

Switch contact design

A switch can be constructed with any mechanism bringing two conductors into contact with each other in a controlled manner. This can be as simple as allowing two copper wires to touch each other by the motion of a lever, or by directly pushing two metal strips into contact. However, a good switch design must be rugged and reliable, and avoid presenting the operator with the possibility of electric shock. Therefore, industrial switch designs are rarely this crude.

The conductive parts in a switch used to make and break the electrical connection are called *contacts*. Contacts are typically made of silver or silver-cadmium alloy, whose conductive properties are not significantly compromised by surface corrosion or oxidation. Gold contacts exhibit the best corrosion resistance, but are limited in current-carrying capacity and may "cold weld" if brought together with high mechanical force. Whatever the choice of metal, the switch contacts are guided by a mechanism ensuring square and even contact, for maximum reliability and minimum resistance.

Contacts such as these can be constructed to handle extremely large amounts of electric current, up to thousands of amps in some cases. The limiting factors for switch contact ampacity are as follows:

- Heat generated by current through metal contacts (while closed).
- Sparking caused when contacts are opened or closed.
- The voltage across open switch contacts (potential of current jumping across the gap).

One major disadvantage of standard switch contacts is the exposure of the contacts to the surrounding atmosphere. In a nice, clean, control-room environment, this is generally not a problem. However, most industrial environments are not this benign. The presence of corrosive chemicals in the air can cause contacts to deteriorate and fail prematurely. Even more troublesome is the possibility of regular contact sparking causing flammable or explosive chemicals to ignite.

When such environmental concerns exist, other types of contacts can be considered for small switches. These other types of contacts are sealed from contact with the outside air, and therefore do not suffer the same exposure problems that standard contacts do.

A common type of sealed-contact switch is the mercury switch. Mercury is a metallic element, liquid at room temperature. Being a metal, it possesses excellent conductive properties. Being a liquid, it can be brought into contact with metal probes (to close a circuit) inside of a sealed chamber simply by tilting the chamber so that the probes are on the bottom. Many industrial switches use small glass tubes containing mercury which are tilted one way to close the contact, and tilted another way to open. Aside from the problems of tube breakage and spilling mercury (which is a toxic material), and susceptibility to vibration, these devices are an excellent alternative to open-air switch contacts wherever environmental exposure problems are a concern.

Here, a mercury switch (often called a *tilt* switch) is shown in the open position, where the mercury is out of contact with the two metal contacts at the other end of the glass bulb:



Here, the same switch is shown in the closed position. Gravity now holds the liquid mercury in contact with the two metal contacts, providing electrical continuity from one to the other:



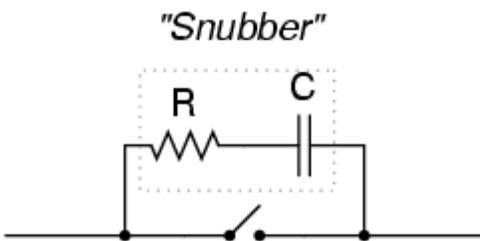
Mercury switch contacts are impractical to build in large sizes, and so you will typically find such contacts rated at no more than a few amps, and no more than 120 volts. There are exceptions, of course, but these are common limits.

Another sealed-contact type of switch is the magnetic reed switch. Like the mercury switch, a reed switch's contacts are located inside a sealed tube. Unlike the mercury switch which uses liquid metal as the contact medium, the reed switch is simply a pair of very thin, magnetic, metal strips (hence the name "reed") which are brought into contact with each other by applying a strong magnetic field outside the sealed tube. The source of the magnetic field in this type of switch is usually a permanent magnet, moved closer to or further away from the tube by the actuating mechanism. Due to the small size of the reeds, this type of contact is typically rated at lower currents and voltages than the average mercury switch. However, reed switches typically handle vibration better than mercury contacts, because there is no liquid inside the tube to splash around.

It is common to find general-purpose switch contact voltage and current ratings to be greater on any given switch or relay if the electric power being switched is AC instead of DC. The reason for this is the self-extinguishing tendency of an

alternating-current arc across an air gap. Because 60 Hz power line current actually stops and reverses direction 120 times per second, there are many opportunities for the ionized air of an arc to lose enough temperature to stop conducting current, to the point where the arc will not re-start on the next voltage peak. DC, on the other hand, is a continuous, uninterrupted flow of electrons which tends to maintain an arc across an air gap much better. Therefore, switch contacts of any kind incur more wear when switching a given value of direct current than for the same value of alternating current. The problem of switching DC is exaggerated when the load has a significant amount of inductance, as there will be very high voltages generated across the switch's contacts when the circuit is opened (the inductor doing its best to maintain circuit current at the same magnitude as when the switch was closed).

With both AC and DC, contact arcing can be minimized with the addition of a "snubber" circuit (a capacitor and resistor wired in series) in parallel with the contact, like this:



A sudden rise in voltage across the switch contact caused by the contact opening will be tempered by the capacitor's charging action (the capacitor opposing the increase in voltage by drawing current). The resistor limits the amount of current that the capacitor will discharge through the contact when it closes again. If the resistor were not there, the capacitor might actually make the arcing during contact closure worse than the arcing during contact opening without a capacitor! While this addition to the circuit helps mitigate contact arcing, it is not without disadvantage: a prime consideration is the possibility of a failed (shorted) capacitor/resistor combination providing a path for electrons to flow through the circuit at all times, even when the contact is open and current is not desired. The risk of this failure, and the severity of the resulting consequences must be considered against the increased contact wear (and inevitable contact failure) without the snubber circuit.

The use of snubbers in DC switch circuits is nothing new: automobile manufacturers have been doing this for years on engine ignition systems, minimizing the arcing across the switch contact "points" in the distributor with a small capacitor called

a *condenser*. As any mechanic can tell you, the service life of the distributor's "points" is directly related to how well the condenser is functioning.

With all this discussion concerning the reduction of switch contact arcing, one might be led to think that less current is always better for a mechanical switch. This, however, is not necessarily so. It has been found that a small amount of periodic arcing can actually be good for the switch contacts, because it keeps the contact faces free from small amounts of dirt and corrosion. If a mechanical switch contact is operated with too little current, the contacts will tend to accumulate excessive resistance and may fail prematurely! This minimum amount of electric current necessary to keep a mechanical switch contact in good health is called the *wetting current*.

Normally, a switch's wetting current rating is far below its maximum current rating, and well below its normal operating current load in a properly designed system. However, there are applications where a mechanical switch contact may be required to routinely handle currents below normal wetting current limits (for instance, if a mechanical selector switch needs to open or close a digital logic or analog electronic circuit where the current value is extremely small). In these applications, it is highly recommended that gold-plated switch contacts be specified. Gold is a "noble" metal and does not corrode as other metals will. Such contacts have extremely low wetting current requirements as a result. Normal silver or copper alloy contacts will not provide reliable operation if used in such low-current service!

REVIEW:

- The parts of a switch responsible for making and breaking electrical continuity are called the "contacts." Usually made of corrosion-resistant metal alloy, contacts are made to touch each other by a mechanism which helps maintain proper alignment and spacing.
- Mercury switches use a slug of liquid mercury metal as a moving contact. Sealed in a glass tube, the mercury contact's spark is sealed from the outside environment, making this type of switch ideally suited for atmospheres potentially harboring explosive vapors.
- Reed switches are another type of sealed-contact device, contact being made by two thin metal "reeds" inside a glass tube, brought together by the influence of an external magnetic field.
- Switch contacts suffer greater duress switching DC than AC. This is primarily due to the self-extinguishing nature of an AC arc.
- A resistor-capacitor network called a "snubber" can be connected in parallel with a switch contact to reduce contact arcing.

- *Wetting current* is the minimum amount of electric current necessary for a switch contact to carry in order for it to be self-cleaning. Normally this value is far below the switch's maximum current rating.

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