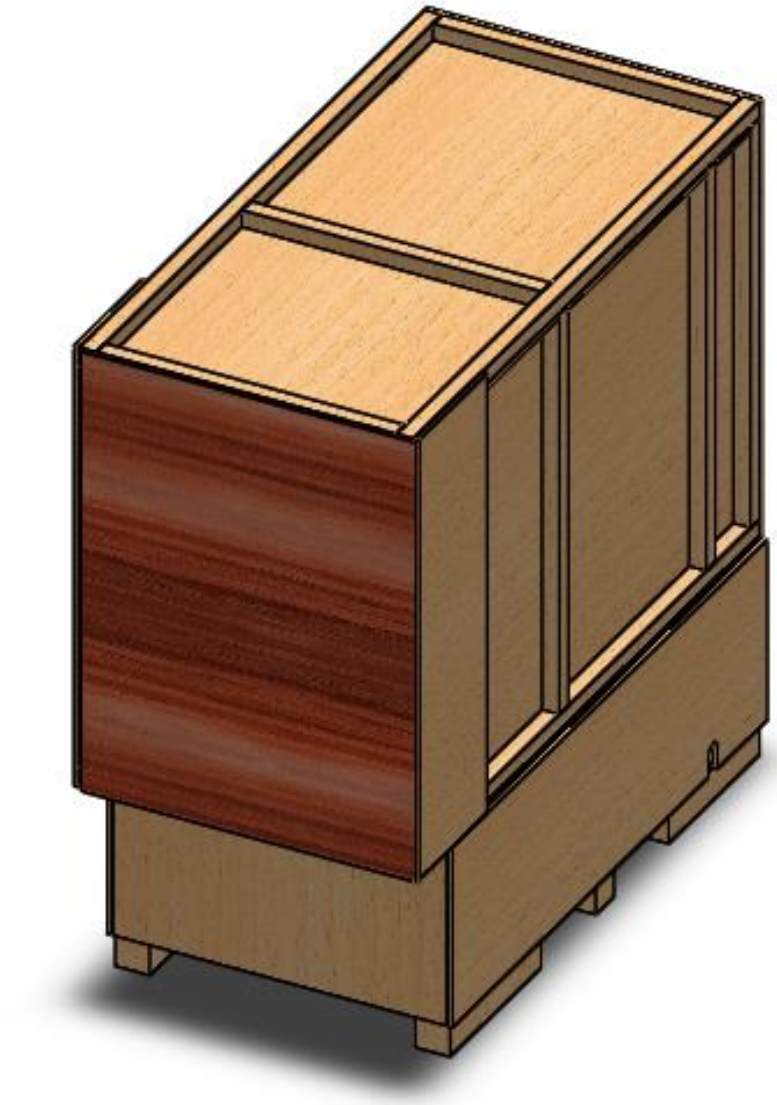
HEAT PUMP FRUIT DRYER

TECHNICAL MANUAL



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TECHNICAL HANDBOOK OVERVIEW

This handbook was created to guide the user through the construction and operation of the heat pump fruit dryer. Before any assembly, read the safety concerns in Chapter 2 carefully. Chapter 1 is an overview of the three sub-assemblies of the fruit dryer (chambers and pallets, electrical system, and heat pump system). Chapter 3 describes the construction steps for each of the three sub-assemblies. Chapter 4 outlines the procedures to operate the dryer once installation is complete. Keep in mind the following important considerations when using this manual:

- The manual was designed assuming that carpenters will build the chambers and pallets, electricians will assemble the electric system, and air conditioning technicians will assemble the heat pump system.
- The manual was written to provide enough information for the dryer to be assembled from parts that are ordered and fabricated on-site, without any components or sub-assemblies shipped.
- The dryer can be adapted to suit the resources and materials available in the community where it is implemented. Aspects of the fruit dryer that can be readily modified are noted throughout the manual.
- The necessary tools to build the dryer can also be adapted to suit the availability of tools at each location. The recommended tools in the list provided in the handbook have been labeled with the following priority rank:

  H — High: necessary to complete the fruit dryer.

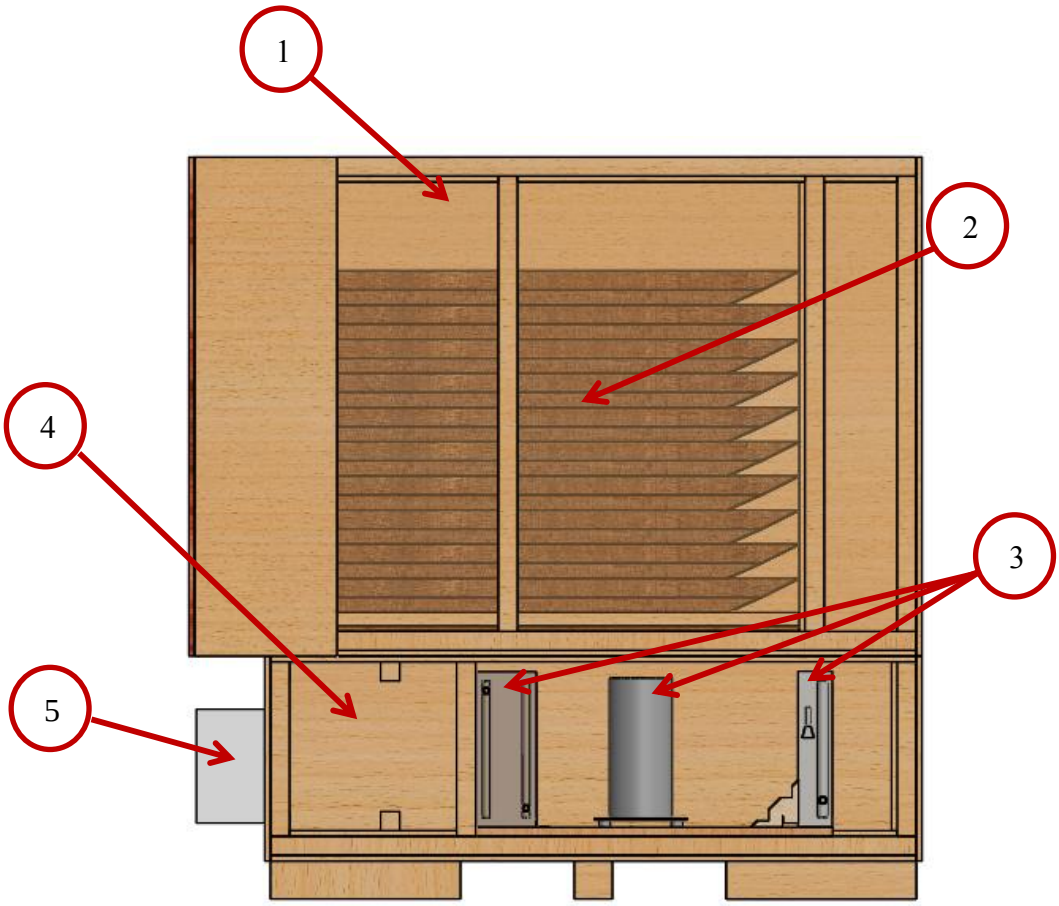
  M — Medium: perform a task necessary to complete the fruit dryer, but can be replaced by a tool of similar function.

  L — Low: not necessary, but reduce time to construct the fruit dryer.

- The manual includes drying instructions for apples and mangoes. Different fruits and vegetables can be dried, but make sure to adjust the preparation steps and drying time accordingly.
- The crucial aspect when constructing the drying chamber is to guarantee it is **air tight, waterproof, and food safe** (even at high temperatures).
- The evaporator, condenser, compressor, and ventilator are unique to the fruit dryer's heat pump system and must follow exact specifications before any modification occurs.
- The product codes of the electrical components shown in the parts list of the electrical system pertain to specific manufacturers. These codes will change if similar components are purchased from different manufacturers.

CHAPTER 1: MACHINE OVERVIEW

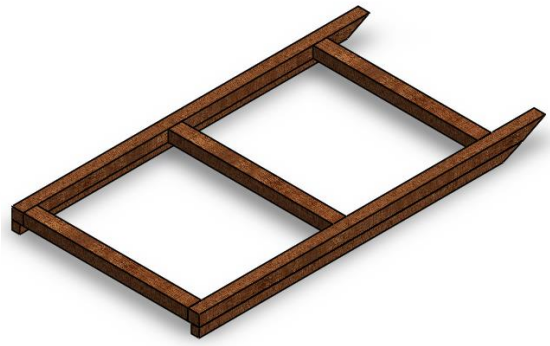
FINAL ASSEMBLY



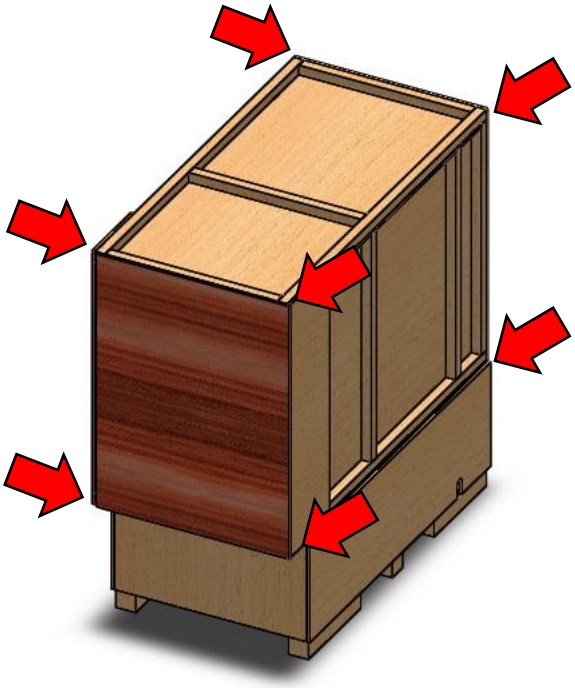
1. Drying Chamber
2. Pallets
3. Heat pump System
4. Heat pump Chamber
5. Electrical System

CHAMBERS AND PALLETS

The chambers and pallets make up the structure of the fruit dryer and are comprised of the heat pump chamber, drying chamber, and pallet assembly.

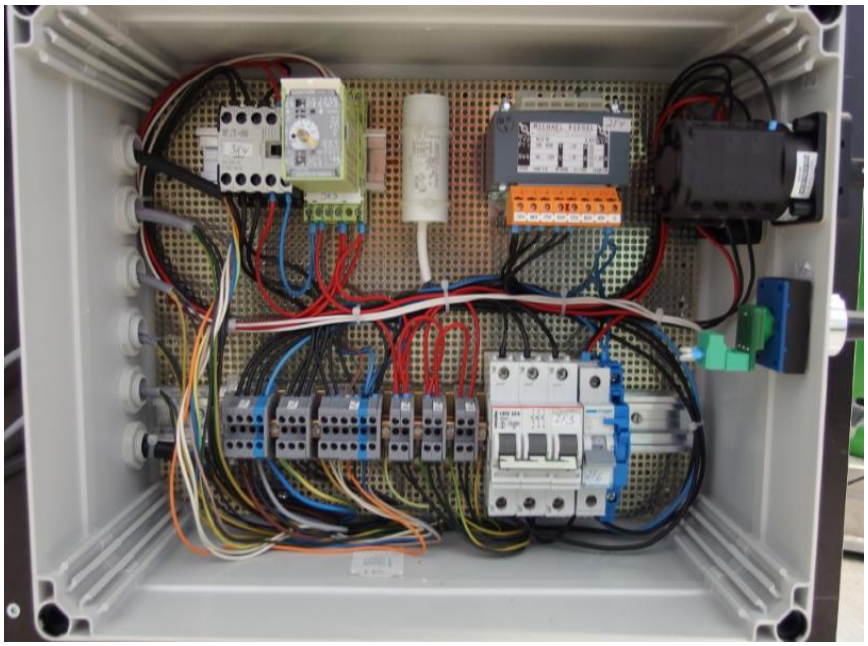


This section of the manual will be based on the fruit dryer framework built at NTB University in April 2015 and can be found on page 7. The drying and heat pump chambers in this manual were made with laminated wood, however this is not necessary as long as the chambers are waterproof. This can also be accomplished by lining the drying chamber with foil or replacing the wooden panels with metal. The drying chamber also needs to be air-tight, with a material that is food safe on the inside. The important areas in which to keep an air-tight seal are the corners of the drying chamber shown below. **All chamber and pallet components can be adapted to the resources available.**



ELECTRICAL SYSTEM

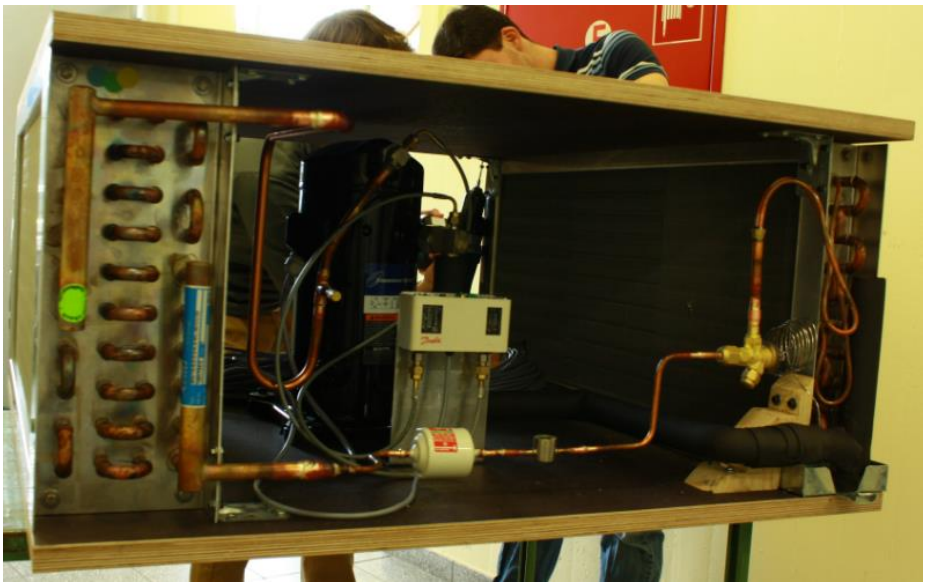
The electrical system control's the compressor, ventilator and the temperature settings for the heat pump system.



This section of the manual will give an overview based on the materials used in the CUBO case and can be found on page 33. **All electrical components can be adapted to the resources available.**

HEAT PUMP SYSTEM

The heat pump system is what produces the heat to dry the fruits.



The evaporator, condenser, compressor, and ventilator are specific to this fruit dryer. Exact specifications are indicated on the parts list that starts on page 54. **All other heat pump components can be adapted to the resources available.**

Approximate timeframe for each sub-assembly		
Name of section	Number of people required	Time required
Heat pump chamber	1	16 hrs.
Drying chamber	1	16 hrs.
Pallets	2	20 hrs.
Electrical system	1	6 hrs.
Placing heat pump components	1	2 hrs.
Heat pump piping	1	6 hrs.
Prepping the heat pump system	1	24 hrs.
Operations	2	20-30 hrs.

CHAPTER 2: SAFETY CONCERNS

⚠ Caution: can cause minor or moderate injury.

⚠ Warning: can cause death or serious injury.

⚠ All edges of the wooden panels must be filed or sanded to remove sharp edges and corners.

⚠ When operating heavy machinery (i.e. saws, drills, and grinders), use the utmost awareness to prevent serious injury.

⚠ The ends of the aluminum rail for mounting electrical components must be filed to remove dangerous sharp edges.

⚠ The fins in the evaporator and condenser are extremely sharp and should not be touched with bare hands.

⚠ The water that is produced from the evaporator is deionized and not safe for drinking.

⚠ Keep liquids away from all electrical components. Spills can cause electric shocks and can damage the electrical equipment.

⚠ When working with electrical components, always disconnect the power source from any equipment beforehand to avoid electric shock hazards.

⚠ When working with brazing equipment, be aware of high temperatures that can cause serious burns or lesions.

⚠ Be aware that refrigerant leaks are not only harmful for the environment, but can also cause nausea and headaches.

⚠ Cutting tools for preparing the fruit are extremely sharp, so use with caution.

⚠ When removing pallets from the fruit dryer, make sure that two people are grasping each side of the pallet to reduce the risk of injury.

⚠ After the heat pump is set up, be aware that the pipes running from the evaporator to the condenser will be extremely hot.

CHAPTER 3: INSTALLATION

CHAMBERS AND PALLETS

PARTS LIST

Hardware for Chambers (total)		
Name	Dimensions (mm)	Number Required
Screw 01	5 x 20 Flat Head	18
Screw 01	5 x 25 Flat Head	27
Screw 02	5 x 35 Flat Head	85
Screw 03	5 x 60 Flat Head	87
Screw 04	5 x 80 Flat Head	35
Screw 05	6 x 100 Flat Head	8
Washer 01	8.5/35/2.5	39
Nut 01	M5	39
Hinge	N/A	3
Door clamps	N/A	3

Hardware for Pallets		
Name	Dimensions (mm)	Number Required
Screw 06	3 x 16	230
Screw 07	6 x 120	120
Mosquito netting	730 x 1345	10
Wire	11580	10
String	2940	10

Heat Pump Chamber			
	Name	Dimensions (mm)	Number Required
Wooden Panels	Panel 01	15 x 970 x 1700	1
	Panel 02	15 x 540 x 970	1
	Panel 03	15 x 445 x 540	2
	Panel 04	15 x 445 x 840	1
	Panel 05	15 x 445 x 840	1
	Panel 06	15 x 220 x 940	1
	Panel 07	15 x 445 x 940	1
	Panel 08	15 x 970 x 1700	1
	Panel 09	15 x 460 x 1110	1
	Panel 10	15 x 540 x 1730	1
	Panel 11	15 x 540 x 970	2
	Panel 12	15 x 460 x 1110	1
	Panel 13	15 x 540 x 1730	1
Beams	Beam 01	100 x 100 x 100	3
	Beam 02	100 x 100 x 500	4
	Beam 03	50 x 50 x 870	7
	Beam 04	50 x 50 x 1700	2
	Beam 05	50 x 50 x 460	6
	Beam 06	50 x 50 x 970	2

Drying Chamber			
	Name	Dimensions (mm)	Number Required
Wooden Panels	Panel 14	15 x 970 x 1900	1
	Panel 15	15 x 1235 x 1900	2
	Panel 16	15 x 840 x 1235	1
	Panel 17	15 x 970 x 1900	1
	Panel 18	15 x 840 x 1592	1
	Panel 19	15 x 970 x 1315	2
	Panel 20	15 x 375 x 1315	2
Beams	Beam 03	50 x 50 x 870	7
	Beam 07	50 x 50 x 1900	4
	Beam 08	50 x 50 x 1200	8
	Beam 09	50 x 50 x 870	2
	Beam 10	50 x 50 x 1117	2
	Beam 11	50 x 50 x 1135	2
	Beam 12	35 x 42 x 1592	2
	Beam 13	50 x 60 x 840	1
Pallets			
	Name	Dimensions (mm)	Number Required
Beams	Beam 14	35 x 40 x 1435	2
	Beam 15	50 x 50 x 1535	2
	Beam 16	50 x 60 x 730	3

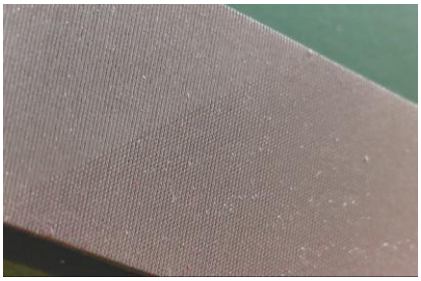
This drying and heat pump chambers were built with laminated wooden panels of 1.5 cm thickness. Other thicknesses can be used, but the dimensions shown in the table need to be adjusted accordingly. The chambers can also be made of metal or lined with foil.

The choice of the material needs to ensure that the drying chamber is air-tight, waterproof, and food safe.

TOOLS LIST

Necessary Tools

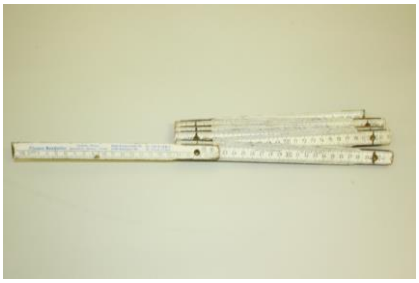
Abrasive Material



Used to shape or polish a work piece

M

Measurement Tool

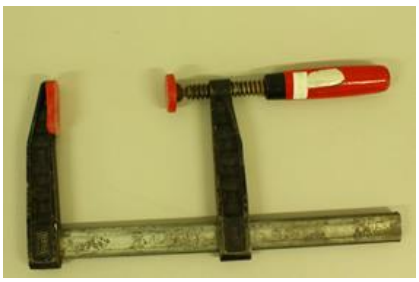


H

Saw

H

Clamp



Used to hold objects tightly

L

Drill

H

Assorted Drill Bits

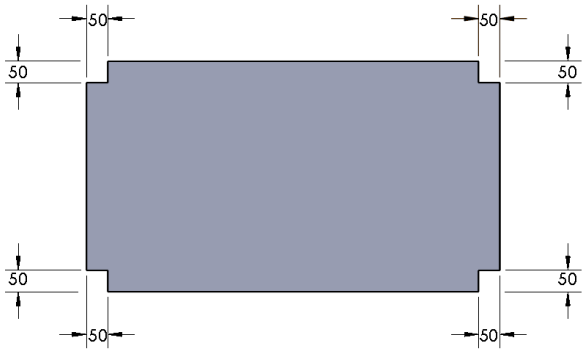
H

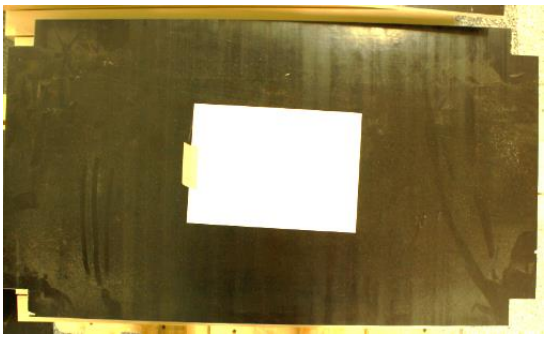
Countersink Drill Bit	
 Used to widen the entrance of a hole to allow for the screw head to sit flush with the surrounding material. H	

ASSEMBLY INSTRUCTIONS

SECTION 1: Prepare the wooden panels and beams

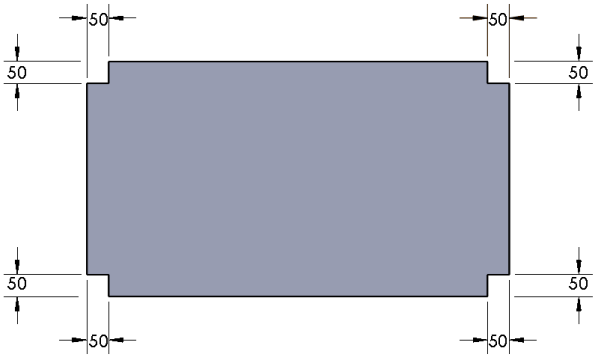
Step #1: Cut the wooden panels and beams



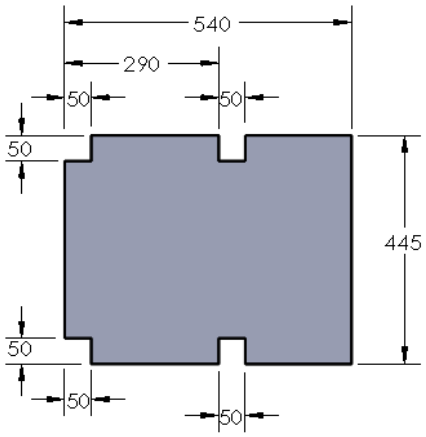


Cut the wooden panels and beams, following the example above:

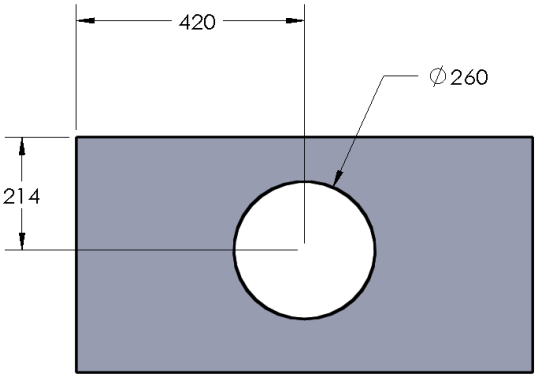
1. Use the drawings that follow to mark the cuts on the wooden panels and beams.
2. Cut the wooden panels and beams according to the specified dimensions (all in mm).



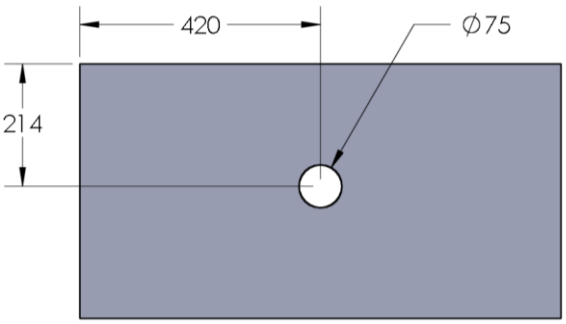
Panel 02



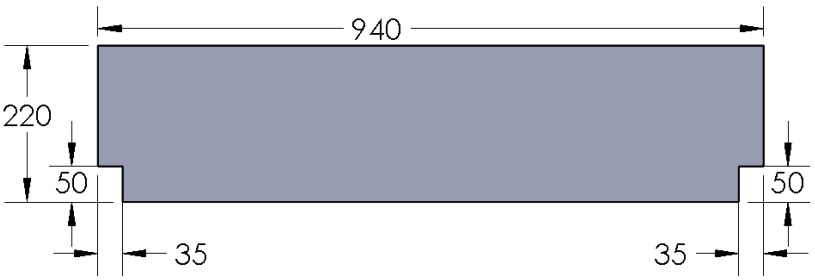
Panel 03



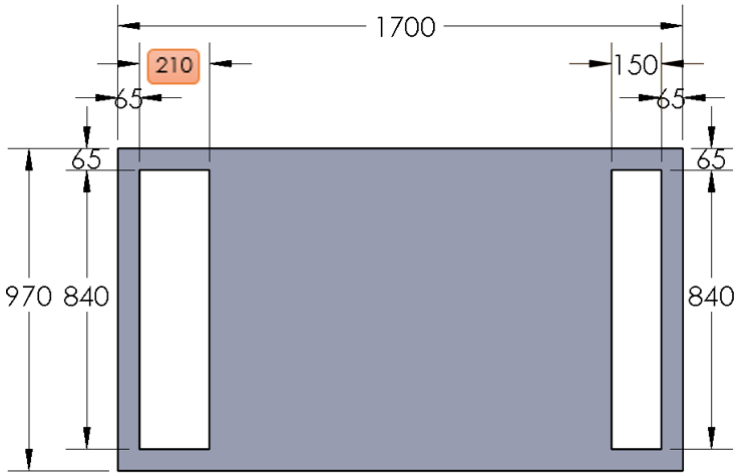
Panel 04



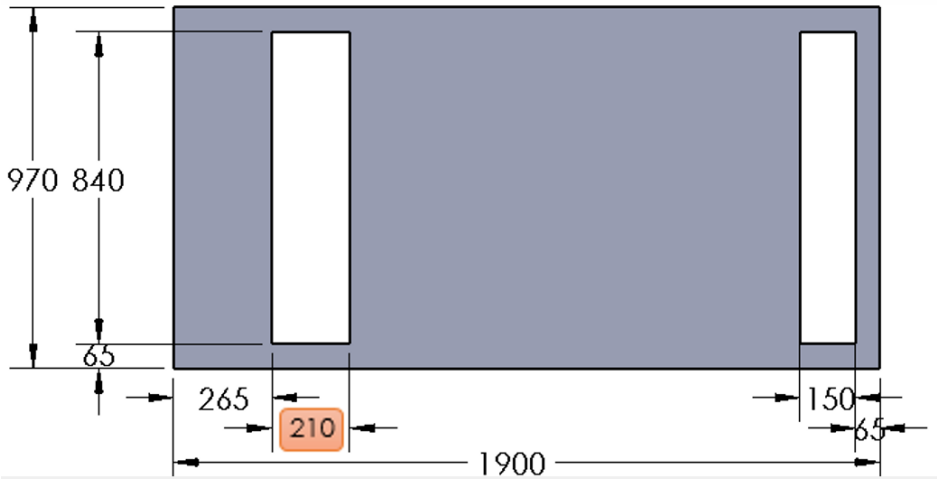
Panel 05



Panel 06

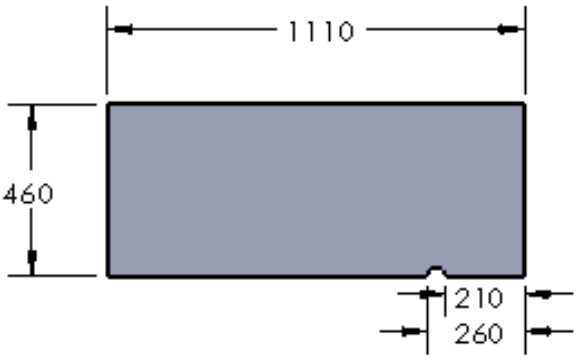


Panel 08

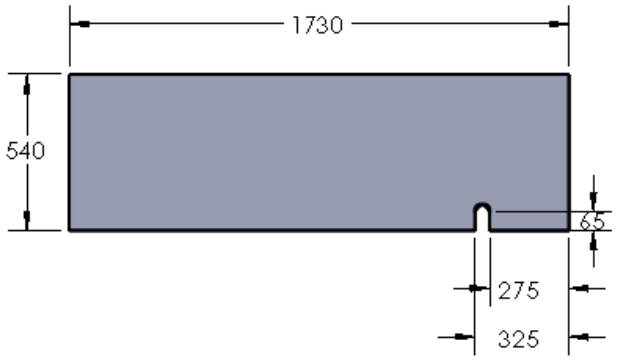


Panel 14

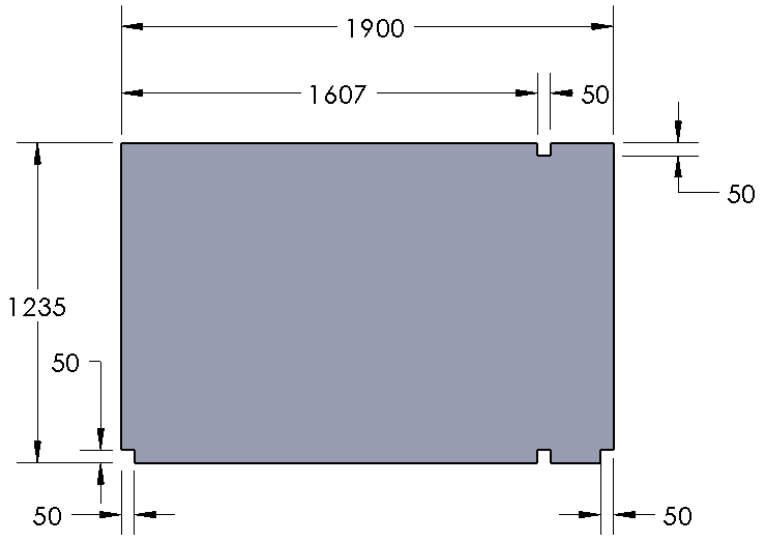
The 210 mm dimension for one of the openings in Panel 08 and Panel 14 is designed to match the dimensions of the ventilator that is chosen for the dryer (see section on the heat pump system). If a different ventilator is selected, this dimension must be adjusted to suit the dimensions of the ventilator.



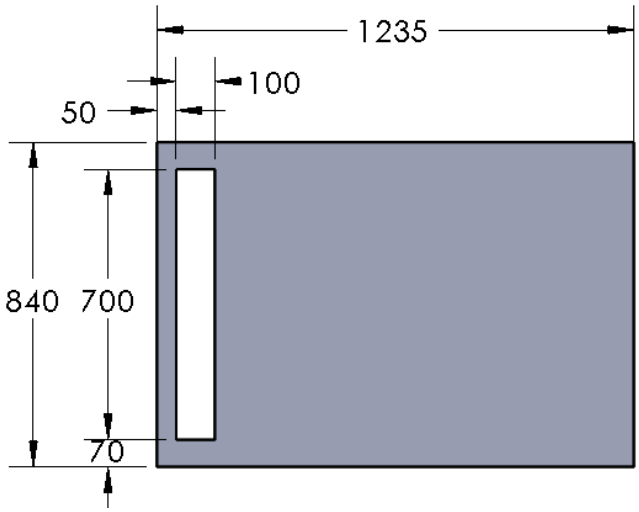
Panel 12



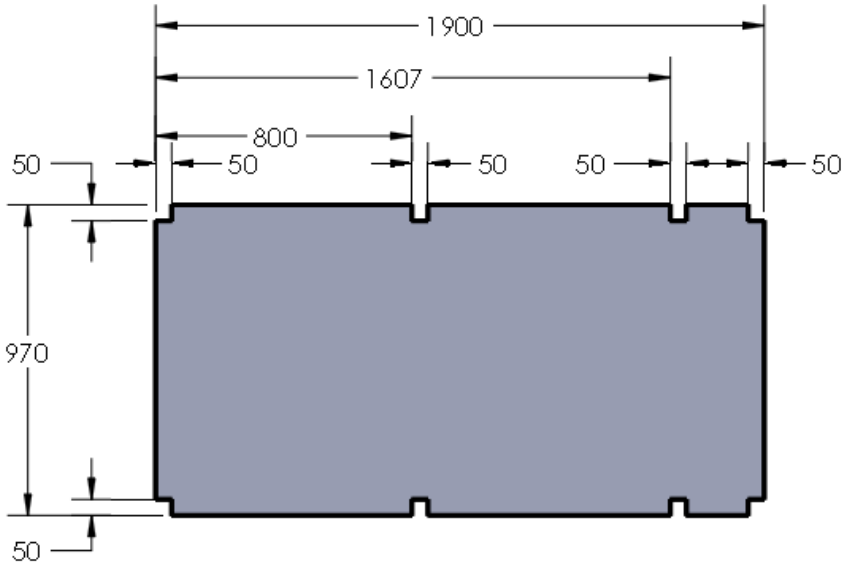
Panel 13



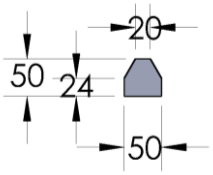
Panel 15



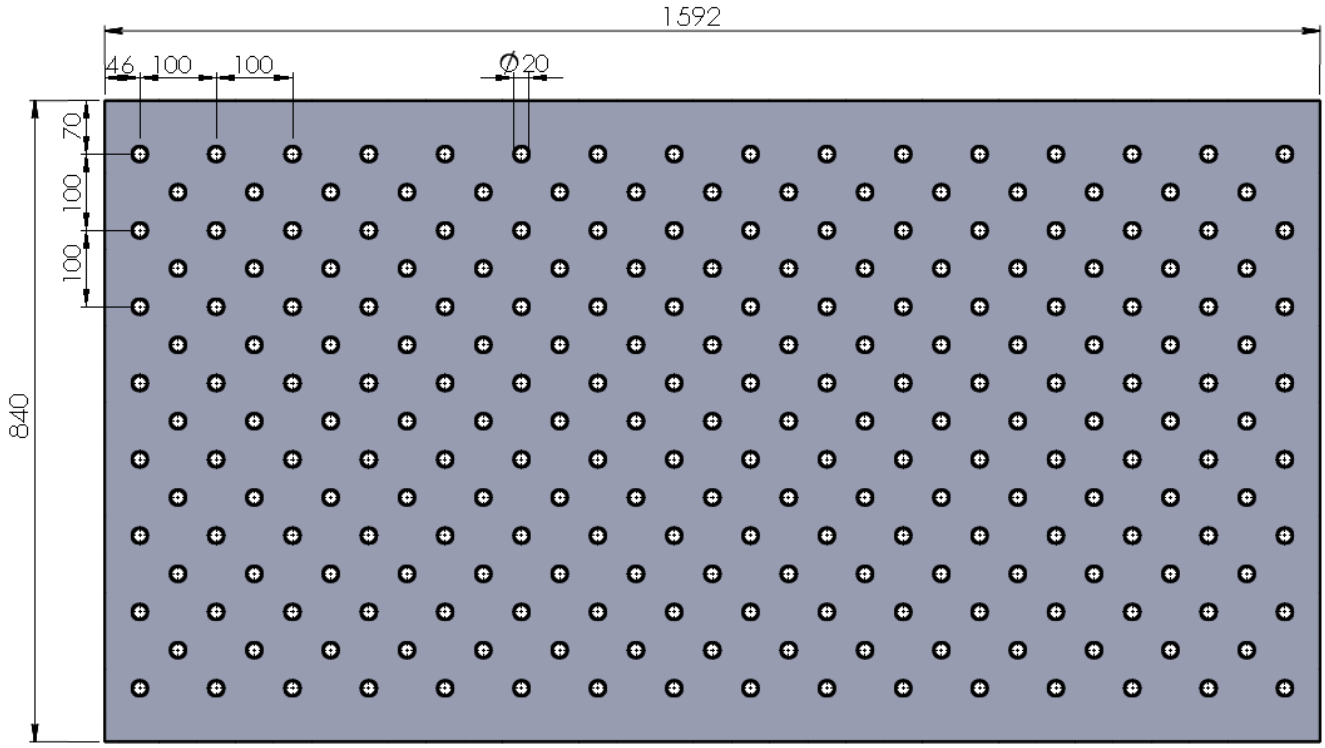
Panel 16



Panel 17



Beam 09



Panel 18

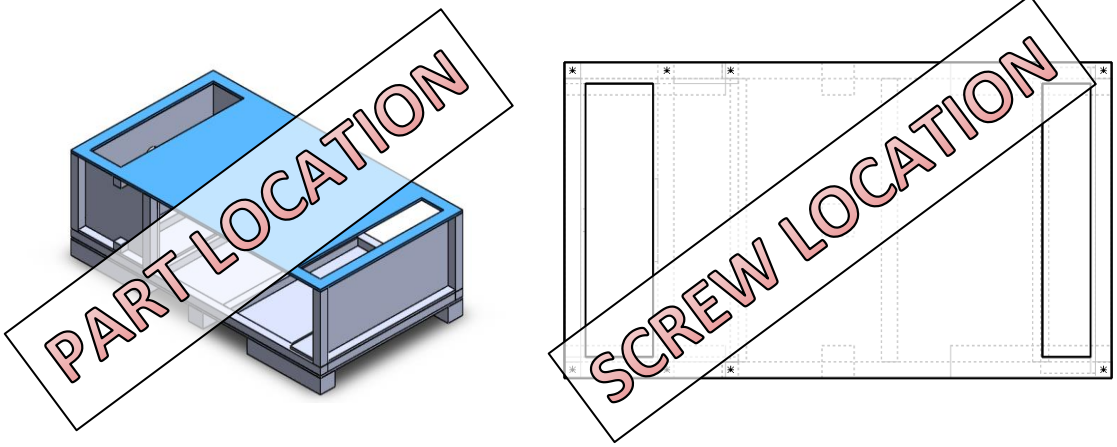
Step #2: Sand

1. File the wooden panels.
2. File the beams.

SECTION 2: Assemble the heat pump chamber

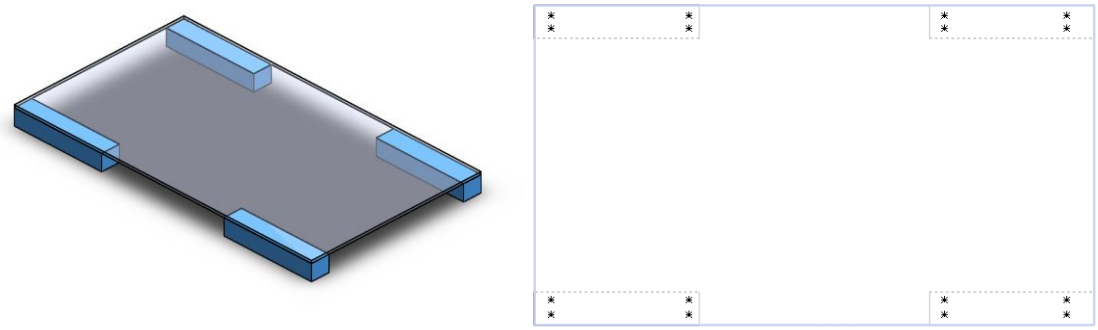
Example Step

All steps described in Sections 2 and 3 are formated as shown:



- The image on the left depicts the piece (in blue) that is being added to the system.
- The image on the right shows the placement of all screws in that piece. Note that since dimensions are not specified, an approximate placement is sufficient.

Step #1

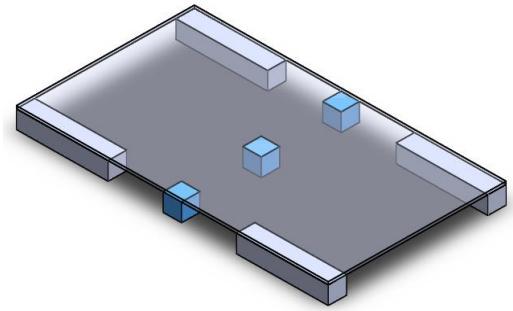


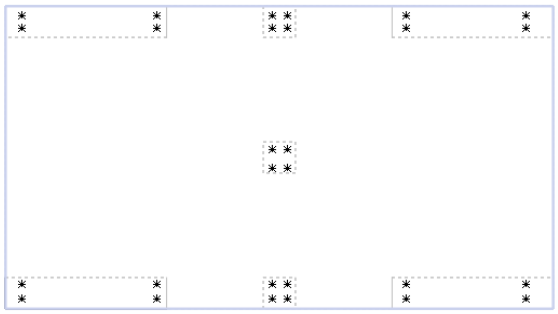
Place and fasten four Beam 02's under Panel 01 (interior side of the panel facing up).

Always countersink the holes so that the tops of the screw heads will be flush with the surface.

The reference "Interior Side" indicates the side of the wood that is water resistant and food safe. If the inside of the drying chamber will be lined with other materials that fit the requirements, disregard orientation.

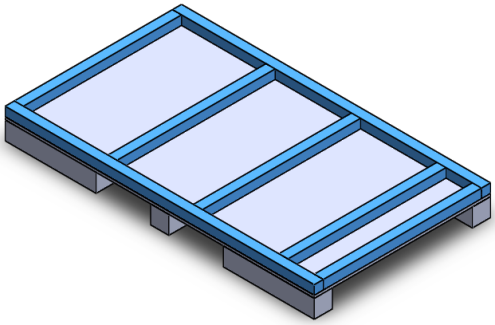
Step #2

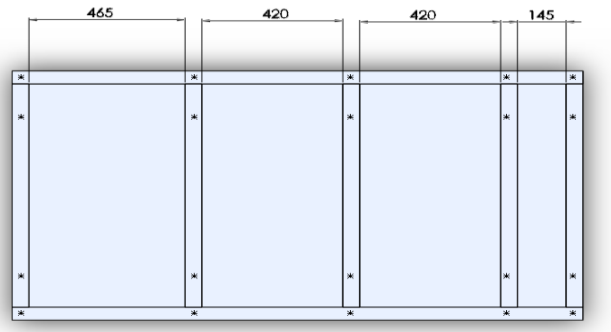




Place and fasten the three Beam 01's under the center of the wooden panel.

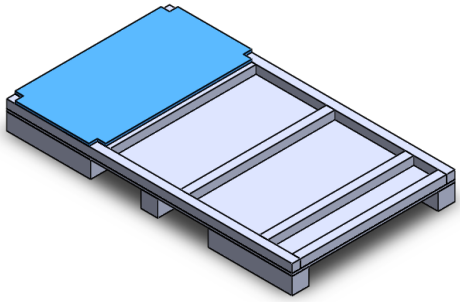
Step #3

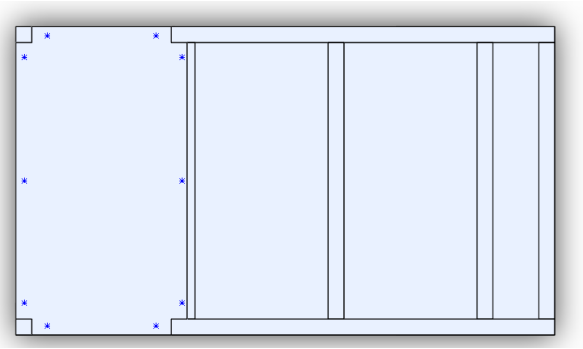




1. Lay and fasten two Beam 04's lengthwise so that they are flush with the sides of Panel 01.
2. Lay five Beam 03's across Panel 01 between the Beam 04's.

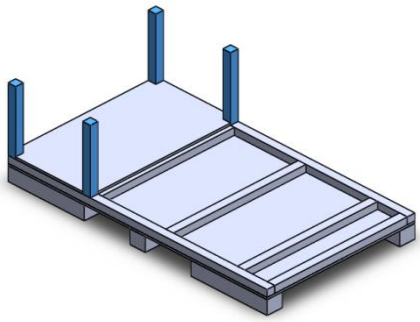
Step #4

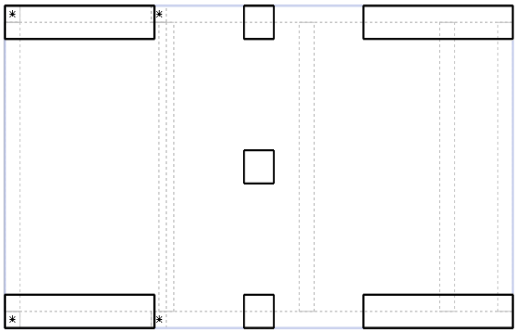




Place and fasten Panel 02 (interior side facing up) on top of the beams, flush with the end of the dryer.

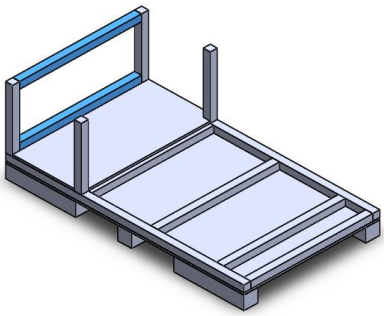
Step #5

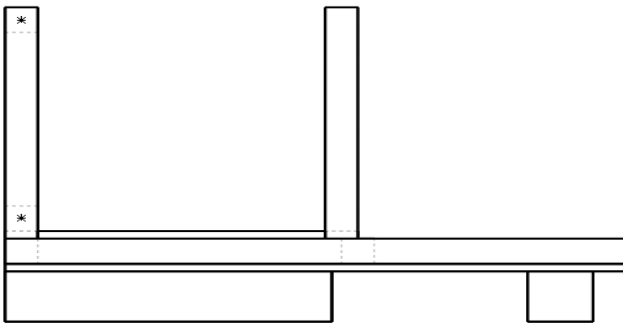




Place and fasten four Beam 05's upwards in each of the corners of Panel 02.

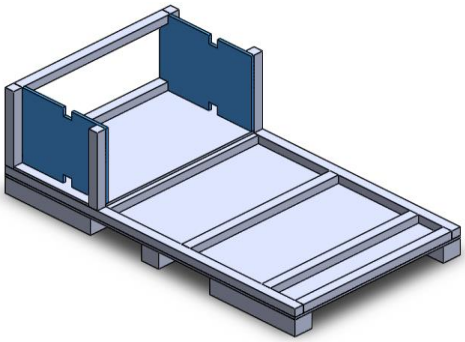
Step #6

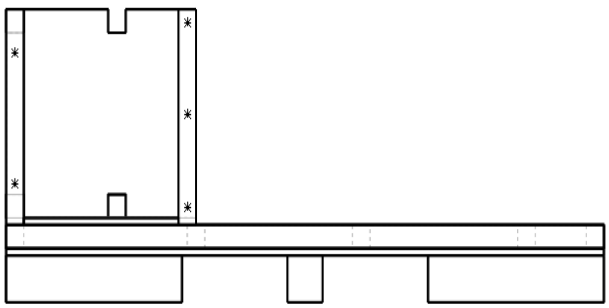




Fasten two Beam 03's to be flush with the end of the dryer: one on top of Panel 02 and another flush with the tops of Beam 05's.

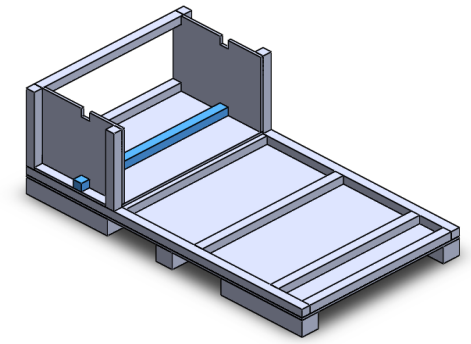
Step #7

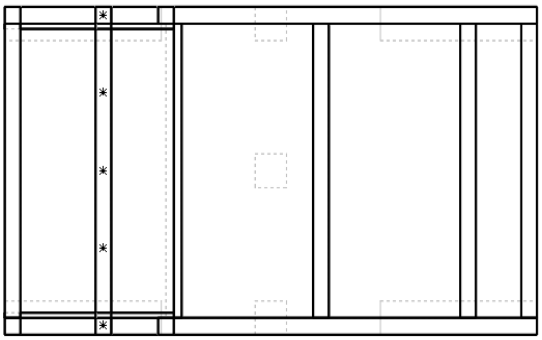




Place two Panel 03's so that the interior sides are facing each other.

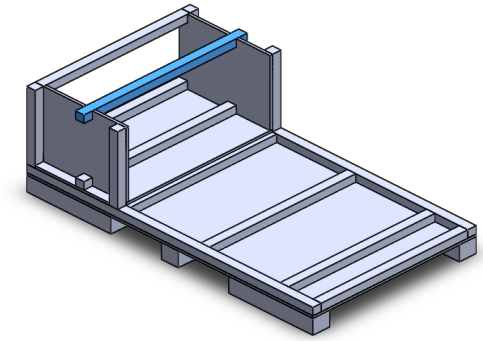
Step #8

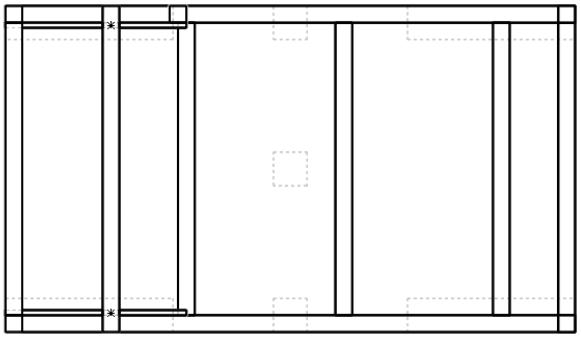




Slide one Beam 06 through the bottom cutouts of both Panel 03's so that it is flush with the long sides of Panel 01.

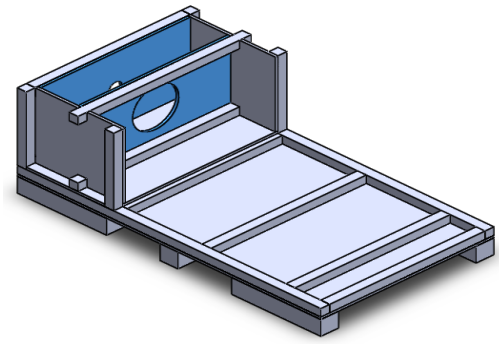
Step #9

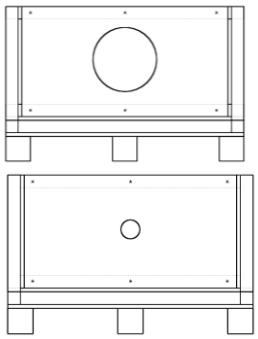


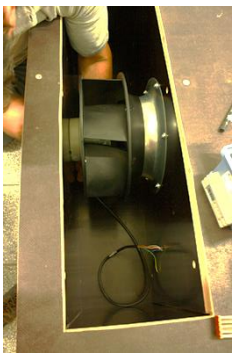


Place the other Beam 06 in the top cutouts of both Panel 03's.

Step #10



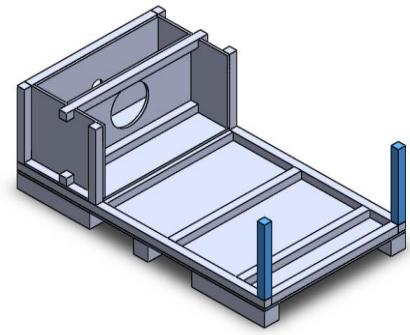


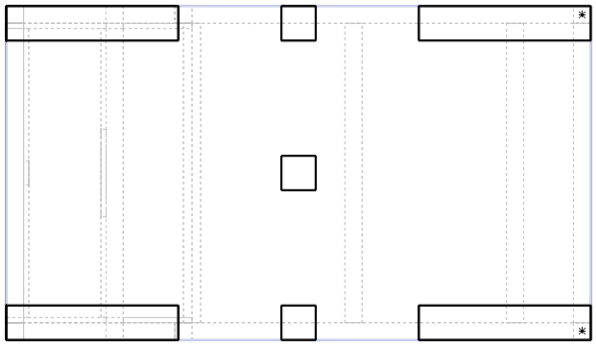


Install ventilation and attach Panel 04 and Panel 05 with the interior sides facing each other. Place Panel 04 in between the two Beam 06's.

For details on instalation of the ventilation, see ‘Assembly Instructions’ in the ‘Heat Pump System’ section.

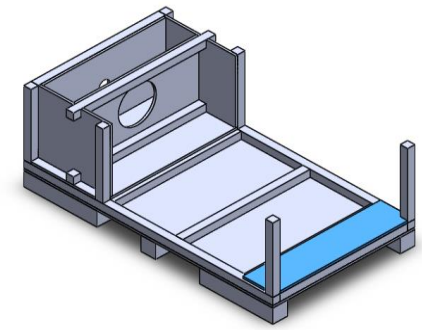
Step #11

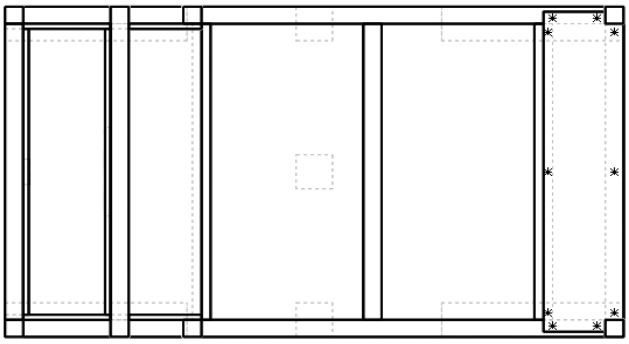




Place and fasten two Beam 05’s oriented vertically in each of the remaining corners of Panel 01.

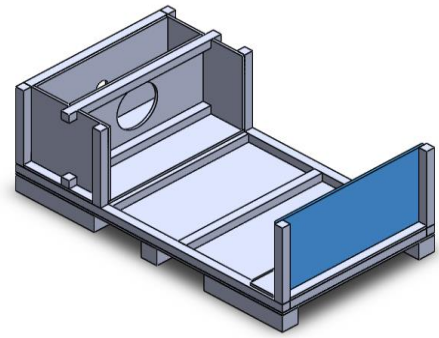
Step #12

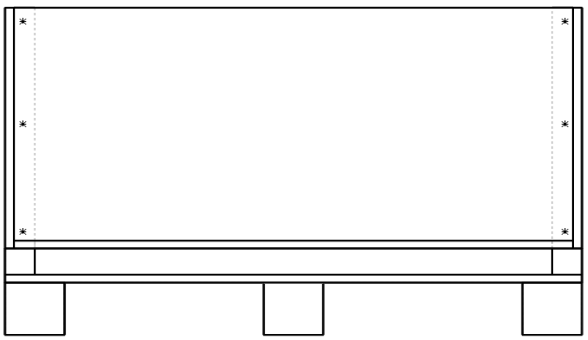




Place and fasten Panel 06 (interior side up) flush with the end of the dryer that is opposite of Panel 05.

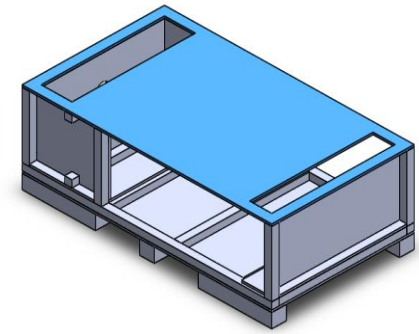
Step #13

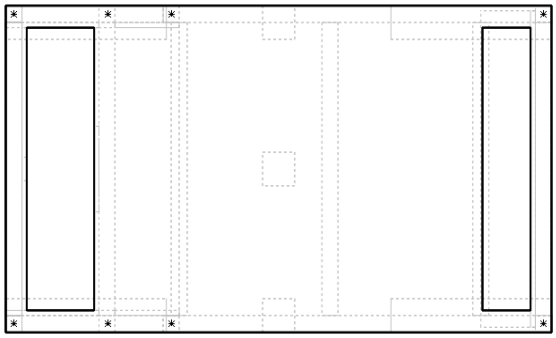




Attach Panel 07 (interior side facing inwards) against the insides of the Beam 05’s on top of Panel 06. Make sure that the sides of the plate are 15 mm from the edges of the beams.

Step #14

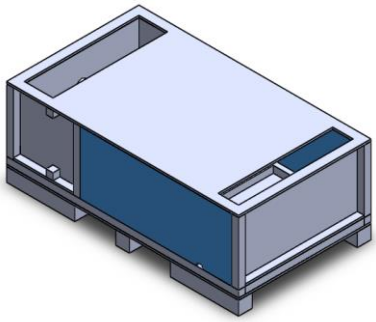


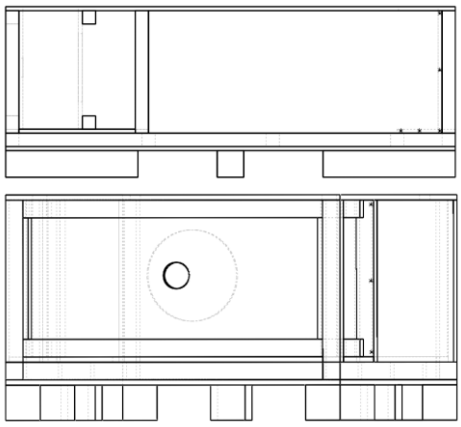


Place Panel 08 (interior side facing down) on top of the assembly.

Leave one side of the heat pump chamber open until the heat pump is inserted into the chamber and has been tested to run properly.

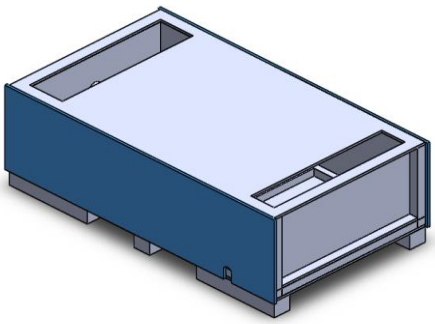
Step #15

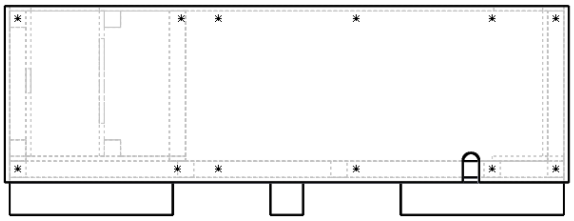




Place and fasten Panel 09 (interior side facing inwards) to fit on the right side of the chamber, and fasten Panel 12 similarly on the left side of the chamber.

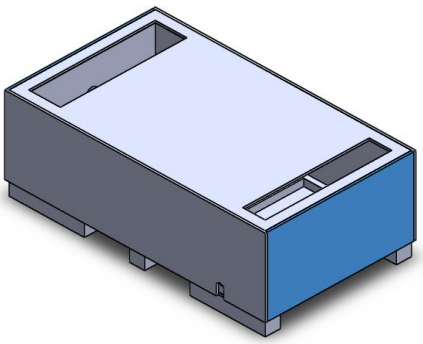
Step #16

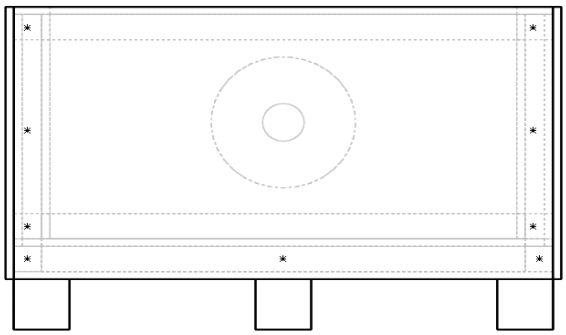




Place and fasten Panel 10 (interior side facing out) to the exterior of Panel 09 and Panel 13 to the exterior of Panel 12.

Step #17

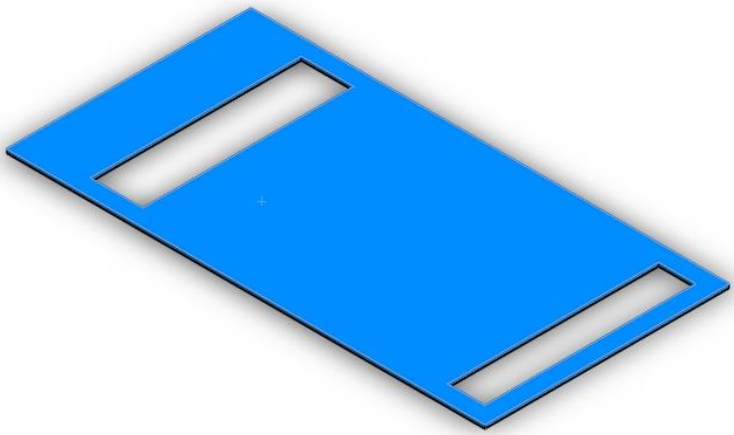




Place and fasten two Panel 11's (interior side facing out) to the short ends.

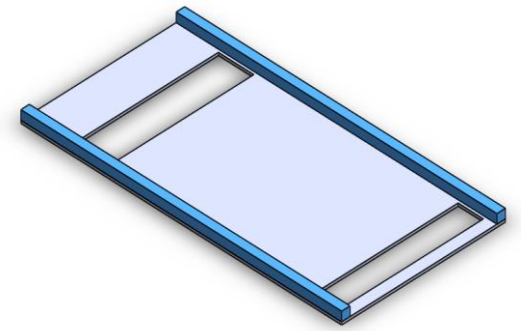
SECTION 3: Assemble the drying chamber

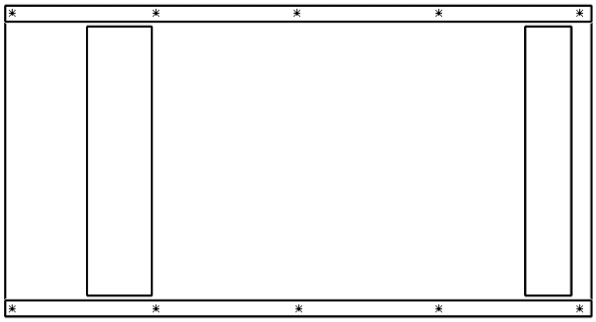
Step #1:



Place Panel 14 interior side facing up.

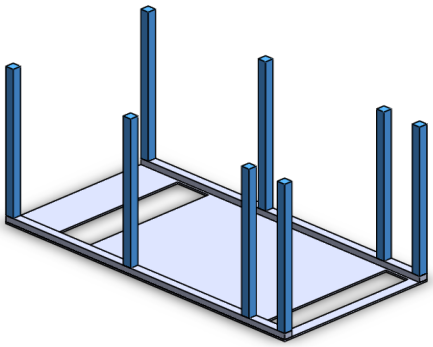
Step #2

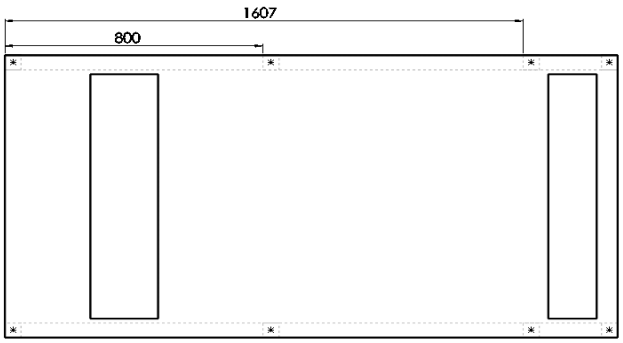




Place and fasten two Beam 07's flush with the long sides of Panel 14.

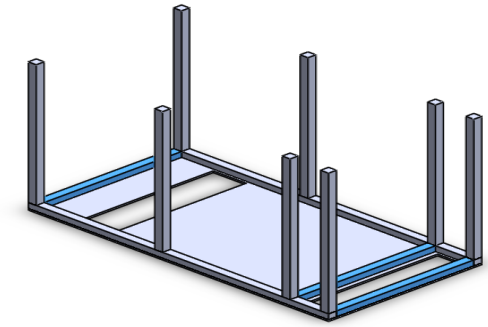
Step #3

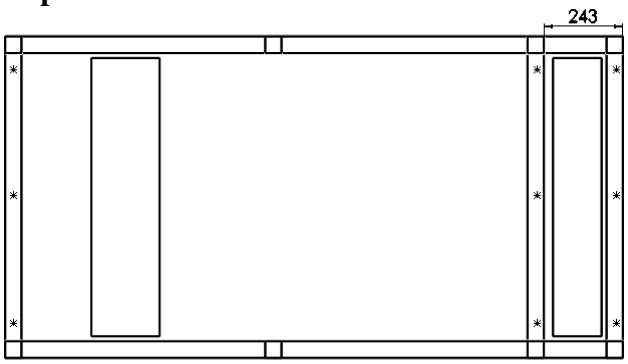




Place and fasten eight Beam 08's oriented vertically to the two Beam 07's. These are drilled from the BOTTOM of Panel 14.

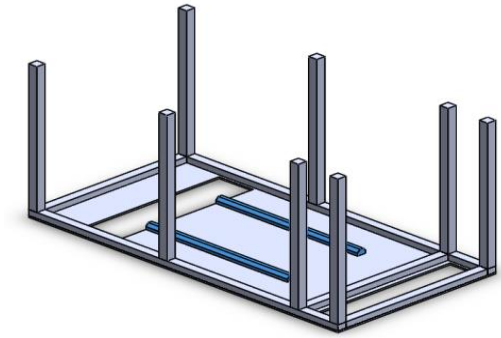
Step #4

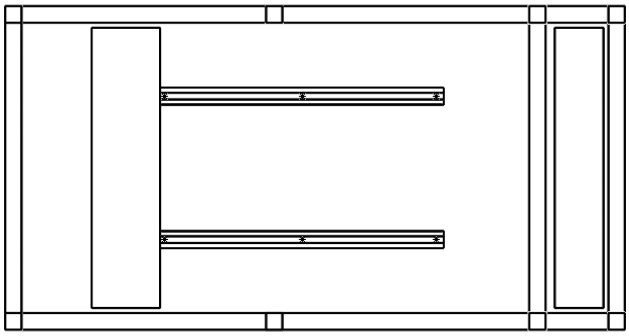




Place and fasten three Beam 03's on Panel 14: two flush with either end of the drying chamber and one aligned with two Beam 08's.

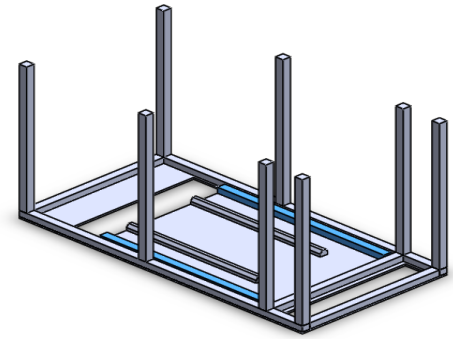
Step #5

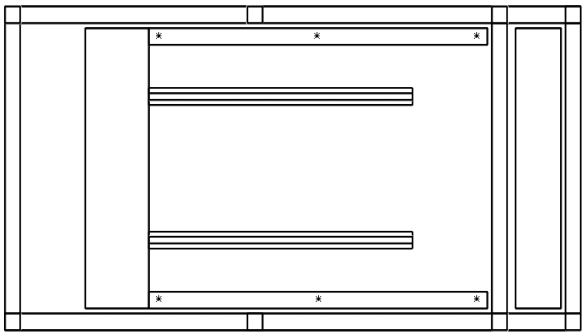




Place and fasten the two Beam 09's that were cut to the interior side of Panel 14, with the cut sides facing up and one end flush with the edge of the 210 x 840 cutout.

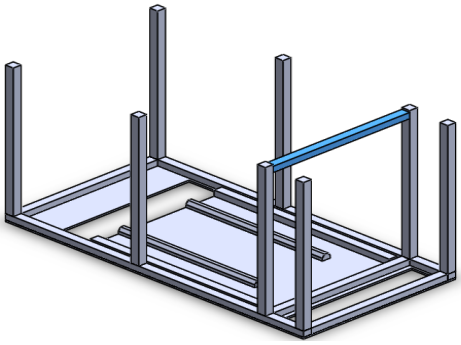
Step #6

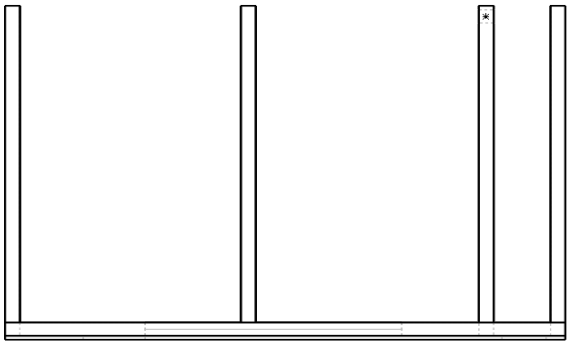




Place and fasten two Beam 10's flush with the corners of the 210x840 cutout of Panel 14

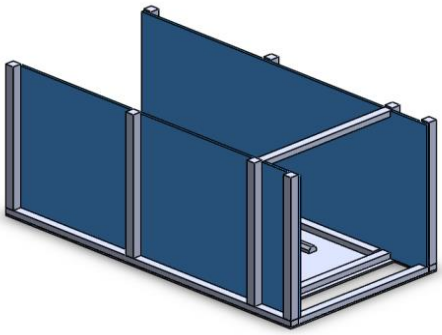
Step #7

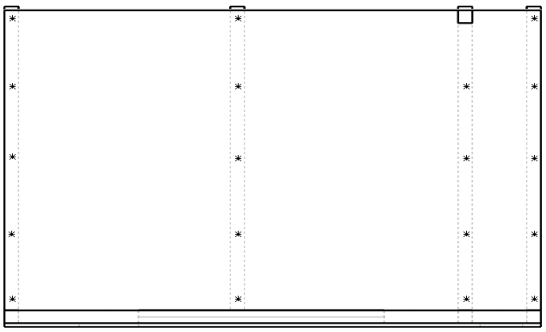




Place and fasten Beam 03 between the two Beam 08's 15 mm from the top of the beams.

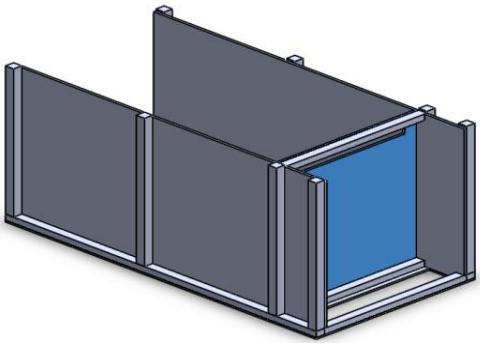
Step #8

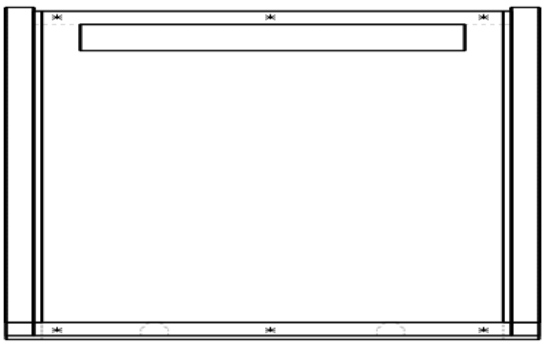




Place and fasten the two Panel 15's (interior sides facing each other) oriented vertically on the interior sides of the Beam 08's.

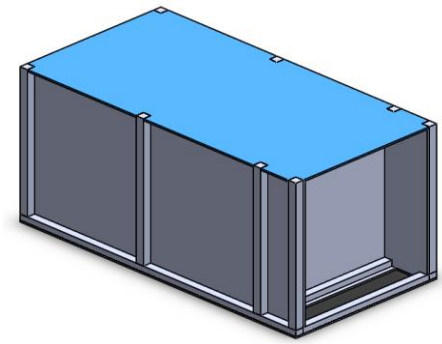
Step #9

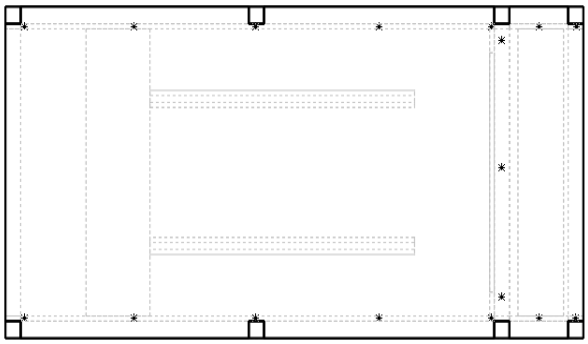




Place and fasten Panel 16 (interior side facing inwards) oriented vertically against the two Beam 03's.

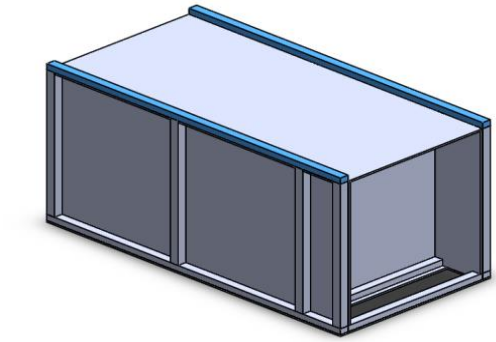
Step #10

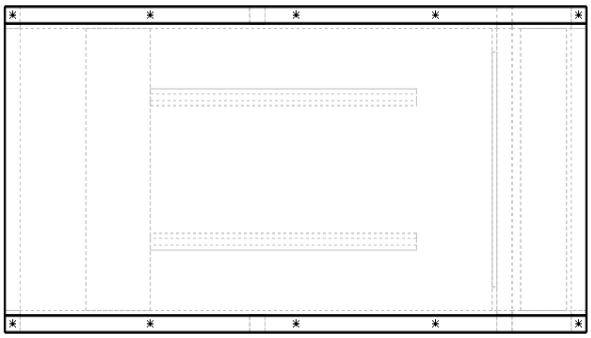




Place the Panel 17 (interior side facing down) on the top of the dryer.

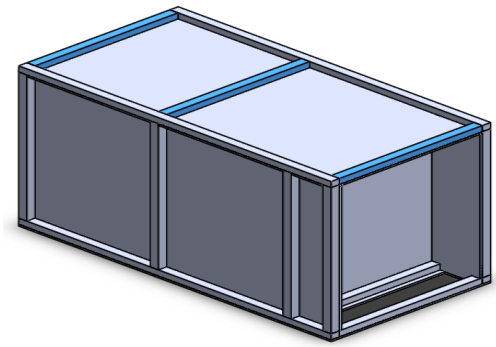
Step #11

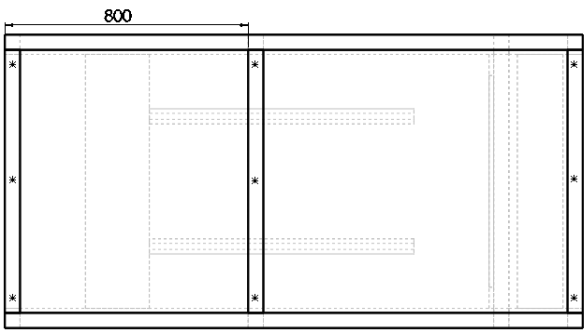




Place and fasten two Beam 07's on the top of the dryer, flush with the long sides.

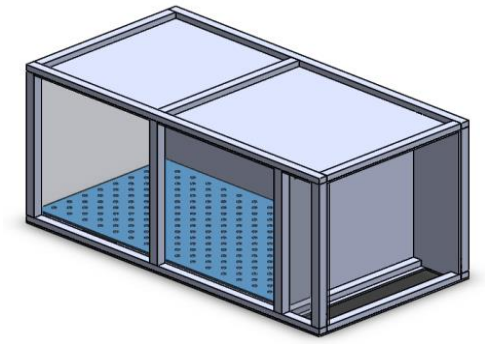
Step #12

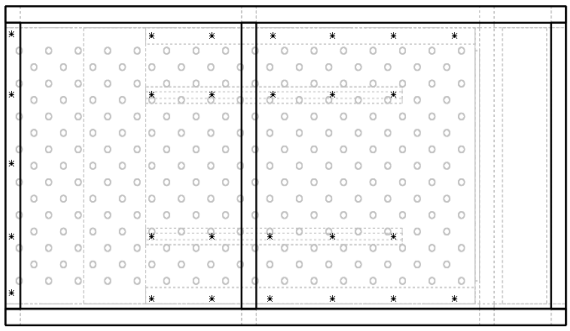




Place and fasten three Beam 03's on the top of the dryer.

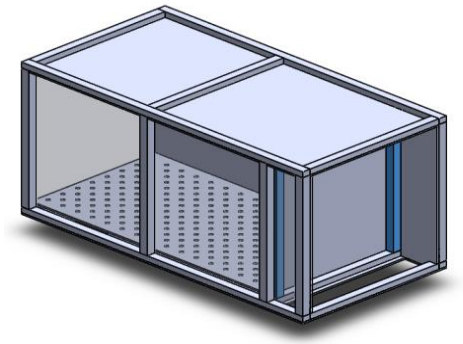
Step #13

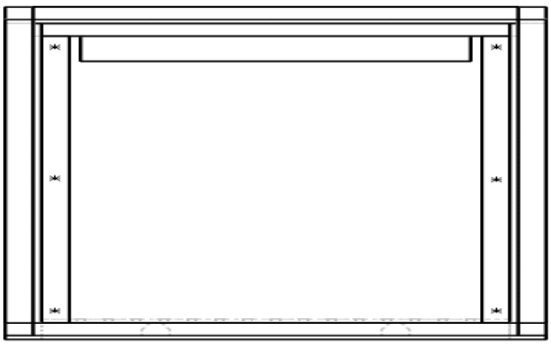




Place and fasten Panel 18 (interior side facing up) on top of the Beam 09's and Beam 10's so that it is flush with the back of the dryer. Make sure that the holes are not blocked by the beams.

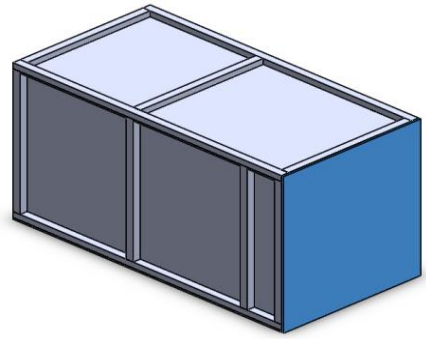
Step #14

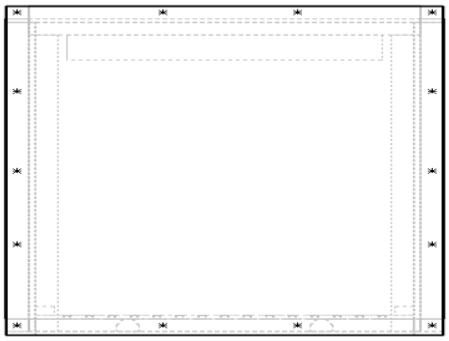




Place and fasten two Beam 11's against Panel 16 so that they are between both Beam 03's.

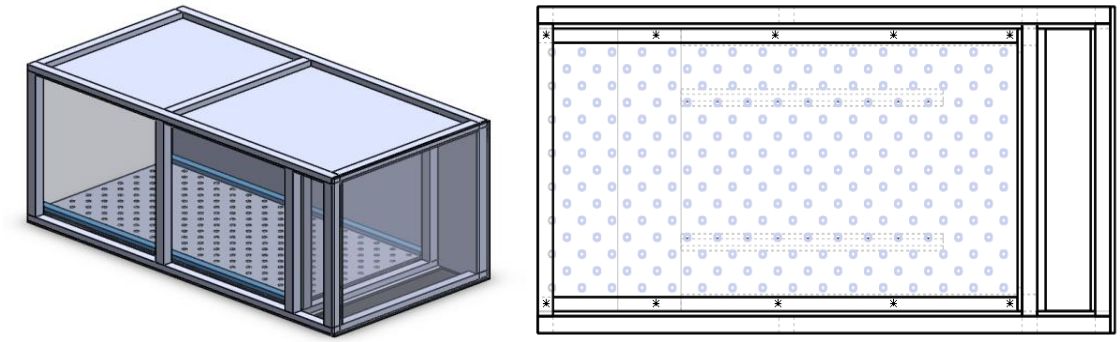
Step #15





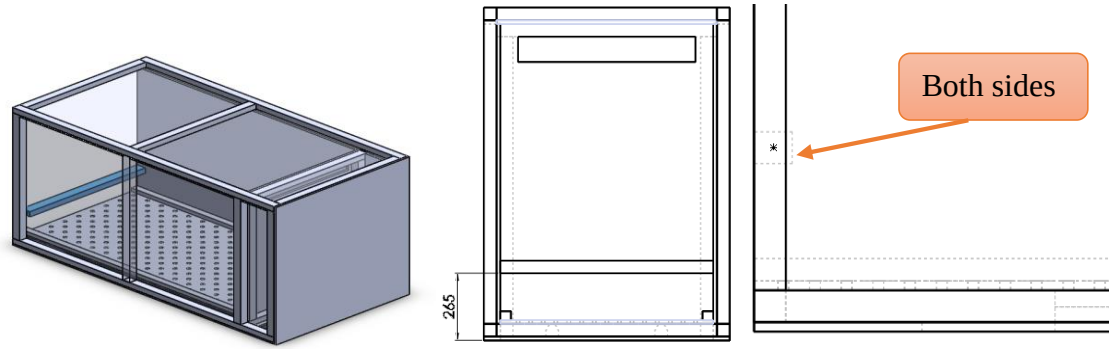
Place and fasten Panel 19 to the Beam 03s and Beam 08's.

Step #16



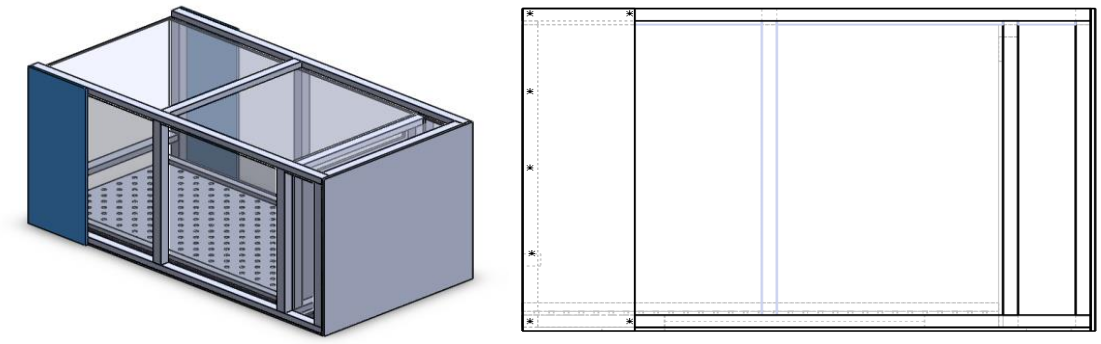
Place and fasten Beam 12's to the interior side of Panel 18, flush with either end.

Step #17



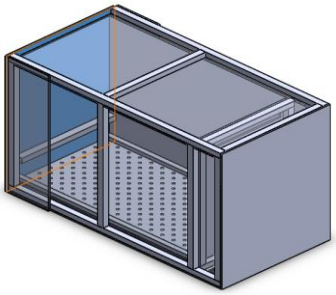
Place and fasten Beam 13 so that it is on the interior side of the Panel 15's.

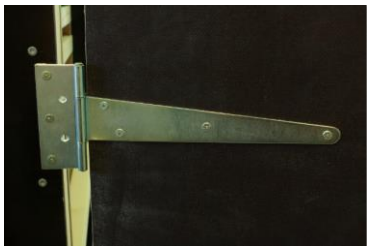
Step #18



Place and fasten two Panel 19's to the Beam 08's so they are flush with the top and bottom of the Beam 07's.

Step #19

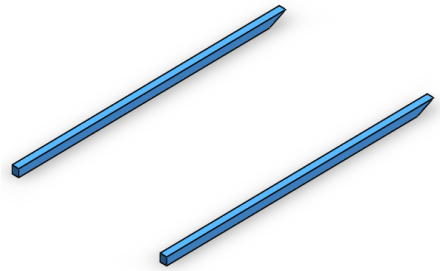


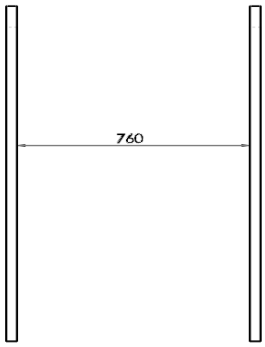


Attach a Panel 19 to either side of Panel 21's using a hinge on one side and a latching mechanism on the other side to allow the door to open and close.

SECTION 4: Assemble the pallets

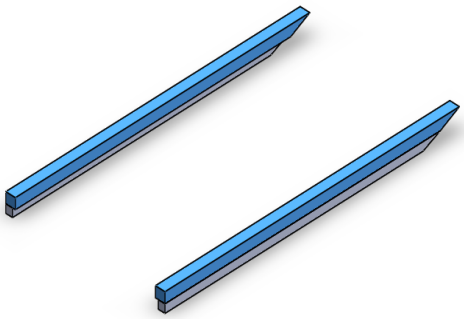
Step #1:

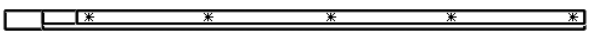


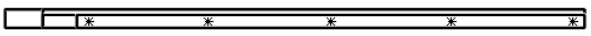


Place two Beam 14's 760 mm apart.

Step #2:

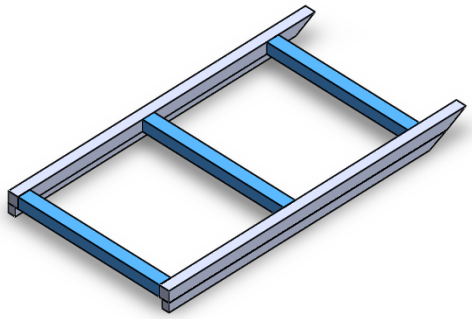


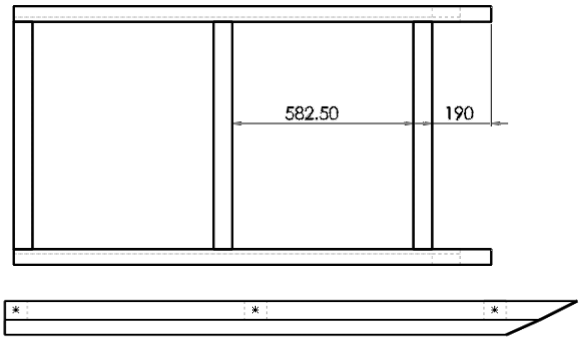




Place and fasten two Beam 15's to the two Beam 14's so that the beams are flush with one another.

Step #3:



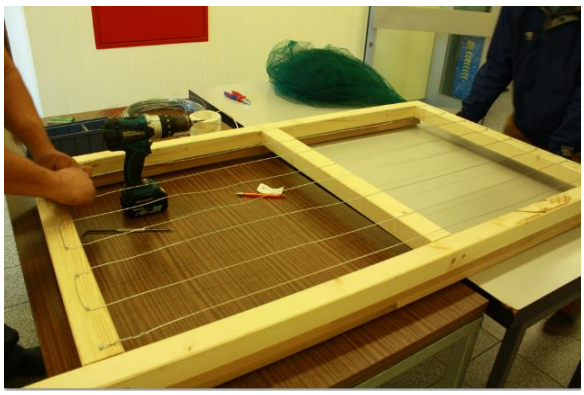


Place and fasten three Beam 16's in between the two Beam 15's.

Step #4:

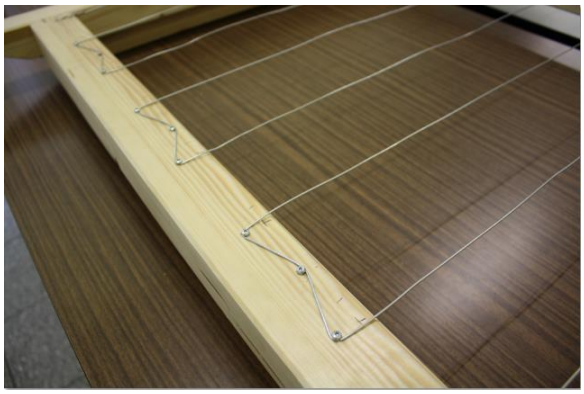
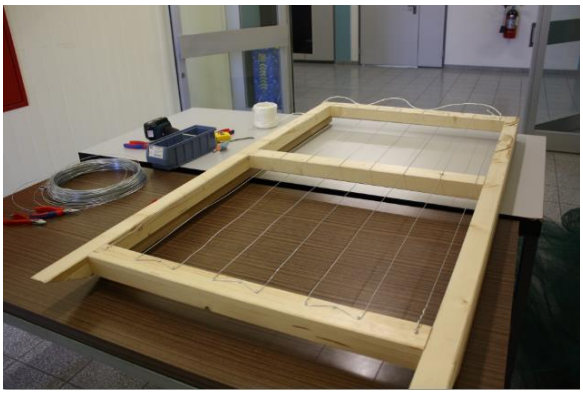
Drill 6 screws into the Beam 16's on the outer edges of the pallet that are 10 cm apart. Leave enough room beneath the screw head to wrap wire around the screw.

Step # 5:



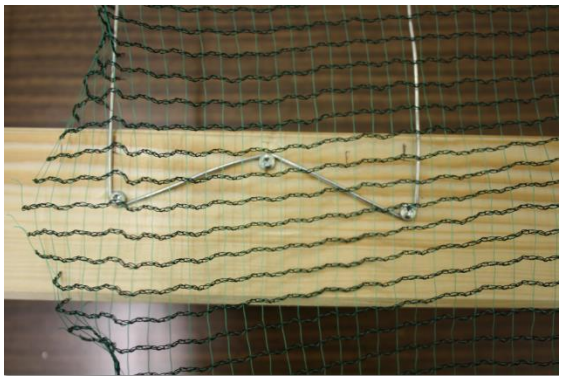
Wrap wire around the screws and tie off both ends.

Step #6:

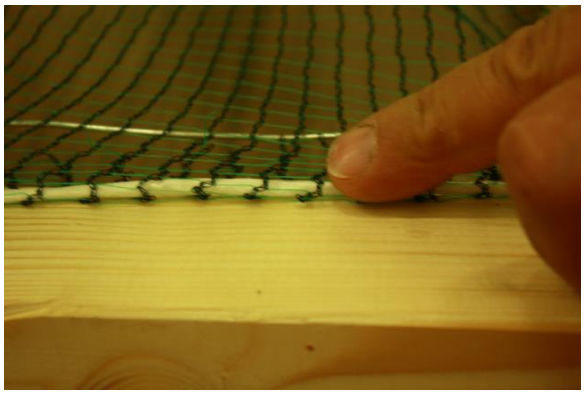
Tighten the wire by placing additional screws in the locations shown to take up slack. Tighten all screws.

Step #7:



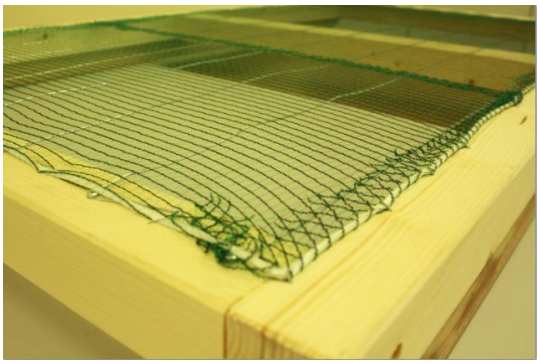
Staple the ends of the netting on one corner of the pallet.

Step #8:



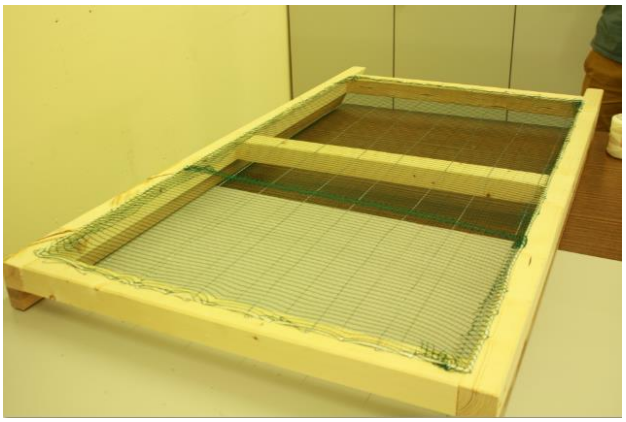

Run string along the inner edge of the pallet and fold the edge of the netting around the string, then staple the netting and string to the pallet.

Step #9:



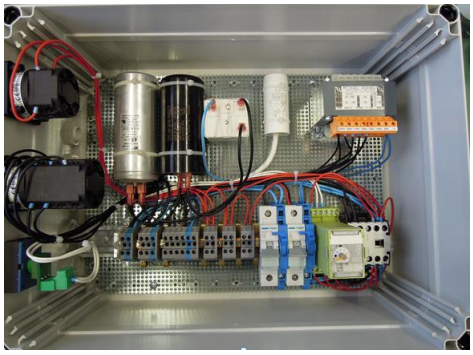
Cut the end of the string and add staples when necessary to attach loose portions of netting.

Step #10:

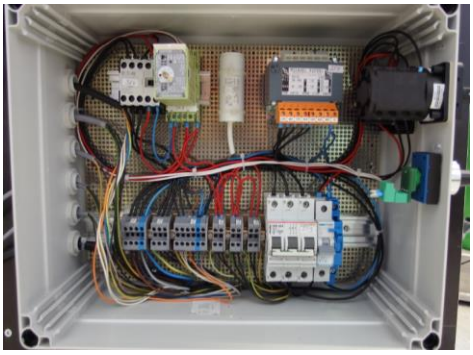


Repeat steps 1-9 to make more pallets.

ELECTRICAL SYSTEM



One-phase System

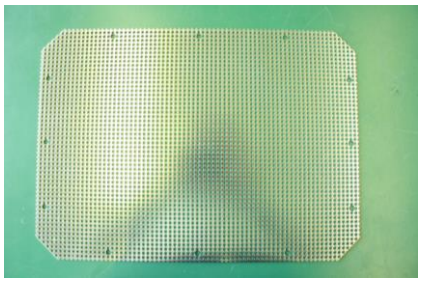


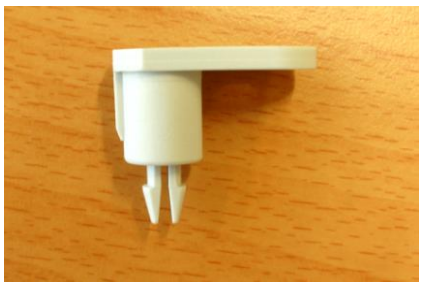
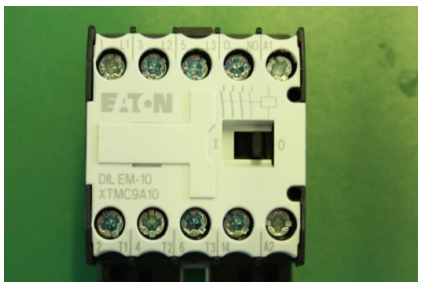
Three-phase System

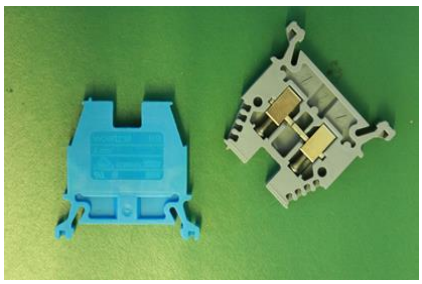
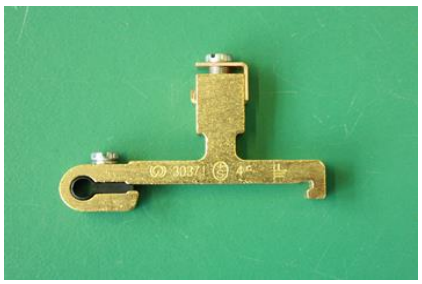
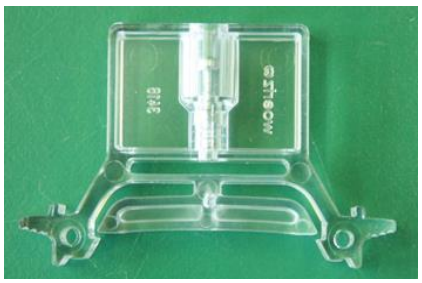
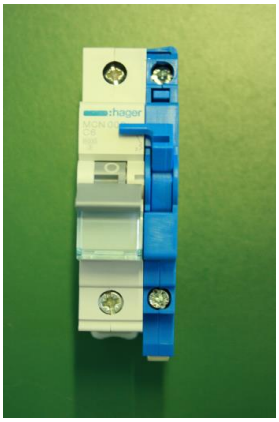
The power components shown in this section are based on a three-phase system. A one-phase system can be adapted with the addition of a capacitor. Schematics for both phases are provided at the end of the section.

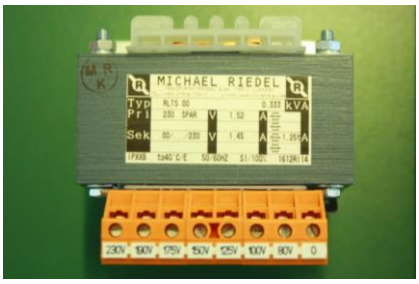
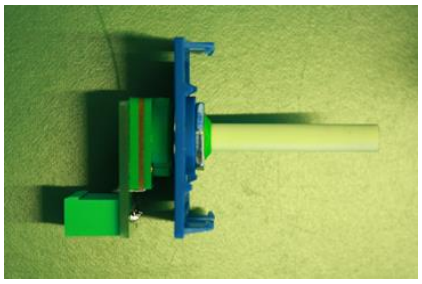
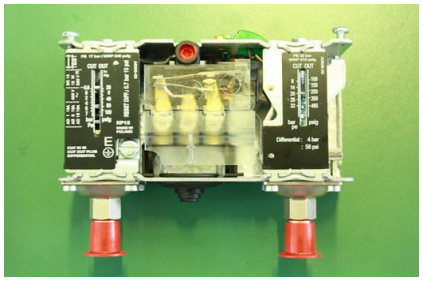
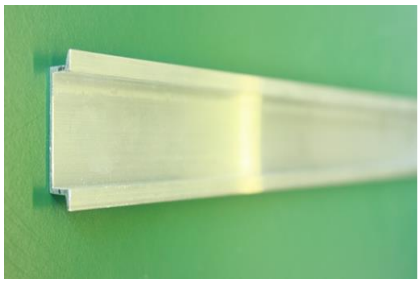
PARTS LIST

Hardware for Electrical components		
Name	Dimensions (mm)	Number Required
Screw 06	3 x 20	16
Screw 07	3.5 x 20	4
Screw 08	5 x 45	12
Screw 09	5 x 60	3
Wire 01	1.5	4.5 meters
Wire 02	0.75	12 meters

Electrical Components	
Electrical Case (CUBO O 300x400x180)	**Mounting plate (Lochplatte 270x370)**
	
Dimensions (cm): 30 x 40 x 18 Number required: 1	Dimensions (cm): 27 x 37 Number required: 1

Wall mounting brackets (Wandbef.lasche zu CUBO)  Number required: 1	**Lock nut M20 (Gegenmutter Polyamid M20Agro)**  Number required: 7
Cable gland M20 (Polyam.-Verschraub.M20 Agro)  Number required: 7	**Power cord (Cable 3*2.5mm2)**  Number of wires: 3
Circuit breaker for the compressor* (LS-Schalter Hager C 6KA 3P 10A)  Number required: 1	**Contactor (DIL EM 10 (230VAC))**  Number required: 1

Feed-through terminal block (R-Klemme 4mm2)**  Number required: 14 grey, 3 blue	**Ground terminal (Trennwand)**  Number required: 6
Ground partition (Erdklemme 4 mm^2, blank)  Number required: 6	**Locking piece (Arretierstuck)**  Number required: 6
Circuit breaker for the ventilator (LS C6A 1pol)  Number required: 6	**Multifunction time relays (CS2/UC12-240V)**  Number required: 1

Switch for the ventilator (P220-61062-003M1-S)  Number required: 1	**Switch for the 2 temperature modes (P220-61025-003M1)**  Number required: 1
Transformer (RLTS80)  Number required: 1	**Potentiometer (SP-01/1M)**  Number required: 1
Emergency Cutoff (PS2-W7A)  Number required: 1	**Adapter rail for terminalys and relays (Hutschiene 35mm)**  Dimensions (cm): 3.2 x 0.37 Number required: 2

Capacitor for the fan (GC 6uF)	Analog temperature meaurement
 Number required: 1	 Number required: 1
Temperature switches (heatTHERM-AT)  Number required: 2	

* Picture shown is for a three-phase system, but one-phase can be used as well (LS C13A 1pol)
** Can be replaced with simple soldering

TOOLS LIST

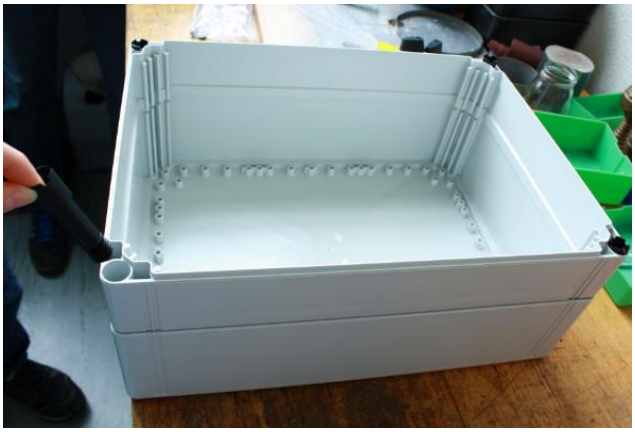
Necessary Tools	
Assorted Screwdrivers  H	**Needle-Nose Pliers**  M
Wire Cutters  M	**Wire Strippers**  L
Crimping Tool  Used to fasten crimps to wires L	**Zip-Ties**  L

Drill  H	**Assorted Large Diameter Drill Bits**  Used to cut holes in the plastic electrical case H
Deburring Tool  Used to remove sharp edges from metals or plastics L	

ASSEMBLY INSTRUCTIONS

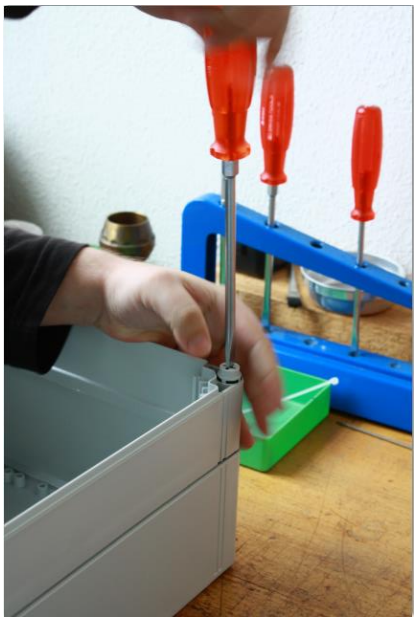
SECTION 1: Assemble the plastic case for electronics

Step #1:



Attach the case extension using the four black threaded pegs.

Step #2:



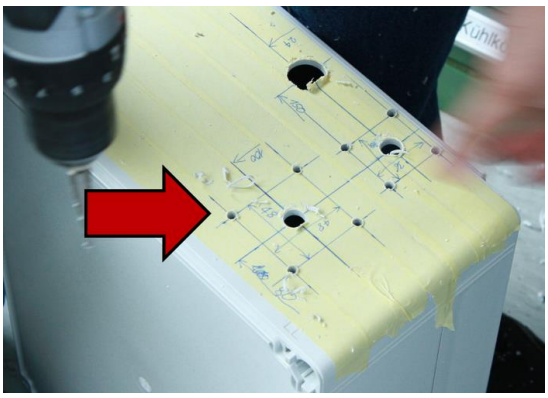
Tighten the threaded pegs using the grey screwdriver fitting provided.

Step #3: Drill

Mark and drill 6 evenly spaced 20 mm diameter holes for cable fittings that are approximately 4 cm from the bottom of the case.

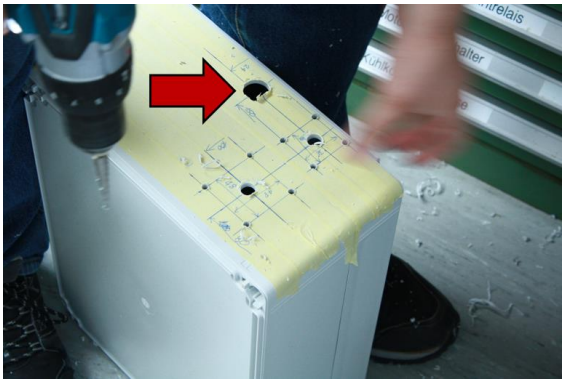
There are two templates attached on the following pages that can be used as a guide for the drilling in steps #3 and #4.

Step #4: Drill

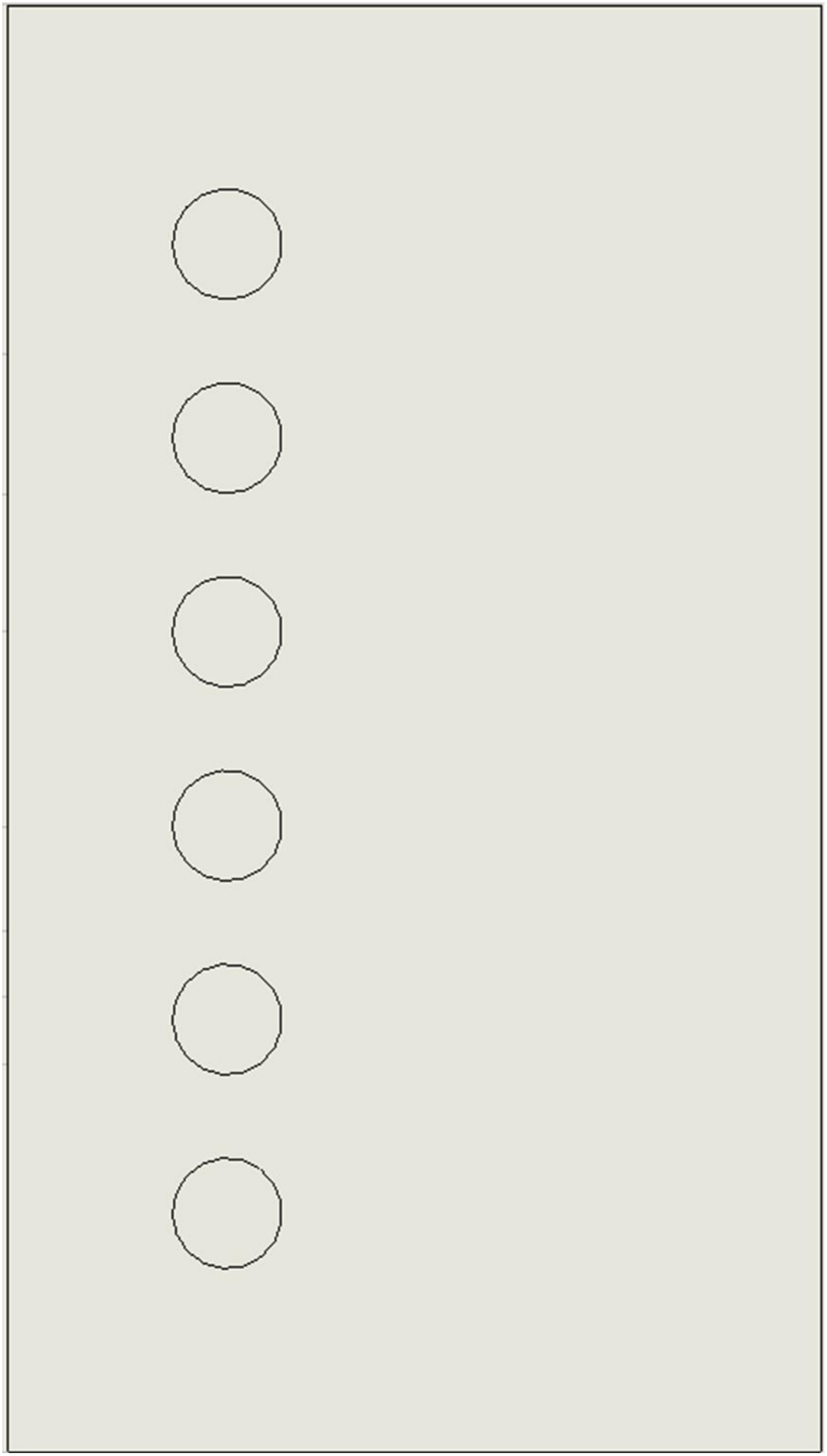


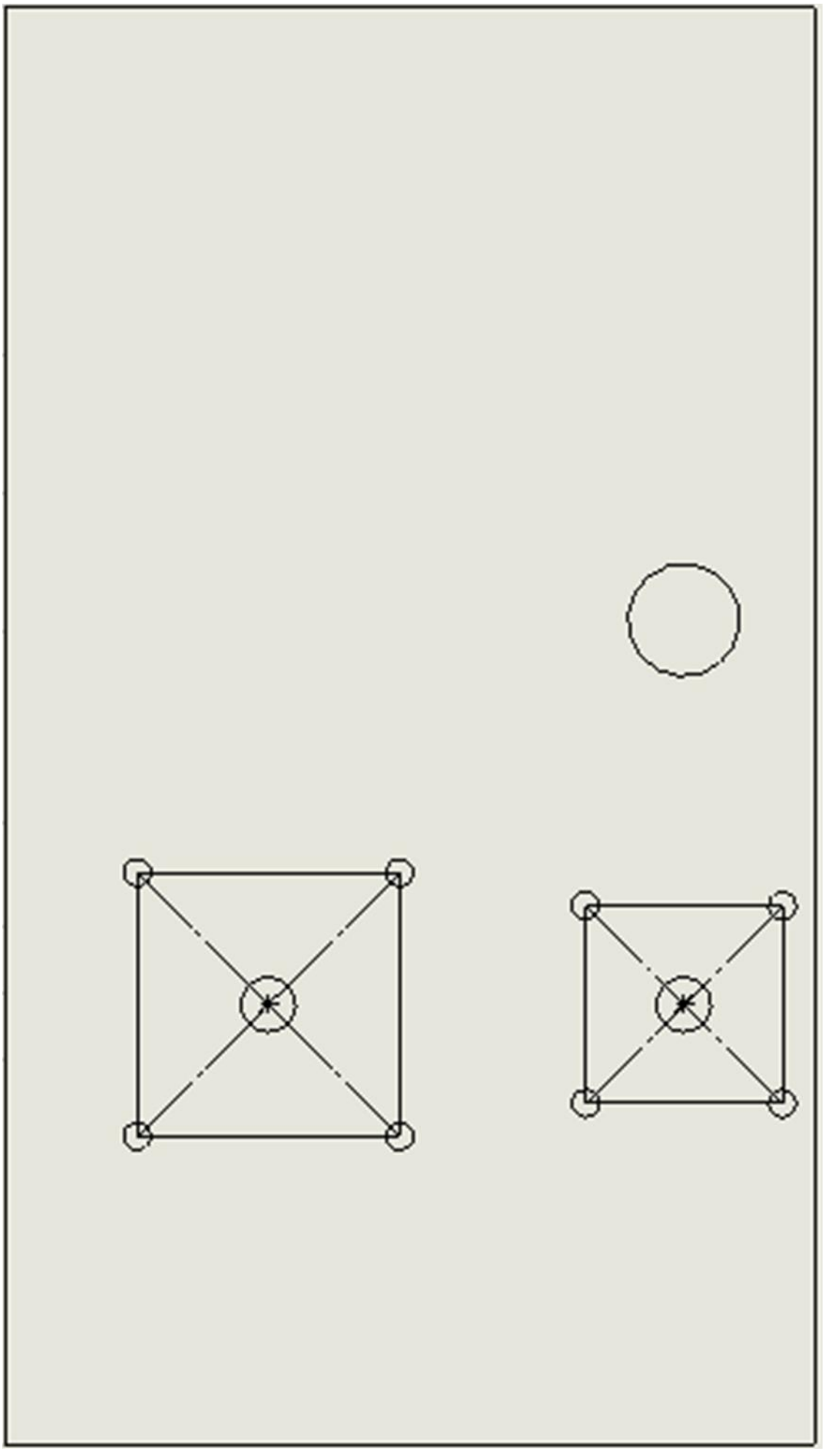
Mark and drill 4 holes 5 mm in diameter for each switch plate.

Step #5: Drill



Mark and drill a 20.5 mm hole for the potentiometer.



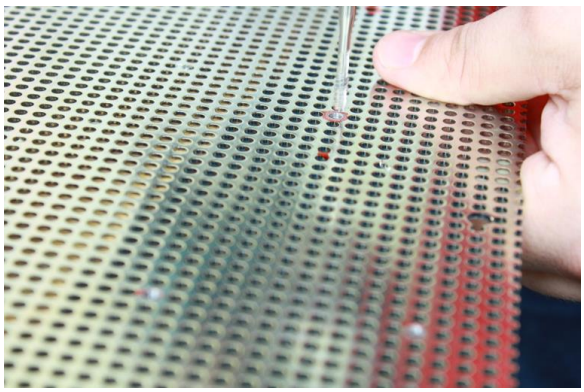


SECTION 2: Assemble the components within the electrical case

Step #1: Remove sharp edges

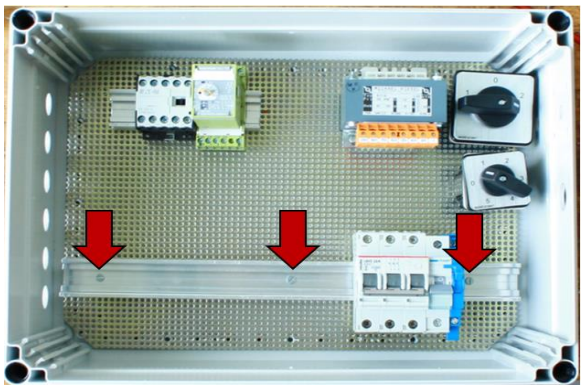
File the ends of the aluminum rail for placing electrical components.

Step #2: Drill



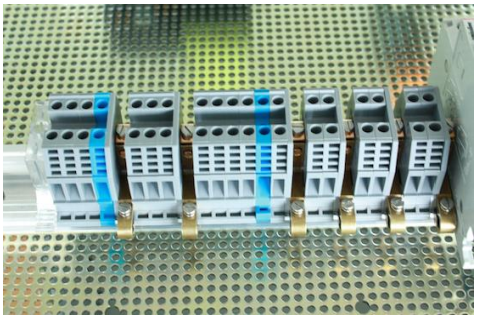
Tap three M4 thread size holes in the metal screen for mounting the aluminum rail.

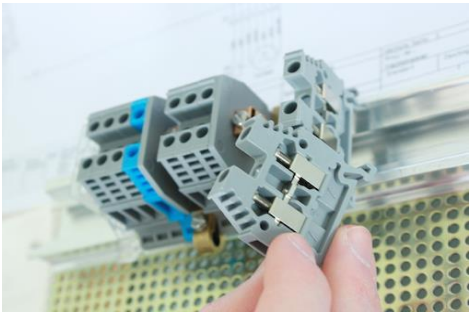
Step #3: Screw



Drill three holes (diameter 4.5 mm) in the aluminum rail and mount the rail on the metal screen with screws that correspond to the size of the tapped holes.

Step #4: Place Terminals



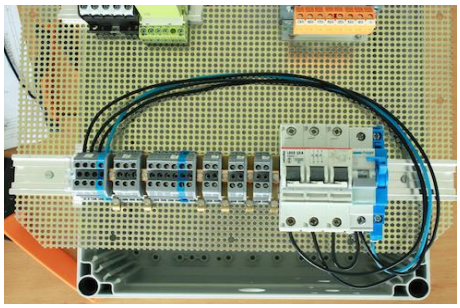


Follow electrical schematics on the following pages, and attach the terminals to the aluminum rail. Begin by attaching the transparent terminal that acts as a stopper to the left end of the aluminum rail.

Step #5: Label

Label the terminals as shown in the appropriate schematics.

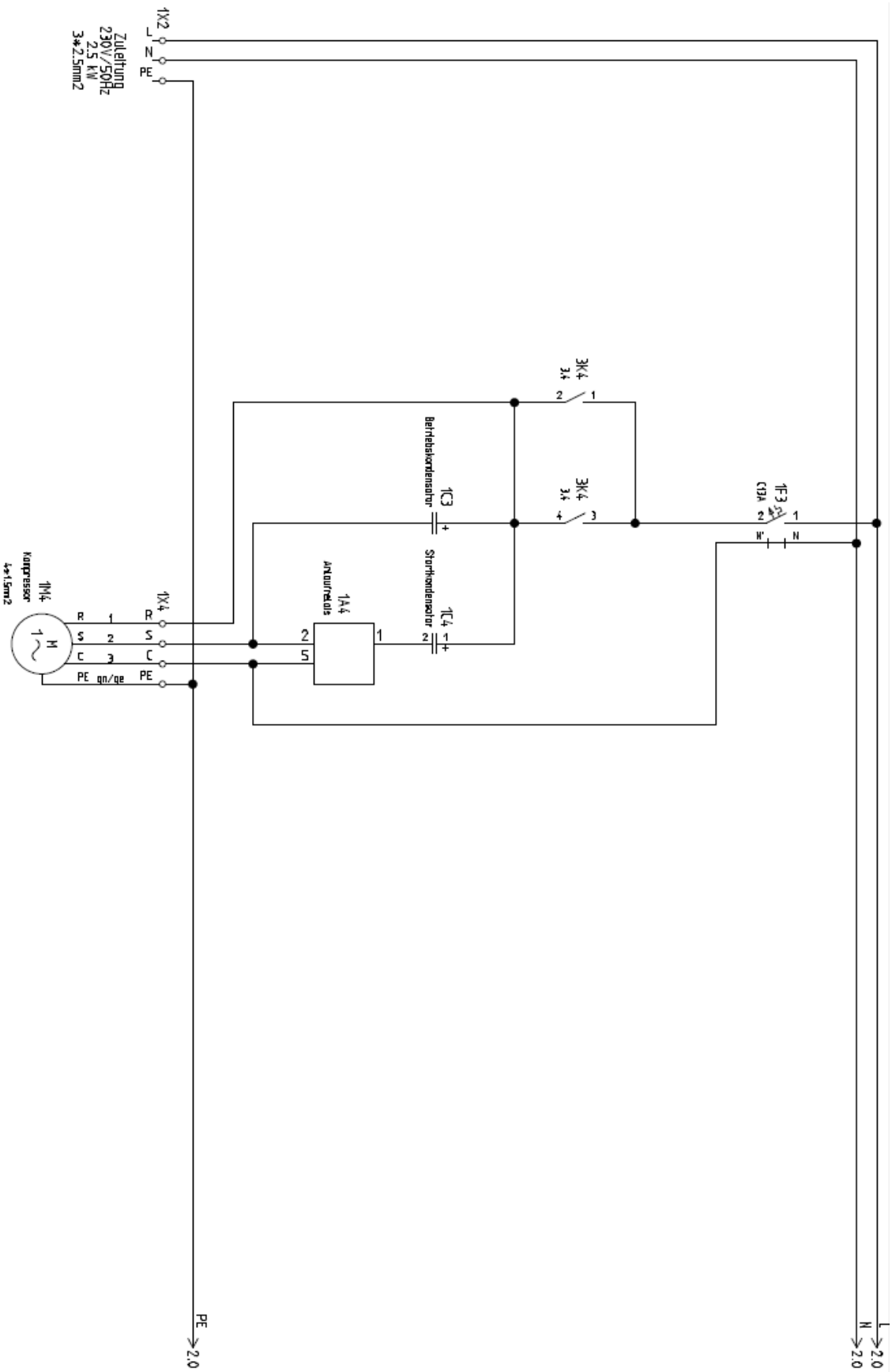
Step #6: Wire



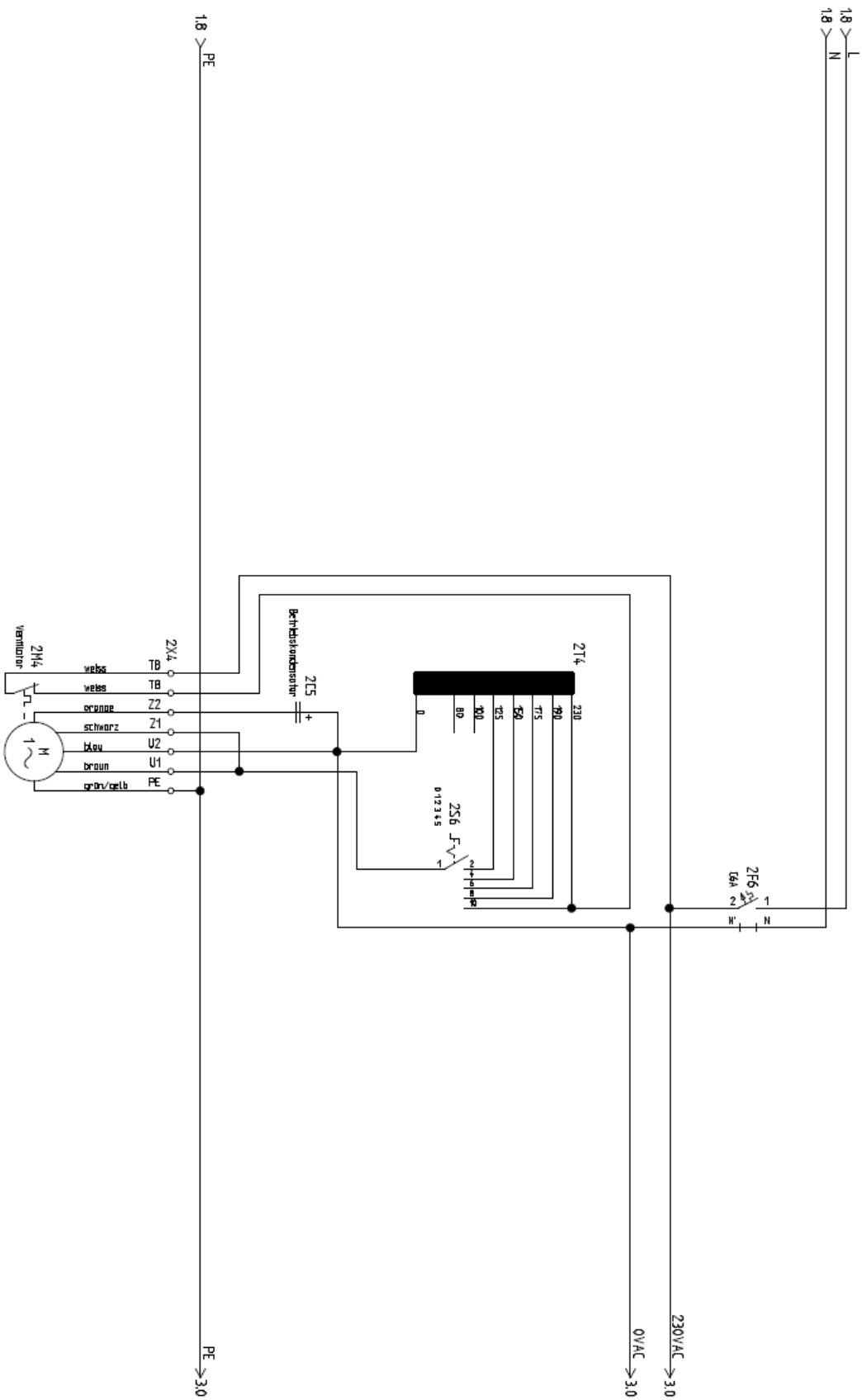
Cut wires to connect the components as shown in the schematics. Strip the wire ends, place end fittings, and crimp the wires before inserting them into the cages.

If the wire insulation is pinched in the cages, a full contact might not be made with the wire.

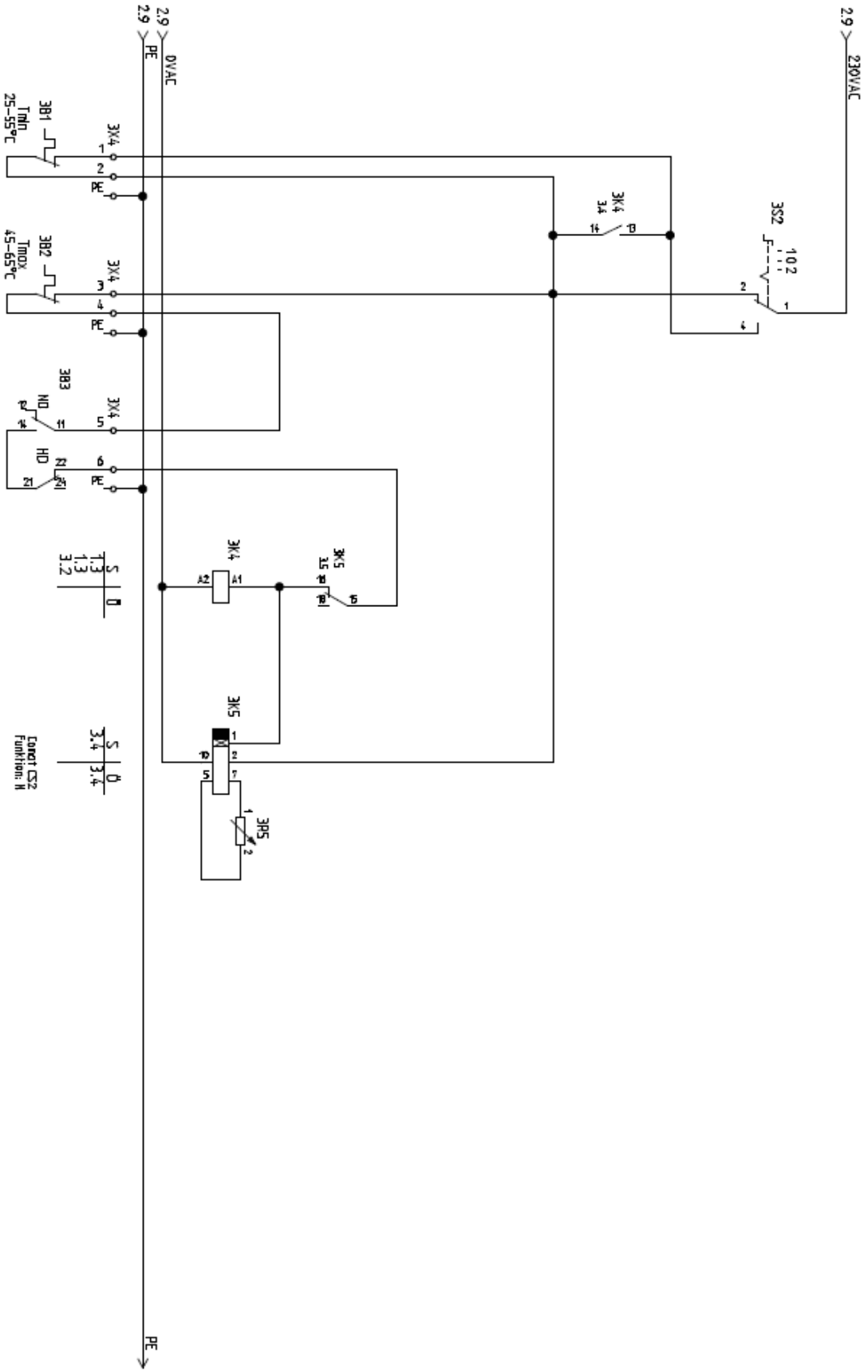
Schematic for a one-phase system: Compressor



Schematic for a one-phase system: Ventilator

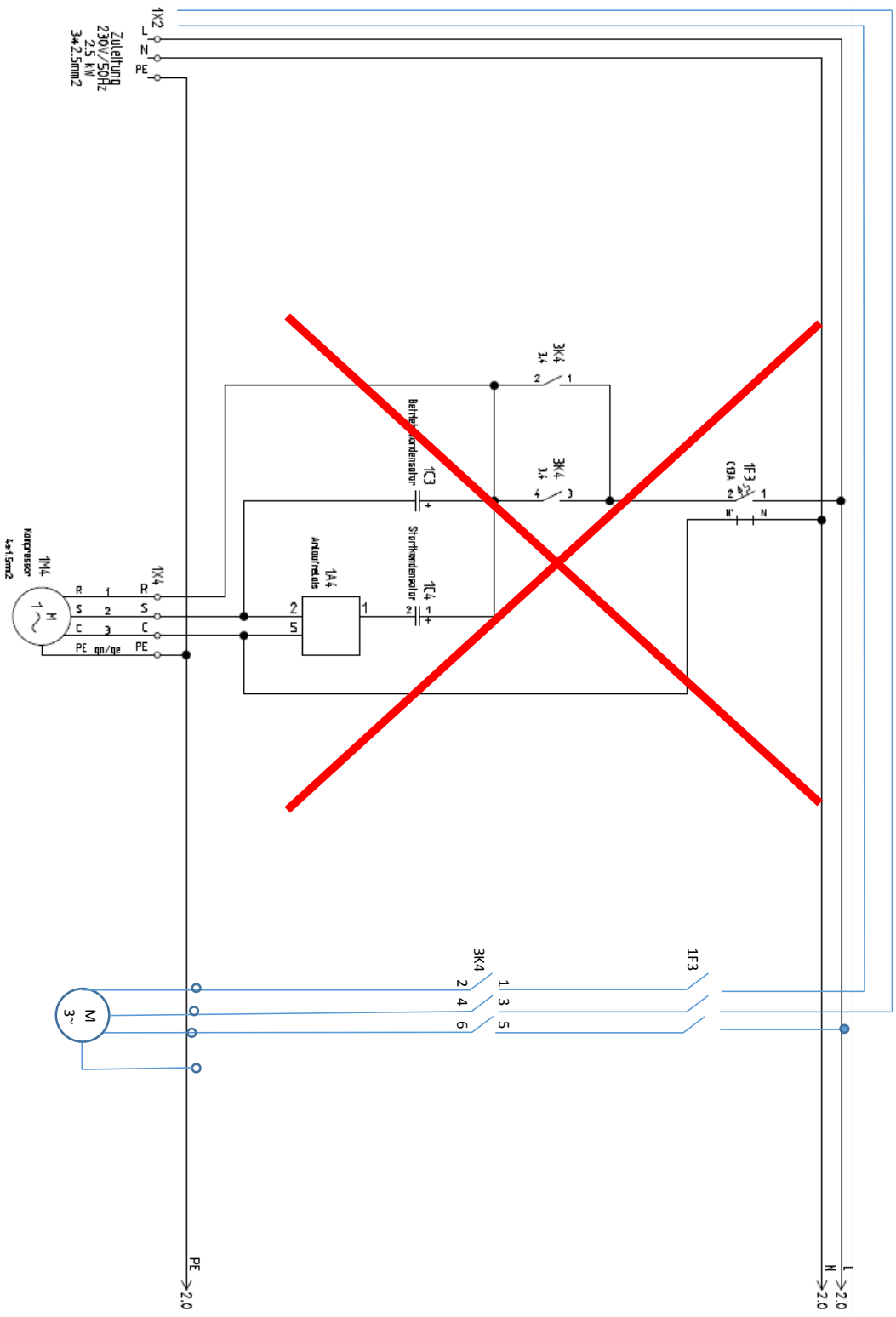


Schematic for a one-phase system: Controller

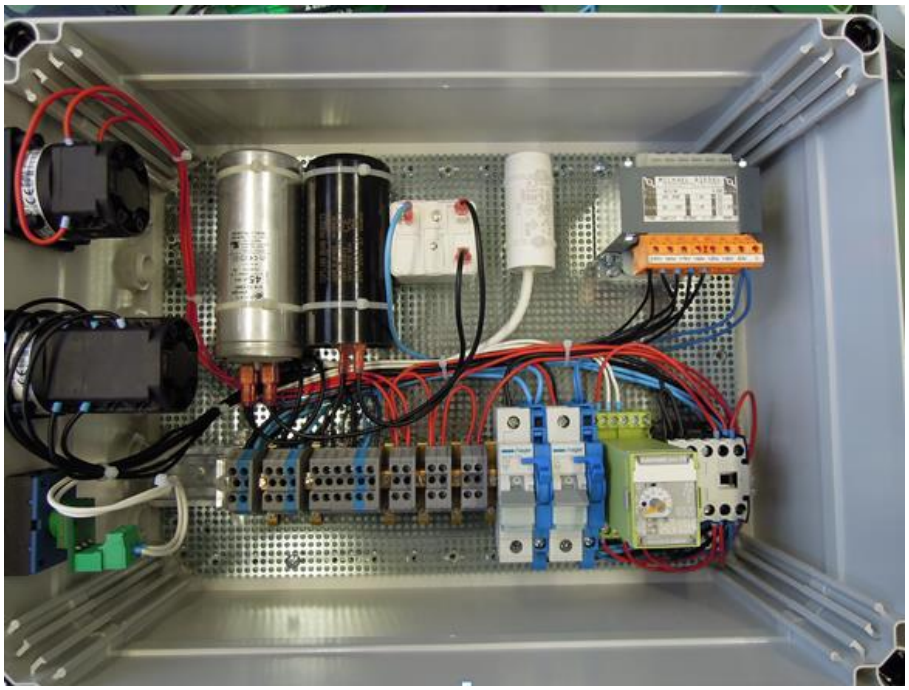


Schematic for a three-phase system: Controller

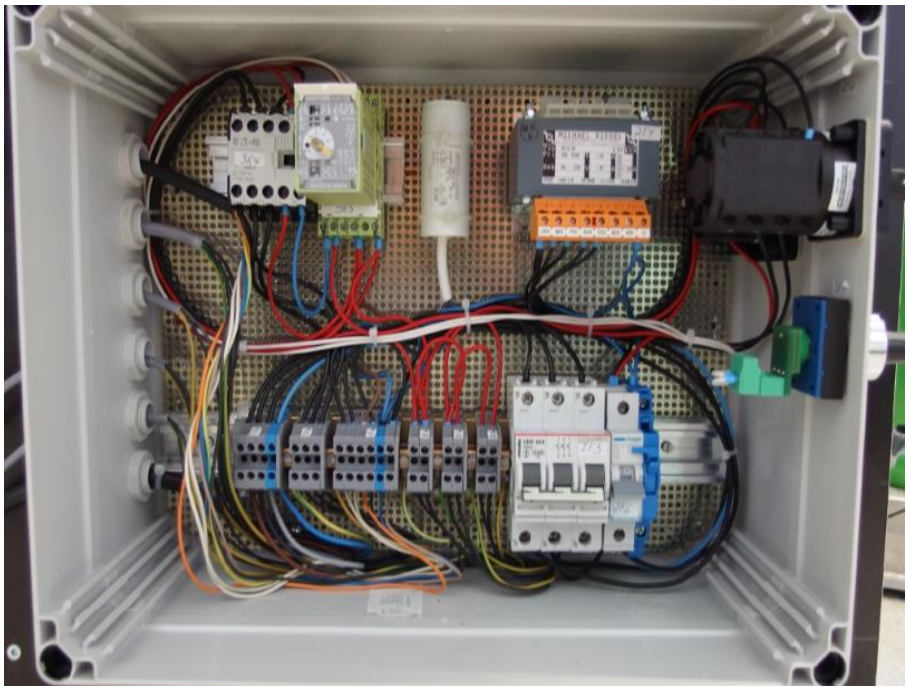
The schematics for the compressor and ventilator for a three-phase system are the same as the ones for a one-phase system.



Completed circuit for a one-phase system



Completed circuit for a three-phase system



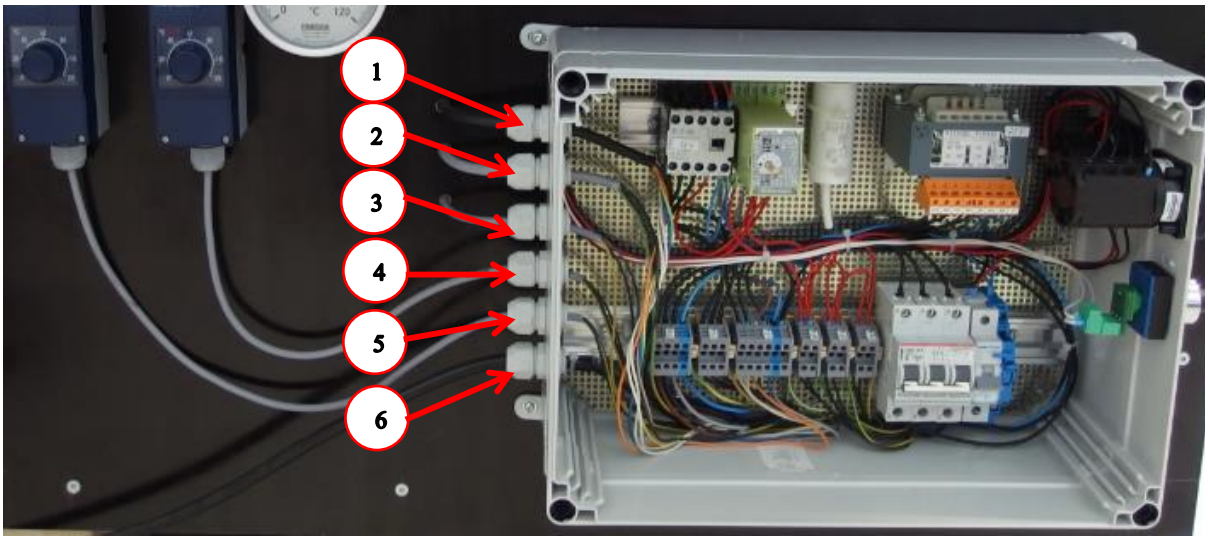
SECTION 3: Attach the electrical components to the dryer

Step #1:

Attach the electrical case, analog temperature gauge, and two temperature switches to the front Panel 11 of the dryer.

Move on to the heat pump system assembly before continuing this section in order to wire electrical components to the heat pump.

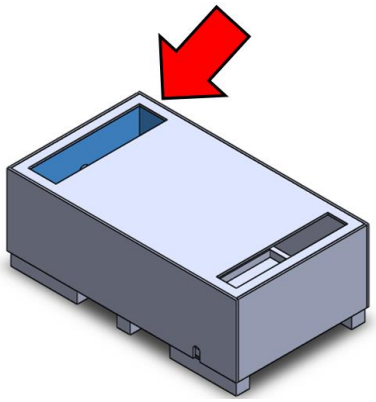
Step #2:



Attach the wiring to their proper locations:

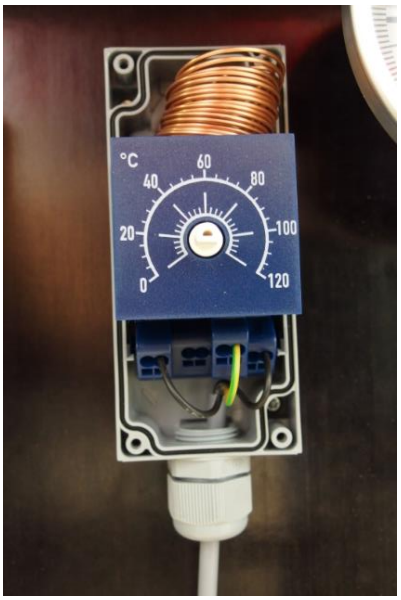
1. Fan
2. Compressor
3. Emergency cutoff (heat pump)
4. Temperature switch for mode 1
5. Temperature switch for mode 2
6. Power cord

Step #3:



When inserting the copper wire from the temperature switch make sure that it goes through the fan chamber, into the center to the ventilator.

Step #4:



Wire the inside of the temperature switches.

Step #5:

Set the maximum and minimum range of the temperature controls:

Temperature switch for mode 1: 35-73 ºC
Temperature switch for mode 2: 25-45 ºC

HEAT PUMP SYSTEM

PARTS LIST

Hardware for Heat pump assembly (total)		
Name	Dimensions (mm)	Number Required
Screw 10	M4 x 10 Machine Screw	30
Screw 11	M4 x 35 Machine Screw	4
Screw 12	4.5 x 20 Pan Head	20
Screw 13	4.5 x 45 Pan Head	4
Screw 14	5 x 20 Pan Head	6
Screw 15	M6 x 20 Machine Screw	4
Screw 12	M8 x 40 Machine Screw	4
Washer 02	4.3/12/1	54
Washer 03	5.3/15/1.2	12
Washer 01	5.4/15/1.2	16
Washer 04	8.5/35/2.5	4
Nut 02	M4	34
Rivet	2.4 or 3.0	8
Elbow Joints	½ Zoll – ¾ Zoll	5
Tubing	Diameter: 3.5 Length: 2000	Length: 2000 mm
Threaded Slotted Insert	Inside diameter: M8 Outside diameter: M12 Length: 18	4
Piping	Diameter: 6.4	Length: 39.7 mm
	Diameter: 8	Length: 10 mm
	Diameter: 12.6	Length: 100 mm
	Diameter: 19	Length: 112 mm

Parts			
	Name	Dimensions (mm)	Number Required
Wooden Panels	Panel 21	24 x 940 x 940	2

The compressor, condenser, evaporator, and ventilator must be ordered as specified.

Heat Pump Components

Compressor

Number required: 1
Flow Rate: 6.8 m^3/h
Must be able to sustain:
Evaporator temperature: 25°C
Condenser temperature: 65°C

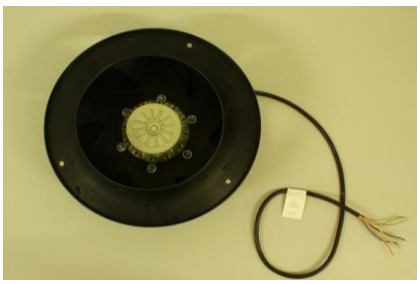
Condenser

Number required: 1
Total surface area: 10 m^2
Fin Spacing > 3.5 m
Overall heat rate trasnfer: 8 kW
Dimensions: 920 x 410 x 160 mm

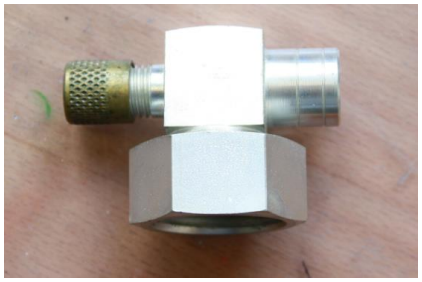
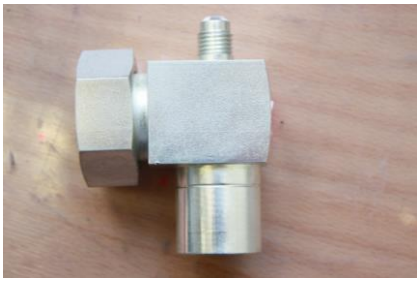
Evaporator

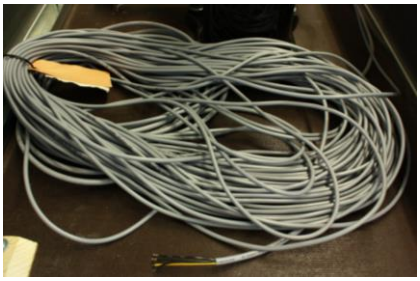
Number required: 1
Total surface area: 10 m^2
Fin Spacing > 3.5 m
Overall heat rate trasnfer: 6 kW
Dimensions: 920 x 410 x 90 mm

Ventilator



Number required: 1
Flow Rate: 1500 m^3/h
Pressure: 80 Pa
Temperature: 70°C
Variable Speed
Dimensions: Thickness 216mm
Outside Diameter 330mm

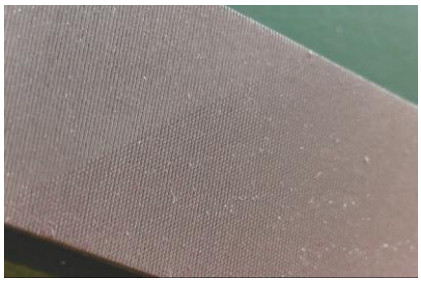
Metal Shroud  Number required: 1 Dimensions: match ventilator	**Refrigerant Filter Drier**  Number required: 1
Sight Glass  Number required: 1	**Metal Bracket**  Number required: 2 or 4
Pressure Valve  Dimensions: ¾” Number required: 1	**Pressure Valve**  Dimensions: ½” Number required: 1
Schrader Valve Core  Number required: 2	**T Joint**  Number required: 2

Insulation  Length required: 1 meter	**Emergency Cutoff**  Number required: 1
Metal Strap  Number required: 1	**Valve Seal**  Number required: 4
Expansion Value with Thermometer  Number required: 1	**Wire**  Length required: 1.5 meter

TOOLS LIST

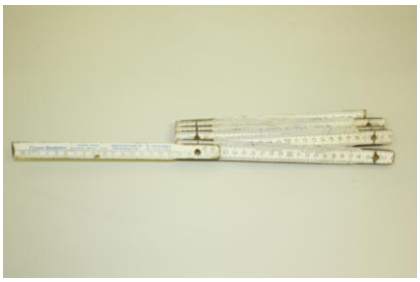
Necessary Tools

Abrasive Material



Used to shape or polish a work piece **L**

Measurement Tool



H

Metal Saw

H

Metal Cutter

L

Drill

H

Brazing Equipment

H

Countersink Drill Bit (High)

Used to drill out the end of an open pipe to allow the solder to better fill the pipe joint.

H

Assorted Drill Bits

H

Pipe Cutter

H

Pipe Bender

M

Cleaning Material

H

Deburring Tool

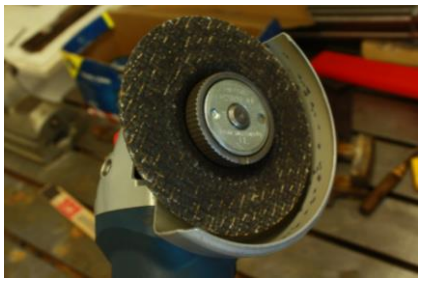
L

Pipe Expander

H

Compressed Air Hose

H

Hammer  H	**Pressure Monitor**  H
Grinder  L	**Solder & Flux**  H
Vacuum Pump  H	**Riviter**  L
Bench Vice  L	**Allen Wrench**  M

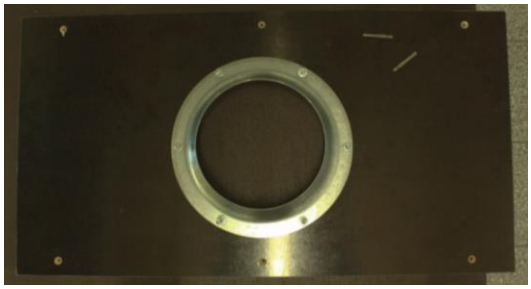
Insulation Tape  L	**Insulation Glue**  M
Electrical Tape  L	**Wrench**  L
Assorted Screwdrivers  L	

ASSEMBLY INSTRUCTIONS

It is highly important to clean all piping component through the process of building the heat pump system. Foreign contaminants could restrict or damage the operation of the system.

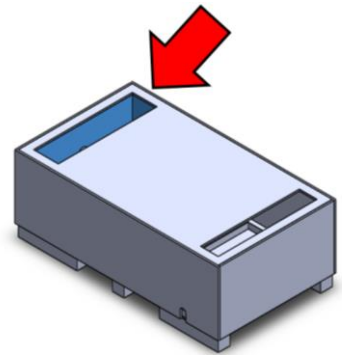
SECTION 1: Install ventilation

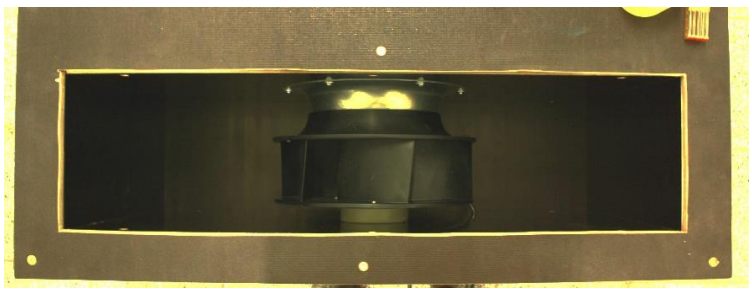
Step #1



Center and fasten the metal shroud on Panel 04 (interior side up).

Step #2





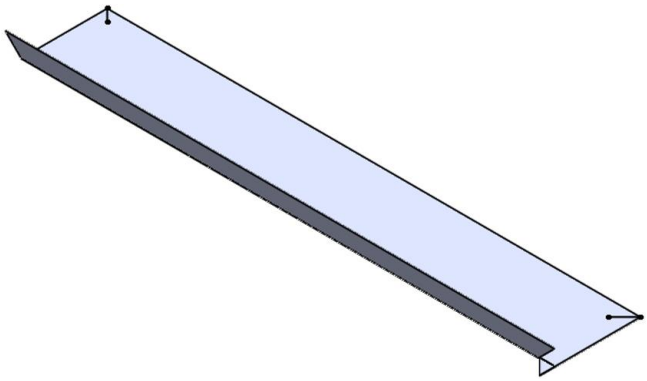
Overhead view

Place and fasten the ventilator in place by securing it to Panel 05 and the Metal Shroud.

Adjust the ventilator accordingly to prevent rubbing from occuring between the ventilator fan and the shroud when the fan is spinning.

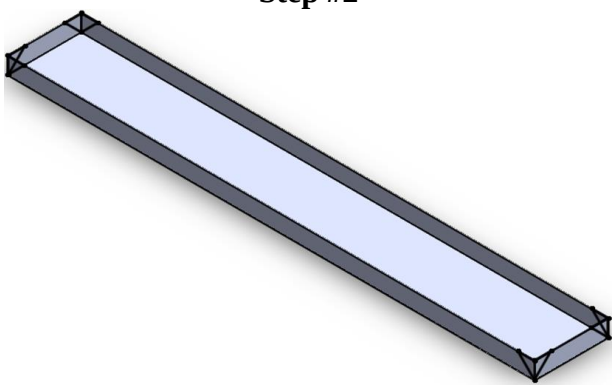
SECTION 2: Construct water collector

Step #1



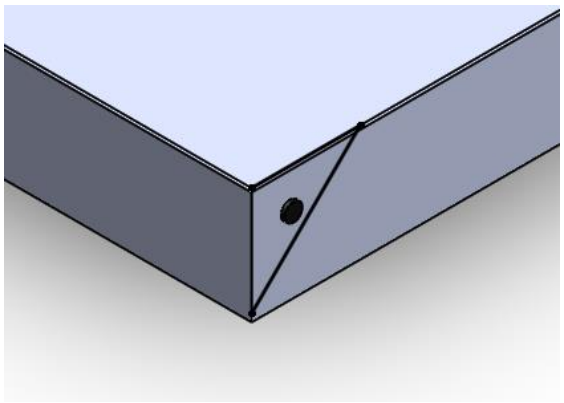
Obtain a metal sheet measuring 190 x 1000 mm in area. Cut the corners of the sheet to create foldable sides that are 30 mm tall.

Step #2



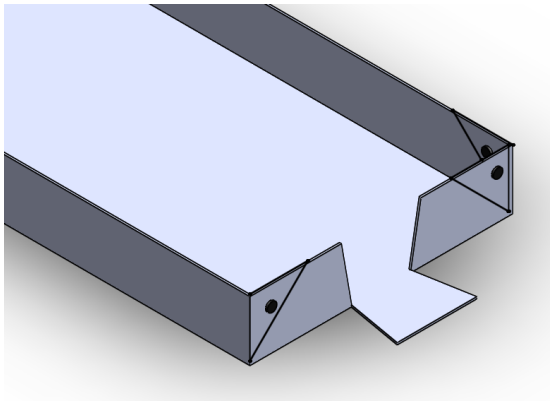
Fold the sides up and create four 90 degree corners.

Step #3



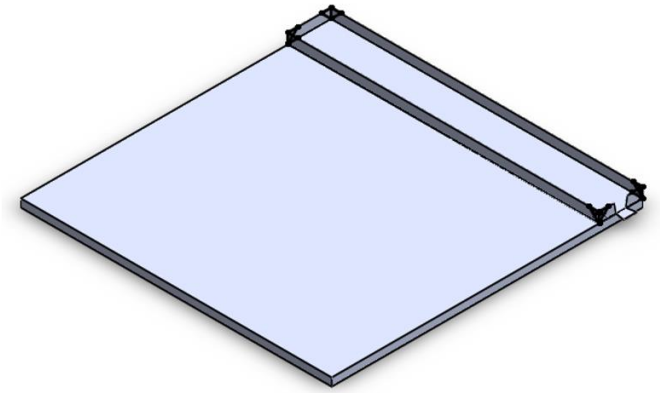
Rivet each side of the corners with 2.4 or 3.0 mm rivets.

Step #4



Make two cuts near the center of one end of the water collector to create a spout for the water to exit through.

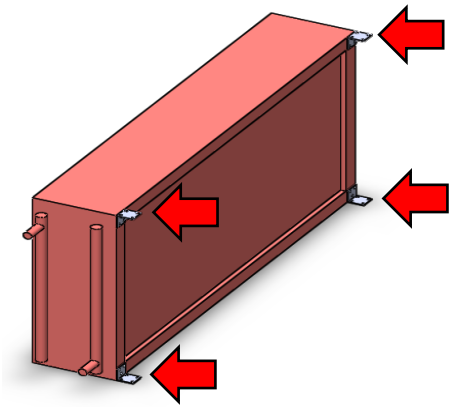
Step #5



Place the water collector on Panel 21 so that the back corner is flush with the back corner of the panel.

SECTION 3: Fasten condenser, compressor, and evaporator

Step #1



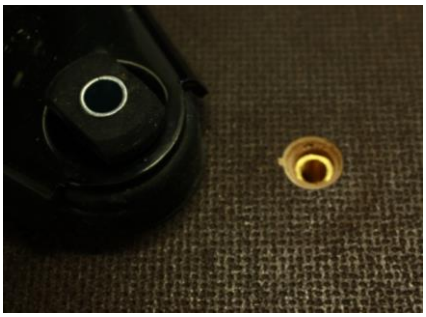
Attach four 90 degree metal brackets to the flanges on the condenser that are facing the evaporator.

> Be careful to not puncture any of the metal tubing while drilling.
>
> For safety, file the holes after drilling to remove sharp edges.

Step #2

Insert rubber bushings into the mounting points for the compressor.

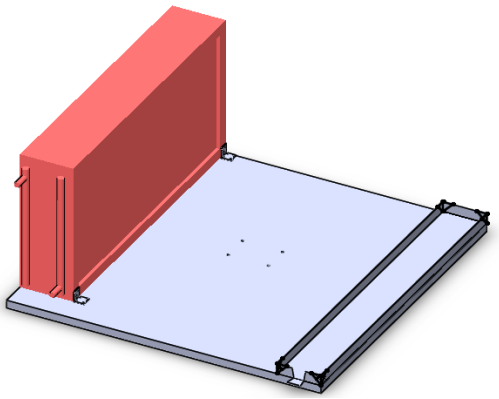
Step #3



Place and fasten the compressor using the threaded slotted inserts, and the Washer 04's.

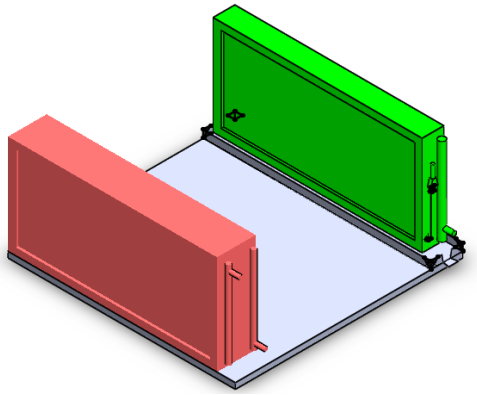
This washer size is crucial to hold the compressor securely in place if the fruit dryer is transported.

Step #4



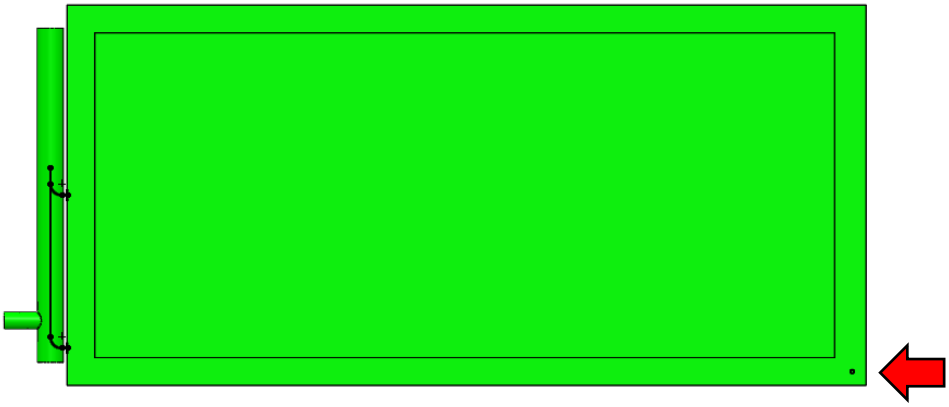
Place and fasten the condenser on Panel 21 (interior side facing up) with the back edge of the condenser flush with the edges of the panel.

Step #5



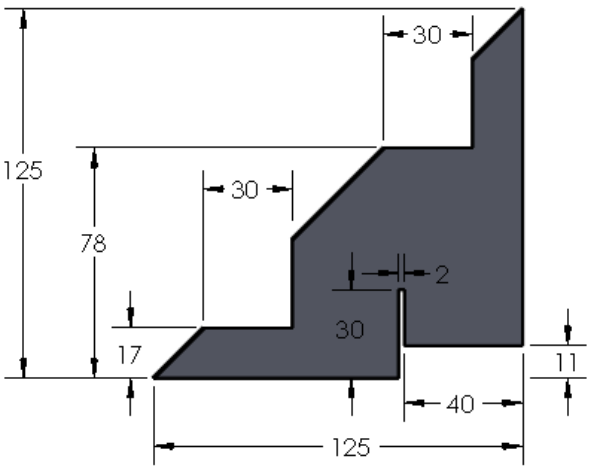
Place the evaporator in the water collector so that its back corner is also aligned with the back corner of the collector plate.

Step #6



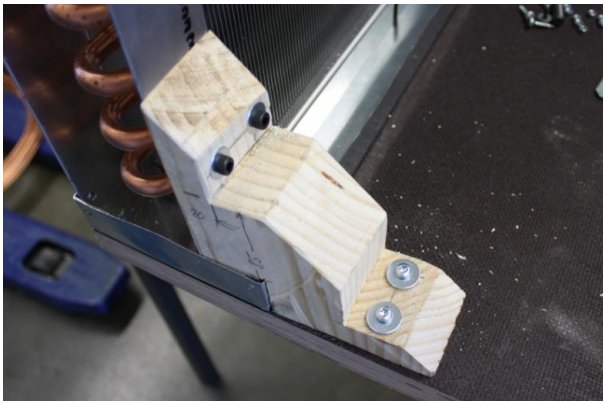
Drill a hole in the rear flange of the evaporator to allow for the rivet.

Step #7



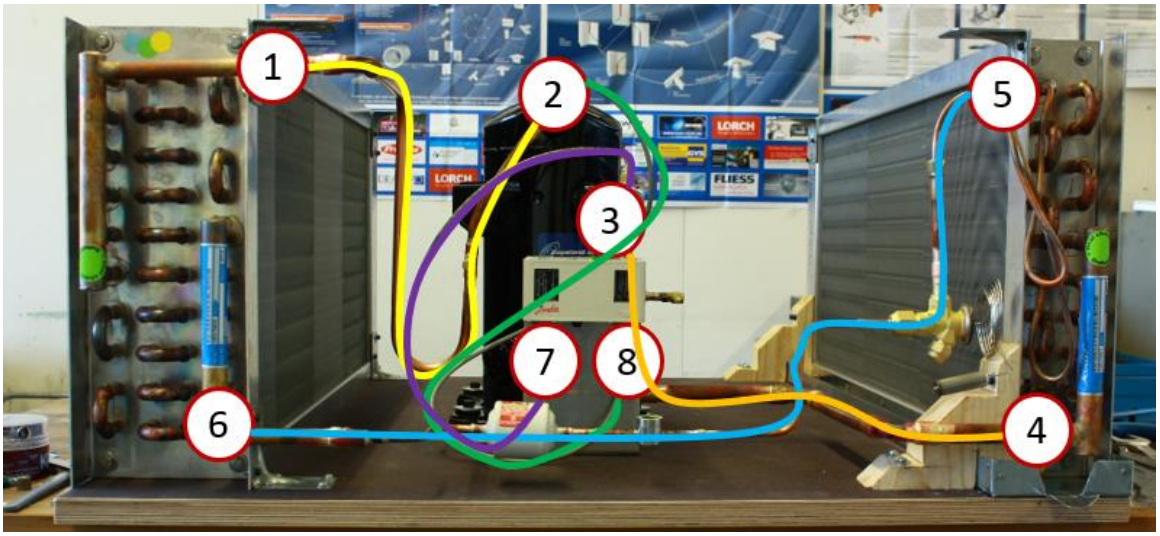
Cut two triangular pieces of wood and make the required cuts as shown. These will act as brackets to hold the evaporator and water collector in place.

Step #8



Fasten the wooden brackets in place.

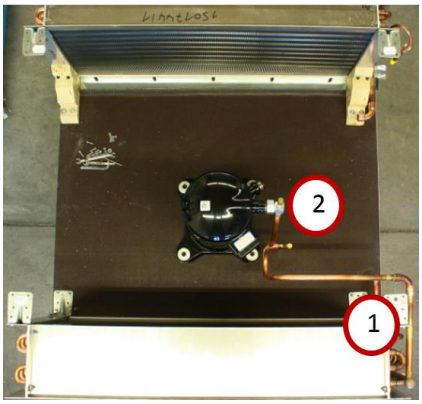
SECTION 4: Assemble the piping



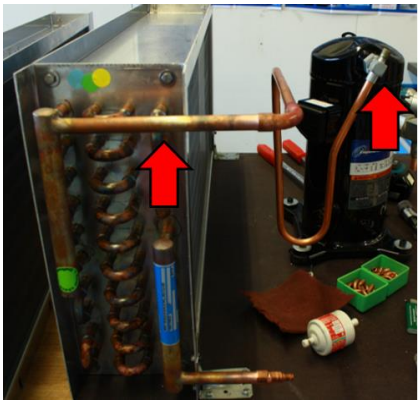
Side View

Each number represents a connecting location in the heat pump system.

Step #1



Top View

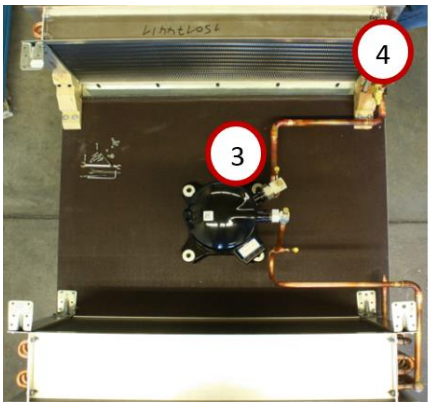


Side View

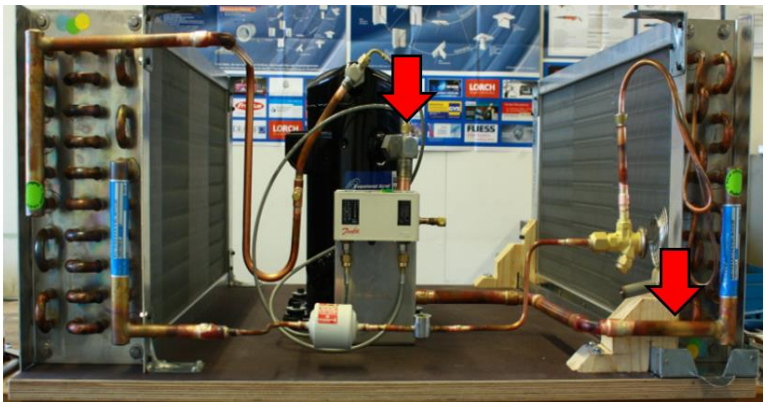
Connect location 1 to location 2 using piping, a reducer, and a T joint.

Allow for enough additional piping to dampen vibrations and reduce the risk of failure.

Step #2

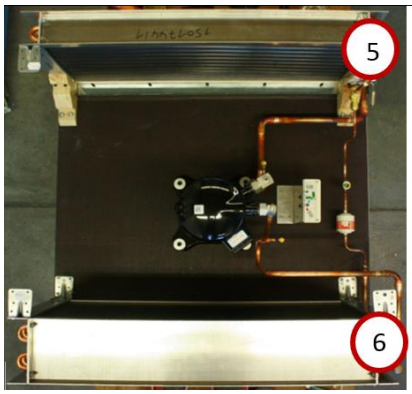


Top View

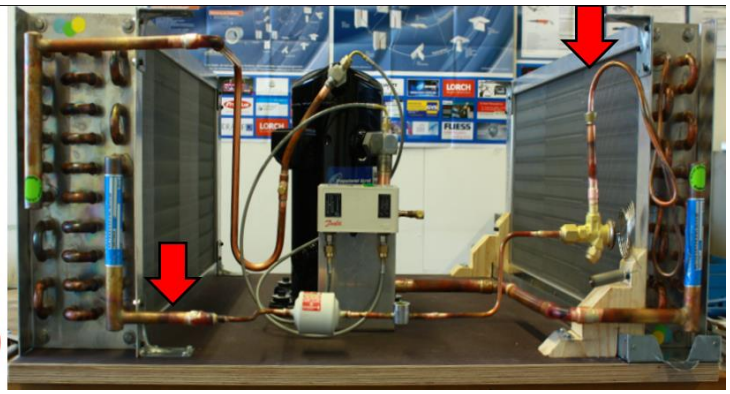

Side View

Connect location 3 to location 4 using piping, a reducer, a T joint, and the expansion valve (with thermometer).

Step #3



Top View

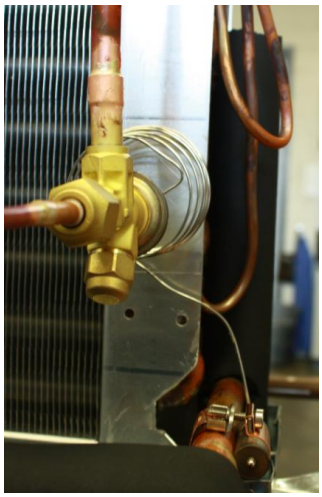

Side View

Connect location 5 to location 6 using piping, a reducer, the refrigerant filter drier, and the sight glass.

This filter dryer must be oriented to match the refrigerant flow direction. A label on the filter indicates the proper flow direction.

Step #4

Side View

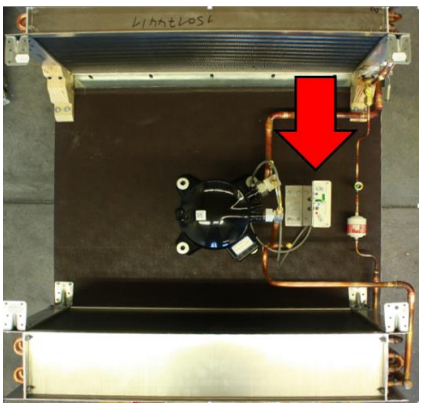


Front View

Fasten the thermometer reservoir from the expansion valve to the piping from location 5 to location 6. The reservoir must be oriented at a 1 o'clock position around the pipe if the pipe diameter is ½ Zoll, and at a 3 o'clock position if the pipe diameter is ¾ Zoll.

SECTION 5: Install emergency cutoff

Step #1

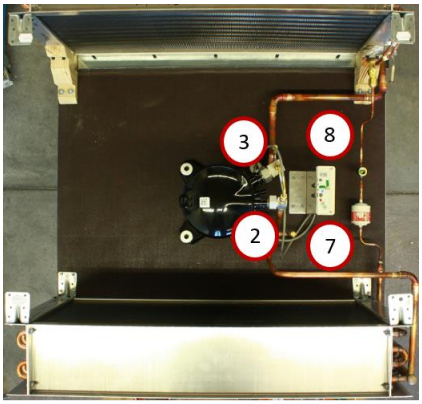


Top View

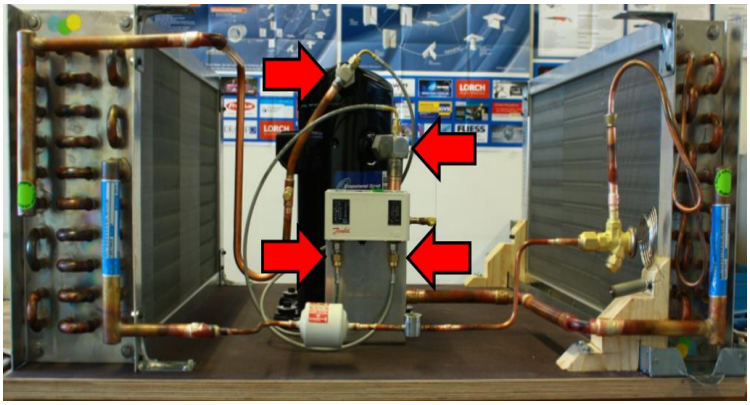
Side View

Place and fasten the emergency cutoff switch.

Step #2



Top View


Side View

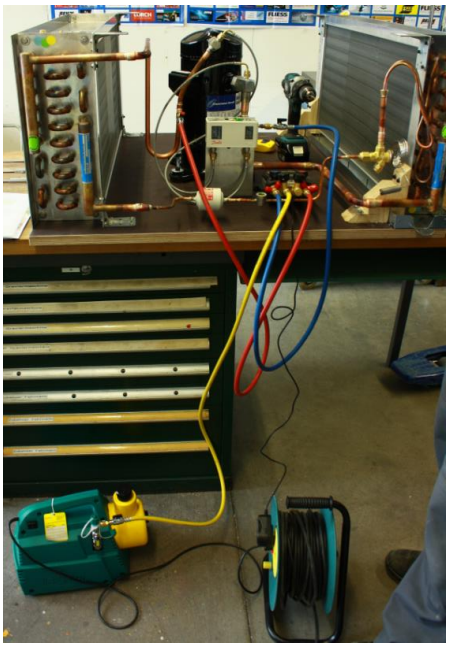
Connect location 7 to location 2 and location 8 to location 3 using flexible tubing.

Step #3

Set the pressure minimum to 1.5-2.0 bar and the pressure maximum to 20-25 bar.

SECTION 6: Perform pressure test

Step #1



Attach a vacuum pump to the high and low pressure fittings on the compressor and run the vacuum pump overnight to remove moisture from the heat pump system.

Step #2

Check the sight glass after the vacuum test is completed to make sure that the system is DRY.

Step #3

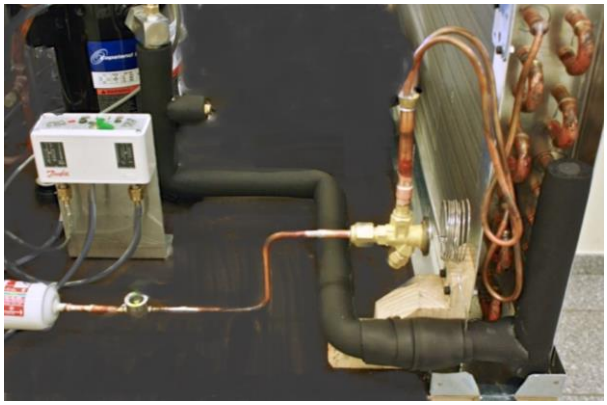
Use pressurized nitrogen to pressurize the system to 10 bar.

Step #4

Wait 5 hours, and make sure that the pressure remains at 10 bar. If there is no leak, then the pressure can be released.

SECTION 7: Attach insulation

Step #1

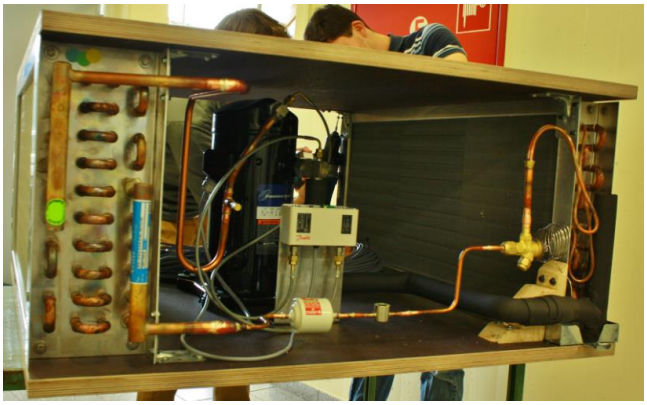


Insulate the piping connection from location 3 to location 4.

Insulation will decrease the refrigerant's heat loss when moving from the evaporator to the compressor, increasing the efficiency of the heat pump.

SECTION 8: Attach the lid

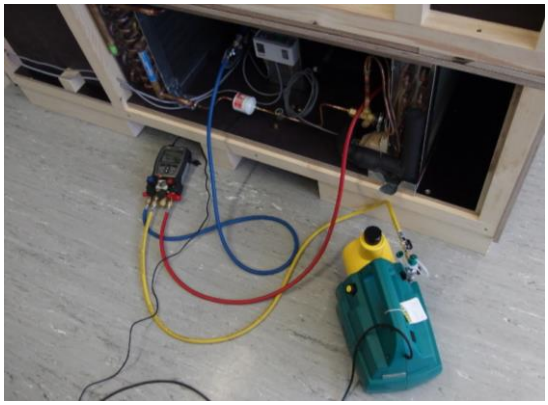
Step #1



Place the second Panel 21 on top of the heat pump assembly and fasten it to the 90 degree metal brackets on the condenser and evaporator.

SECTION 9: Add refrigerant

Step #1



Re-attach the vacuum pump and create a vacuum in the system to remove moisture.

Step #2

Turn on the ventilator and begin adding refrigerant to the low pressure fitting on the compressor.

> Instructions for turning on the ventilator and compressor can be found in Operations Section 3.

Step #3

When the amount of refrigerant added reaches 1000-1500 grams, turn on the compressor.

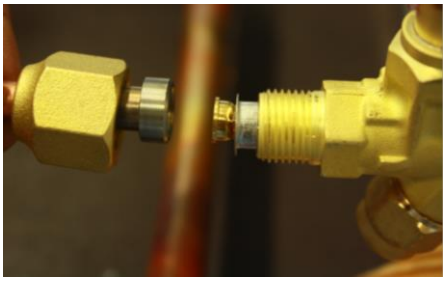
Step #4

Gradually add refrigerant until the amount of refrigerant added reaches 2200 grams.

Step #5

Disconnect the refrigerant hoses and check the sight glass to make sure that the color depicts DRY and that there are no bubbles visible.

Step #6

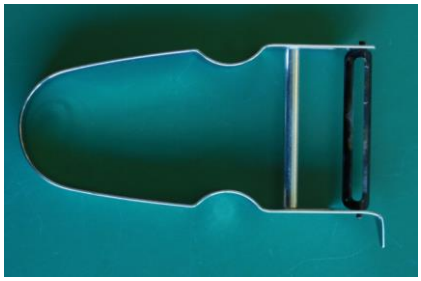


Adjust the regulator in the expansion valve as necessary to prevent overheating of the system.

CHAPTER 4: OPERATIONS

The manual includes drying instructions for apples and mangoes. Different fruits and vegetables can be dried, but make sure to adjust the preparation steps and drying time accordingly.

TOOLS LIST

Tools for Preparing the Fruits	
Knife	**Peeler**
	
H	L

PREPARATION INSTRUCTIONS

SECTION 1: Prepare the apples

Step #1

Wash the apples and wipe off the excess water.

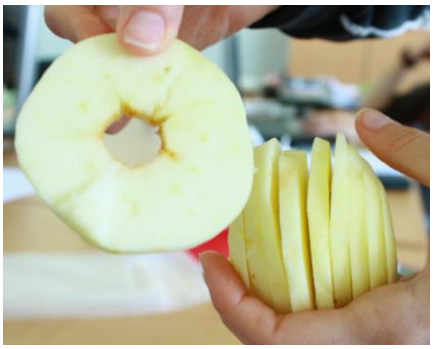
Step #2

Decore the apples.

Step #3

If desired, peel the apples. This is not required and depends on the consumer's preference.

Step #4



Cut slices of approximately 5 mm.

If the apples will not be imediately dried after the preparation, place the slices into a container with water and lemon juice to keep the apples from getting brown.

SECTION 2: Prepare the mangoes

Step #1

Wash the mangoes.

Step #2

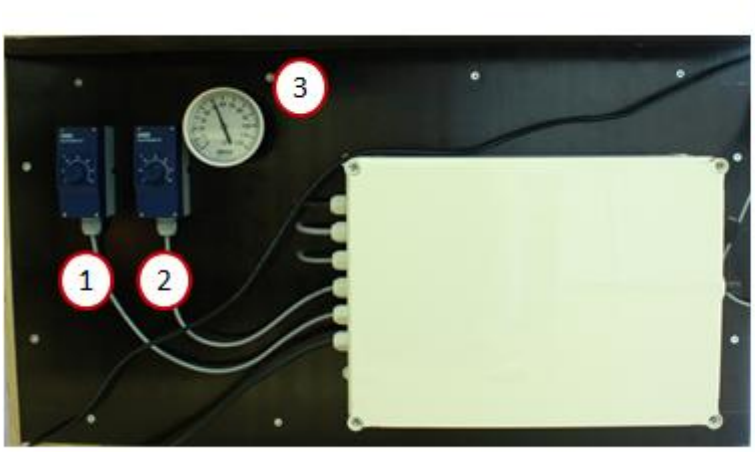
Peel the mangoes.

Step #3

Cut slices of approximately 7 mm, avoiding the pit.

SECTION 3: Turn on the dryer and load fruits

Step #1: Turn on the fruit dryer



1. Thermostat for minimum temperature: Adjust to 45ºC
2. Thermostat for maximum temperature: Adjust to 60ºC
3. Drying chamber thermometer
4. Ventilator: Turn to position 5. Let the dryer ventilate for 10-15 minutes
5. Compressor: Turn to position 1

Once the temperature in the drying chamber begins to increase, lower the ventilator setting to position 1 or 2

Step #2

Place a container for water underneath the spout of the water collector.

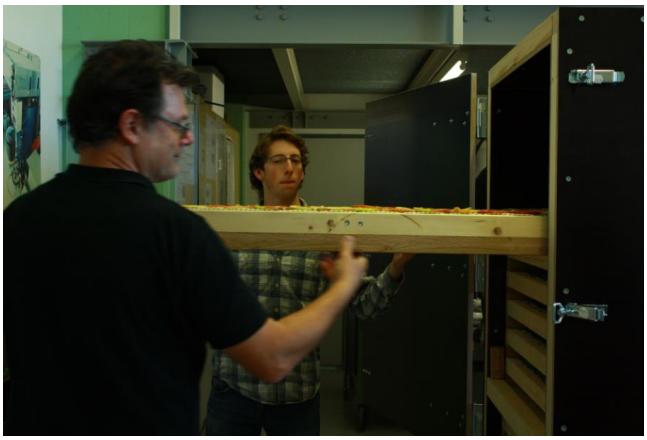
CAUTION: DO NOT DRINK THE WATER! It is only for general cleaning (e.g. the dryer).

Step #3

Place the fruit slices onto the pallets so they are not overlapping. Completely cover the area of the netting, but DO NOT place fruits over the wooden sections.

Dry the mangoes imediately after preparing them.

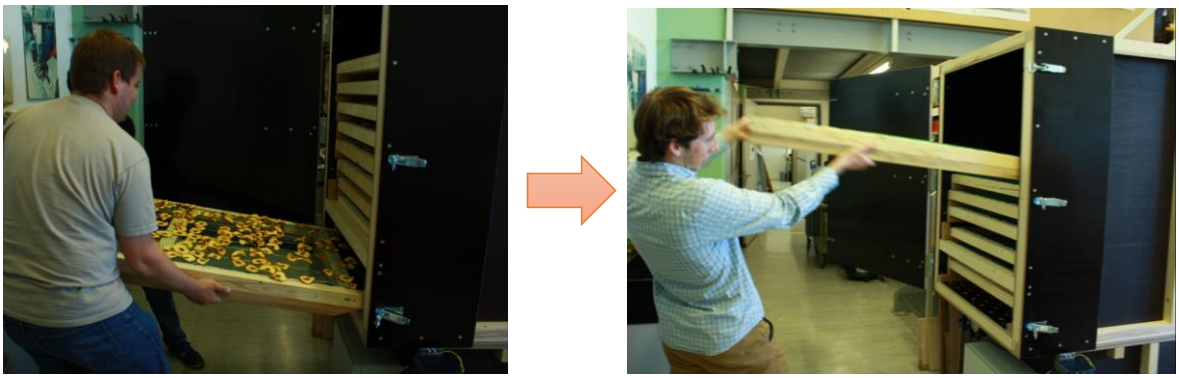
Step #4



Insert the pallets into the drying chamber. Avoid leaving the door open whenever possible

SECTION 4: Unload fruits and turn off the dryer

Step #1: Unload fruits



When the fruits on the bottom pallet have finished drying (see below), remove the pallet and unload the dried fruits. A new pallet of fruits can then be inserted on top of the stack if a continuous operation is desired.

Step #2: Turn off the dryer

When the entire operation is finished, turn off the dryer:

1. Turn off the compressor to position 0.
2. Increase the ventilator to position 3, and let the dryer air out for 10-15 minutes.
4. Turn off the ventilator to position 0.

Examples of the final products

The drying time depends on:

- Fruit or vegetable being dried.
- Thickness of the slices (thicker slices dry more slowly).
- Size of the slices (bigger slices dry more slowly).
- Location in the drying chamber in which the fruits are dried (top pallets dry more slowly).
- Total amount of fruits loaded to the dryer.

Because of all these variations, a precise time cannot be provided. The examples on the next page can be used as guidance. Ultimately, the decision will depend on consumer's preference.

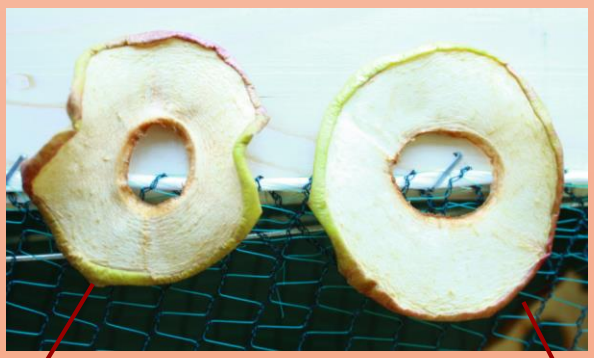
FRUIT ANALYSIS

APPLES

Fresh apples on one pallet: 3.75 kg

Approximate desired weight of dried apples from one pallet: 400 g – 500 g

Approximate drying time: 10 hours – 14 hours



Too crispy!	Too moist!
Time: 16 hours	Time: 4 hours 30 min
Weight per pallet: 380 g	Weight per pallet: 800 g

MANGOES

Approximate weight of fresh mangoes to load one pallet: 7.30 kg

Approximate desired weight of dried mangoes from one pallet: 600 g – 800 g

Approximate drying time: 14 hours – 20 hours

Finished

Unfinished