Portable Forced-Air Evaporative Cooling Chamber Design

CoolVeg's portable forced-air evaporative cooling chamber was developed in collaboration with ColdHubs in Nigeria and Artisana in India with support from the Efficiency for Access Research and Development Fund. This document provides design documentation and guidance for constructing CoolVeg's portable forced-air evaporative cooling chamber, including:

- Photographs of the Portable Chambers in India and Nigeria
- Chamber Materials and Construction Guidance
- 3-D Renderings and Dimensional Diagrams for the 25-Crate Portable Chambers in India
- 3-D Renderings and Dimensional Diagrams for the 20-Crate Portable Chambers in India
- 3-D Renderings and Dimensional Diagrams for the 15-Crate Portable Chambers in India

Additional information related to this technology is available in the technical research report from this project, including:

- The need for post-harvest storage and existing solutions
- Airflow pathway specifications for optimizing energy efficiency and performance
- Best practices for using the chambers
- Thermal performance testing, vegetable shelf-life testing, and user research
- Economic analysis

This report is available at: https://www.coolveg.org/cooling-chambers/portable-and-mobile

The portable chambers are designed for use in a variety of settings, including small farms, local aggregation points, farming cooperatives, and retail environments. Although they do not have built-in wheels, they can be deployed in a wide range of locations, even in rural areas with poor road networks. Weighing 100–150 kilograms when empty, the chambers can be lifted by approximately six people onto a truck or carried short distances for precise placement. This flexibility allows them to be relocated throughout the year to areas where improved storage is most needed.

When making changes to the chamber design, it is important to follow the guidance related to proper dimensions described in "Evaporative Cooler Specifications and Airflow Pathway" (page 20) of the Technical Report. This includes the airflow rate of the evaporative cooler, minimizing air bypassing the crates, having sufficient openings at the bottom of the crates, and avoiding flow constriction in unintended locations. These items will be discussed in more detail in the "Evaporative Cooler Specifications and Airflow Pathway" Section.

Contact, Eric Verploegen, CoolVeg Founder: eric@coolveg.org

CoolVeg Cold Hubs EFFICIENCY FOR ACCESS
energy saving trust UKaid from the British people Transforming Energy Access IKEA IKEA Foundation ARTISANA

Portable Forced-Air Evaporative Cooling Chamber

Four versions of the portable cooling chamber were constructed in India (3) and Nigeria (1). The dimensions of the portable cooling chamber are based on the outer dimensions of the crates being stored. The most common vegetable crates used in Nigeria have a length, width, and height of 60 cm x 40 cm x 23 cm. In India, the most common vegetable crates have a length, width, and height of 54 cm x 36 cm x 29 cm. The dimensions of the insulating panels were adjusted to accommodate the relevant crate size. In addition to design variations dictated by the size of the locally available crates, chambers with different storage capacities and sizes were constructed to meet the needs of specific users.

Top left: Portable cooling chamber with a storage capacity of 25 crates in Zaria, Kaduna, Nigeria; Top right: Portable cooling chamber with a storage capacity of 25 crates in Bhuj, Gujarat, India; Bottom left: Portable cooling chamber with a storage capacity of 15 crates in Bhuj, Gujarat, India; Bottom right: Portable cooling chamber with a storage capacity of 20 crates in Bhuj, Gujarat, India.

Chamber Materials and Construction Guidance

CoolVeg's chambers were designed to be as simple as possible using materials that can be readily sourced in many locations. The 2 most critical components are 1) an off-the-shelf evaporative cooler and 2) insulation panels to form the chamber body. The following is a full list of materials and components needed for constructing a forced-air evaporative cooling chamber:

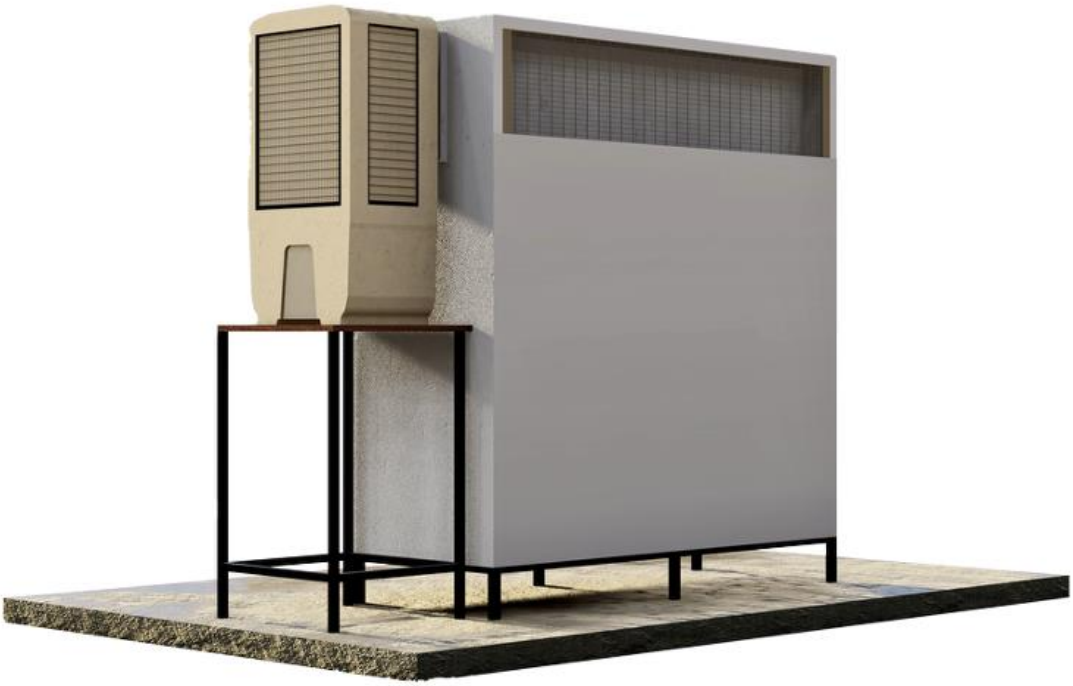
- An evaporative cooler to provide cool and humid air (details described above).
- Insulation panels:
    - Material: expanded polystyrene (EPS), extruded polystyrene (XPS), and polyurethane foam (PUF) are all suitable.
    - Clad in aluminum or galvanized steel on the inside and outside to prevent rust.
    - Thickness: 50 mm. The panels can be thicker if desired, but thinner panels are not recommended as the structural integrity and thermal performance will be negatively impacted.
    - Color: The panels should be white or reflective to minimize the heat absorbed through radiation from direct sunlight and the surrounding environment.
- Brackets to hold panels together.
    - Right angle brackets for most junctions.
    - Hinges for the doors.
- Metal rack to support the crates inside the chamber.
    - 40 mm steel square tube.
    - Galvanized, polymer-coated, or painted for rust protection.
- Metal rack to support the chamber off the ground.
    - 40 mm steel square tube.
    - Galvanized, polymer-coated, or painted for rust protection.
- Sealant for the insulation panel junctions.
    - There are several options that can be used to seal the panel junction, but the high-humidity environment must be considered. Given this consideration, caulk or other sealants that are intended for wet or humid environments is preferred to duct tape.
- Weather stripping or refrigerator door gasket to seal the chamber door.
    - The adhesive used to secure the gasket should be able to withstand getting wet and repeated opening and closing of the doors.
- Screens to protect the air outlets.
    - Metal or plastic mesh.
    - Openings 1-2 mm in size.
        - The opening supporting the screen should be oversized relative to the air outlet channel to prevent the screen from restricting airflow.
    - A coarser support structure (e.g., chicken wire) is recommended to support the finer screen and prevent damage to the finer screen.

Front (doors closed)

Front–right

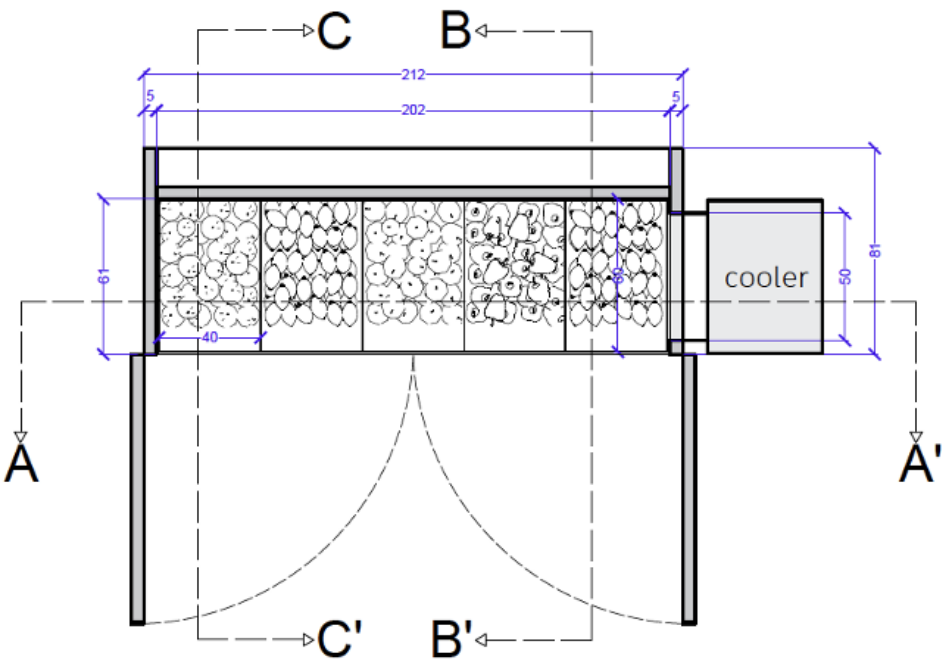
Rear

Rear–right



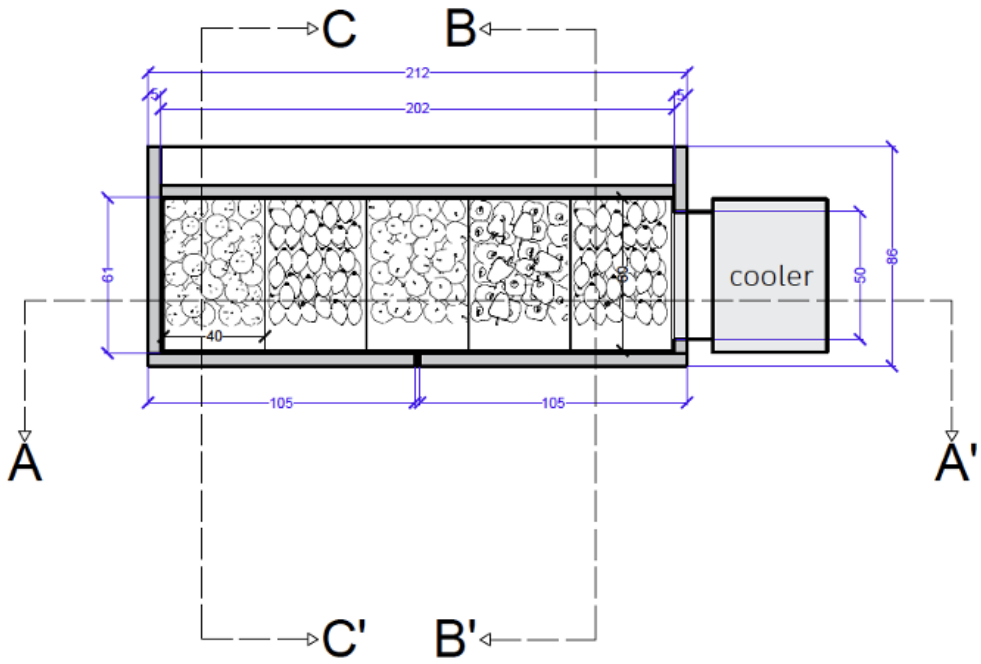
Design Documentation for the 25-Crate Portable Chamber in Nigeria

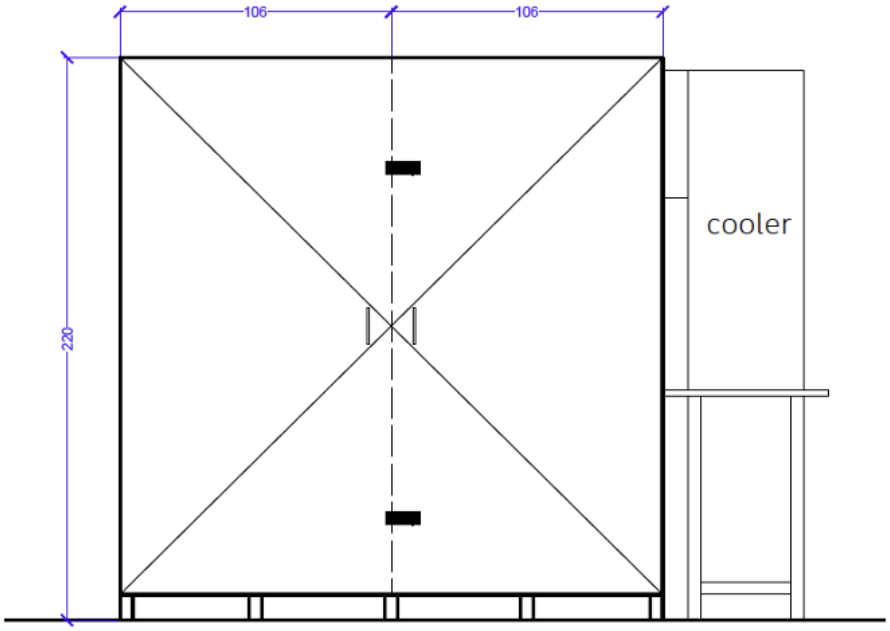
Top view (doors closed)



Top view (doors open)

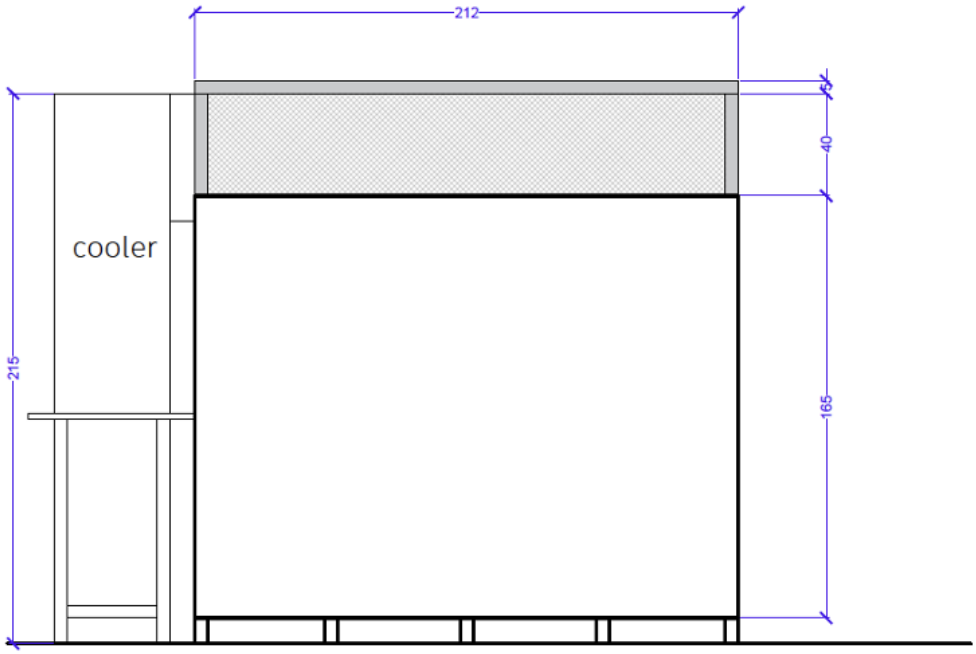
All dimensions are in centimeters (cm)



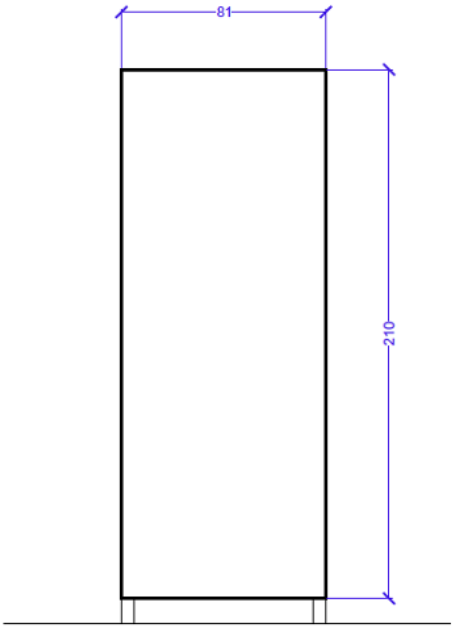


Front Elevation

All dimensions are in centimeters (cm)

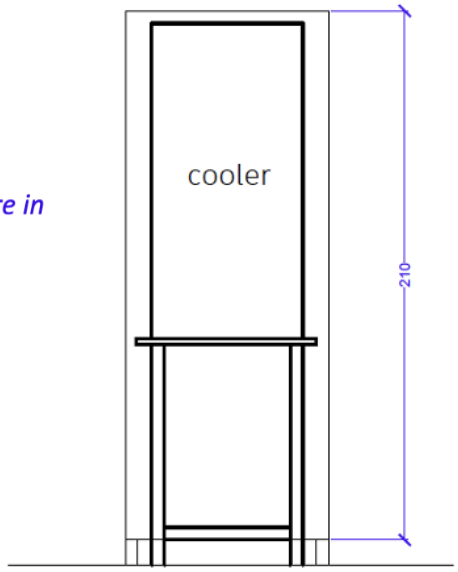


Rear Elevation

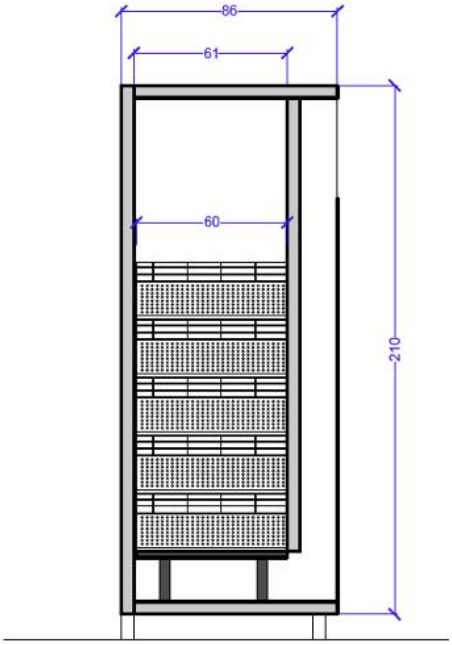


Left side elevation

All dimensions are in centimeters (cm)

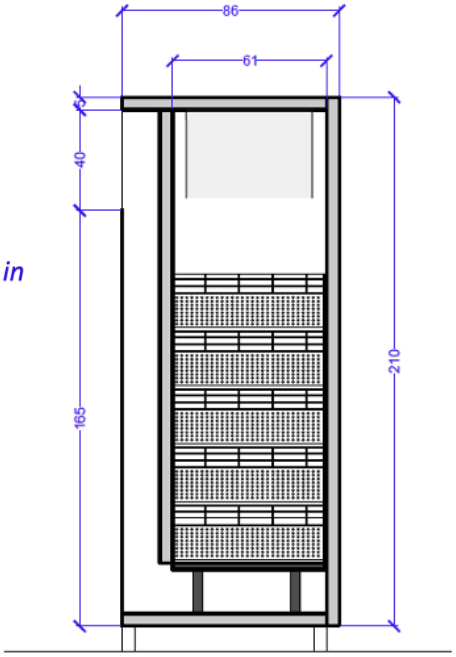


Right side elevation



Section BB'

All dimensions are in centimeters (cm)



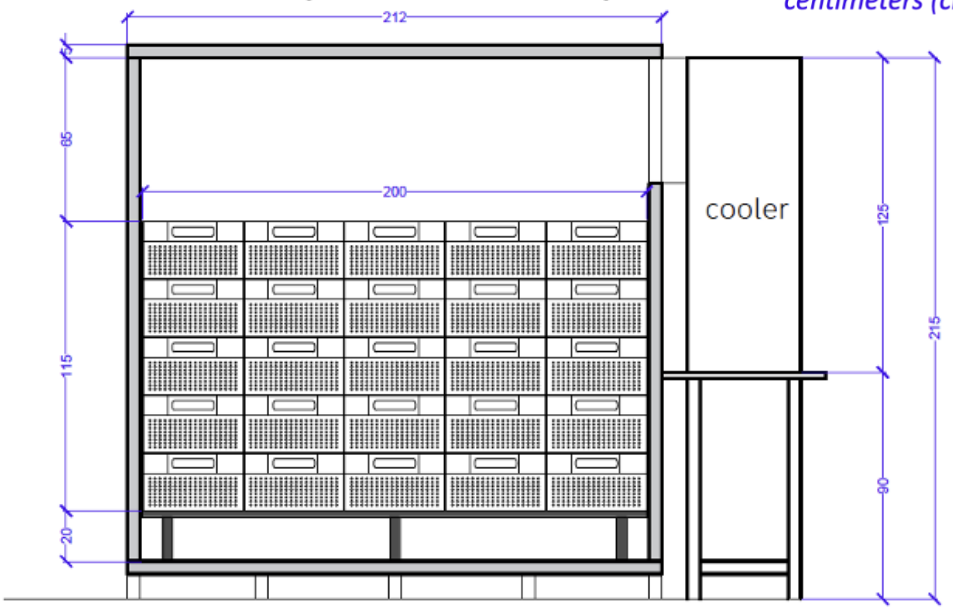
Section CC'

Design Documentation for the 25-Crate Portable Chamber in Nigeria

Front (doors open)

Front (cross-section)

All dimensions are in centimeters (cm)



Section AA'

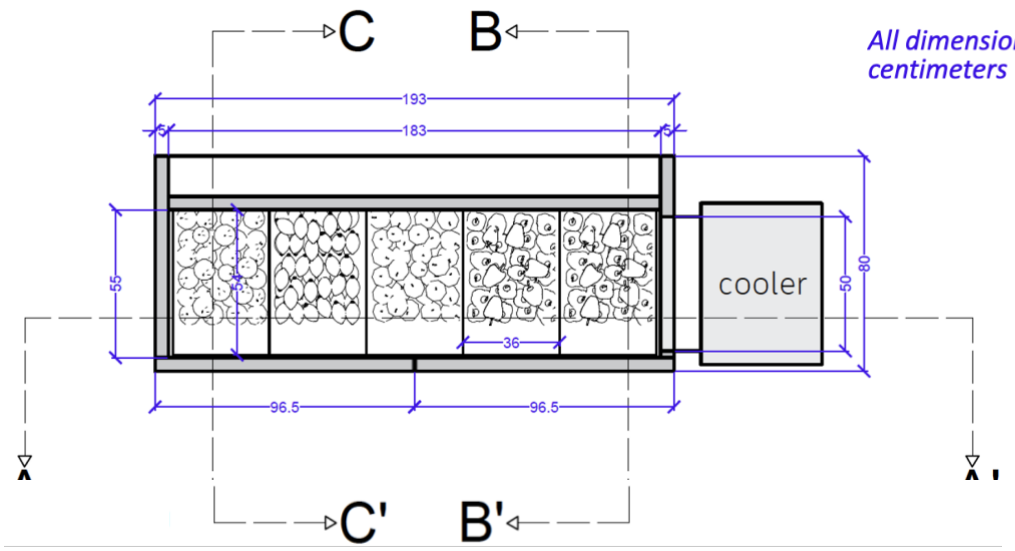
Insulation Panel Sizes for the 25-Crate Portable Chamber in Nigeria

Below is a table showing the dimensions of the insulated sandwich panels that are needed to construct the portable chamber designed for crates measuring 60 cm x 40 cm x 23 cm (length, width, and height).

The sandwich panels can be made from several types of insulation, including: Polyurethane Foam (PUF), Extruded Polystyrene (XPS), or Expanded Polystyrene (EPS). The metal cladding should be made of either aluminum or galvanized steel to prevent rusting. The metal sheet that forms the exhaust channel can be made from either aluminum or galvanized steel to prevent rusting. A hole in one of the side panels (left or right) will need to be cut to allow air from the evaporative coolers to enter the chamber.

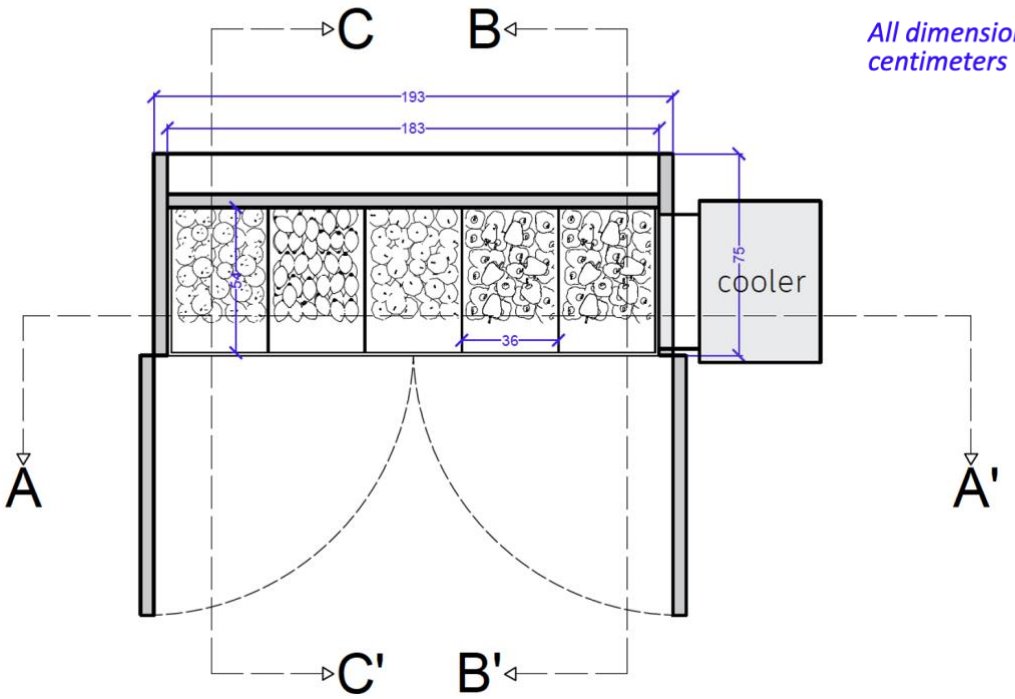
Panel	Material	Width (cm)	Height/Length (cm)	Thickness (cm)
Bottom	PUF sandwich panel	81	212	5
Top	PUF sandwich panel	81	212	5
Rear	PUF sandwich panel	202	180	5
Left door	PUF sandwich panel	106	210	5
Right door	PUF sandwich panel	106	210	5
Left side	PUF sandwich panel	81	200	5
Right side	PUF sandwich panel	81	200	5
Rear - channel	Metal sheet	212	160	0.08

Top view (doors closed)

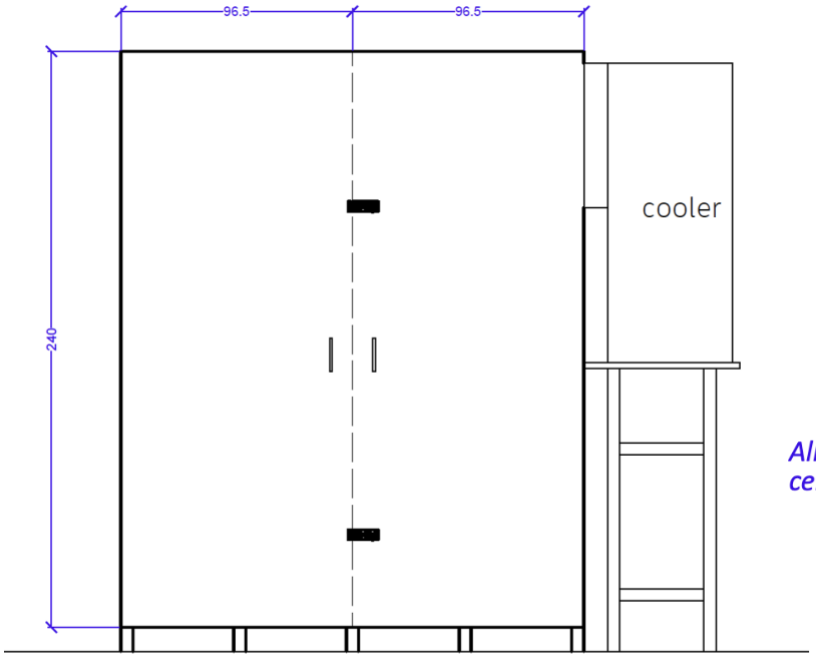


All dimensions are in centimeters (cm)

Top view (doors open)

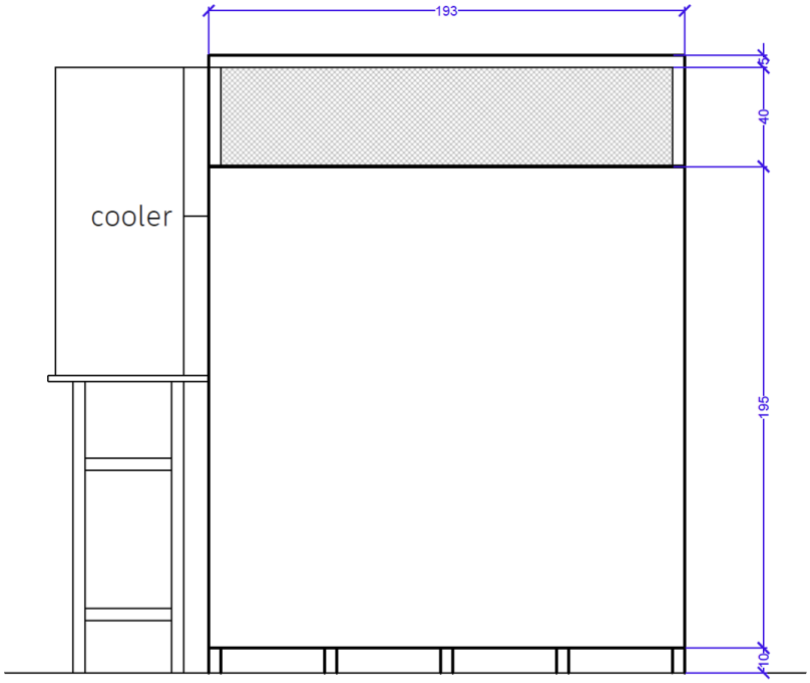


All dimensions are in centimeters (cm)

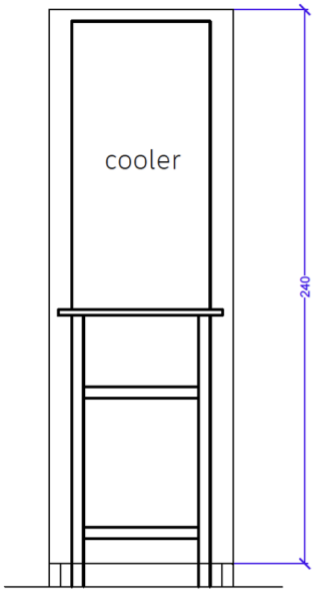


Front Elevation

All dimensions are in centimeters (cm)

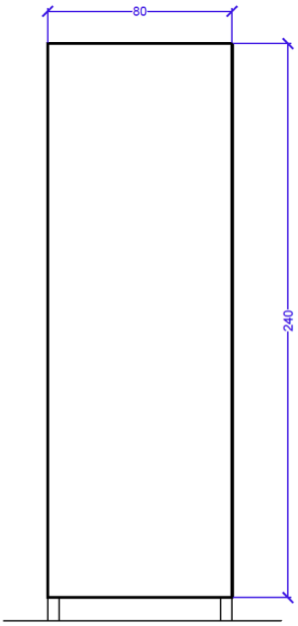


Rear Elevation

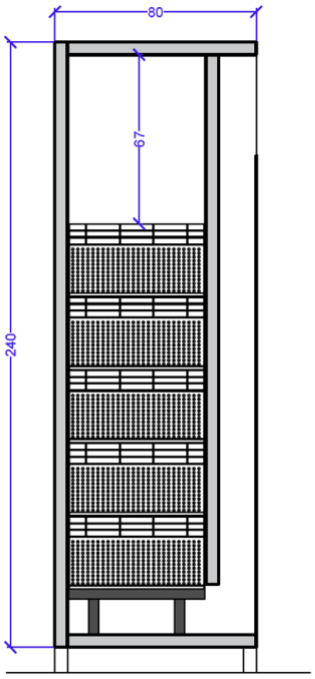


Right side elevation

All dimensions are in centimeters (cm)

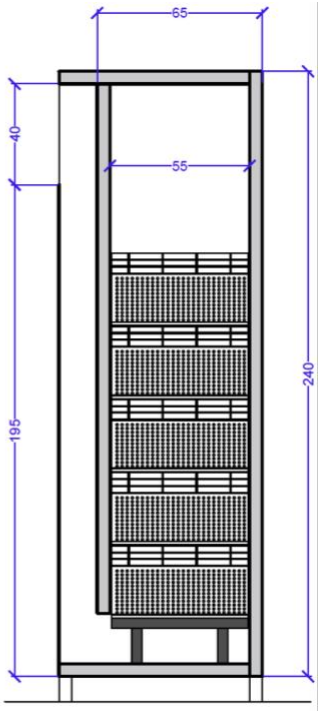


Left side elevation

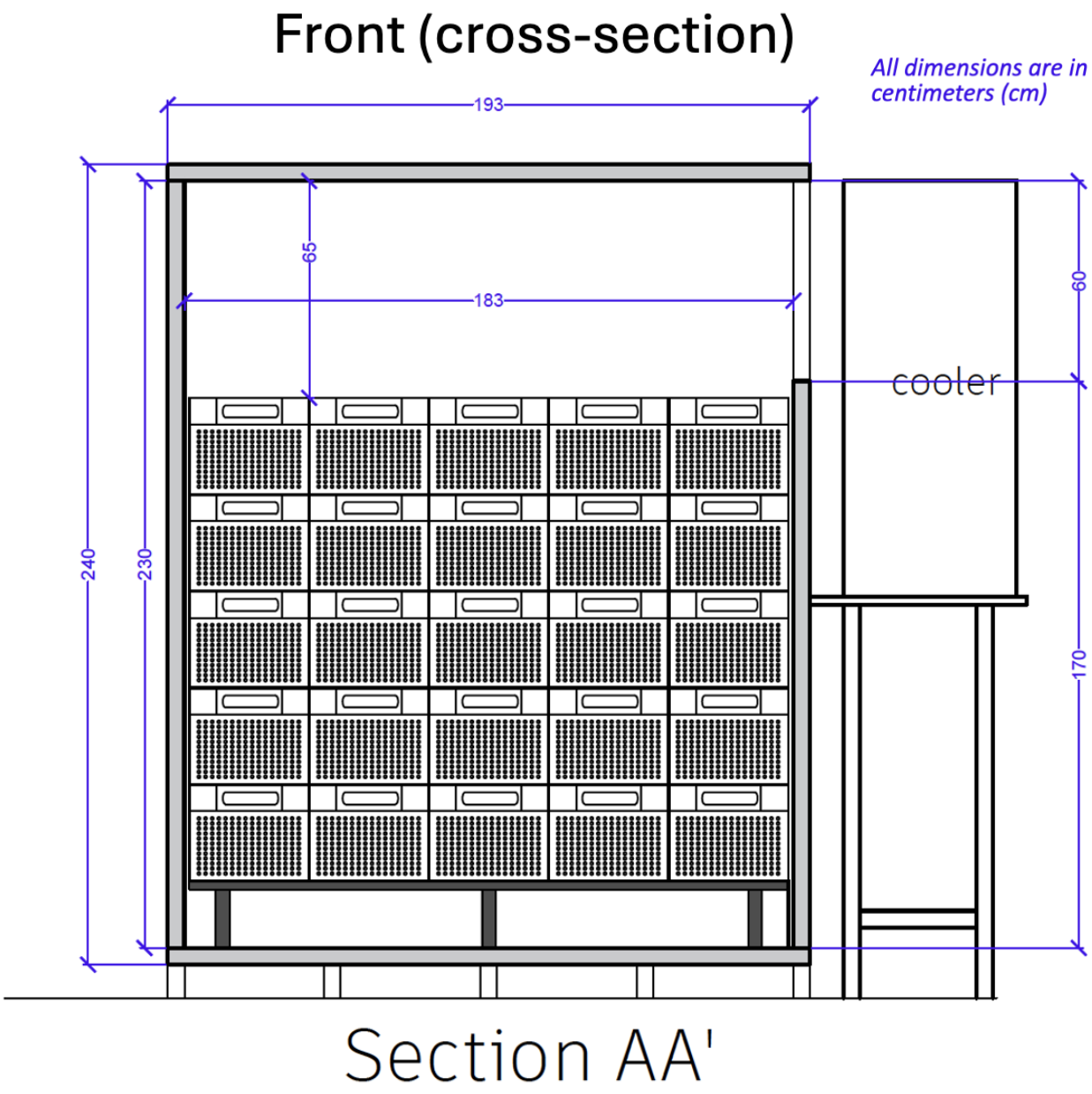


Section BB'

All dimensions are in centimeters (cm)



Section CC'


Front (cross-section)
All dimensions are in centimeters (cm)
193
65
183
60
cooler
240
230
170
Section AA'

Insulation Panel Sizes for the 25-crate Portable Chamber in India

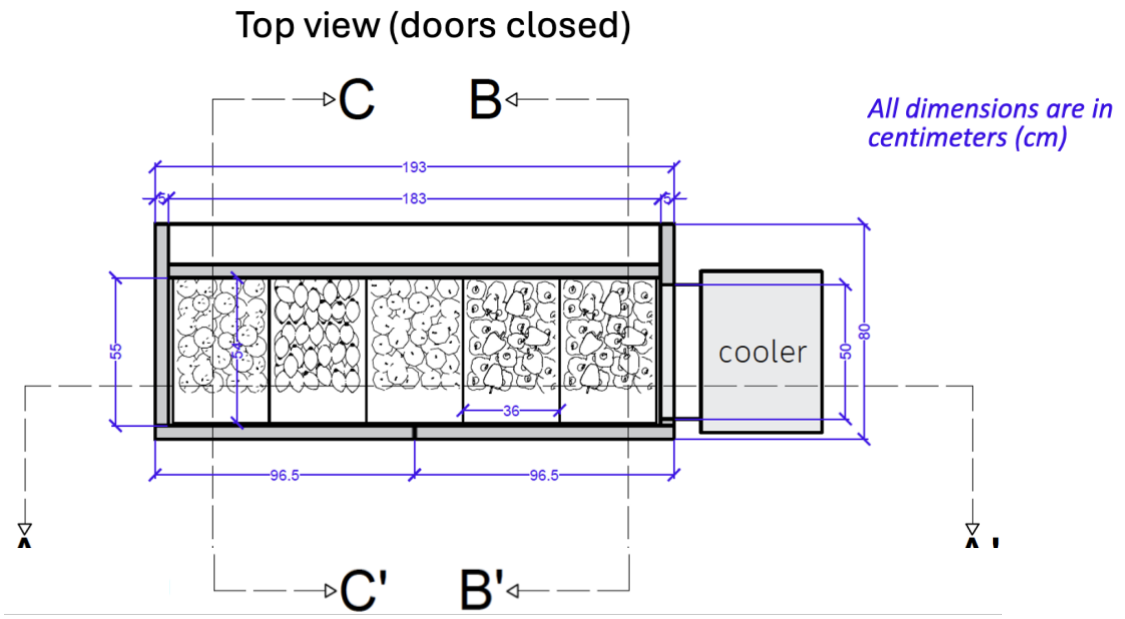
Below is a table showing the dimensions of the insulated sandwich panels that are needed to construct the portable chamber designed for crates measuring 54 cm x 36 cm x 29 cm (length, width, and height).

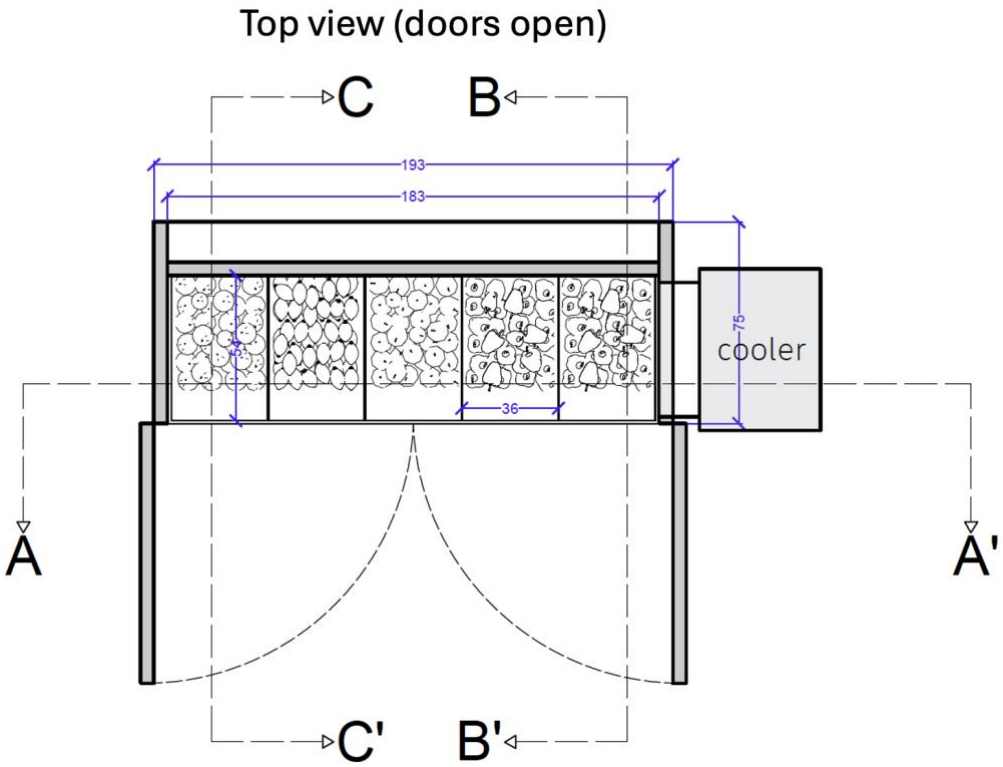
The sandwich panels can be made from several types of insulation, including: Polyurethane Foam (PUF), Extruded Polystyrene (XPS), or Expanded Polystyrene (EPS). The metal cladding should be made of either aluminum or galvanized steel to prevent rusting. The metal sheet that forms the exhaust channel can be made from either aluminum or galvanized steel to prevent rusting. A hole in one of the side panels (left or right) will need to be cut to allow air from the evaporative coolers to enter the chamber.

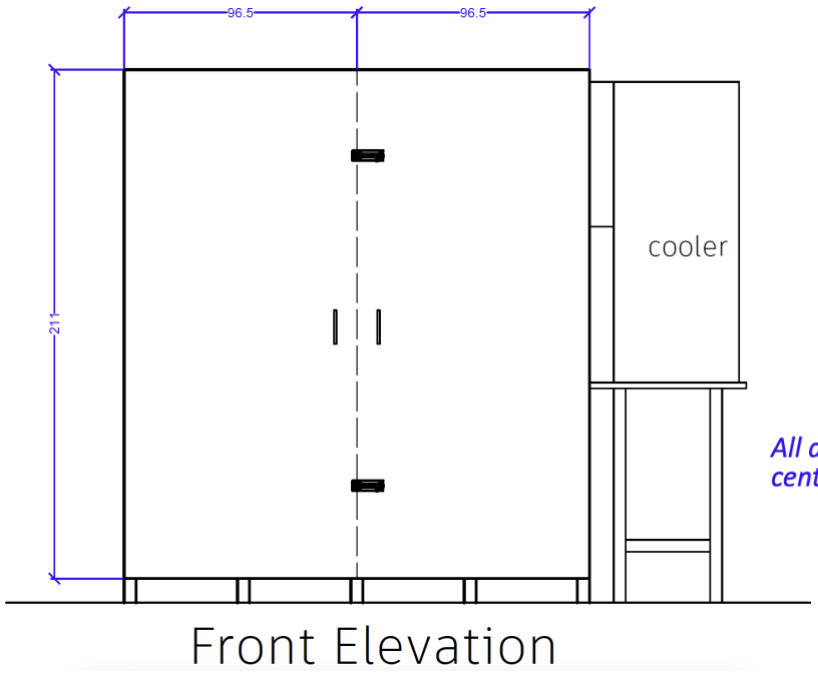
Panel	Material	Width (cm)	Height/Length (cm)	Thickness (cm)
Bottom	PUF sandwich panel	75	193	5
Top	PUF sandwich panel	75	193	5
Rear	PUF sandwich panel	183	210	5
Left door	PUF sandwich panel	96.5	240	5
Right door	PUF sandwich panel	96.5	240	5
Left side	PUF sandwich panel	75	230	5
Right side	PUF sandwich panel	75	230	5
Rear - channel	Metal sheet	193	190	0.08

Design Documentation for the 20-Crate Portable Chambers in India

This chamber is a shorter version of the 25 crate portable chamber described above.

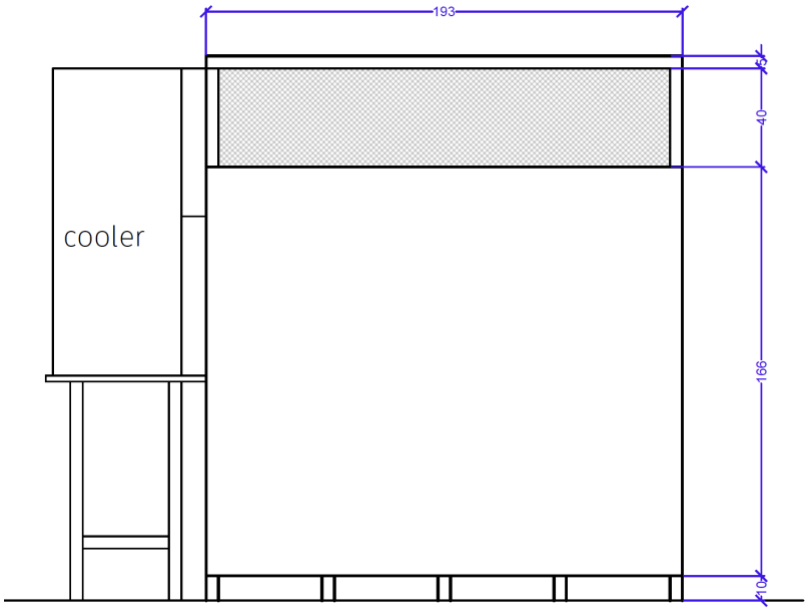




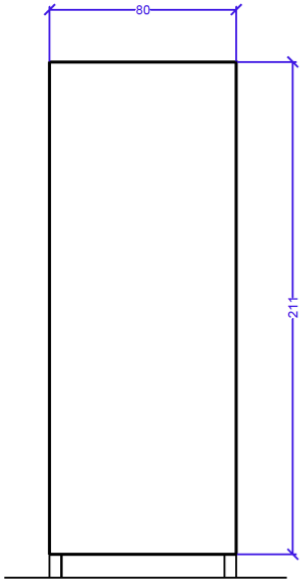


Front Elevation

All dimensions are in centimeters (cm)

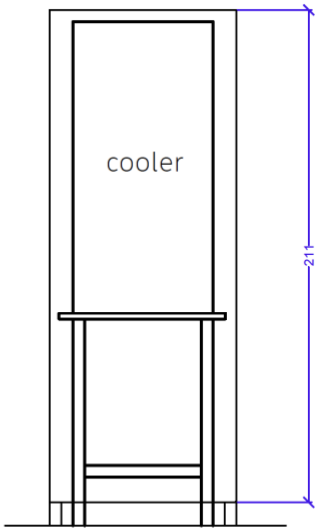


Rear Elevation

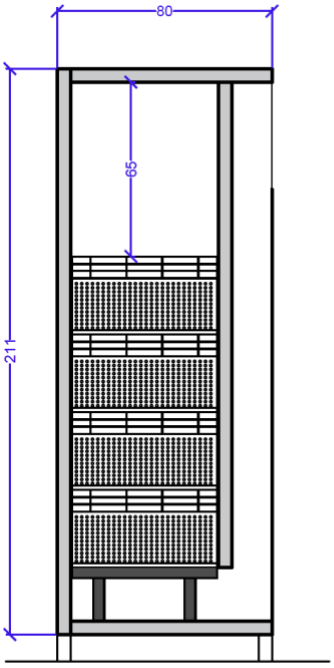


Left side elevation

All dimensions are in centimeters (cm)

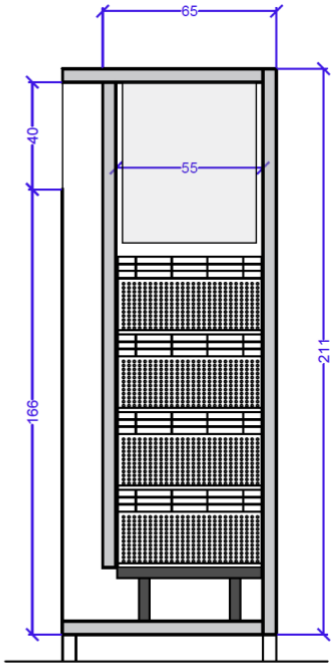


Right side elevation

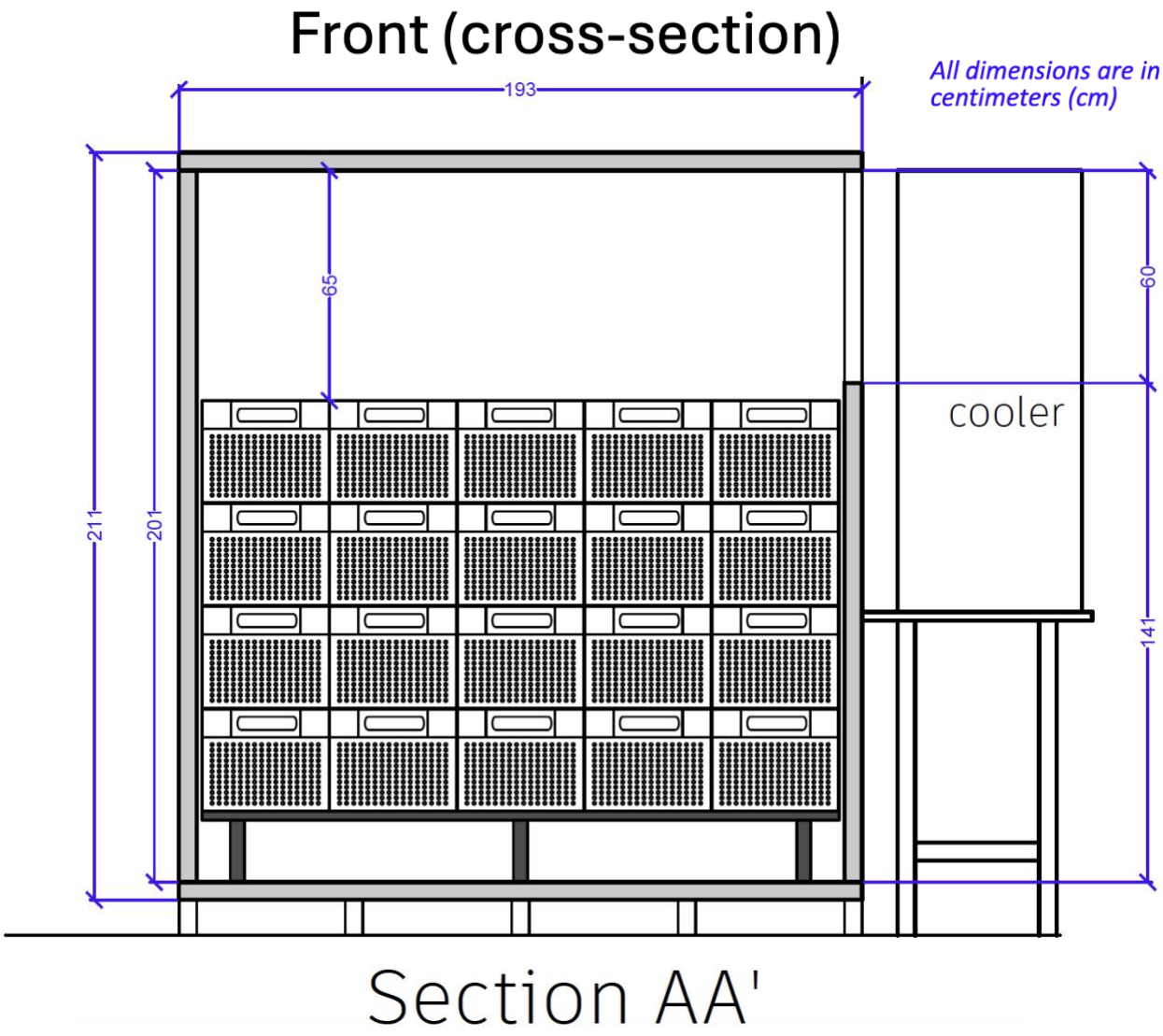


Section BB'

All dimensions are in centimeters (cm)



Section CC'


Front (cross-section)
All dimensions are in centimeters (cm)
193
65
211
201
60
141
cooler
Section AA'

Insulation Panel Sizes for the 20-crate Portable Chamber in India

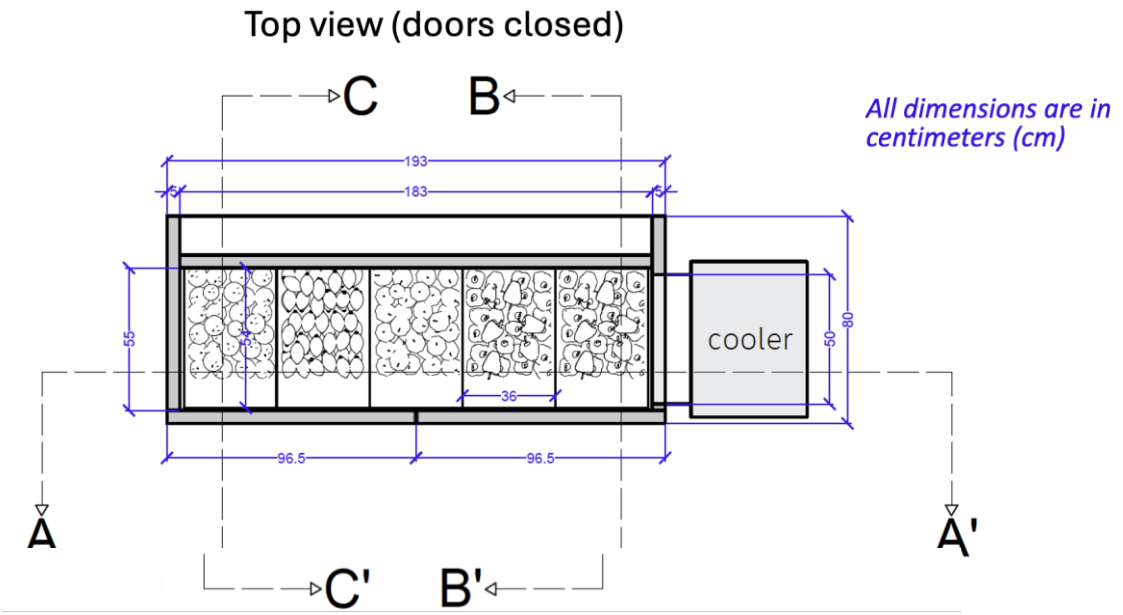
Below is a table showing the dimensions of the insulated sandwich panels that are needed to construct the portable chamber designed for crates measuring 54 cm x 36 cm x 29 cm (length, width, and height).

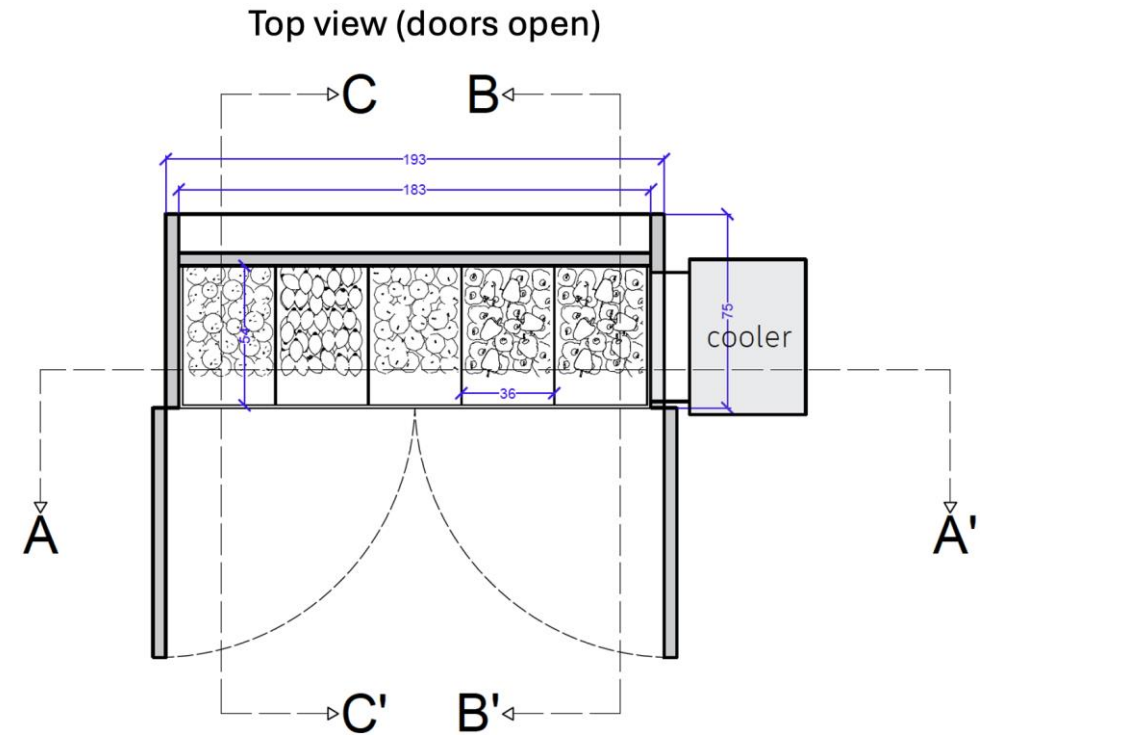
The sandwich panels can be made from several types of insulation, including: Polyurethane Foam (PUF), Extruded Polystyrene (XPS), or Expanded Polystyrene (EPS). The metal cladding should be made of either aluminum or galvanized steel to prevent rusting. The metal sheet that forms the exhaust channel can be made from either aluminum or galvanized steel to prevent rusting. A hole in one of the side panels (left or right) will need to be cut to allow air from the evaporative coolers to enter the chamber.

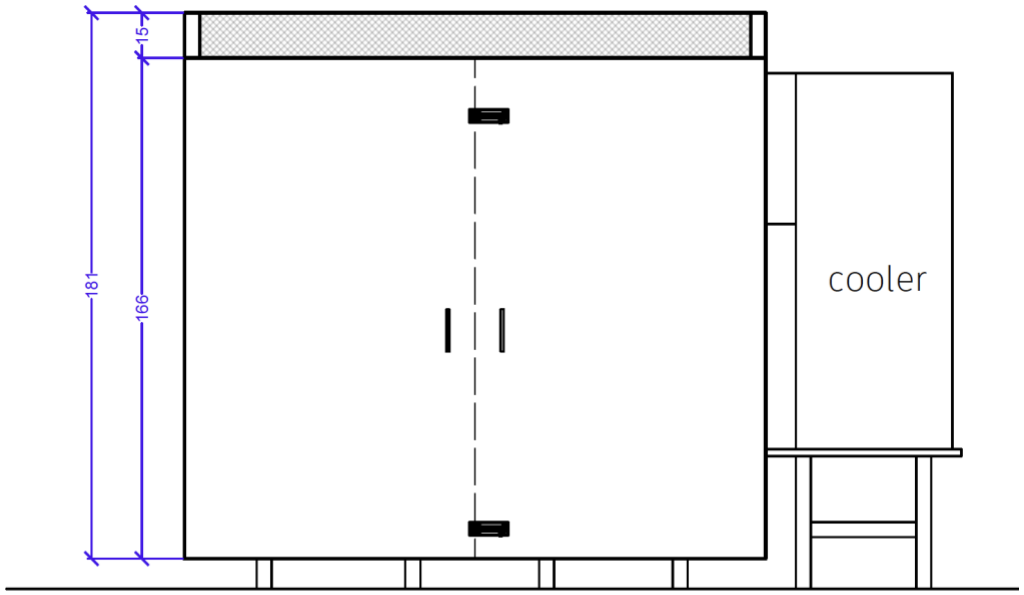
Panel	Material	Width (cm)	Height/Length (cm)	Thickness (cm)
Bottom	PUF sandwich panel	75	193	5
Top	PUF sandwich panel	75	193	5
Rear	PUF sandwich panel	183	181	5
Left door	PUF sandwich panel	96.5	211	5
Right door	PUF sandwich panel	96.5	211	5
Left side	PUF sandwich panel	75	201	5
Right side	PUF sandwich panel	75	201	5
Rear - channel	Metal sheet	193	161	0.08

Design Documentation for the 15-Crate Portable Chambers in India

This chamber is a shorter version of the 20 and 25 crate portable chambers described above. A feature to have the exhaust air directed towards the front of the chamber instead out of the rear of the chamber was integrated in order to provide cooler air in the area in front of the chamber. This feature was included based on user research with vendors who would benefit from having cooler air for the customers and staff of their fruit and vegetable shop.

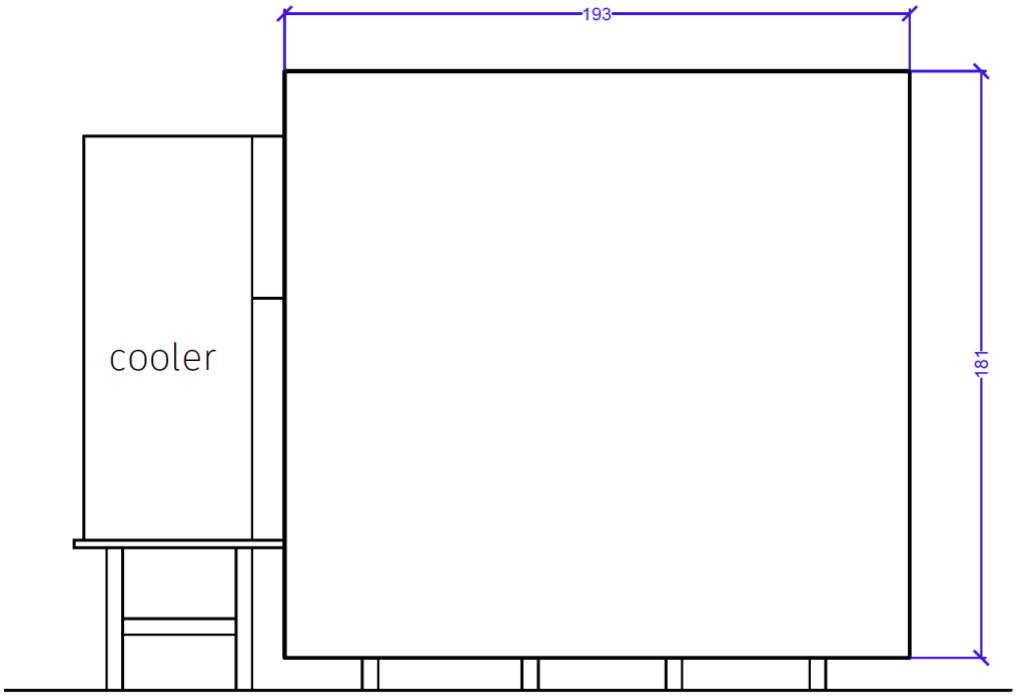




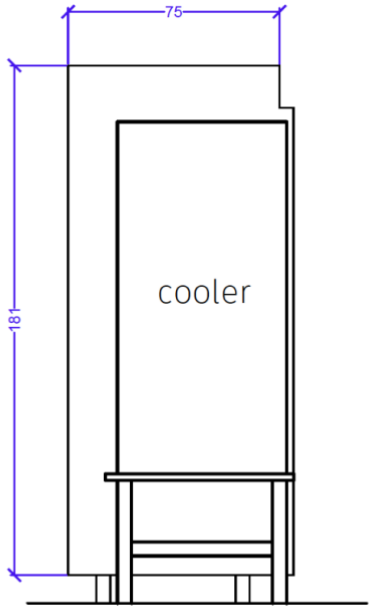


Front Elevation

All dimensions are in centimeters (cm)

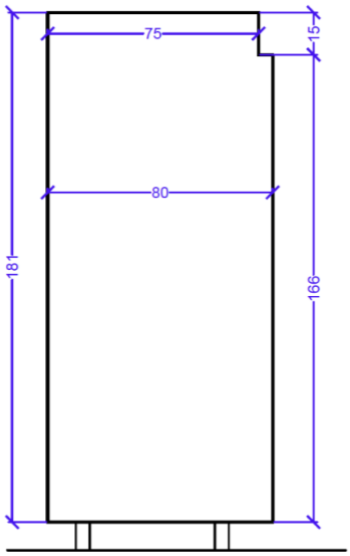


Rear Elevation

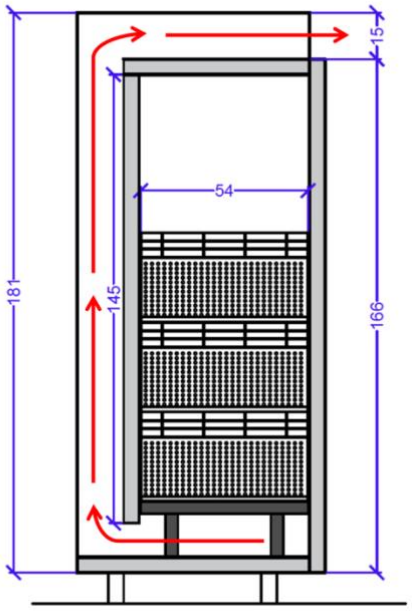


Right side elevation

All dimensions are in centimeters (cm)

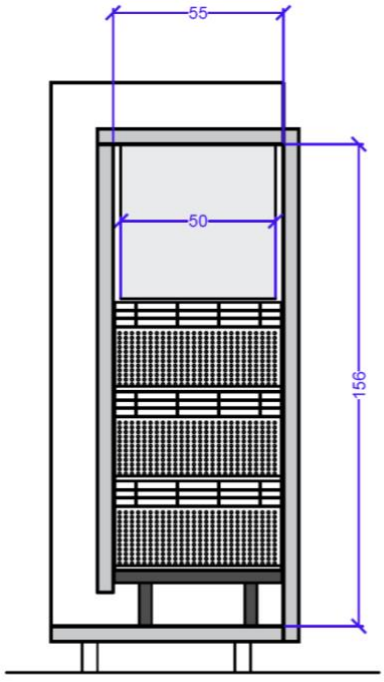


Left side elevation



Section CC'

All dimensions are in centimeters (cm)



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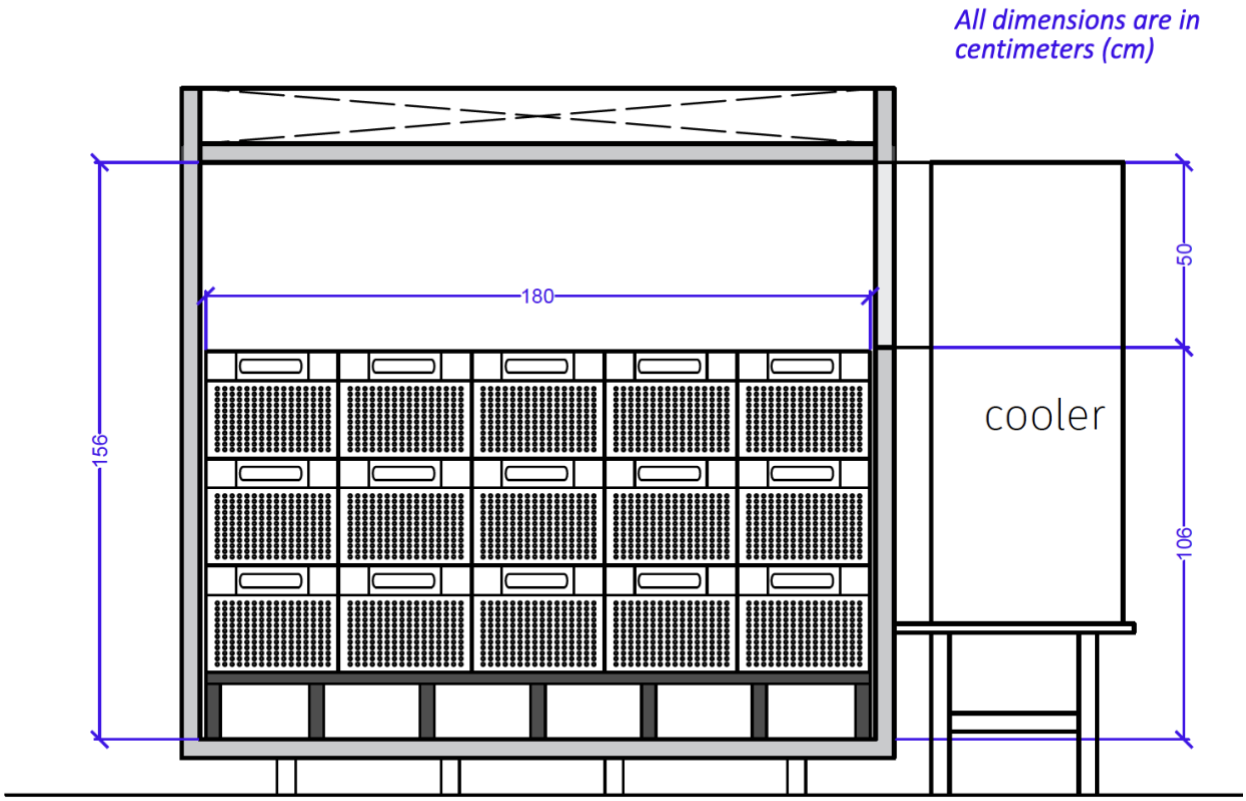

Section AA'

Insulation Panel Sizes for the 15-crate Portable Chamber in India

Below is a table showing the dimensions of the insulated sandwich panels that are needed to construct the portable chamber designed for crates measuring 54 cm x 36 cm x 29 cm (length, width, and height).

The sandwich panels can be made from several types of insulation, including: Polyurethane Foam (PUF), Extruded Polystyrene (XPS), or Expanded Polystyrene (EPS). The metal cladding should be made of either aluminum or galvanized steel to prevent rusting. The metal sheet that forms the exhaust channel can be made from either aluminum or galvanized steel to prevent rusting. A hole in one of the side panels (left or right) will need to be cut to allow air from the evaporative coolers to enter the chamber.

Panel	Material	Width (cm)	Height/Length (cm)	Thickness (cm)
Bottom	PUF sandwich panel	75	193	5
Top	PUF sandwich panel	60	183	5
Rear	PUF sandwich panel	183	145	5
Left door	PUF sandwich panel	96.5	170	5
Right door	PUF sandwich panel	96.5	170	5
Left side	PUF sandwich panel	75	180	5
Right side	PUF sandwich panel	75	180	5
Rear - channel	Metal sheet	193	181	0.08
Top - channel	Metal sheet	193	75	0.08