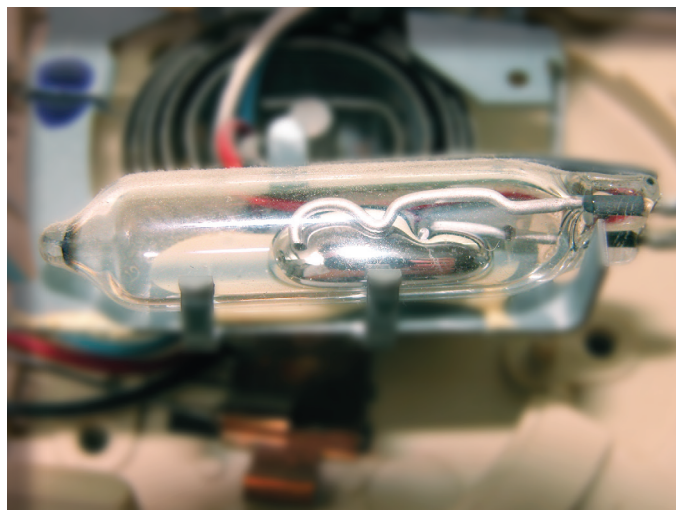


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# Five Signs That it is Time to Replace the Mercury Based Relays and Switches in Your Industrial Application



*And What to Look for in a Suitable Replacement*



## Summary:

Mercury relays have been used in industrial applications for decades, most commonly for power switching. For example, in applications that use process heating, mercury relays are traditionally used to power on and off of electric heaters efficiently. But these kinds of relays are being replaced for several reasons. The latest generation of mercury relay/mercury switch alternatives is safer and more accurate and just as durable.



## The background: mercury in industry

U.S. patents for a mercury-based relay can be found as far back as 1937, and they have been used in industry for decades.<sup>1</sup> They were first developed for applications where contact erosion could present a challenge for more conventional relay contacts, or where constant cycling was needed (such as heating operations).

Mercury relays have been known to overheat, however, and there have been known cases of relays exploding and sending vaporized mercury into the workspace. This can potentially create a serious environmental and safety issue, not to mention the need for costly clean-up.

But even with that risk, and with the EPA and the European Union placing bans on the use of mercury, some manufacturers are still using mercury relays or similar outdated switching devices. Why?



Some industrial engineers claim to prefer mercury relays because they believe them to be durable and capable of handling difficult and dirty environments. While this might be the case for some applications, financial pressure and limited design resources are more likely the issue: When a relay goes bad, it just seems simpler to order a replacement relay of the older design, rather than think through the introduction of a more modern alternative.

*The truth is that older mercury relays are more costly in the long run*, both in terms of time and money, especially when it comes to applications like diffusion bonding and superplastic forming. Replacing mercury switches and relays should be high on an engineer's list, especially when the following circumstances — “red flags,” if you will — present themselves.

- **You find that your application is going through more heaters than usual.**
- **You have had multiple switches fail, or even “blow.”**
- **Local laws or company policies are “going green.”**
- **Your production line is switching from riveting to robotic welding, diffusion bonding.**
- **Your HS&E engineer says mercury has to go.**

## You find that your application is going through more heaters than usual

Both excessive thermal cycling and temperature swings can accelerate heater failure. This is especially true when it leads to high-frequency expansion and contraction of the heater (approximately 30 to 60 seconds on and off). Mercury switches are limited in their ability to control such thermal excursions, meaning that heaters can have a shorter lifespan and fail more often.

Another issue is moisture. Over time, the moisture in a humid environment (like that found on many factory floors) will seep into a heater and be absorbed by the insulating material (usually magnesium oxide (MgO)). When voltage is then applied to the heater, it can lead to a blown fuse or voltage arc, destroying the heater. For this reason, many applications use a “bake-out” phase when starting a heater. This requires a more modern controller, however, and so heater failure due to moisture is bound to be more common in some applications still using mercury switches.

<sup>1</sup> See, for example, [United States Patent US2085316A](#).



## You've had multiple switches fail, or even "blow"

Though mercury switches are known for their durability, they can still fail. When they do, the result can be messy. A switch that has overheated can crack or burst, potentially releasing mercury into the workspace.

Less dramatically, there is also evidence that mercury switches can experience a "bridging failure," where an accumulation of debris particles (NiHg<sub>4</sub>) in the mercury can form a kind of bridge between the contacts, causing the switch to fail.<sup>2</sup> This tends to happen to switches at higher temperatures, and can cause the switches to stick in an "on" position.

## Local laws or company policies are "going green"

If you are lucky, your facility has not had a problem with heater failure or switch failure. But it is still worth being proactive about switch replacement, given the increasing pressure on manufacturers over the past decade to "go green." That pressure is coming not only from governments, but also increasingly from policy decisions made by company leadership. While much press has focused on CO<sub>2</sub> emissions, the use (or rather, the discontinuation) of mercury is also a significant part of these environmental initiatives.



**In the U.S.:** The U.S. EPA, as well as several state EPAs, have banned mercury in a number of applications. While many of these restrictions speak to specific non-industrial uses—such as mercury switches in automobiles and thermostats—it is not too far of a stretch to imagine that states will be restricting the use of mercury relays and mercury switches in all but a few manufacturing applications.

Here is the EPA's stance on the issue, from its *Guide to Mercury Reduction in Industrial and Commercial Settings*:

**Mercury is a pollutant of concern due to its toxic and bioaccumulative properties. Large industrial complexes often use devices such as gauges, relays, switches, manometers and thermometers that contain mercury...These devices can leak or break, and when they do, the resulting uncontrolled mercury spills may pose dangers to human health and the environment and impact the facility's ability to meet discharge permit limits. In addition, properly cleaning up a mercury spill in order to meet current safety standards is extremely expensive.<sup>3</sup>**

**In Europe:** Europe has been even more aggressive in its stance toward the use of mercury and other substances in manufacturing, specifically via European Union's Directive 2002/95/EC, the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS). RoHS prohibits the use of six substances in electrical and electronic equipment in the EU: Lead (Pb), mercury (Hg), cadmium (Cd), hexavalent chromium (Cr 6+), polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE). Switches would thus be covered by RoHS.

<sup>2</sup> J. Bennett, M. Van Der Wielen, W. Asbell and M. Pinnel, "Prevention of Bridging Failure in Mercury Switches," in IEEE Transactions on Parts, Hybrids, and Packaging, vol. 12, no. 4, pp. 380-387, December 1976, doi: 10.1109/TPHP.1976.1135148.  
<https://ieeexplore.ieee.org/document/1135148>

<sup>3</sup> A full copy of this report can be found at  
<https://archive.epa.gov/region5/mercury/web/pdf/delta%20inst%20merc%20red%20guide%20ind%20comm%2001.pdf>.

## Your production line is switching from riveting to robotic welding, diffusion bonding

In many industrial processes, riveting is being replaced with robotic welding, and for good reason: Robotic welding is less labor intensive, uses less material and creates less waste. That said, it also has stricter specifications and requirements. Precise measurements and temperature control are needed.

Diffusion bonding is a solid-state welding technique, widely used to fuse sheets of dissimilar metals together. To do this, the metals need to be brought to a temperature that is approximately 50%-70% of the absolute melting temperature of the metals involved. Again, temperature control is important to get a proper weld, and the heater cannot experience too much swing during the process. Mercury switches are a poor fit in this application.

## Your HS&E engineer says mercury has to go

Even with all of the above, it is quite possible that the push to replace mercury relays comes more from inside your organization. If an internal HS&E engineer expresses concerns over mercury relays, or asks to consider other alternatives, it might be time to prioritize their replacement.

While there have historically been some applications where mercury relays make more sense, modern replacements have caught up in terms of lifespan, reliability and tolerance of dirty and difficult environments. Thus, replacing older mercury relays (or even older solid-state alternatives) might be the most financially feasible option in the long run, as well as the safest option.

## Things to look for in a mercury switch replacement

There are naturally some qualities that any switch must have in an industrial application—things like durability, accuracy and safety. The real question when looking for a mercury switch replacement is how a given switch will perform with regard to these qualities under usual operation conditions. It is worth asking about:

- **Durability** - How many cycles of switches can be performed before the part needs to be replaced (“switching life”)? What is its contact life? What is its heat tolerance like? What is its mechanical/vibrational tolerance like?
- **Accuracy** - How accurate does the switch need to be, and under what load and temperatures? What thermal excursion can be tolerated? Will you need RC suppression, or will your output device tolerate output leakage?
- **Safety** - Is the switch touch safe? Even if it becomes cracked or bursts? Does it have a tendency to heat up? Can it work with heaters that have higher watt densities?

Some other features to consider include:

- **Zero-cross switching**
- **Heat dissipation/need for heat sinks**
- **Three-phase operation (no need to wire multiple command signals)**
- **Touch-safe terminations**





## Have further questions?

For decades, Watlow has been manufacturing and selling both mercury-based and non-mercury relays and switches to control industrial process heaters. Our engineers and sales staff are happy to discuss the pros and cons of different switches and help your organization plan out its shift to non-mercury-based options. We can match a switch to your product's or application's unique specifications.



Further information is available at: [www.watlow.com](http://www.watlow.com)