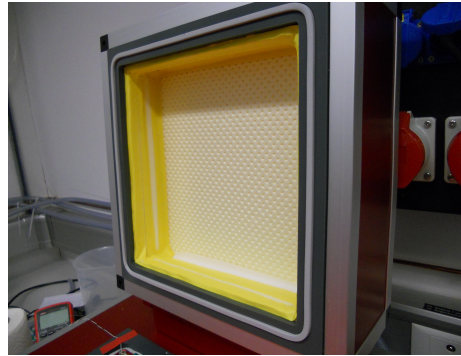
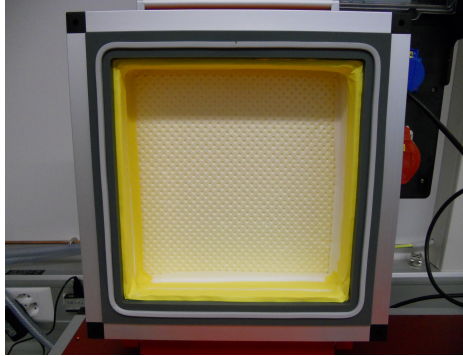


# COMISSIONING OF COLD BOX

## 1. Isolation for the cap using the styrofoam

*The temperature isolation should be made of styrofoam filling space inside a cap. Adhesive tape can be used for all edges and gaps between styrofoam layers to make everything tight. Only small volume should be empty what is shown in the pictures.*



## 2. Programming the JUMO

*There is JUMO softec PC program for setting up JUMO. The procedure is simple but one has remember about proper USB port to connect JUMO with PC, e.g. if the cable is connected to port COM13, the same port has to be inserted in connection settings. The software is compatible with Windows, it can be found in /data/Equipment/coolingbox and at <https://twiki.cern.ch/twiki/bin/view/CMS/ETHZurich-PixelUpgrade>.*

*NOTE: In order to check which COM(port) the JUMO controller is connected to; go to Start -> Devices and Printers, and find the controller listed. Next, right-click on the device, and go to the Hardware tab, the number of the COM(port) will be listed.*

## 3. Humidity and Temperature sensor

*A common problem with the cold boxes is that either the temperature or humidity sensor are plugged in incorrectly. Input 1 is in control of temperature measurements, if it is showing a temperature drastically different from room temperature, then the connections are most likely plugged in incorrectly. Check Input 1 connected to the back of the JUMO controller. The cables should be connected to slots 2 and 4. Likewise, if the humidity sensor is showing a value that is negative, the connections for Input 2 should be checked. The cables for the humidity sensor should be connected to slots 1 and 4. More information about this can be found in the JUMO manual, p.15.*

## 4. Air/water tightness

*First, all connectors (clamps on the water and air pipes) should be tightly screwed.*

*Next, the water pipes should be tested for leaks by using dry air. To do this connect air hose to the water inlet, and connect an open hose to the water outlet of the cold box. Turn on the air flow, close the open end of the hose, and run any of the starter programs. The cold box should be doing nothing for the moment (it would be flushing air but since the air is connected to the water for the moment, it won't). Press next, now the cold box should be in "cooling" mode, and water (air in this case) will flow. If there is no leak, the water external pipes (inlet and outlet) can be connected. Water flow should be carefully increased and followed by an observation of pipes inside the box.*

*NOTE: During these operations, the Peltier elements should be disconnected. Additionally, if the air or water valves seem to be turned on when they are supposed to be turned off, it is most likely due to the fact that the magnetic valves are backwards.*

*IMPORTANT: Remember about re-tightening the screws in clamps after some time!!!*

## 5. First cooling/heating test

*Now the cooling box is ready for its first test. Reconnect the Peltier elements, and vacuum tubes. Select and start a program that will bring the cooling box to a low temperature (<0C).*

### 5.1 Voltage of Power Supplier

*The voltage of PS should be fixed at maximum. The display of the PS inside coolingbox should indicate voltage of around 15 V. To be sure if this is maximum, adjust voltage to max. value using regulator in front panel of PS. Check also the current while cooling down. It should be over 50 A.*

*NOTE: The power supply will not actually be providing power to the cooling elements until it is actively cooling, make sure that it is cooling before checking the voltage indicator.*

### 5.2 Peltier Inversion

*The cooling effect that the Peltier elements depends on the direction of the current. If current passes in one direction, one side will cool down, and the other will heat up. For this reason one has to be sure whether Peltiers are mounted correctly. If the cold box is heating when it is in cooling mode, the program should be stopped immediately. Then, the cold box should be turned off, and unplugged. The cables providing power to the cooling elements will need to be reversed, so that the direction of current flow is corrected.*

*NOTE: It will be readily apparent if the cold box is heating or cooling, once it switches to its cooling mode. Simply touch the surface above the Peltier elements to see if it is working properly.*

## 6. Vacuum system and vacuum test with a pump

*This is a simple test to check if all of the vacuum tubing is connected properly. Place 4 module holder dummies. Then simply attach a vacuum, and turn on the vacuum switch on the cold box. The module dummies may need to be adjusted a bit, so that they are not allowing air to pass through.*

*NOTE: It has happened that some of the module dummies are bent a bit, in which case it will not be possible to get a good seal around the vacuum holes.*

## 7. Self-optimization

*In order to have nice temperature curves (smooth approach to setpoint) one needs to perform JUMO training. It is called Self-optimization.*

*To start this procedure, choose a program (e.g. -20 °C) and start it. While it is cooling down, press subsequently:*

- 1. exit button and hold it to activate soft keys*
- 2. display change button (repeatedly, if necessary) to have Program Chanel 1*
- 3. choose details and press a button with round arrow*
- 4. start self-optimization with the button with question mark.*

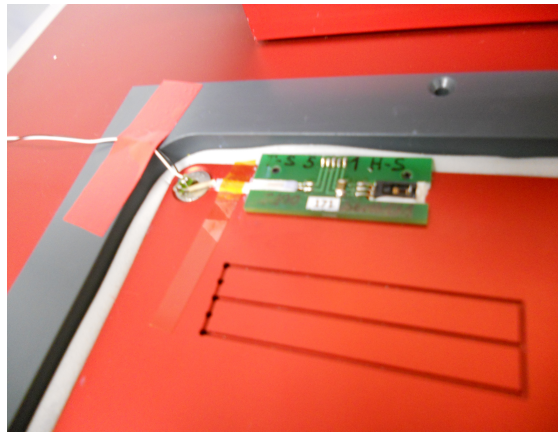
*After that operations, symbol with question mark should be flashing. After some time the symbol of coffee should appear which means the end of self-optimization.*

*One can repeat that process as many times as needed. It usually gets better if you repeat the procedure few times.*

*NOTE: There are multiple optimization methods. For the cold box it is important that the Oscillating method is used. To change this go to Menu -> Configuration level -> Controller -> Controller 1 ->Self-Optimization*

## 8. Sensor calibration

*In order to have more reliable temperature, recalibration procedure is recommended. For this, reference measurements are needed. The most accurate is 4-wire measurement (using Pt1000 sensor and Keithley 2400). In the picture the external sensor placed next to JUMO sensor is shown.*



*The idea is to measure the temperature with the external sensor at two points which are far apart, e.g. +17 °C and -20 °C. One should write down the result of external measurement and JUMO result for each point. Then, the program going to one of the setpoint should be launched. While the setpoint is reached and stable, one can insert new temperature which is a result of external measurement. To do this, go to: Menu->Configuration->Analog inputs->Analog input 1->Recalibration and insert new value as Start value. For the second setpoint do the same but insert new value as End value. Then, calibration is done.*

*For calculating the temperature using Pt1000 sensor you can use a calculator online, e.g.: <http://www.pfoertner-messtechnik.de/div/rtd.htm>*

*The formula for Pt100 sensor is the following:*

$$T = -5.67 \times 10^{-6} R^3 + 0.0024984 R^2 + 2.22764 R - 242.078$$

## 9. Temperature and humidity curves

*The picture presents an example of curves. The temperature is measured by JUMO and by multimeter using Pt1000 sensor. The correction of 1 Ohm is applied for multimeter measurements because of cables resistance. The same formula (as above) can be used for multimeter measurements.*

