# Humidor Humidity and Temperature Modification

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Rev 4: 10/23/14

Rev 4: Update for operating data after 1 year. Minor changes in the Controller's settings due to sensor placement change in the humidor to produce improved accuracy of temperature and humidity.

This report details modifications to my humidor to control the internal temperature and relative humidity. The object is to allow the cigar humidor to operate in normal room conditions without need of room air conditioning.

The excessive humidity and temperature control problems in my cigar humidor is solved!

## The Problem:

70F and 70% RH is a goal of many cigar aficionados who want to keep their smokes as fresh as possible. Controlling the temperature is a problem mainly in the summer. So a Peltier effect cooler was installed to solve the 70F temperature. The automatic humidifier, Cigar Oasis XL Plus, maintains the 70F + 70% RH goal, so now all is achieved. So I thought!

During summer months, weather conditions can completely ruin these goals. Outside weather can cause the cigar "room" to experience high temps along with high humidity. Then this heated, wet “air” ingresses the humidor and dramatically changes/effects the humidor's operation. The 70F / 70% RH goal is now extremely difficult, if not impossible, to attain or maintain under these conditions.

Many think that a humidor is a "closed" (or sealed) system but it's NOT! Certainly a humidor constructed of wood can't be considered as "sealed". In fact this humidor is porous due to the wood only construction. When ambient conditions exceed the desired humidor internal conditions, the external conditions *always* modify the desired settings. ** This principle is inviolate! You'd be surprised how many cigar-experts don't understand this simple physics principle!

** **Heat Load Calculations:**

To see what effect that "conditions" have in the design of a TE cooled humidor, a heat load analysis is performed where input parameters such as the humidor's make-up (how it's constructed along with what materials are used) and the room's ambient conditions are considered. The results will size the TE cooler's "watts" and resultant temperatures including the very important "dew point" temperature.

For a 7.6cu ft humidor, 22" x 22" x 27" x 1.25" thick - wood/cedar, placed in a non air-conditioned room, the results might surprise you. The results show the heat load (no internal power dissipation) entering through the cabinet calculated with the desired **70F humidor operating temperature** with no loss from door seals, window glass, etc. being included. The actual results in the real world will be a bit worse than the calculations below; **Pwr btu/hr = 3.393 x P watts**

| Description | 84F / 80%RH | 78F / 78%RH | Remarks |
|---|---|---|---|
| Total Heat Load [HL]: | 59.3 W (201 BTU) | 33.9 W (115 BTU) | HL drops 43% |
| Exterior Wall Temperature: | 80.0 °F | 75.7 °F | |
| Interior Wall Temperature: | 72.5 °F | 71.4 °F | |
| Dew Point [DP] Temperature: | **77.2 °F** | **70.6 °F** | |

For case 1, there is excessive moist air that must be removed b/c of the high **77.2 °F** Dew Point temperature.

For case 2, even seemingly mild temperature and humidity conditions yield a **70°F Dew Point** temperature, so some moist air will be generated.

Notice that the Heat Load for case#1 is almost double that of case#2, so it should be clear by now that ambient conditions actually **dictate** how the humidor ***must*** be designed. Clearly shown is that some form of dehumidification is necessary to remove moist air in both cases. It's either that or smoke soggy cigars!

The TE cooler that's is cooling the humidor now becomes an enemy! Why? The cold plate on the TE cooler condenses the humid air and extracts water that the TE cooler's fan atomizes and blows it into the humidor. The RH can climb to very high levels that if sustained, will ruin the cigars.

For the months of August thru September, the weather has been awful; outside it was 96F with 90% RH, a veritable steam bath! The cigar room temperature sees 84F with 80% RH with the home's AC off. When I open the humidor's door for only 2 secs, the humidor's RH increased by 3 points! Something has to be done, quickly! There are two (2) distinct problems to solve; humidity control first and temperature control last.

The Humidity Fix:

I purchased a small Peltier effect de-humidifier to remove water from the moist air. The unit is an Eva-Dry Petite 1100 dehumidifier (ED-1100) unit shown in the picture. It contains a 16oz water reservoir that automatically switches the unit off when full via a 'float bar', as it's called. Price is apx $45. It uses a small fan (very quiet) to draw air from the front, dehumidify it and send it out the top. The condensate is collected in the plastic tray below.

The unit is 6" W x 4" L x 8" H, consumes 22W and fits nicely in the back corner of the humidor. It's the smallest electronic dehumidifier on the market today but has 1100 cu ft capability. This is obviously much more than my 7.6 cu ft humidor requires! The good news is the large capacity allows for a short run time to lower the humidor's RH. The dehumidifier run time is around 2 - 4 mins so it takes a long time to fill the water reservoir. Simple to operate; place the unit into the humidor, plug in the power cable, set the ON/OFF toggle switch to the "on" position and it's ready to go.

Next, I purchased the WH8040 Humidity Controller. It provides negative feedback to the humidor's TE cooler such that when pre-set conditions are exceeded, the controller energizes an internal relay that turns on the ED-1100 dehumidifier. Wiring is shown below.

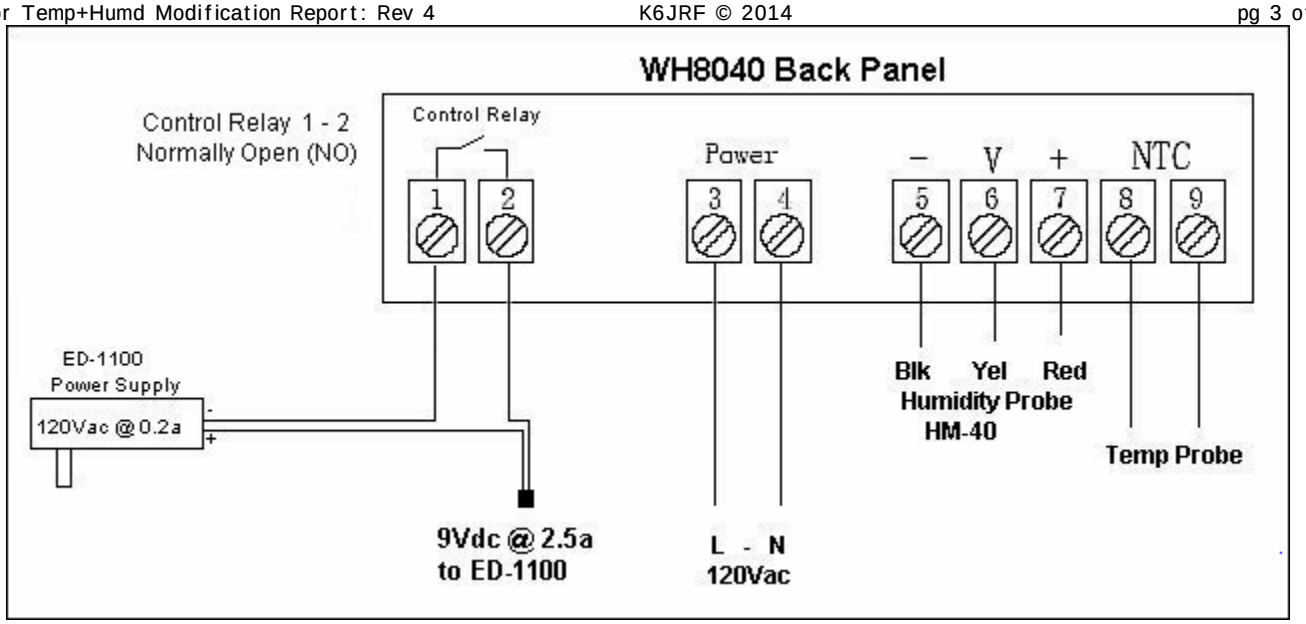

The unit measures 2"W x 3"D x 1.25"H. It requires 2 watts operating power supplied from 120Vac. Overall accuracy is +/- 5%RH. Long term stability = 0.5%RH/yr. Current market price is $25.

It has two (2) main inputs; a calibrated humidity and temperature probe. The object is to locate both probes into the humidor in an area that represents the most accurate summary of the humidor's temperature and humidity. Once mounted, the probes are wired into the main unit along with AC power and relay I/O.

Practically, there will be difference in readings from two different devices, so use of the WH8040's "CA" function allows the humidity reading to be corrected to read closely to the "calibrated" hygrometer.

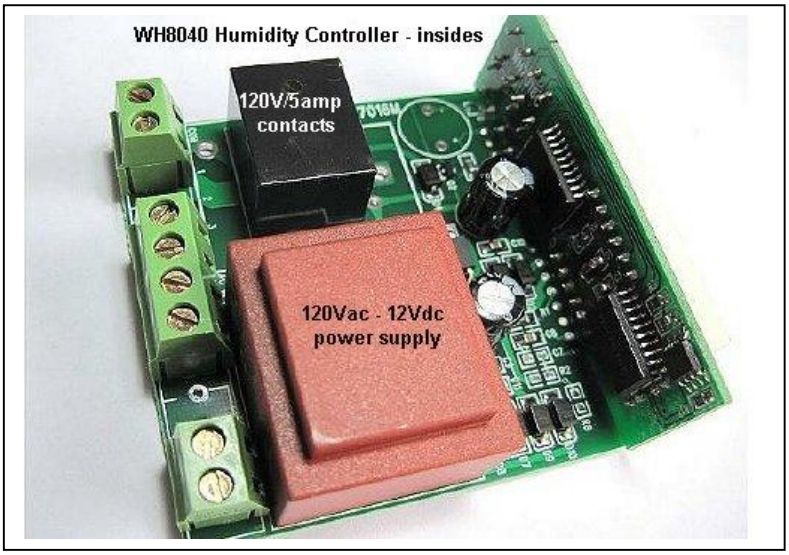
The temperature sensor (NTC sensor) gives more precise humidity measurements b/c it temperature compensates the humidity probe. It should be installed in the vicinity of the humidity probe. This may require some experimentation. Once located, the sensors do not need to be moved. The detailed WH8040 controller's operation is explained below.

Connection to the WH8040 is straightforward. The wiring/interconnection diagram is shown below:




The object is to wire the WH8040 control relay's NO contacts in series with the low voltage side of the power supply output (9Vdc @ 2.5a) that powers the ED-1100 dehumidifier; cut the "minus" side of the two-pair output cable and wire it in series with the WH8040's control relay as shown.

There's no need to control the "AC" side, although you could if you wish. This method is preferred and is very safe since the total power switched is apx 22 watts with no high-voltage.




Normal controller operation is; when the RH level exceeds the upper limit (HS) plus hysteresis (D), the control relay is energized to start an external appliance. When the RH level falls below the lower limit (LS), the control relay is opened.

The WH8040 operates differently; when the RH level exceeds the Set Limit plus the hysteresis (D) setting, the control relay closes. When the RH level falls below the Set Limit, the control relay is opened. In the end, the controller accomplishes the same effect with subtle differences. You MUST ensure that the Set Limit equals your lowest desired humidity level; press "Set", with up/dwn buttons, make sure it is what you want.

The unit's settings are summarized in the table below with my settings in the "K6JRF Settings" column. The manual is translated from Chinese and is a bit difficult to follow. However, the control settings are not difficult to understand and are self-explanatory. You can access the internal menus by pressing the "Rst", "Set" and “up" / "dwn" buttons in various combinations. When the "Work" LED illuminates, the programmed limit has been exceeded and the control relay is closed. The "Set" LED when illuminated shows the current Set Limit point for humidity.

C = Dehumidifier mode; this activates a relay when the RH level exceeds the Set Limit + hysteresis. I use the "C" mode.
H = Humidifier mode: this activates a relay when the RH level is less than the Set Limit.
D = Hysteresis; increasing this settings directly adds to "delay" by adding it directly to the current RH level, mine = "1".
LS = Lower limit; any reasonable limit here, mine = "71".
HS = Upper limit; any reasonable limit here, mine = "72".
CA = Humidity Offset; provides an offset to probe's reading, mine = "1" [CA = 1, then if probe = 70, unit reads = 71].
PT = Delay time before relay is closed, mine = "0"

- Make sure that the parameter "Set Limit" is programmed to lowest value for the range (HS - LS); mine is "71" -

**WH8040 Humidity Controller Settings**

| Symbol | Details | range | K6JRF Settings | Units |
|---|---|---|---|---|
| HC | **Humidifier/Dehumidifier** | H = Humidifier<br>C = Dehumidifier | C | - - - - - |
| D | Hysteresis | 1~15 | 1 | % RH |
| LS | min limit | -50~110 | 71 | % RH |
| HS | max limit | -50~110 | 72 | % RH |
| CA | **Humidity Offset** | -5~+5 | 1 | % RH |
| PT | Delay time | 0~10 | 0 | Minutes |

The humidity sensor is mounted to the left of the WH8040 on the back wall. The reference temperature sensor is located near the humidity probe near the TE Cooler. This placement represents the most accurate readings for my installation and gives high correlation with the analog hygrometer. The ED-1100 starts at 72%RH and shuts off at 70%RH.

Compare the internal analog meter's RH (70%) with the WH8040's reading of 70.7%.

## The Temperature Fix:

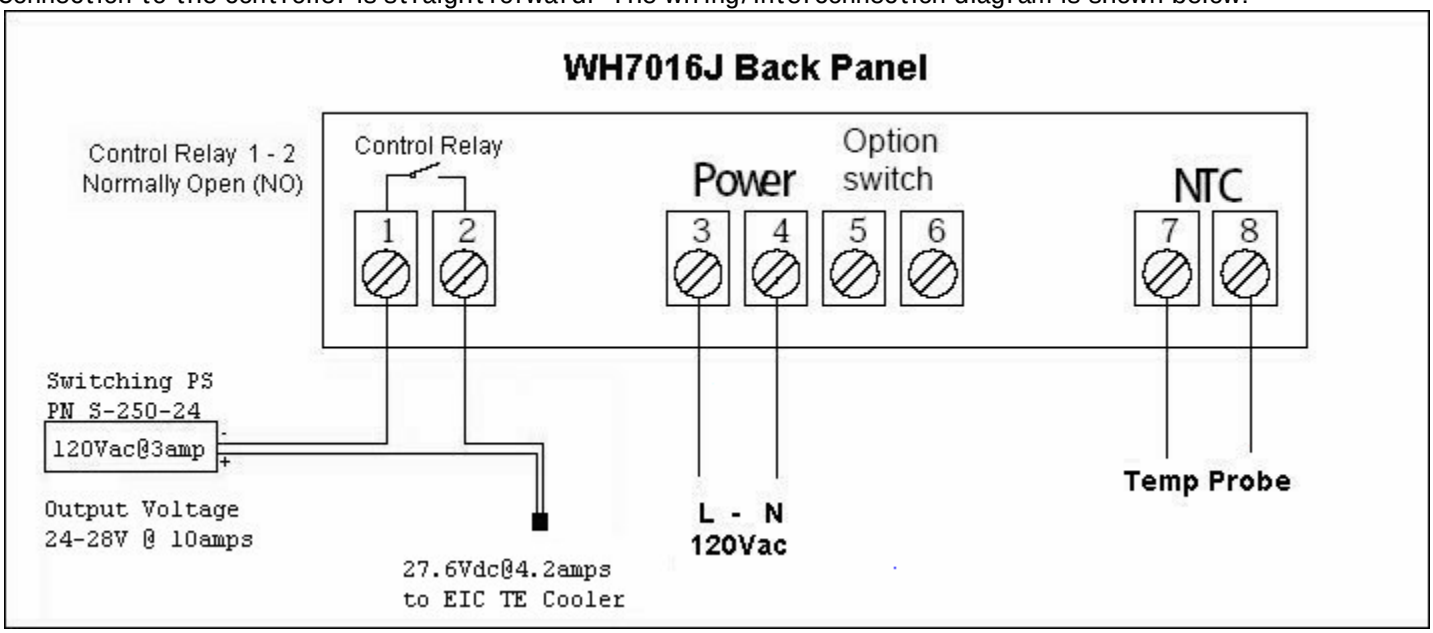
I purchased the WH7016J Temperature Controller that reads directly in degrees Fahrenheit. It provides feedback to the humidor's TE Cooler such that when pre-set conditions are exceeded, the controller energizes an internal relay that turns on the EIC TE Cooler to lower the humidor's temperature. Wiring is shown below.


The unit measures 2"W x 3"D x 1.25"H. It requires 2 watts operating power supplied from 110Vac. Overall accuracy is +/- 0.5F. Long term stability = 0.25F/yr. Current market price is $19.

It has one (1) main input; a calibrated temperature probe. The object is to locate the probe in an area that represents the most accurate summary of the humidor's temperature. Once mounted, the probe is wired into the main unit along with AC power and relay I/O connections.

Practically, there will be difference in readings from two different devices, so use of the WH7016C's "CA" function allows the temperature reading to be corrected to read closely to the "calibrated" thermometer.

Connection to the controller is straightforward. The wiring/interconnection diagram is shown below:




The object is to wire the WH7016J control relay's NO contacts in series with the low voltage side of the power supply output (27.6Vdc @ 4.2a) that powers the EIC TE cooler; cut the "minus" side of the two-pair output cable and wire it in series with the WH7016J's control relay as shown. There's no need to control the "AC" side, although you could. This method is preferred and is very safe since the total power switched is apx 116 watts with no high-voltage. A new PS replaced the failed EIC PS furnished with the TE Cooler. The output voltage was increased apx 16% resulting in 12% more cooling power.

Normally, a temperature controller operates as follows; when the temperature level exceeds the upper limit (HS) plus hysteresis (D), the control relay is energized to start the external appliance. When the RH level falls below the lower limit (LS), the control relay is opened.

The WH7016J operates differently; when the temperature exceeds the Set Value plus the hysteresis (D) setting, the control relay closes. When the temperature falls below the Set Value, the control relay is opened. In the end, the controller accomplishes the same effect with subtle differences. You MUST ensure that the Set Value equals your lowest desired temperature point; press "Set", with up/dwn buttons, make sure it is what you want.

The unit's settings are summarized in the table below with my settings in the "K6JRF Settings" column. The manual is translated from Chinese and is a bit difficult to follow. However, the control settings are not difficult to understand and are mostly self-explanatory. You can access the internal menus by pressing the "Rst", "Set" and "up"/"dwn" buttons in various combinations. When the "Work" LED illuminates, the programmed limit has been exceeded and the control relay is closed. The "Set" LED when illuminated shows the current Set Limit point for temperature.

C = Cooling mode; this activates a relay when the RH level exceeds the Set Value + hysteresis. I use the "C" mode.
H = Heating mode: this activates a relay when the RH level is less than the Set Value.
D = Hysteresis; increasing this settings directly adds to "delay" by adding it directly to the current temperature, mine = "1".
LS = Lower limit; any reasonable limit here, mine = "70".
HS = Upper limit; any reasonable limit here, mine = "71".
CA = Temperature Offset; provides an offset to probe's reading, mine = "0" [CA = 0; if probe = 70F, unit LED readout = 70F].
PT = Delay time before relay is closed, mine = "0"
AH = Hi temperature Alarm; to alert you if upper temperature set point + AH is exceeded, mine = not used.
AL = Lo temperature Alarm; to alert you if lower temperature set - AL is exceeded, mine = not used.
AT = Timer Off; to use as countdown timer to shut off controller after programmed time, mine = not used.

=Make sure that the parameter "Set Value" is programmed to lowest value for the range (HS - LS); mine is "70"=

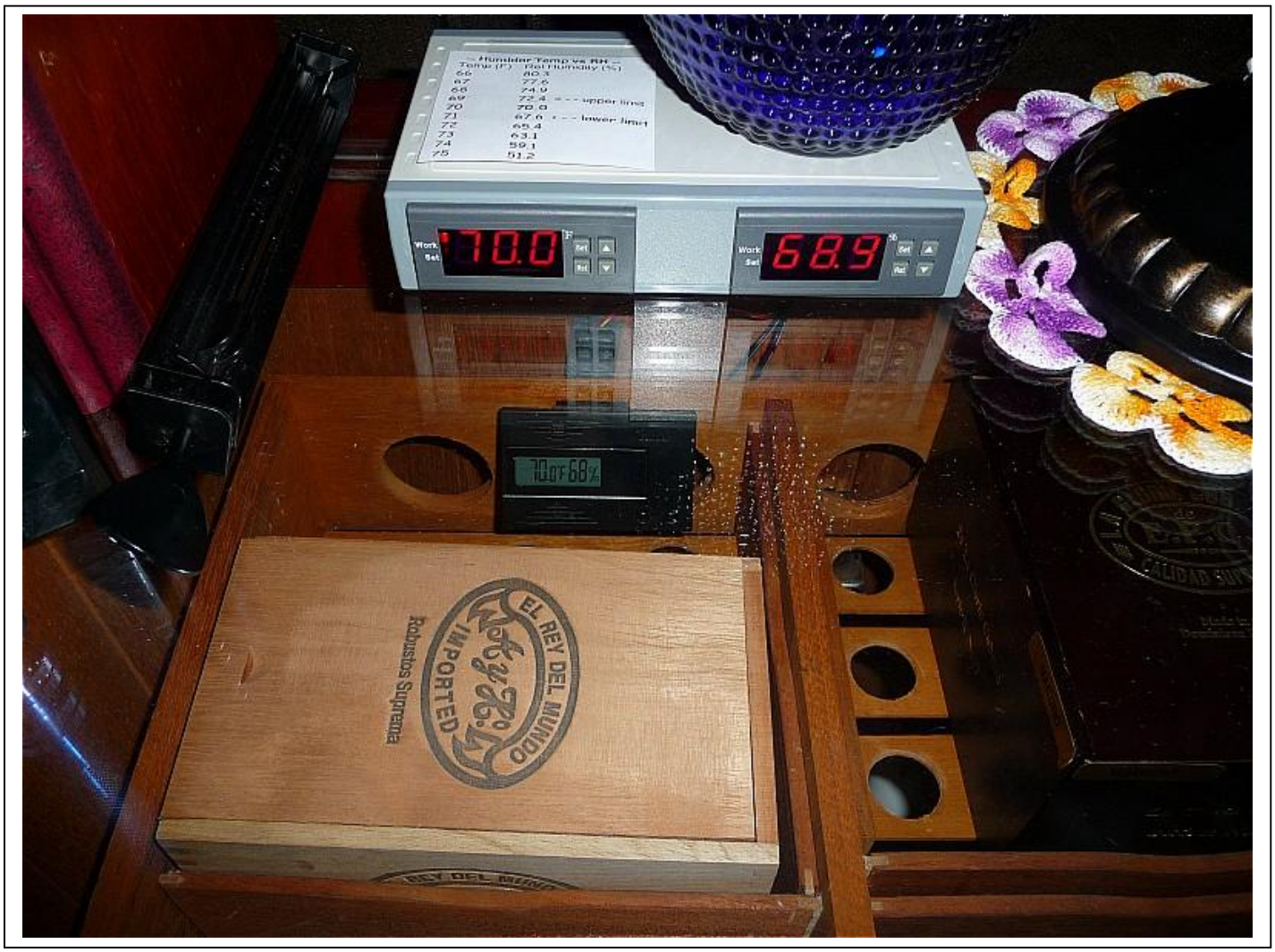
**WH7016J Temperature Controller Settings**

| Symbol | Details | Set Range | K6JRF Settings | Units |
|---|---|---|---|---|
| HC | Heating/Cooling | H / C | C | ------ |
| D | Hysteresis | 1 ~ 15 | 1 | deg F |
| LS | Min Limit | -58 | 70 | deg F |
| HS | Max Limit | +235 | 71 | deg F |
| CA | Temp Offset | -5 to +5 | 0 | deg F |
| PT | Delay Time | 0 ~ 10 | 0 | Minutes |
| AH | Hi Temp Alarm | Hi Alarm Limit | N/A | deg F |
| AL | Lo Temp Alarm | Lo Alarm Limit | N/A | deg F |
| AT | Timer Off | Countdown Timer | N/A | Minutes |

The WH7016J's temperature probe is mounted near the WH8040's temperature probe on the side of the TE cooler. This placement represents the most accurate readings for my installation and gives high correlation with the analog thermometer.

**-- Humidor Temp vs RH for Cigar Storage--**

| Temp (F) | Rel Humidity (%) | |
|---|---|---|
| 66 | 80.3 | |
| 67 | 77.6 | |
| 68 | 74.9 | |
| 69 | 72.4 | < - - upper RH limit |
| 70 | 70.0 | |
| 71 | 67.6 | < - - lower RH limit |
| 72 | 65.4 | |
| 73 | 63.1 | |
| 74 | 59.1 | |
| 75 | 51.2 | |




Compare the internal analog meter's indicated output with the WH7016J (left) and WH8040 (right) readings. The temperature reads 70.0F is the same as the controller's reading of 70.0F. The humidity reading of 68% compares nicely with the controller's readout of 68.9%. Not bad in anybody's book!

Note that the temperature controller is in the 'active' mode since the Work LED is illuminated. This means that the TE Cooler is actively cooling the humidor.

I put both units into a plastic "project box" complete with rubber feet to make a clean installation that is easy to move if need be.

Summary & Conclusions:

The addition of the WH8040 Humidity controller, ED-1100 Dehumidifier and the WH7016J Temperature controller to my humidor has made a substantial change in its operation.

In operation for about 14 months and I'm pleased that my humidor now holds 70F, +/-1 deg and 70%, +/- 1.5% RH all day, every day for an ambient room temperature range of normal room (~ 70F) to an upper temperature of 80F. It will hold the stated range within this temperature range. For higher temps such as 84F, the humidor rises about 1deg F b/c the TE Cooler's 200 BTU/hr capability is exceeded. The humidity control is not affected.

For a 71F room, the system cycles about every 40 mins; 6mins on and 34mins off. At higher room temps, the duty cycle changes to as much as 20mins on, 10mins off. Again a TE Cooler w/ large BTU/hr reserve would improve this.

Previously, the humidity would range from nominal 70%RH to as high as 80%RH. During the summer months when the temperature and humidity was high, the cigars could 'soak' in this excessive humidity for months! Obviously not a good thing for the sticks!
Street price for the added hardware; WH8040 for $25; WH7016J for $19; ED-1100 for $45. So for a modest expenditure of $89 you can completely control the humidor's operation to the benefit of your smokes!

The snap-together case, MBS-818 can be purchased from All Electronics on the web; www.allelectronics.com

The completed humidor, finished in cherry wood, resides in the living room and is 'wife-approved'.

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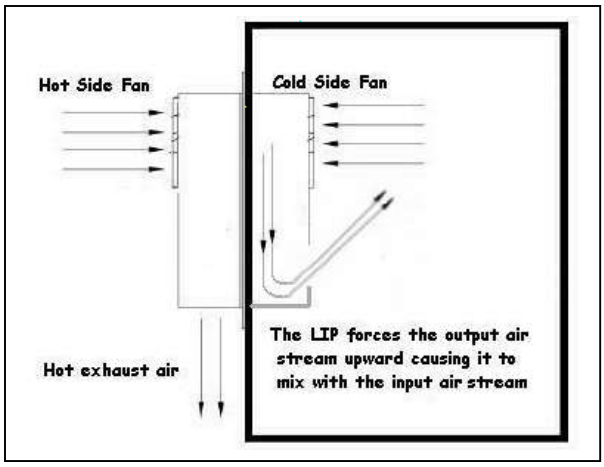
# Appendix: Cabinet and TE Cooler Changes

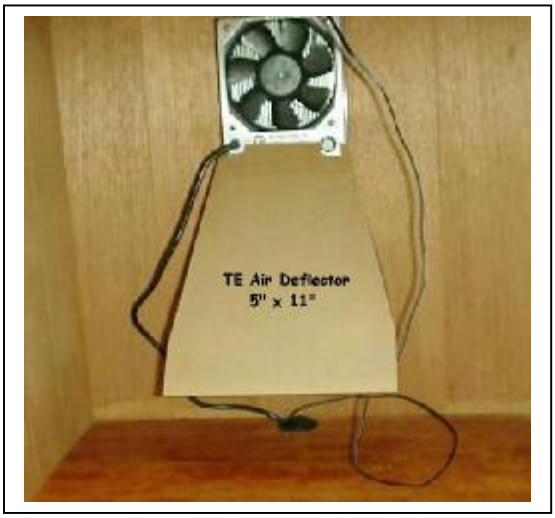
One of goals for this humidor experiment was to see if some improvement of the overall humidor operation could be achieved by making changes to the TE Cooler and cabinet.




As part of this effort, changes were made to the EIC TE Cooler (AAC-120-4XT). As delivered, the hot and cold side fans were not as shown in the sales brochure; they were reversed.

After making some measurements, I REVERSED both fans as shown in the sketch to the right. Both hot side and cold side fans have been operated this way for five (5) years.

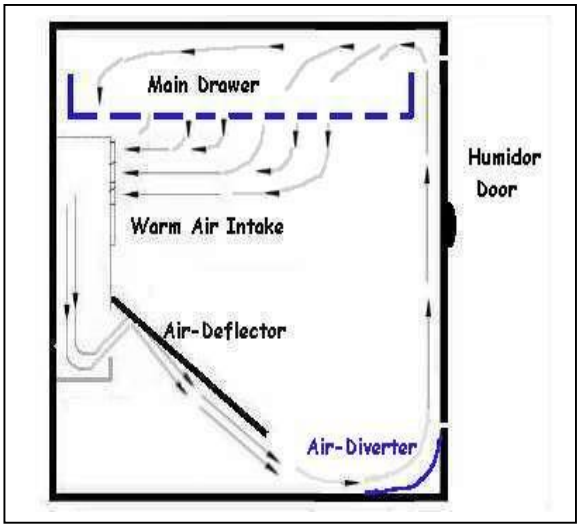
The "LIP" (the ridge in the bottom of the condensate collector) on the cold side causes the output air to go upward causing it to mix with the input air stream. An air deflector was designed and installed to make sure that the air streams were not mixed.




Some have commented that the restricted air could cause excess moist air generation. This was never able to be conclusively proved one way or the other but it was easy to see water vapor 'droplets' in the cold side heat sink when it was near, at or below, the dew point temperature!

The air deflector does at least two (2) things: the obvious is that it directs the cooled output air away from the cigar drawer and onto the floor. The sketch shows how the air flows inside of the humidor. The air-diverter increases the airflow efficiency allowing more of the air to flow up the door panel and into the main cigar drawer. The output air stream from the TE cooler is at least 15 CFM and so no additional fans are needed.

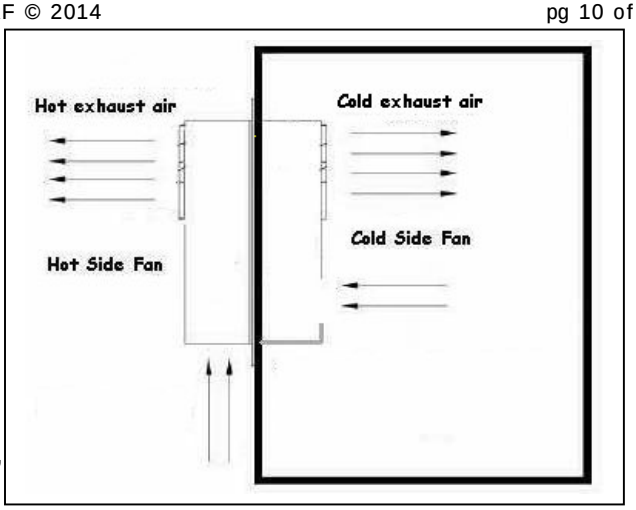
The picture shows the 5" x 11" tapered air deflector diverting the cold air stream downward to the floor.




The second, not so obvious, is that the intake air stream and output air stream are not mixed as they were before. The "lip" on the TE cooler causes a portion of the output air stream to deflect upwards and mix with the input air being drawn into the cold side intake as shown in the sketch. This adds more humidity to the already moist air stream. With the air-deflector in place, the air streams are totally separate. Separating the two air streams *seemed* to lower the humidity level in the humidor. However, based on the fan reversal, I'm now not sure that both additions were really beneficial.

Once the air deflector was installed it was obvious that the air flow would "bang" into the interface of the floor and wall, so an air diverter was built and installed to shape the air flow upward along the door, up to the top of the cabinet and then to be drawn into the air stream going to the TE cooler's air input. It worked quite well b/c when the door was opened, the air stream could easily be felt.

The direction of the both fans was revered; the hot side fan draws air from the 'floor' and exhausts it out the top and front of the fan. Similarly, the cold side fan was reversed so that air is also drawn from the 'floor' and exhausted out the top. No water droplets have been seen so far with the fans in this mode. However, humidity has been lower than when this effort was first undertaken.



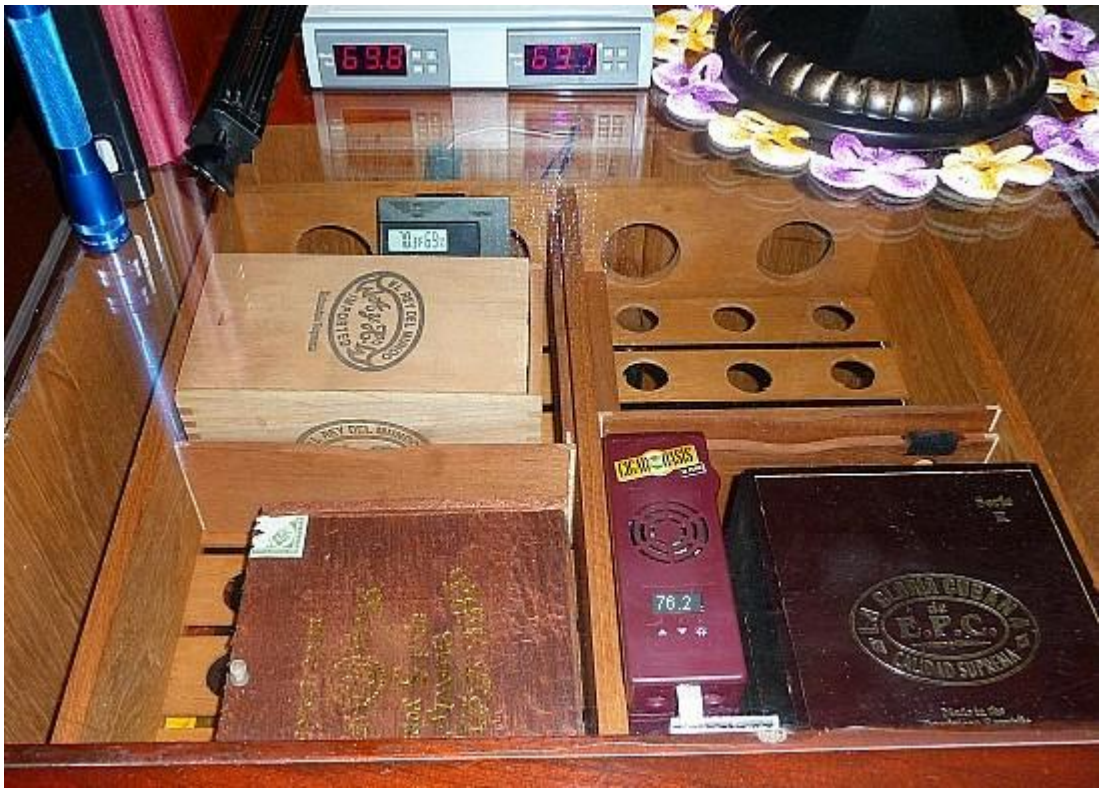

The air deflector and air diverter were removed and discarded. Reversing the cold and hot side fans has resulted in better humidor operation. Haven't seen water droplets forming on the TE Cooler's cold side heat sink but in fairness, the humidity has been lower. With the fan's reversal, there seems to be no need for these parts.

Humidifier:

A Cigar Oasis XL Plus (CO XL+) humidifier keeps the humidor at apx 70%RH during "normal" weather conditions found in San Diego over most of the year. It is rated for up to 10cu ft humidor. Testing shows that it is near its humidity limit in my 7.6 cu ft humidor. It requires an RH "offset" but does work ok.

One of its positive features is that it's "sealed", ie it does not 'leak' humidity into the humidor. Unlike other units, the CO XL+ completely stops its fan and so there's minimal RH leakage if any. It's has its own humidity controller and when the 'correct' setting is arrived at (through trial), it is quite good. Due to its limited capacity, you must set the RH sensor to apx 5% higher in order to achieve the correct RH level in the humidor.

The CO XL+ is placed in the front compartment and elevated to raise its output above all of the cigars. It is set to 75.0% RH to maintain apx 70%RH in my humidor. The picture shows the humidor's current RH as 76.2% at the CO XL+. It will vary a lot b/c it depends on the ambient conditions. It has its own internal controller and after you find the correct setting for your humidor, the WH8040 will now "fine-tune" the overall humidor's RH level.

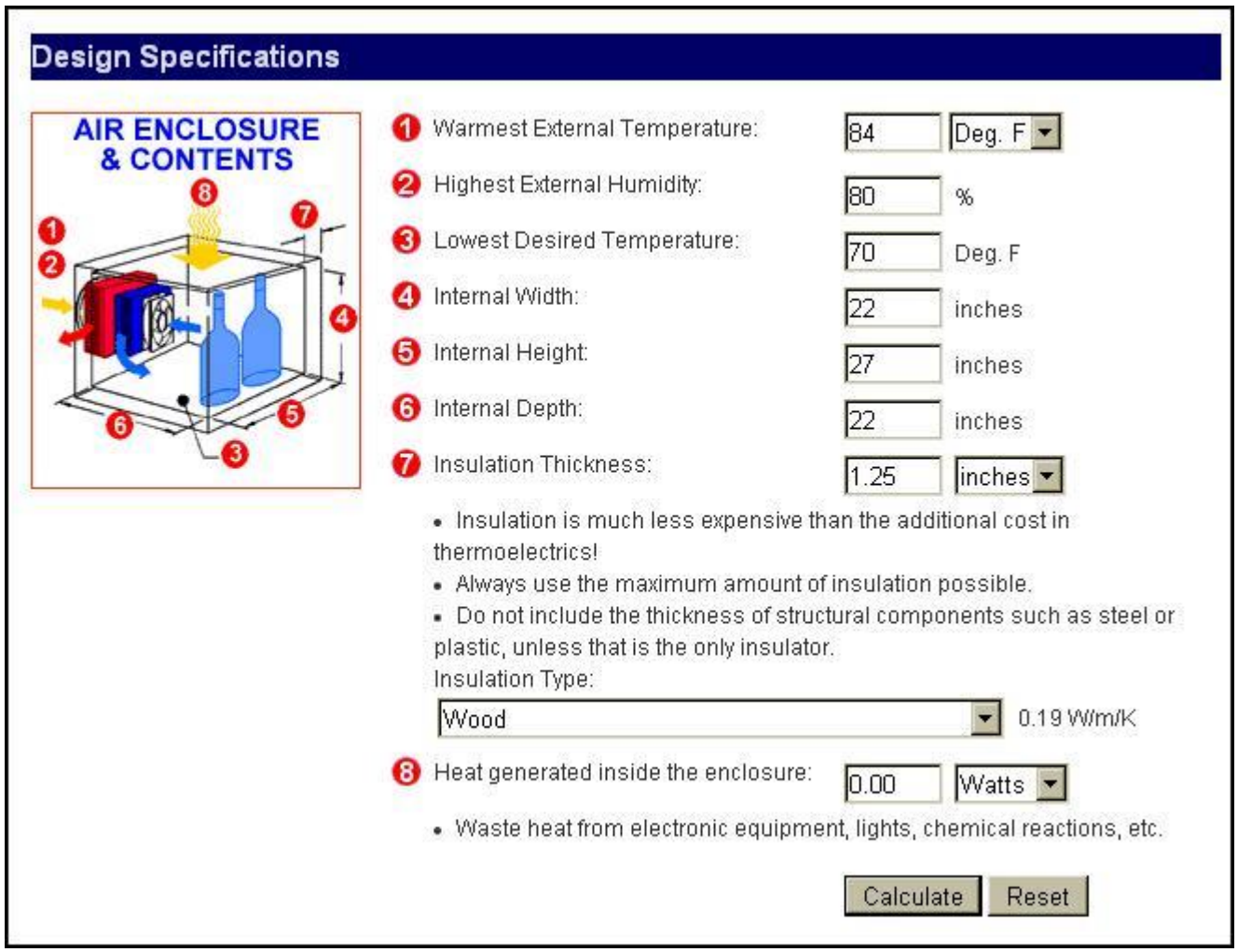


TE Cooler Sizing Design

Have received some requests for humidor design data specifically for the required TE cooler sizing. So I've added current links that supply design calculations online or via downloadable software.

The one I used on the page 1 for the Heat Load analysis is an easy to use online design tool. All you need do is connect TE Tech's site specifically to "TE Technology's Cooling and Heat Load Calculator". With it you can size the TE cooler in Watts or BTU/hr, for your given humidor size, construction (wood) plus insulation or not. It's very easy to use and will put you in the ballpark for the required TE cooler's power needed to cool the humidor.

The main online link is: http://www.tetech.com/Cooling-Assembly-and-Heat-Load-Calculator/index.php First select "Air Enclosure and Contents". Then select dimensions (mm or inches), select temp units (deg C or deg F) and then enter the dimensions (L x W x H) for your humidor. Enter the warmest external temp (ex 84F) and the highest external humidity (ex 80%). Next enter the desired humidor inside temp (ex 70F). Then enter the insulation thickness, (ex 1.25") and type of construction (ex wood). Press "calculate" and you will have a great start to solving the cooling portion of the humidor. Results are shown on page 1 of this report. Finally you'll see suggested TE coolers along with the required quantity that will cool your humidor.




TECA (ThermoElectric Cooling America) corporation has their sizing software available for d/l. It runs under Windows XP but not on earlier Windows releases. It is similar to the TE Tech sw but a bit more advanced.

Links with TE design software;

TE Tech Home Page: http://www.tetech.com/ --- Use the online TE Analysis SW

TECA Home Page: http://www.thermoelectric.com/ --- D/L "TECA Sizing SW 3.0"