (1) The influence of vibration of the other shaft appearing with frequency of the other shaft, or (2) vibration due to turbulence in the oil in the impeller-runner cavity, with a frequency which is typically between the rotational frequencies of both shafts and which peaks when the output shaft speed is around 2/3 of the input shaft speed. For a fluid drive input shaft at 3600 rpm, the peak amplitude of type (2) non-synchronous vibration usually occurs around

2300-2400 rpm (38-40 hz), and usually affects the input shaft more than the output shaft. When in this speed range, as the torque transmitted increases, the turbulence in the oil increases with two results: (a) the amount of unbalanced oil increases leading to increased rotor vibration, and (b) the temperature of the oil leaving the impeller-runner chamber increases. To understand the effect of unbalanced oil on vibrations, note that there are 4 to 10 gallons of oil (512 to 1280 ounces of oil) in the fluid drive rotating element chamber subject to a “g” force on the order of 5000. Therefore, one ounce of unbalanced oil produces 5000 ounces (312 lb) of force, which is adequate to cause several mils of vibration.

Fluid drive vibration problems are typically encountered when the bfp discharge pressure is reduced and bfp water flow is increased, such as occurs in “low flow” operation or in “sliding throttle pressure” turbine-generator operation. The resulting economic benefits strongly encourage these modes of operation.

As vibration amplitudes of the rotors increase, oil films become too thin in the original fluid drive “pressure dam” bearings, causing metal-to-metal contact, which “wipes” the Babbitt and opens up the bearing clearance. The fluid drive bearing degradation cycle continues until it becomes necessary to stop the fluid drive due to the severity of the vibrations.

**TRI’s proven solutions** for such problems are (a) a precise fluid drive rebuild procedure, and (b) the use of heavy duty **TRI Align-A-Pad® Bearings** capable of withstanding extreme vibratory forces. These TRI Fluid Drives have low vibration amplitudes and, as a result, can be successfully used for “low flow” and/ or “sliding pressure” turbine-generator operation.

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This Technical Note was written by Dr. Melbourne F. Giberson, P.E., President of TRI Transmission & Bearing Corp., Turbo Research, Inc. The objectives of Technical Notes are to disseminate information and experience on understanding problems and how to solve them. We attempt to send this Technical Note only to those people for whom the information might be useful. Over the years, many people have asked to be added to the distribution list (see our website). Occasionally, a few individuals inform us that they do not wish to receive the information. Should you desire not to receive future Technical Notes, please advise TRI by [info@turboresearch.com](mailto:info@turboresearch.com) or click [visit the removal page](#) on the TRI web site MFG 6/2003