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TECH MEMO

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Re: **Heat Limit *(HLS-II)* Output Considerations**

Background:

The FireRight Heat Limit Controller II (HLS-II) is a small directional temperature limit controller, typically used to provide over-temperature protection for test chambers, ovens and other industrial equipment using electric heaters.

The HLS-II provides a simple normally open relay contact as its output. When the measured temperature is within limits, the contact is closed. When the temperature exceeds the limit setting, this relay contact opens. This contact is ordinarily used to disable the definite purpose contactors that provide electric current to the heating elements.

Since the solenoid coils of typical load devices ... definite purpose contactors, and especially mercury relays ... are inductive components, the output is bypassed by a “snubber” composed of a 0.1uF film capacitor connected in series with a 100-ohm resistor, as a means of preventing RFI arising from arcing at the contact.

When the output is used in ac circuits, and connected to certain solid state devices or small relays, the small leakage current that passes through this snubber can result in a loss of protection if it exceeds the “holding current” specification of the load device ... which is usually considerably lower that the current required to actuate it.

Technical Considerations:

For example, a popular small relay manufacture by Potter & Brumfield, Omron and many others has the following specs:

Pull-In Power -	**Nominal:**	**915mW**
	Minimum:	**700mW**

Although manufacturers guarantee that this relay will actuate with as little power as 514mW, some units will in fact actuate with as little power as 230mW.

The “Holding Power” for these relays is much less than the pull-in power. Bench tests indicate that once closed, these relays will typically remain closed until the power applied to their coil drops below 40mW.

The snubber network used in the Heat Limit Controller has an impedance of about 26.6k-ohms. The above relays have an impedance of about 15K-ohms. Since the snubber’s impedance derives almost entirely from capacitive reactance X_c while that of the relay derives partly from inductive reactance X_L the resulting impedance of the series connection of these two circuit elements is their vector sum. In practice this turns out to be about 2/3’s of X_c ... about 18K-ohms.

With the output contact open, the snubber will therefore permit a current of about 6.4mA through the output circuit. Although this is less than the specified minimum pull-in power for this relay, it is greater than the “real world” minimum identified above.

The result is that the output leakage current of the Heat Limit Controller is sufficient to actuate a small number of these little relays. In other cases, the situation may be more marginal, and with the coil of the relay “biased” by the snubber leakage current, a small amount of shock or vibration may be enough to permit the relay to close. And, of course, the electrical and mechanical characteristics of these little relays also varies with temperature.

In any case, the snubber leakage current is sufficient to hold these relays closed, once they are actuated.

Power relays typically have a “sealed” coil current of at least 90mA on 115vac, and typically require as much as an amp for pull-in. Even standard size “control relays” (P&B type KUP, for example) usually require something in excess of 1-watt for pull in. So these larger relays present no problems.

Using miniature relays in control circuits with the Heat Limit Controller, however, can result in a total loss of control. In some cases, the situation may be marginal, so it is not wise to assume that because one unit works as expected, all will perform reliably. If such relays must be used, be sure to get some detailed specifications and do the arithmetic to assure that they will perform reliably under all circumstances.

Solutions:

When non-compatible miniature relays must be used, a quick way of resolving the reliability question is to disable the snubber by simply clipping it's 100-ohm resistor, which is found just above the "012014" marking on the HLS-II's printed circuit board. If RFI/EMI problems then arise, they can ordinarily be fixed by adding a similar network across the terminals of the offending load device.

Another way to solve the problem while retaining HLS-II inter-changability is to shunt the relay coil with a "swamping" resistor. The size of this resistor must be selected so that it takes the open-contact voltage across the relay coil well below its lowest "holding" value.

This must usually be done empirically, since the holding power isn't usually specified on relay data sheets, and is usually widely variable. The drop-out voltage can easily be observed by adjusting the power to the rely coil using a variac (not a light dimmer), or using a potentiometer as a rheostat. Once the drop-out voltage is determined, choose a resistor value that pulls the coil voltage below this level when connected to the open contacts of the HLS-II. A good starting point is to select a resistor size which is about equal to the X_L of the relay coil:

$$R_X = 115v/I_L$$