

Thermographic Inspection of Mechanical Couplings

Couplings allow for some misalignment along either the X-axis or Y-axis without exerting anything other than torsional loads on the rotating components.

What are couplings?

A coupling (for the purpose of this paper) is a device that mechanically links together two rotating pieces of equipment so that leverage or torque can be transmitted between them. Couplings typically allow for a slight misalignment between the two rotating component; as a result loads outside the rotating axis, are kept to a minimum. By this I mean, side loads or bending moments that are perpendicular to the rotating shafts are reduced or preferably eliminated. Couplings are most commonly located between a motor and some sort of driven device, such as a pump, reducer, fan, grinding or crushing mechanism.

What do couplings look like?

Couplings come in many shapes and sizes. They range in size from as small as a few thousandths of an inch to as large as six to ten feet in diameter. They can be made from a multitude of materials such as plastic, steels, exotic metals, composites and many combinations thereof. Some transmit their loads through metal-to-metal contact, while others have metal-to-rubber contact or even synthetic-to-metal contact. The shape is usually round in nature that helps with even distribution of weight for balancing purposes.

What are the common types of couplings?

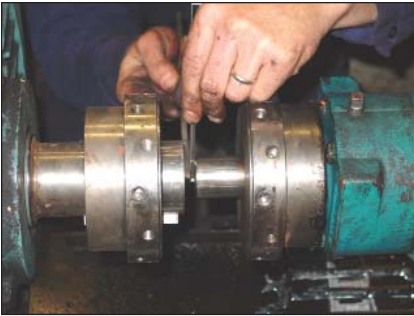
There are a number of different types of couplings. Among them are Grid, Gear, Flex, Magnetic, Fluid, Spider, Insert, Viscous, and Constant Velocity. The coupling types are specialized for various situations and often one will have some sort of advantage over the others. Of course there are tradeoffs with all of them too as no one coupling fits all situations. It is vital to understand what kind of coupling you are looking at when conducting a thermal inspection.

How do couplings work?

Couplings allow for some misalignment along either the X-axis or Y-axis without exerting anything other than torsional loads on the rotating components. They also allow for small amounts of angular misalignment, axial displacement, or axial thrust. In general terms, couplings provide a degree of axial freedom. In some cases, a coupling can act as a “weak link” that will fail before damage is caused to either the driver or the driven components.

How do couplings fail?

A multitude of circumstances and forces can cause failures in a coupling. Many couplings require some degree of lubrication. Because of this, the lack of lubrication will cause internal parts to wear prematurely in these devices. In the case of couplings utilizing a rubber component, the rubber can lose its strength with age or direct contact with certain types of chemicals or prolonged exposure to sunlight.



Magnetic couplings have very few parts that will wear out due to the fact that there is no physical contact between the two halves of the coupling; the torque is transmitted via a magnetic field. If the two halves of a magnetic coupling did, in fact, ever come in contact with each other, a catastrophic failure would probably result.

Magnetic couplings can also build a lot of heat from magnetic eddy currents that develop during normal operation. This heat can result in a situation where the thermal limits of the coupling components, or even the shaft seals and bearings, are exceeded and damaged.

Couplings also commonly fail when they are sized improperly and loads exceed their design limits. Severe misalignment between components can dramatically reduce the useful life of a coupling; it can also lead to damage in the motor and the driven component—typically from the side loads exerted on the shafts and bearings of the two rotating components. Improperly installed couplings will also sometimes result in premature failure.

For example, anti-seize lubricants such as should not be used on a press fit or shrink disk type coupling. Couplings that are installed without proper clearance between hubs can cause the coupling and/or other component failures. Improperly sized couplings can catastrophically fail due their design limits being exceeded.

A common root cause for failure in fluid couplings is improper maintenance of fluid levels. Low levels of lubricant result in overheating and high levels may produce too much torque. The wrong viscosity oil can also damage a fluid coupling because the lubricant is unable to perform its intended function adequately.

What thermal signatures are associated with coupling operation?

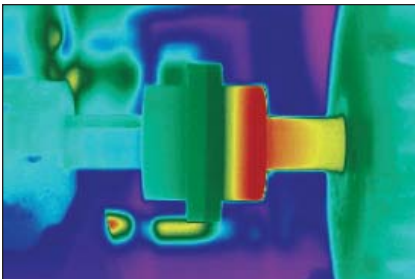
On most mechanical couplings the normal thermal signature should appear as follows:

- The coupling should be at or near ambient air temperature.
- The bearings of both the motor and driven component will provide the only “local” heat source.
- The coupling typically acts as a heat sink, so the coupling appears cool while the shafts that enter the coupling on each end will appear warmer the further from the coupling you look.
- Magnetic couplings are a different case and operate at elevated temperatures. I have not been able to figure out what thermal pattern represents a good coupling or which one shows a bad one. Fortunately you will not often encounter this type of coupling in the field.
- Fluid couplings are sensitive to fluid levels and torque loads; unfortunately a higher than normal temperature on a fluid coupling could be due to either of these problems. Trending the thermal images of fluid couplings over time is suggested.

What conditions are needed to see thermal signatures?

While it is not always *necessary* to have a direct line of site, it is usually desirable. If possible, coupling guards should be made of expanded metal or have some sort of small door that allows for easy viewing of the coupling.

Usually just one side or the other of a mechanical coupling will become abnormally warm as a result of a coupling failure.



It may be possible to utilize a thermal mirror to up under or around a guard. This should be done, however, only with *extreme caution*. Using a thermal mirror carelessly in proximity to moving equipment can quickly result in a catastrophe, either for the equipment or any nearby personnel.

When a direct line of site cannot be obtained, use your knowledge heat transfer and coupling operation. The thermal signature of a normally operating coupling is cooler than the bearing in either the motor or the driven component. By viewing even a small portion of the shaft on each side of the couple—often as little as a half of an inch—it may be possible to determine the direction of heat flow and, thus, the root cause of the problem. If the shaft is warmer toward the direction of the coupling, it is likely the coupling is failing. It is important to view the shaft on *both* sides of the coupling guard, however, to learn as much as possible about the thermal signature. Even then you may, or may not, see a failing coupling because the guard hides the signature.

What variations may there be in thermal signatures?

Usually just one side or the other of a mechanical coupling will become abnormally warm as a result of a coupling failure. The air gap between the two halves of the coupling will keep them thermally disconnected so the heat cannot transfer across the entire device. Fluid couplings will generally become warmer over the entire fluid cavity of the coupling rather than on one side or the other.

Flex couplings that use rubber or synthetics can be difficult to inspect, because the flexible part of the coupling typically has a higher emissivity than the metal (lower-emissivity) portion attached to the shaft. This difference in emissivity makes the inspection confusing and difficult. Once again, trending can be a useful tool on a flex coupling as it can show any change in the temperature of the flexible parts over time.

Whenever possible, shut down the suspect coupling and inspect it visually; this will often reveal details and information that are not obvious thermally. Certainly it can also be extremely valuable to use other technologies to help verify your thermal findings, such as vibration analysis.

What difficulties might be encountered?

The fact that most couplings, when operating, are rotating rapidly can result in cause data to be skewed or blurred. Convective cooling will also be a strong influence during operation, perhaps causing subtle patterns to drop below the threshold of detection.

Typically, however, the greatest difficulty is simply getting a direct line of site. You need to keep working at the technique of “peeking” around the coupling guard whenever possible.

Don't become lax about your *safety*. Danger always lurks around moving equipment and, if you become careless even for a moment, it can be too late before you know it. Avoid any loose clothing or dangling cords that may become entangled in the equipment. Use extreme caution when opening doors or access panels in guards. Never try to insert a thermal mirror or anything else into an opening on a coupling guard. Never try to remove a guard while the equipment is in operation.



The magnets in magnetic couplings may cause pacemakers, defibrillators, or other electronic medical devices to malfunction or reset to factory settings. People having any of these medical devices should maintain a safe distance (10 ft) when coupling is disassembled.

There are always a number of variables such as rotational speed, load on the system, ambient conditions, emissivity variations and transient heating; any of these, individually or together, can yield images that may be confusing, difficult to compare, or with signatures that are not easily detected or, perhaps, simply undetectable.

If you are determined, there are often ways around all of these difficulties. Try gathering data from a number of couplings of the same type in the same ambient conditions before rushing into your evaluation. It can be relatively simple to increase the emissivity across the coupling with paint (the most uniform solution) or a film of grease (easier even if not completely uniform).

What is the cost of not inspecting?

A failed coupling often results in large losses, the greatest of which is lost production of product or services. The additional cost of repairing damaged equipment, however, can also be significant. Finding coupling problems before failures may mean the difference between being able to repair or rebuild the components or having to scrap and replace them completely. Of course, in some cases coupling failures can be very dramatic and dynamic, causing equipment to explode and become airborne. Needless to say, this usually represents not only a significant expense, but also a serious safety concern. 🌐