



*Ground Leakage and How to Reduce its Effect on Hot Runner Systems*

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By Peter Kalantzis

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All heating elements have a certain amount of electricity that “leaks” from the internal construction of the heater to the surrounding metal sheath. This leakage is typically not a problem where two conditions exist: a good ground connection between the mold connector and the tool steel and a good ground connection between the mold connector and the hot runner controller.

**What is ground leakage current?**

Leakage current can’t be seen, but those who have repaired hot half tools on a bench have noticed that if the tool isn’t properly ground they can receive a nasty electrical shock. That shock is the result of leakage current passing from the hot half plate through the person to ground.

*To understand leakage current you'll need a brief understanding of typical heater construction and what a ground is.*

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### Typical heater construction:

A heating element starts with a coil of Nichrome wire (the actual heating element) wound around a ceramic core, which is then placed in a metal sheath and surrounded by a thermally conductive, electrically isolating material — typically magnesium oxide (MgO).

To enhance the thermal conductivity between the coil and the metal sheath (moving heat away from the coil to the sheath), the MgO is compacted. This compaction completely surrounds the coil and transforms the MgO from what was once a loose powdery substance into a firm substance with limestone consistency.

The coil's two wires have to be connected to a controller, so a set of wiring leads are typically welded to the coil and brought out the back of the heater. In order to provide some strain relief and protection against moisture, the end is sealed with a high temperature epoxy.

### What is ground?

The nature of electrical circuits are a bit complex for this paper, but in simple terms every electrical circuit is based on its potential of electricity and ground gives us a reference for measuring those circuits.

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Suppose you are trying to measure two circuits — one an injection-molding machine and the other a temperature controller. The circuits are from two separate AC supplies, but the grounds are not connected. When an AC voltmeter is placed between the two grounds, you sometimes can detect AC voltage. The reason for this is the two grounds are at different potentials and leakage current is present.

*Source of leakage current:*

Now that we understand the construction of the heating element, let's look at the actual cause. Nearly every heating element used today in hot runner molding is constructed in such a manner where it has, or eventually will have, some leakage of current (voltage) to ground.

Picture a simple circuit of a light bulb, switch and battery in series. When the switch is closed the light bulb turns on. Current flows from the battery's positive terminal through the closed switch, through the light bulb and back to the negative terminal of the battery.

A circuit of leakage current is very similar to the light bulb circuit. Even though magnesium oxide is an insulator, a combination of a few things allow for leakage current to occur. The primary source is water. Moisture finds its way into a heating element because of the expansion and contraction of the wire seal.

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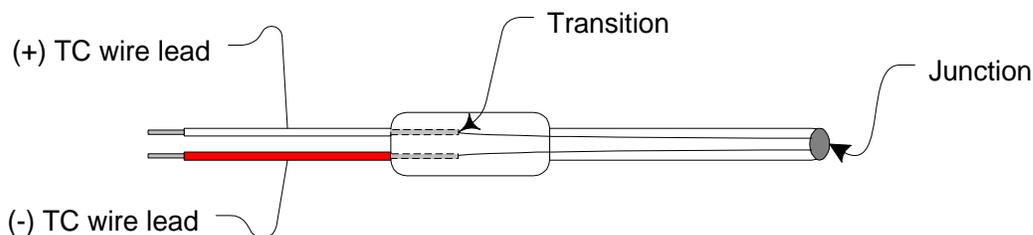
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Pure water is an insulator. It is the impurities in the water between the coil and the sheath that allows the connection to occur.

**Reliability: What happens when there is NOT a good ground between the tool – mold connector – controller?**

About 99 percent of all hot runner thermocouples produced today are known as grounded thermocouples. This means that the thermocouple has its junction or point of measurement welded together directly to metal sheath surrounding the two wires. (See diagram below.)



When the ground between the tool-mold connector-controller is missing or becomes worn (forms a slight resistance), the next best ground path is through the thermocouple wire. This then exposes two major weaknesses present today in all cases.

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First, the weakest point is in the hot runner control module. If enough current were present, the thermocouple input circuitry would blow. This happens on most hot runner controls today with the exception of the Pulse series which has ATP built into its input circuitry. When this failure occurs, the module usually is damaged beyond repair. This failure causes damage in the hundreds of dollars, not to mention the downtime.

The most cost destructive effect is when the transition in the thermocouple (this is where the small diameter wire is connected to the lead wire) becomes a weak point. With enough leakage current, this transition blows open. This failure is similar to a fuse blowing open. The failure here is not so much the inexpensive thermocouple but the expensive downtime of stopping production, opening the tool and replacing this thermocouple. This can cost thousands of dollars.

### **How does a ground get “lost” between the tool – mold connector – controller?**

There are numerous ways, but some of the most common:

1. In most situations the ground connection between the tool and the controller is through the mold box or junction box. The box itself serves as a grounding point when the box is properly mounted onto the tool – tightly. If the box loosens, it can intermittently break the ground connection between the tool and controller.
2. On each heater connector in the mold box there is a connection point for ground. If this connector is re-wired or replaced, the ground is almost always forgotten or ignored. This

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ground is the main point of guarantee that the ground is connected between the tool and controller.

3. The controller itself is not grounded. On the power input the ground is loose or not connected.

### **If I ensure that I have a good ground why do I need ATP?**

In almost every case in an injection molding machine where consistent high amplitude vibration is present, there is an opportunity for the mold box to loosen. This can in turn loosen the ground, if it is left unattended.

### **How does ATP work?**

ATP is a “non-powered” circuit specially designed for hot runner applications. There are basically two points of protection. First, it contains a resettable PTC or “positive temperature coefficient device” that goes into a high resistive protection mode when excessive current is present. It basically opens the thermocouple circuit protecting the junction and controller input circuitry. Second, a specialized protection device turns excessive “noise” and leakage current into heat. This is primarily used for any short duration pulses present in all industrial applications. This device serves a second function in cleaning up any noise present and giving the controller a “cleaner” and more accurate signal to work with. Finally, it assists the PTC in its function in protecting against leakage current.

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**When the PTC opens, when will it close again?**

The PTC device's main purpose is to remain in an open state showing up as an open thermocouple on the diagnostics in the hot runner controller. Once that ground fault is removed (by tightening down the mold box or reconnecting the ground wire), the PTC will automatically reset itself. This saves the thermocouple from blowing open and a control module from becoming unusable.

**So what is ATP?**

ATP can be thought of as a “guard dog” against leakage current. It is always there and ready to assist in the protection of the thermocouple transition and control module.

**Do I have to connect any power to the ATP once I connect the Smart Mold Box™ to my tool?**

No, the ATP circuit does not require any power. It is powered by the thermocouple connection.

**Does the ATP affect the thermocouple reading?**

No, it continues to output the standard acceptable range of temperatures. There is more loss seen through connections in the thermocouple cable and mold connector than through the ATP circuit.

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