UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola Superior d'Enginyeries Industrial, Aeroespacial i Audiovisual de Terrassa

Transforming Shipping Containers into Primary Care Health Clinics

Project Report

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Abstract

The present project consists in the design of a primary health clinic inside intermodal shipping containers.

In recent years the frequency of natural disasters has increased, while man-made conflicts continue to afflict many parts of the globe. As a result, societies and countries are often left without access to basic medical assistance. Standardised and ready-to-deploy mobile clinics could play an important role in bringing such assistance to those who need it all over the world.

This project promotes the adaptation of the structure of shipping containers to house a primary healthcare center through a multidisciplinary approach. Ranging from the study of containers and the potential environments where a mobile clinic could be of use to the design of all the manuals needed for the correct deployment, operation and maintenance of a mobile healthcare center inside a shipping container, this project intends to combine with knowledge from many sources to develop a product of great human, social and ecological value.

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1. INTRODUCTION

This chapter contains all the information about how this project will be undertaken. The goal of the project will be set, its scope will be defined, a justification for it will be provided, the method to be followed will be determined and the schedule used to complete it will be shown. This project has been developed during the Autumn/Winter semester of 2020 in the Projects department in the ESEIAAT, UPC.

1.1. Aim

The proposed dissertation's goal is to design a Primary Health Center in a shipping container, which will be installed in areas with lacking or substandard healthcare facilities and will have to endure the conditions of its environment. The design of this Primary Health Center must take into account all the necessary aspects for its correct operation, from the tools it must contain to the electrical and mechanical installations it will require.

This project can be divided into three sections. In the first one all information and characteristics of shipping containers and Primary Health Centers are studied, along with three possible locations' climates and conditions. This will facilitate the optimal choice of container and design. The second part, the core of the project, will cover the design of a Primary Health Center inside the container along with all the manuals for its correct implementation. In the closing section, a project budget will be made to identify if the resulting product is economically viable, and its cost will be detailed.

1.2. Scope

The following tasks should be fulfilled in order for the project to accomplish its goal:

- Study of the history and characteristics of intermodal containers:
    - Research on the history of shipping containers and its use within architecture.
    - Study of the current types of shipping containers on the market.
    - Comparison of prices between container types and according to whether they are new or reused.
- Recap of the background information:
    - Study of the settings where the product will be located.
    - Study of the weather conditions to which the container will be exposed.
    - Study of transport restrictions.
    - Study of the structural needs of a conventional primary health center.
    - Study of the necessary equipment in a primary health center.
- Selection and design of the container:

  - Study of viability regarding size, availability, necessary adaptations, etc.
  - Selection of the most suitable container type.
  - Design of the interior layout of equipment.
- Development of engineering needs:
  - Choice of insulation.
  - Design of sections and doors.
  - Design of equipment clamping mechanisms.
  - Styling of interior.
  - Design of electrical installation.
  - Design of plumbing installation.
  - Design of thermal installation.
  - Choice of interior and exterior coatings.
- Design of manuals and specifications:
  - Design of the transport manual.
  - Design of the maintenance manual.
  - Design of the installation manual.
  - Design of the scope statement for the potential implementation of the project.
  - Search for the standards and implement regulations.
  - 3D draw.
- Calculation of the project budget.
- The following tasks aren't in the scope of the project:
  - Study into obtention of permits or certificates.
  - Commissioning of the project.
  - Design of the health center equipment.

1.3. Justification

The project of designing a Primary Health Center inside shipping containers arose from the need for a versatile, innovative solution to the lack of access to basic medical care in many undeveloped countries and therefore bringing social value through engineering expertise.

On one hand, in 2017 the average spending in healthcare in countries classified as LDC (Least Developed Countries, UN classification) was 4.25% of the GDP (Gross Domestic Product), compared to 12.55% [1] for countries belonging to the OECD. This indicates that healthcare standards in countries belonging to LDC are very often poor. Natural disasters, which include from earthquakes to pandemics, and whose tendency to happen has increased exponentially in recent years, can place a sudden burden on their healthcare system, while help from abroad often encounters logistical issues when being deployed. [2]

On the other hand, all around the world a considerable number of shipping containers reach the end of their life cycle every day, due to damage or, significantly, because it is cheaper to source new containers than to return them empty to the cities of origin. They accumulate without the possibility of a new use, and contribute to a growing environmental problem.

This project wants to provide a solution to those two problems; it will aim to develop a product that helps provide health services of the same quality as those of developed countries while being easy to deploy, and at the same time gives unused containers an outlet.

1.4. Method

The main study of the project is to obtain information about primary health centers and shipping containers, and to see how the former can be modified to fit into the latter.

“The data collected using surveys, case studies, and problem-solving are called primary data because they are obtained first hand. While the data collected using the desk study approach are called ‘secondary data because the data are obtained from other sources.” (Naoum 1998) [3]

Following the definitions by Naoum, a desktop study approach using secondary data sources will be used.

This research will be carried out through a desktop study of construction guidelines and specifications approved in different countries. Once all the information has been collected, design will take place to turn the learnt knowledge into a potentially operational project.

1.5. Schedule

The following Gantt diagram shows the project schedule.

2. HISTORY AND CHARACTERISTICS OF INTERMODAL CONTAINERS

Since the main objective of the project is to design a medical center inside intermodal containers, this section will detail the history and characteristics of shipping containers. It will be argumented that being standardized and easy to transport makes them a great choice for this purpose, and a study into the best fitting type will be conducted.

2.1. History

Until 1956 goods packed in bales, sacks or barrels were individually transferred from the vehicle to the waiting cargo ship. Shipping containers were conceived during the Second World War when Malcom McLean, tired of making large and numerous journeys with distributed cargo, devised a revolutionary invention: metal boxes designed for the transport of goods. McLean was a land transport entrepreneur who came up with the idea of loading entire truck trailers onto ships, with their contents still inside, with the intention of reducing costs and increasing efficiency. For the reason that the space was important, he soon realized that it was much faster and easier to exclusively load the full container of goods onto a ship.

McLean created the Pan Atlantic Steamship Company, which, with the help of engineers, modified a Second World War oil tanker (IDEAL-X). Thus, on April 26 of 1956, the IDEAL-X set sail with 58 40-foot containers on its modified deck. The journey marked a milestone in the transportation system, as McLean's idea would give rise to the so-called intermodality, that is, the articulation between different modes of transport using a single load measure, as a way of carrying out the transshipment of materials and goods more quickly and efficiently. The logistics process was simplified and this led to a revolution in freight transport and international trade.

Sea transport boomed during the Vietnam War with military and supply transportation for US troops. McLean decided that instead of his ships returning empty, they would stop in Japan to bring products to the USA, opening up new trade opportunities between Asia and the West.

After seeing McLean's model copied by many other freighter companies, the industry's next step in search of maximum efficiency was a push for standardization. In 1969 Richard F Gibney simplified the statistics used for comparing different container sizes by coining the phrase Twenty Foot Equivalent (TEU).This unit of cargo is still used today to describe capacity.

Relevant to this dissertation is the emergence in recent years of container architecture as one of the younger branches of architecture. It refers to the use of shipping containers as structural elements because of their characteristics and availability. [4]

2.2. Shipping containers and their architectural use

A shipping container is a steel frame, generally cuboid, with adequate strength to withstand large transits of cargo and stowage. There are several types of containers, covering a wide range of possible cargo. For world trade, the term container is directly associated with a shipping container of a standardized size that can be loaded onto a large number of transport options without the requirement of unpacking its contents.

In recent years the idea of using shipping containers as modular units for housing construction has grown in popularity. Maritime containers are one of the key pieces of shipping transport, so by design they are resistant and durable. In addition to that, to make them easier to stack and distribute in ships and ports, their shape follows globally set standards. This is one of the main benefits when using them for other applications.

Shipping container architecture is characterized by the reuse of steel shipping containers as a structural element to house a specific function or human activity. This type of architecture is also called cargotecture, and has been widely applied because of the strength, low cost and obtainability of shipping containers..

There are further advantages to it, including its lower environmental impact compared to more traditional buildings made of brick and reinforced concrete structures, the shorter building time , and the possibilities of easily moving buildings to other places or adding spaces in a modular way. An important point is that beyond being internationally standardized, the dimensions of some types of containers have an adequate human scale. That is, they are very valid for projecting living spaces without modifications to the supporting structure. [5]

2.3. Why use a container?

One of the first needs of this project is to find a space to house the healthcare center. The sections above provide many arguments supporting the use of containers for that purpose.

In short, a list of advantages and disadvantages is made:

Advantages:

- The size standardization allows for easy replication of the healthcare center everywhere in the world.
- Containers are airtight and prepared to withstand the worst weather conditions.
- Since most types have walls and ceiling, they are a habitable structure by themselves.
- They are specifically designed for easy transport.

- The price of a container is low.
- Recycling them is an environmentally conscious philosophy.

Disadvantages:

- The coating used on the containers to allow them to withstand the marine environment and the wood component of the floor may contain harmful chemicals.
- Limitation in dimensions.
- An economic investment needs to be made to adapt them to a new application.

While there are some issues that need to be taken into account if a container is to house our medical center, all of them can be addressed with proper planning. The advantages are very numerous, so the following sections will delve deeper into types of containers and specific needs, select the best one and plan for its adaptation to our purposes.

2.4. Container dimensions

There are various measures for containers varying in length and width. The following table shows the standard dimensions, volumes and weights of the three most common shipping container sizes.

Specifications	20' Container	40' Container	40' Container High-Cube
External length	6,10 m	12,19 m	12,19 m
Internal length	5,86 m	12,03 m	12,03 m
External width	2,44 m	2,44 m	2,44 m
Internal width	2,35 m	2,35 m	2,35 m
External height	2,59 m	2,59 m	2,89 m
Internal height	2,39 m	2,39 m	2,66 m
Inside cubic capacity	33,20 m^3	67,50 m^3	76,20 m^3
Max. gross weight	30480 kg	30480 kg	30480 kg
Tare weight	2050 kg	3750 kg	3890 kg

Table 1. Sizes of the containers [6]

The sizes of all containers are regulated by ISO 6346 standard.

2.5. Container types

There are several types of containers on the market, adapted to the specific needs of the goods or the special conditions of the transport.

- Dry Van: a standard container, hermetically sealed and without cooling or ventilation.

Figure 1. Dry Van container [7]

- Ventilated container: Essentially a dry van but either passively or actively ventilated.

Figure 2. Ventilated container [8]

- Reefer container: Equipped with a cold or heat preservation system and a thermostat.

Figure 3. Reefer container [9]

- Open Top and Open Side container: Its most notable feature is that it is open on top or on one of its sides. It is used for larger loads that cannot be loaded through the container door.

Figure 4. Open Top container [10]

- Flat-rack: It also lacks side walls and even, sometimes, front and rear walls. It is used for atypical loads.

Figure 5. Flat-Rack container [11]

- Tank container: Used for liquids, gases or powders. It is a cistern held between a structure of steel beams whose dimensions are equivalent to those of a dry van. In this way, the cistern has the inherent advantages of a container.

Figure 6. Tank container [12]

Container architecture uses mostly Dry Vans, since a container's function is purely structural, with additional adaptation covering other needs. This approach will be followed and from this point onwards only Dry Vans will be considered.

2.6. Container prices

Another of the parameters to take into account when choosing a container is the price. For this, the prices of 20 'and 40' Dry Van containers have been studied, both new and used. A company has been contacted as the potential source of containers for our Primary Health Center.

All the containers are from Ocean Container Trading S.L. with this common characteristics:

- Maximum delivery time: 1 week.
- Available in Barcelona.
- Suitable for transport, warehouse, etc.
- Made of Corten steel (anticorrosive).
- 28mm hardwood floor.
- Forged and galvanized closing bars.
- CSC plate in force.

20' standard container Dry Van:

- External measurements: 6,058 (L) x 2,438 (W) x 2,591 (H) m
- Interior measurements: 5,898 (L) x 2,350 (W) x 2,390 (H) m
- Tare weight: 2155 Kg (approx.)
- Price of a new one: € 2270,00 / unit
- Price of a used one: € 1440,00 / unit with a 2-5 years of life.

40' standard container Dry Van:

- External measurements: 12,192 (L) x 2,438 (W) x 2,591 (H) m
- Interior measurements: 12,031 (L) x 2,352 (W) x 2,395 (H) m
- Tare weight: 3630 Kg (approx.)
- Price of a new one: € 4670,00 / unit
- Price of a used one: € 2130,00 / unit with a 2-5 years of life.

40' High-Cube standard container Dry Van

- External measurements: 12,192 (L) x 2,438 (W) x 2,896 (H) m
- Interior measurements: 12,031 (L) x 2,352 (W) x 2,700 (H) m
- Tare weight: 3940 Kg (approx.)
- Price of a new one: € 4850,00 / unit
- Price of a used one: € 2220,00 / unit with a 2-5 years of life.

3. STUDY OF POSSIBLE LOCATIONS

In this section a study on three potential locations will be conducted, focusing on climate and transport conditions. These are important as they will determine if a container can be adapted to withstand the local weather, and can be brought with relative ease.

3.1. Locations

Three locations with very different climates and means of access were chosen, which due to their geolocation and/or political situation could potentially be in need of the product being designed in this project.

Nauru, Australia's dumping ground for refugees

Australia has twice used Nauru as a remote site for the "offshore processing" of people who seek asylum and protection. It is current government policy that no person who arrives in the country by boat seeking asylum is ever settled in Australia. Instead, they are sent to Nauru. In effect, people accused of no crime are warehoused in appalling conditions in arbitrary and indefinite detention.

International Health and Medical Services (IHMS), a company hired by the Australian government, is the leading provider of health services for refugees and asylum seekers. Part of its staff has publicly condemned the terrible treatment that refugees receive. In Nauru there are no specialized teams or medical personnel; Nauruans who need more than basic medical care are sent to Australia or Fiji but refugees and asylum seekers stay in the island and they reported that the hospital lacks even basic supplies. Since no one can leave the island without authorization, refugees are totally dependent on Australian authorities to manage the transfer to a medical center outside Nauru. [14]

The medical center that is being designed could be a great help to refugees by providing a space where minimum medical requirements are fulfilled.

Kashmir, an earthquake in the Himalaya

On 8 October 2005, a devastating magnitude-7.6 earthquake struck the Kashmir region in the Himalaya. Sovereignty of the region is disputed between India and Pakistan, and militar insurgence has left it lacking behind in basic services. Amid this backdrop, the earthquake of 2005 killed more than 80,000 people. According to official figures, it devastated around 600,000 houses, causing the displacement of more than 3.5 million people. Up to 800 health structures collapsed. The water supply systems were destroyed. The earthquake caused extensive damage to other civil and administrative infrastructure, schools and police headquarters. The district hospital, with a capacity of 150 beds, was completely destroyed by the earthquake.

Doctors Without Borders installed a hospital tent immediately after the catastrophe and soon realized that this structure was not suitable to withstand local weather conditions: in winter, snow that can reach up to a meter in height and cold, with temperatures up to 9 Under zero grades; in monsoon season, torrential rains; and in summer the temperature inside the store reaches 44 degrees. With this in mind and wanting to offer quality services to earthquake victims, the swift decision was made to build an easy-to-assemble semi-permanent structure. It turned out to be a challenging project, and it took a long time to solve practical problems such as getting permission to build it from the Pakistani Government, finding the right location to build it, manufacturing delays, transportation problems within the country and other difficulties. [15]

This is another situation where this project could provide great benefits, due to its easier and quicker deployment process even in remote areas.

Lebanon, neighbor to a Civil War

The serious humanitarian crisis derived from the Syrian Civil War began 8 years ago, and the effects of the conflict continue to reverberate throughout the international community. One of the most important implications is the displacement of more than 13 million Syrians, both internally and to other countries.

Lebanon in specific has the highest per capita concentration of refugees worldwide and the attitude towards reception of Syrians has quickly become hostile. The Lebanese health system is highly privatized and extremely costly, which is why many refugees depend on care funded by UNHCR, the UN agency for refugees. The severe decline in international support has left many Syrian refugees in Lebanon unable to access crucial medical care, according to a new report published by Amnesty International. The situation is so desperate that in some cases refugees choose to return to Syria to receive the treatment they need. [16]

This medical center could serve as another support apart from UNHCR to offer primary health care.

3.2. Environmental climatology

This primary health center is intended for all underdeveloped countries affected by a natural disaster or in a situation of need.

Most underdeveloped countries have a tropical or desert climate. As one of the objectives is to be able to cover the largest number of countries, the climates of the countries above will be studied to develop a solution for any destination within the possibilities. In the case of Lebanon we have changed it to Jordan to have three different climates.

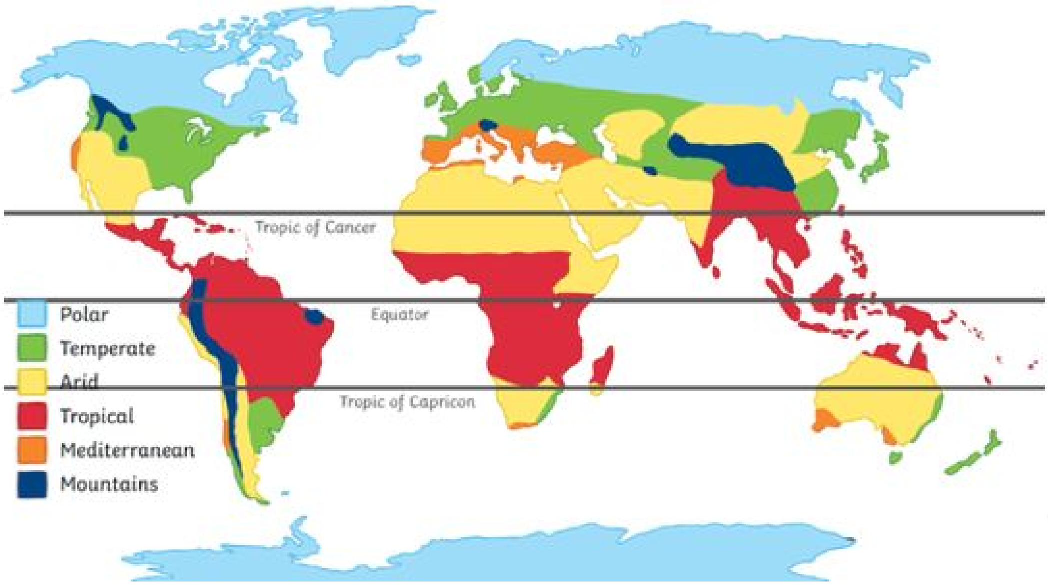


Figure 7. World climate regions [17]

Tropical climate

This climate comprises the north and south around the Equator which includes Central America and South America, Central and Southern Africa, South and Southeast Asia and North and East of Australia and the nearby areas of Oceania.

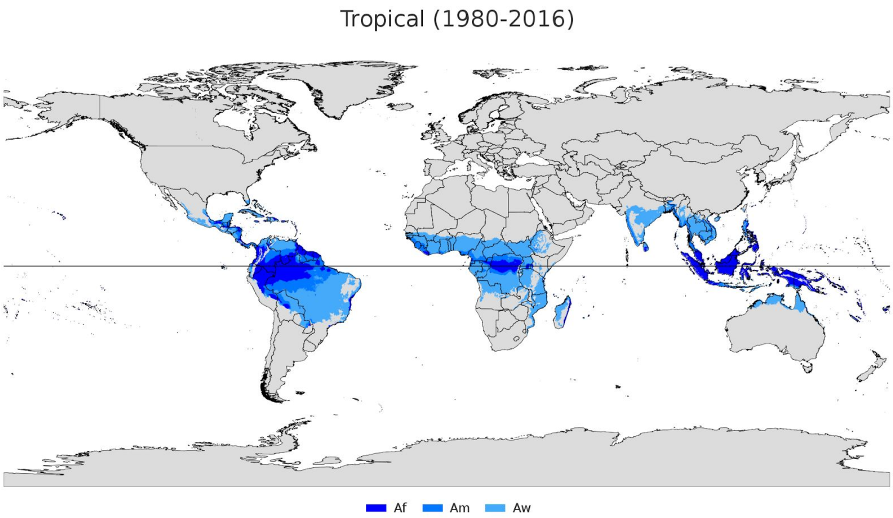


Figure 8. Tropical climate regions [18]

A tropical climate is a non-arid climate where the temperatures are relatively constant, 18 degrees or warmer all twelve months with no significant seasonal variations. Instead, rainfall differentiates two seasons; a wet station in summer which is very rainy, especially during the monsoons in southern Asia and a dry station in winter with a significant decrease or even total absence of rains. The duration of the dry station is longer as bigger is the distance between the country and the Equator, the strip where rainfalls are higher.

Due to its proximity to the Equator, Nauru's climate is tropical, with constant rains and monsoons between the months of November and February. Its climate is going to be studied to have an idea of anual temperature and rainfall range.

	J	F	M	A	M	Jn	Jl	A	S	O	N	D
Tº (C)	27,7	27,7	27,6	27,6	27,8	27,7	27,5	27,5	27,7	28	28	27,7
Rain (mm)	284	251	206	204	129	111	146	140	117	105	115	255

Table 2. Temperature and rainfall in Nauru [19]

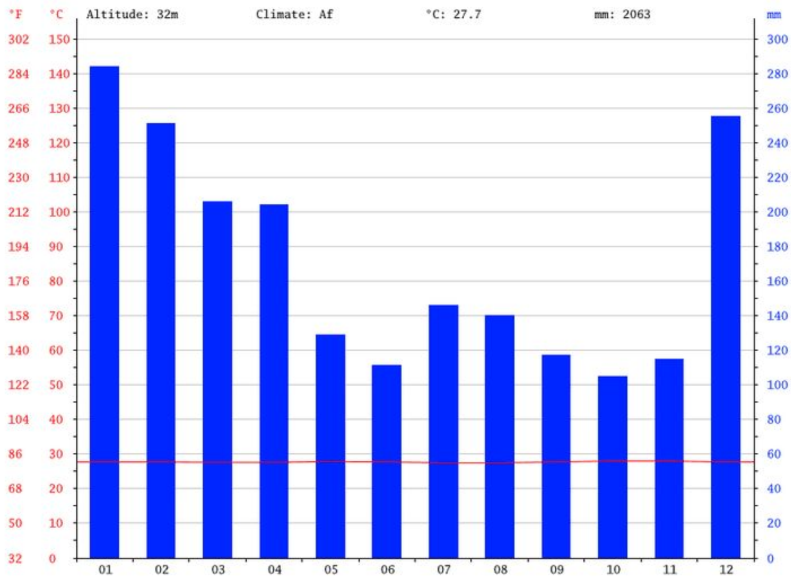


Figure 9. Monthly rainfall in Nauru [19]

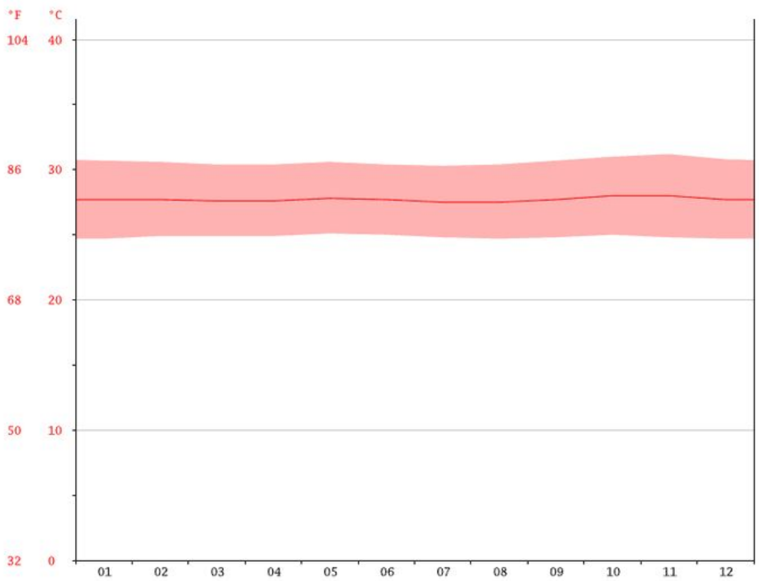


Figure 10. Monthly temperature in Nauru [19]

The variation in the precipitation between the driest and wettest months is 79 mm being a climate with abundant rains. The variation in temperatures throughout the year is 0,5ºC. The driest month is October, with 105 mm of rain. In January, the precipitation reached its peak, with an average of 284 mm. Also, October and November are the warmest months of the year reaching 28 °C of temperature. At 27,5 °C on average, July and August are the coldest months of the year.

As a summary, the most significant values that serve as parameters to design the medical center are highlighted:

- ➔ Annual average temperature: 27,7ºC.
- ➔ Annual thermal oscillation: Maximums of 28 ºC and minimums of 27,5ºC.
- ➔ Total precipitations: 2486 mm.

<u>Temperate climate</u>

This climate occurs in the middle latitudes, which span between the tropics and the polar regions of Earth.

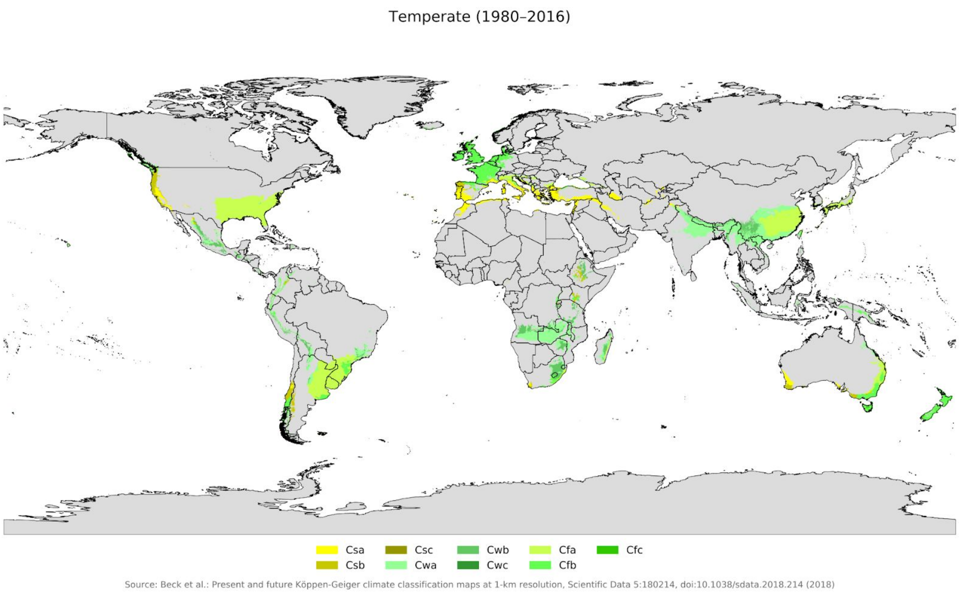


Figure 11. Temperate climate regions [20]

These areas generally have broader year-round temperature ranges and more distinct seasonal changes compared to tropical climates. Earth's temperate climates are characterized by relatively moderate annual mean temperatures, exceeding 10 ° C in the warmer months and above -3 ° C in the colder months. Most regions with a temperate climate have four seasons, and temperatures can change greatly between summer and winter, being Summer the warmest, Fall is transition season to winter, the coldest season, and spring transition from winter to summer. In the northern hemisphere, the year begins with the winter that occurs in the first half of the year until spring then summer starts, which is mid-year, followed by autumn. In the southern hemisphere, seasons are interchanged, with summer during new year and winter in the middle of the year.

Kashmir climate, as an example of temperate climate, is going to be studied to have an idea of anual temperature and rainfall range.

	J	F	M	A	M	Jn	Jl	A	S	O	N	D
Tº (C)	1,5	3,8	8,7	13,7	18,3	21,7	24,6	23,9	20,5	14,6	8,1	3,8
Rain (mm)	57	67	110	99	75	38	53	59	38	37	24	36

Table 3. Temperature and rainfall in Kashmir [21]

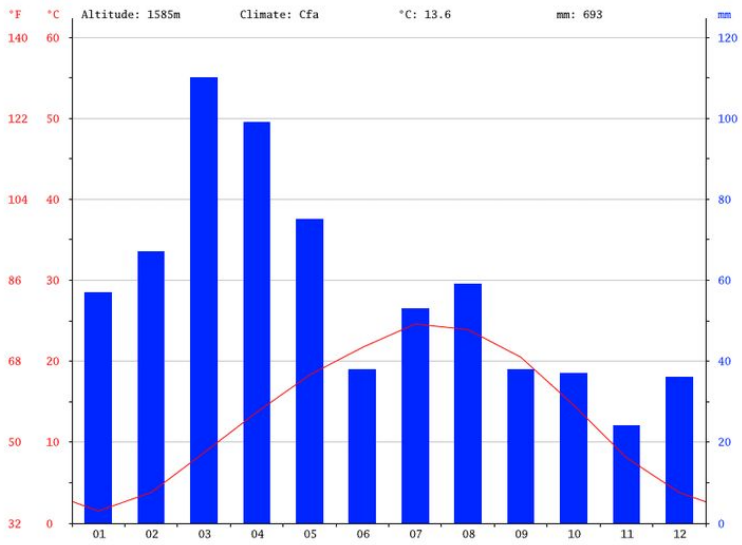


Figure 12. Monthly rainfall in Kashmir [21]

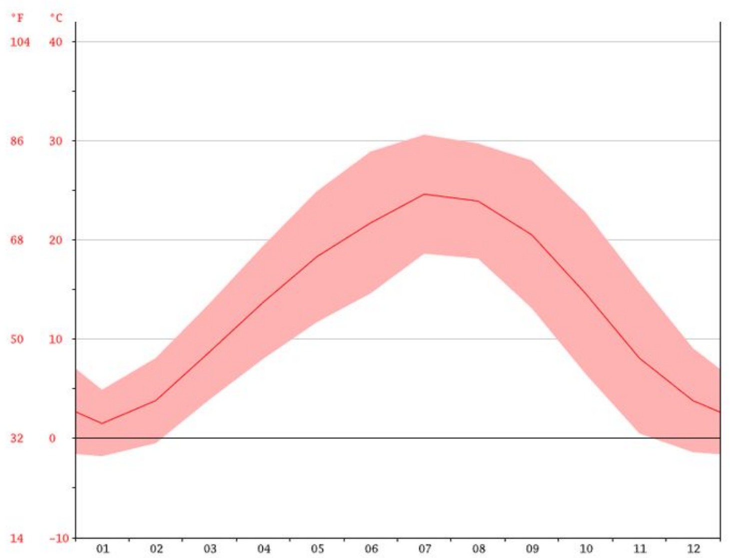


Figure 13. Monthly temperature in Kashmir [21]

The variation in the precipitation between the driest and wettest months is 86 mm. The variation in temperatures throughout the year is 23,1ºC. The driest month is November, with 24 mm of rain. In March, the precipitation reached its peak, with an average of 110 mm. Also, July is the warmest month of the year reaching 24,6 °C of temperature. At 1,5 °C on average, January is the coldest month of the year.

As a summary, the most significant values that serve as parameters to design the medical center are highlighted:

- ➔ Annual average temperature: 13,6ºC.
- ➔ Annual thermal oscillation: Maximums of 24,6 ºC and minimums of 1,5ºC.
- ➔ Total precipitations: 693 mm.

Desert climate

There are two variations of a desert climate, a hot desert climate (BWh) and a cold desert climate (BWk). Hot deserts are located around the tropics where there are high tropical pressures and continental areas far from the influence of the sea.

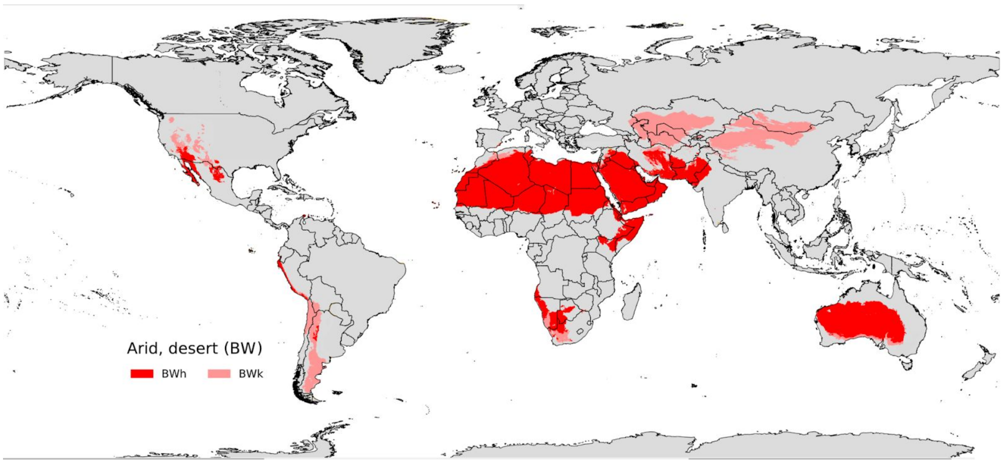


Figure 14. Desert climate regions [22]

In hot deserts, temperatures are very high throughout the year and occur large thermal oscillations between the day (often higher than 50ºC) and night (with temperatures that fall below 0ºC).

Rains are scarce (less than 200-250 mm per year) and irregular, since they are concentrated in a few months of the year. The water is filtered and evaporated quickly due to the dryness of the air. Maximum humidity of air is between 20-50% so evaporation capacity is large and the earth dries and absorbs rainwater quickly.

Because Lebanon has a moderate climate and has already been studied, a country with a desert climate will be studied for a broader range of data. Aqaba (Jordan) climate is going to be studied, as an example of hot desert climates, to have an idea of anual temperature and rainfall range.

	J	F	M	A	M	Jn	Jl	A	S	O	N	D
Tº (C)	15,6	16,8	20,2	23,8	27,8	31	32,1	32,4	29,9	26,6	22,1	17,2
Rain (mm)	5	6	5	4	1	0	0	0	0	1	4	6

Table 4. Temperature and rainfall in Jordan [23]

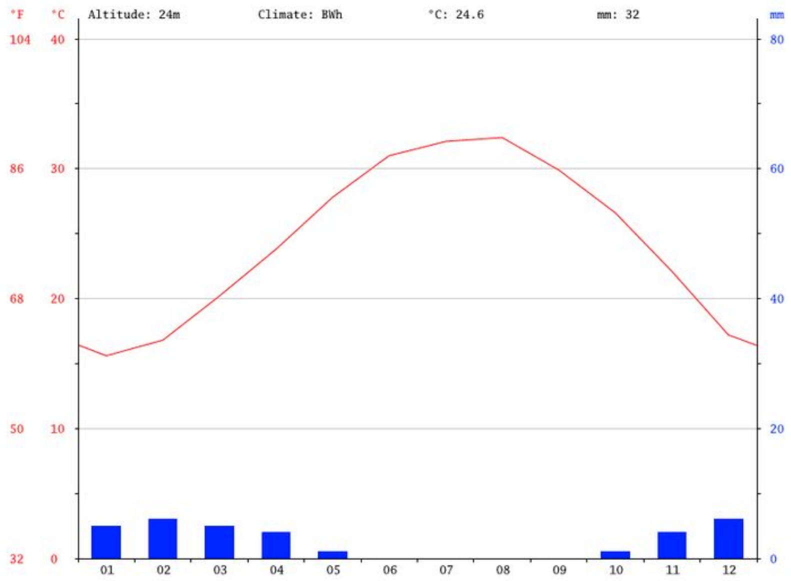


Figure 15. Monthly rainfall in Jordan [23]

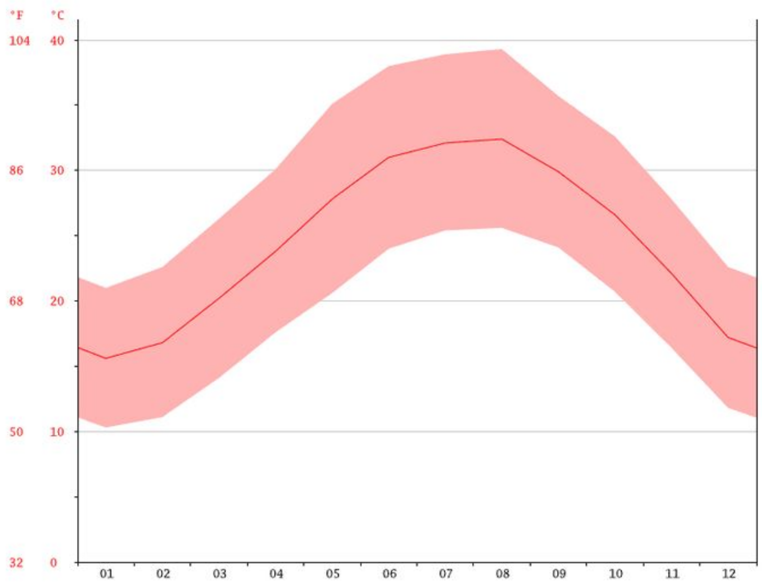


Figure 16. Monthly temperature in Jordan [23]

The variation in the precipitation between the driest and wettest months is 6 mm. The variation in temperatures throughout the year is 16,8ºC. The driest months are June, July, August and September with no rain. In December and February, the precipitation reached its peak, with an average of 6 mm. Also, August is the warmest month of the year reaching 32,4 °C of temperature. At 15,6 °C on average, January is the coldest month of the year.

As a summary, the most significant values that serve as parameters to design the medical center are highlighted:

- ➔ Annual average temperature: 24,6ºC.
- ➔ Annual thermal oscillation: Maximums of 32,4 ºC and minimums of 15,6ºC.
- ➔ Total precipitations: 32 mm.

The container has to withstand temperatures between 32.4 º and 1.5 º and rainfall of 2486 mm in the countries with the most rain.

3.3. Transportation

The transport routes that have been studied to transfer the containers to different areas of the world have been the air, water and land transport, considering trucks and trains. Several transport maps have been made where the roads, the martim container traffic, the rail line and helipads around the world have been analyzed.

3.3.1.

3.3.2. Road network

Nauru

Nauru has a 24 km paved road that surrounds the island and a dirt road that leads to the reserves and offices of Nauru Rehabilitation Corporation (NRC). Rail transport on Nauru is used to move lime phosphate from the interior of the island to the cantilevered docks on the island's west coast. For this purpose, a 3.9 km long narrow gauge railway was built. [24]

Kashmir

The Silk Road offers three different routes that cross the Kashmir valley. The Jammu-Poonch motorway was later designed providing the most fundamental mode of transport in the state. The state of Jammu and Kashmir, except for the Jammu plain and the Jhelum valley, is mountainous. Building rail lines through the difficult terrain of the Siwaliks (Middle Himalayas) and Greater Himalayas is a difficult proposition. It's not just a challenging task, keeping train tracks in fraggle rock strata and snowy winters demands a prohibitive cost. However, the state was included on the Railway Map of India in 1970 when the city of Jammu-Tawi was connected to Pathankot. The total length of the railway lines in the state is currently about 80 km. Efforts are still underway with a 53.2km-long project that will provide a rail link between Jammu and Udhampur. [25]

Lebanon

Lebanon has approximately 8,000 kilometers of roads, as well as a highway network linking the country with Syria. There are three key road routes in the country, each radiating from Beirut. The Lebanese rail system is not currently in use, with services having ceased due to the country's political difficulties. [26]

<u>Limitations of land transport</u>

In the event that the transport of the containers had to be carried out with trucks, there are a series of specifications that must be taken into account in order to choose the size of the containers to be used. Each country has its restrictions so the current regulations in Spain have been used as a basis, specifying the width and maximum height allowed for trucks. This has been used to have a reference and decide a container that can fit within the regulations. The reason this regulation has been chosen is because it is where they are going to be manufactured and the norm that they would have to follow when transporting them from there.

The Gross Vehicle Mass (GVM) is the maximum operating mass that a vehicle can load to circulate on roads. Vehicles of category N, that is, those vehicles destined for the transport of goods, are subdivided into three subcategories established according to their GVM:

- N1 - GVM up to 3,500 kg
- N2 - GVM greater than 3500 kg and up to 12,000 kg
- N3 - GVM greater than 12,000 kg.

The maximum authorized width, as a rule, is 2.55 m.

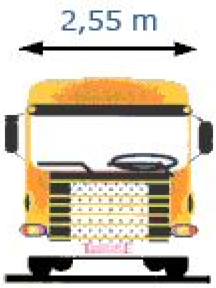


Figure 17. Maximum width of vehicles [27]

The maximum height of the vehicles, including the load, is 4.00 meters.

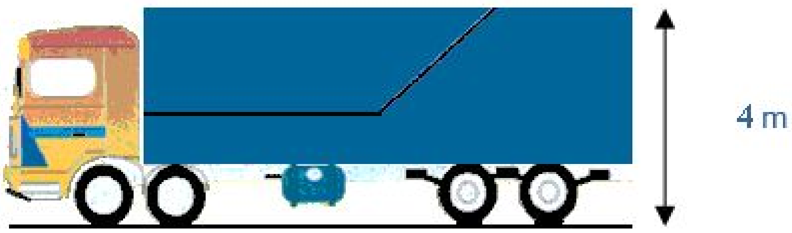


Figure 18. Maximum height of vehicles [27]

In rail transport the restrictions are those of the container itself.

3.3.3. Port assessment

Nauru

The existing port area is in a much deteriorated condition unfit for safe handling of cargo from vessels. The common practice of unloading and loading containers is by old barges, which transfer one container each to the small harbor. At the harbor a crane lifts the containers on shore. In rough weather, vessels and barges cannot operate fully and unloading of around 200 containers differs from a few days to several weeks. [28]

Kashmir

The Jhelum River could be an important transport artery and the government has ambitious plans to start water transport service in North Kashmir but keeping the Jhelum navigable in all areas and through the year is difficult. For now, the river is navigable only in the summer, when the water levels are high. To make the river navigable all year round, it would need a long series of barriers across the river that would raise water levels during lean seasons. Even if the river were made navigable, it would be a long commute. By river, the distance between Sangam and Ram Munshi Bagh in Srinagar is 56.5 km. By road, it is about 42 km. The inland water transport system might work in the congested areas. Beyond that, it would just be too slow for a regular commute. [29]

Lebanon

The Port of Beirut is the main port in Lebanon located in the capital city, Beirut, and is one of the largest ports on the Eastern Mediterranean. It has been selected as a transshipment hub. The Port of Tripoli is the second port in Lebanon after the Port of Beirut. The Port is currently undergoing expansion projects and is located 30 km away from the border with Syria. The port of Sidón is an old port, used mainly as a fishing port and to accommodate small freighters. While the port can accommodate a larger number of ships, winds and waves prevent ships from docking due to the absence of a wave breaker to protect them. Lack of such protection has forced many ships to dock in other ports. However, there have been several initiatives in recent years to modernize the commercial port. The Tire Port is a small port located in southern Lebanon. In this harbor, the breakwater protects the marina that houses fishing boats and some private pleasure boats or sailboats, but it does not extend far enough to accommodate boats that dock in the main port. As such, during the winter season, the port may be inoperable for up to 10 days per month due to waves and surge. [30]

Limitations of water transport

As in rail transport, in maritime transport more than one container is loaded at the same time, so the restrictions are set by the container itself.

3.3.4. Aviation

Although the most suitable transport to access remote or hard-to-reach areas is by air, this has been ruled out for various reasons. It is an economically very expensive transport and if you decided to do the transport with airplanes, you would have to guarantee that near the destination there are runways or a large enough space and in good condition so that the plane can land without problems. Because the destination areas are in underdeveloped countries or areas that have suffered natural disasters, these conditions cannot be guaranteed, so the transportation by plane is ruled out. Another reason why it has been discarded is because the type of containers that can be transported inside airplanes are not shipping ones, which are the ones used in this project, but they are a special type for this transport. In the event that transport with aerial cranes could be carried out, it would greatly facilitate access to the most difficult areas, since unlike the plane they do not need a surface in good condition or large dimensions. But currently there are no helicopters that are dedicated especially to the transport of containers. There are helicopters, which due to their technical characteristics could transport the containers, but they are not designed for this, which means to design special and exclusive cables to carry containers.

After conducting a thorough analysis of the transport that can be used to containers, it has been observed that both sea and land transport is the most common and the cheapest for container transport. For this reason, only the limitations that such transportation provides will be taken into account.

The transport that provides the biggest limitations, after the air that will be avoided, is by road. In order to reach a greater number of trucks capable of transporting the container, it would be advisable to choose the shorter one.

4. STUDY OF PRIMARY HEALTH CENTERS

In this section a Benchmarking is done and as well as the guidelines, normative, basic specifications and instrumentation are studied to have a complete idea of what a PHC requires.

4.1. Benchmarking

In order to begin with the development of the design of the product, it has been carried out a benchmarking whose objective is to observe what is currently in the market related to the field of this project and expand the knowledge. It wants to study those points that are important and those that are not, to design a quality product and adapting it to the required needs.

Military emergency unit

The UME is an integral unit of the Spanish Armed Forces with the purpose of intervening quickly in any place of the Spanish national territory in cases of catastrophe, serious risks, calamity or other public needs. The militaries that form UME have a specific preparation that mainly lies in emergency health training; they are also instructed to action against forest fire, floods, heavy snowfall and landslides.

After analyzing it more internally, focusing on the field hospitals that compose the unit, several advantages and disadvantages have been obtained: [31]:

Advantages:

- Specific tent to detoxify.
- Sterile and non-sterile tents.
- Speed and ease in transport.
- It takes about 15 minutes to build a campaign hospital.

Disadvantages:

- Lack of thermal isolation.
- Lack of hygiene.

Mobile intensive care units and ambulances

Different ambulances will be studied as they are mobile units that offer medical services. There are different types of ambulances but this study is focusing on emergency ones. Among these it can be found basic life support ambulances that provide simple medical care to patients who are far from a hospital or to transport the patient to a medical center where they can closely monitor their evolution and perform a greater number of medical tests. Or advanced life support ambulance for when the patient needs to be stabilized before transfer.

To do the analysis, a table is made where the type and characteristics of the different ambulances are specified. [32].

	Characteristics
SAMUR	- Independent air conditioning. - Independent electrical installation with easy access to the fuse. - Auxiliary power source with independent operation (4 outlets 12V DC / 4 outlets 220V AC). - Portable respirator. - Defibrillator monitor. - Pulse oximeter. - Blood pressure monitor. - Infusion pump.
URO (UME)	- Two batteries. - Two portable respirators. - Defibrillator monitor with pacemaker and possibility of semi-automatic defibrillation. - Widely equipped with extrication and rescue material.

Table 5. Characteristics of two different ambulances

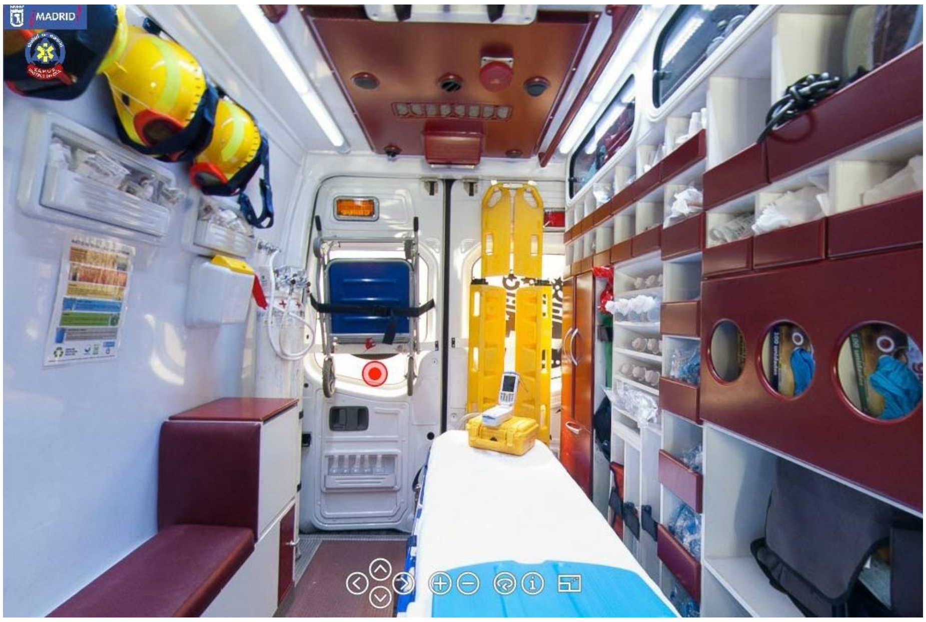


Figure 19. Inside an ambulance [33]

<u>**Non-governmental organizations (NGOs)**</u>

NGOs are independent and non-profit organizations that arise as a result of civil and popular initiatives and are usually linked to social, cultural, development or other projects to generate structural changes in certain communities or countries.

After analyzing some NGOs operating in underdeveloped countries, as UNHCR. There are several advantages and disadvantages about this type of NGOs. [34]

Advantages:

- Simple and practical spaces.
- Fast assembly of the infrastructure.
- Use of rainwater.

Disadvantages:

- Lack of isolation (Insect screen).
- Lack of drinking water.
- Scarce dependencies.
- Lack of any technical resources.
- Shortage of material.
- High working temperature.
- Inability to reach the territory because of the roads, which means long journeys on foot for patients without means of transport.

4.2. Basic specifications of a primary health center

To get an idea of what a primary care center is and how it works, different questions and criteria are answered below.

What are they and what is done in primary health centers?
Primary health centers are the physical infrastructures, the means assigned to them and the structure functional, that integrates preventive, curative, rehabilitative care and the promotion of citizens' health. This is the basic and initial level of the health care process. The objectives of a primary health center are to provide quality health care oriented to the needs of the community, achieve and maintain an acceptable standard of quality of care and make services more responsive and sensitive. [35]

Characteristics and connection between areas [36]:

Lobby and administration area	- Wide space that gives the feeling of a public building. - Number of m^2 depending on the size of the center in surface porcentage. - Space reserved for a stretcher and wheelchair with some not closed separation. - Double door, easy opening, automatic.

	- The installation of fluorescent and low-consumption type luminaires will take precedence. 200 lx is enough.
Clinic area	- They must have natural light and sinks, clinical and computer equipment. - It will have a refrigerator, a continuous worktop to be able to deposit racks and material and a closet for storage. - The minimum useful free height between floor and ceiling will generally be 2.70 m. - The countertops will be made in one piece, avoiding joints, except for the hole to fit the sink. - The installation of fluorescent and low-consumption type luminaires will take precedence. 700 lx is enough.

Table 6. Characteristics of PHC by areas.

4.3. Main equipment and instrumentation of a primary health center

This section is intended to know what instruments are necessary within the primary health center to design. The material is divided according to its destination. [37].

Exploration material:

- Medical scale with height rod
- Tuning fork
- Negatoscope
- Otoscope
- Rhinoscope
- Ophthalmoscope
- Stethoscope
- Blood pressure cuff
- Esthesiometer
- Glucose meter
- Electrocardiograph
- Front mirror with built-in or single direct light
- Laryngeal mirror
- Alcohol burner
- Eye chart

- Medication, material and sufficient equipment to attend emergencies and first aid (basic cardiopulmonary resuscitation equipment: airway mask bag unit, oropharyngeal airway)
- Thermometer
- Medical flashlight
- Reflex hammer
- Approved spirometer

Furniture:

- Examination coach
- Step
- Stool
- Hanger
- Main table
- Table for exploration material
- Floor or wall lamp with magnifying glass
- Desk chair and two confidant chairs
- Sanitary waste container

Educational material:

- For diabetes health education
- For inhalation techniques
- For sex and STD education
- Education related to the reality of the destination country

5. SELECTION OF THE CONTAINER AND DESIGN

This section details the design of the space of the Primary Health Clinic. Based on the studies of location settings and PHC needs and of existing containers conducted in the previous sections, a container will be selected as the physical structure that will house our PHC, the feasibility of that choice will be confirmed, and a proposed interior layout will be detailed.

5.1. Selection of the most suitable size

There are no international regulations on PHC specifications, and the three locations chosen in the study (and virtually all underdeveloped countries) have no local ones either, so the basis for them will be the specifications seen in section 3.4. According to the different guidelines for PHC, two important conditions emerge:

- The area must house at least 2 tables, a stretcher and a lobby area.
- Ceilings must be 2,70 m high.

These are basic characteristics shared by all PHC, and it will be assumed that they will provide the necessary space for adequate healthcare services in underdeveloped countries as well. It should be emphasized that although some local guidelines in highly developed countries present stricter or further specifications, these won't be taken as essential but as desirable, assuming that some minor benefits provided by them can be forsaken in exchange for feasibility and accessibility.

Considering that the two conditions have to be met, that the necessary equipment detailed in 4.3 has to be housed in the PHC, and that the PHC has to withstand the climates detailed in section 3, a few possible designs consisting of layout plus needed installation (thermal/ventilation/plumbing/…) were explored in different sizes of Dry Van containers, which had been earmarked as the optimal type in section 2.5. A design was chosen which satisfied all the requirements and fitted into the used 20' container, because of its advantages in price and ecological value (section 2.6) and transportability (section 3.2).

5.2. Feasibility study

It has been established that using a user container suits the requirements and has some advantages. It is important to mention that used shipping containers are available worldwide, but during their years of service, containers are damaged by friction, handling collisions, and the force of heavy loads overhead during ship transits. Furthermore, most of the floors are made of wood, and when they are manufactured they are treated with insecticides that contain copper (23-25%), chromium (38-45%) and arsenic (30-37%).

Before construction of the primary health center begins, floors must be safely removed and disposed of, and paint-thinning solvents and sealants used in manufacturing have to be eliminated. All the used containers provided by company Ocean Containers Trading S. L. go through an inspection that verifies that the container is without holes, with the floor and doors in good condition and, therefore, guarantees that the container remains hermetic. In addition, used containers have the current approval plate (CSC) which is the approval plate related to the safety of containers according to the International Convention on the Safety of Containers (CSC). So it is necessary to add the cost of cleaning and disinfection to the project budget, but it is feasible to transform a used shipping container into a structure suitable for human activity.

5.3. Design of the interior layout of the equipment and instrumentation

In order to decide the final interior distribution,various factors have been taken into account that have determined the interior design of the primary health center. They are:

- Necessary equipment within the center, which can be seen in ANNEX I.
- Storage of equipment.
- Circulation of staff and patients.
- Electrical, water and air conditioning installations.
- Machinery required for installations.
- Number of staff and patients that may be within the medical block.
- Functionality of the area of each of the containers.
- Exploitation of standard container doors.

Below is a sketch of the interior distribution of the Primary Health Clinic, on which each of the areas can be seen.

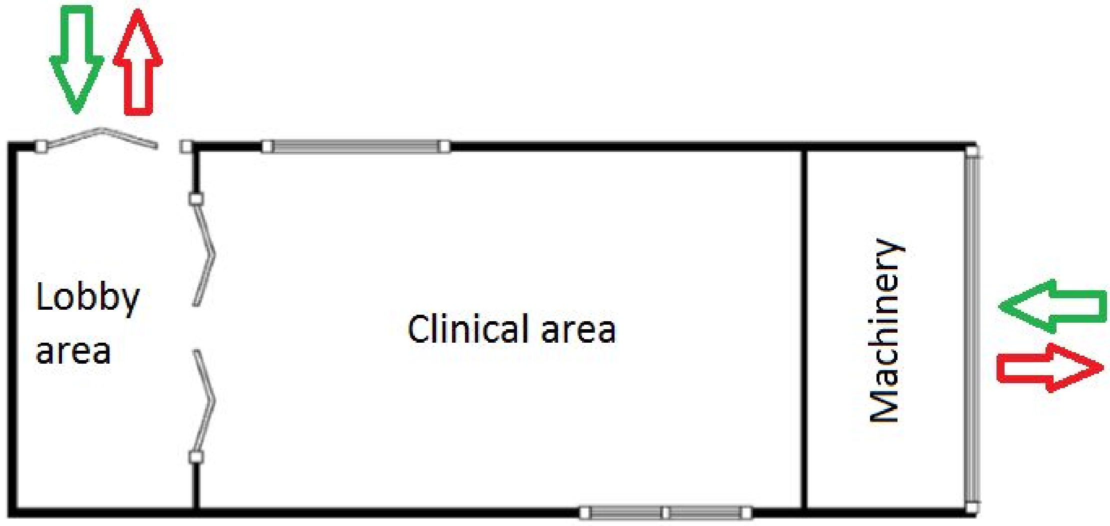


Figure 20. Different areas of the PHC.

The center is split between the clinical area and the lobby, through which the center is accessed. The entrance to both is marked with two arrows, one green and one red. The lobby area is separated from the clinical area by a wall and an access door. In the back there is a small area for the machinery of the installations, such as the outdoor air conditioning unit, the filtration system and the water tank. Machinery area will be separated from the health center by a wall, so that the noise doesn't reach the center. There is an access to the machinery area, to carry out repairs, controls, etc., through the original door of the container, located in the rear. The circulation is indicated by the green and red arrows located on the back of the container.

Once the interior distribution of the container was decided, it was distributed the equipment that would go into the health block, taking into account all the instruments that had to go in each zone of the center. After doing a study of the necessary and essential equipment for all areas of the care block, the instrumentation distribution has been carried out as follows:

Figure 21. Sketch of equipment.

6. ENGINEERING

It must be considered this kind of Primary Health Centers are subject to constant activity, and the resources that are available for its construction and, especially for its maintenance, are limited. Avoiding the use of expensive materials or unsuitable for heavy use required complex solutions of design, whether structural or constructive elements that need complex maintenance is crucial for the viability. Proper construction and choice of materials is important to ensure that building costs are minimized and maintenance is affordable and simple, as technical solutions may not always be available. The characteristics and specifications of all elements used in the section of engineering are shown in ANNEX III.

6.1. Insulation

One of the most important issues is insulation, since a shipping container is basically a metal box, and can be cold as a fridge in winter and hot as an oven in summer.. This can be solved by thermally insulating the container and turning it into an habitable space.

6.1.1. Objectives

- Maintain the Primary Health Center temperature within the established parameters for the required temperature, between 18 and 26ºC.
- Benefit the most of the useful space of the container.
- Help reduce the energy needs of air conditioning systems.

6.1.2. Types of thermal insulation

Mineral insulation

Mineral wool (rock or fiberglass) is a flexible material that has the quality to insulate thermally, acoustically and against fire. It is classified according to its density, the minimum being 50mm:

- Higher density: they are used as thermal insulation in areas that need greater resistance to compression and weight.
- Lower density: they are not waterproof and allow condensation steam to pass through.

Its thermal conductivity is between 0,023 and 0,040 W/m·K. [38]

Synthetic insulation

- Expanded polystyrene: white insulating material, of different densities and thicknesses (from 30 to 120 mm). At the same time that it isolates, it supports the plaster and paint of the most outer layer. Its thermal conductivity is between 0,030 and 0,040 W/m·K. [39]

- Extruded polystyrene (XPS): it has a higher density than expanded polystyrene and therefore greater insulating power. It is impervious to water, recycled, and offers high resistance to compression, high temperatures and deformation. Its thickness ranges from 30 mm to 100 mm. The greater the thickness, the greater the thermal insulation capacity. Its thermal conductivity is between 0,025 and 0,040 W/m·K. [40]

Both materials are highly flammable.

Multi-layer insulation

It is a very light material, of minimal thickness, made up of wadding and several layers of reflective. It is considered one of the best insulators because of its behaviour against the cold, its antioxidant and antiallergic characteristics, and its resistances to fire, water and humidity. It is very easy to install, since it adheres to the surface with staples and it allows to save space. Its thermal conductivity is around 1·10^(-5) W/m·K. [41]

6.1.3. Selection of insulation

In order to choose the type of insulation, the temperatures to which the container will be exposed must be taken into account. According to the locations studied, the temperature range is quite wide (section 3.2), so an insulator with low thermal coefficient is needed, to minimize the exchange of cold and heat with the outside as far as possible. As for rainfall, there are also locations with abundant rainfall, so preferably it will have to be hydrophobic.

Traditional insulators are effective only by acting on the heat received by conduction and convection, but they do not act upon heat transfer by radiation. Most traditional insulators work on the principle that the air trapped inside is a good insulator. Insulations such as fiberglass, foams and cellulose use layers of fiber, plastics or vegetable fibers to reduce convection and therefore heat transfer, but they have a saturation point at which they lose their properties and allow the heat. Multi-layer insulation has no saturation point.

Considering that insulation must have reduced thickness, be fireproof and does not contain toxic gases, also effective against the intensities of solar radiation, large temperature differences and abundant rains and being studied the different types of existing insulation, the best option for this application are multi-layer insulators.

Multi-layer insulators are effective against all 3 types of heat transfer. Thanks to its pure aluminum exterior sheets, 97% of the heat received by radiation can be reflected, while the interior dry air sheets prevent temperature changes between both sides of the insulator and therefore, heat transfer by conduction or convection.

Other advantages of reflective insulation are:

- Vapor barrier; does not absorb water or moisture.
- Does not contain fibers or asbestos.
- Little thickness and gain of space in a house.
- Easy installation; does not produce skin irritations or allergies.
- Prevents the creation of fungi and bacteria.
- Great durability; does not lose efficacy over time.
- High mechanical resistance.
- Sustainability. As it is made with 100% recyclable aluminum.
- Energy saving.
- They are not eaten by rodents or insects.

6.2. Sections and doors

For the purpose of access to the container through the main door, it is necessary to open a section of the wall When doing so, the following recommendations have to be taken into account:

- It is not recommended to open large gaps. If it has to be opened, it is necessary to study the distribution of these and put specific reinforcement supports in place.
- Always leave at least 10 cm of sheet metal on the top as a lintel.
- The weakest points of the containers are the ends, therefore, the best option for drilling is on the longer wall sides of the containers.
- The perimeter of the holes must always be reinforced with rectangular welded metal profiles. This not only serves to reinforce the structure, but it will also later facilitate the placement of doors and windows.
- Windows are used to allow ventilation inside. To aerate effectively, they must be windows crossed, it is to say, open one window and another on the opposite side, to enable the movement of air circulation.

6.2.1. Dimension of the section

The dimension of the section to be made in the container is determined by the height and width of the doors and windows standard for houses, and for the height and width of the steel reinforcement that these must carry. To execute the section an oxyacetylene torch will be used.

- Height

Total Height D = Door height + reinforcement thickness

THD = 2050 + 30 = 2080 mm

Total Height W = Window height + reinforcement thickness

THW = 150 + 30 = 180 mm

- Width

Total Width = Door width + reinforcement thickness

$$TW = 1660 + 2 \cdot 30 = 1720 \text{ mm}$$

Total width W = Window width + reinforcement thickness

$$TWW = 118 + 2 \cdot 30 = 178 \text{ mm}$$

6.2.2. Necessary items

For the opening, rectangular profiles of steel and a stainless steel door will be used.

Door and windows

The doors will be folding, accordion type, in order to optimize space and provide easy opening, and must be screwed into a metal profile. The measures are enough for a stretcher and a person to pass through. The windows are vertical sliding to be able to house the air conditioning.

Steel reinforcing profiles

To reinforce the section that will be made to the container, it is necessary to install a rectangular stainless steel profile, which will give more stability and consistency to the section made.

Welding

The reinforced profile is fixed to the container using manual metal arc welding (MMAW). This will be done in all sections of the container every 25 cm of the profile. For the weld bead to be resistant to corrosion, as well as to the material of the container (Corten Steel), a filler material with a 2.5% Ni content, approximately, or similar in composition to that of metal base is needed to be used. Therefore, a Corten Steel electrode will be used [42].

Below are the basic specifications of Corten Steel welding:

- Characteristics of the Corten Steel electrode:
  - Basic electrode with excellent weldability in all positions due to its double coating, even in alternating current.
  - Suitable for Corten Steel wildings.
  - Its high mechanical characteristics make it suitable for large thickness welding.
  - Easily detachable slag.
  - Seamless welds.

- Standards

  The regulation related to welding of Corten Steel is AWS A5.1 - E8018G and ISO 2560 - A:E 46 2 B 4 2

- Welding Parameters

- Electrode diameter (mm): 2.5.
- Length (mm): 350.
- Current Intensity (mm): 65-95.
- Current Type (Pole +): Direct Current.

- It is indicated for weakly alloyed and atmospheric corrosion resistant steels.

Profile sizes

- 2 profiles of 2080 mm (45º cut at one end).
- 1 profile of 1720 mm (45º cut at both ends).
- 4 profiles of 180 mm (45º cut at both ends).
- 4 profiles of 178 mm (45º cut at both ends).

6.3. Leveling

In container applications such as homes it is necessary to insert a base to raise them, in order to carry out the installations and guarantee a greater isolation from the ground which helps prevent the appearance of humidity.

For those containers that are located in a certain place temporarily, the use of hardwood dowels or metallic column shoes is enough. In the event that they are going to be for an extended period or permanently, it is convenient to support them on firm foundations that keep them level and in place with the passage of time. These foundations could well be concrete slabs, piles of concrete or iron beams.

The Primary Health Center has a temporary application and may be installed on an uneven ground. A leveling system ensures the horizontality of the floor. It will use adjustable metal column shoes fixed to the container base, supported on wooden planks in order to ensure that the supporting relief is completely smooth.

6.3.1. Adjustable column shoes

Due to the structural system of the containers used, 4 supports, one in each corner, would be enough. To guarantee that there will not be flexural failures 6 adjustable column shoes will be used, placing one in each corner and two in the middle of the container. The height of the column shoe can be adjusted between 10 and 15 cm. The installation is simple and fast and, in addition, they can be adjusted even after assembly of the container, providing the option to make readjustments over time.

A PPRC type column shoe will be used whose characteristics are shown below:

- Steel - S235 - JR according to NF / EN / 10025.

- Electro-galvanized iridescent yellow (without Chromium VI) according to NF / EN / ISO 2081.
- Thickness: 5mm.

Advantages:
- PPRC column shoes can be adjusted after assembling.
- They do not require any type of machining.
- They support a load of more than 1,900 Kg per pillar.
- Thanks to their innovative regulation system, they allow a quick and easy leveling.

Anchoring:
- Mechanical anchor: bolt WA M10 - 78 / 5.
- Lag screw LAG Ø10x80.

Installation:
These column shoes are always assembled in the same position:
- 130 x 130 plate on the ground.
- 100 x 100 plate attached to the pillar.

The PPRC column shoe can be adjusted with a 30mm wrench once both tape decks are attached.

Technical data:

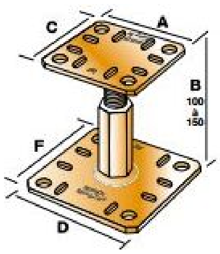


Figure 22. Technical data of the column shoes

Model	Dimensions (mm)						Top coat	Holes
	A	B	C	D	F	Sp		
PPRC	100	100 to 150	100	130	130	5	BC	8Ø12

Table 7. Dimensions of the column shoe.

6.4. Clamping mechanisms for instrumentation

The instrumentation and equipment inside the Primary Health Center may be subject to sudden movements during transportation. Therefore, a system must be put in place that prevents damage to objects during the journey to ensure that they arrive in good condition at their destination. A clamping system that guarantees stability of the equipment is designed. The most common system for the transport of bulky items is the use of tie down straps, which have great resistance, fixed to the wall with buckles and ratchets. This system is the one that will be used for all mobile equipment. Depending on the type of mobile device or its dimensions, the size of the tie down strap will vary. For the most voluminous elements, straps will be a minimum length of 1m. On the other hand, for equipment that has bars or legs, such as a stretcher, tie down straps as the ones used for bottles and other small diameter objects.

The following table shows the items of mobile equipment that require a clamping to be transported and the type of cinch that will be needed.

Equipment	Anchoring
Step	Short tie down strap
Stool	Short tie down strap
Sanitary waste container	Short tie down strap
Chairs	Short tie down strap
Stretcher trolley	Long tie down strap
Bag (Inside instrumental cabinet)	Long tie down strap

Table 8. Equipment by anchor specification

A series of eye bolts will be placed on the side walls of the containers, so that when placing the equipment for transport it can be attached where the user considers it more appropriate, always procuring that the items are fixed safely. Two possible heights will be arranged, one more suitable for equipment with legs or bars, that require a clamp with short straps, and another height for larger volume appliances with long tie down straps. If the device is delicate or large, double clamping can be used with two tie down straps.

All equipment that is placed in a fixed way will be anchored to the wall with fastening nails. These installations are made before its transport and are the following:

- Air conditioning: anchored at the side window.
- Waiting chairs: anchored to the walls and the floor of the lobby area.
- Main table: anchored to the floor.
- Negatoscope: anchored to the wall behind the main table.
- Fridge: anchored to the wall.
- Table for exploration material: anchored to the wall and the floor.
- Lights: hanging in the ceiling of the Primary Health Clinic.
- Examination light: hanging in the back wall.
- Paper dispenser: anchored to one of the side walls.

- Instrumental cabinet: anchored to the side wall and the floor of the clinic area.
- Coat rack: anchored to one of the side walls of the lobby area.
- Examination coach: anchored to the floor.

To carry out the transport so that the container structure isn't weakened because of vibration or movement, any piece of wall removed to make space for the door and other openings will be used to cover them during transport. In order to do so it is necessary to drill some holes at a distance of 10 cm between them, to be able to fix the sheet on the rectangular metal profile. The screws used to fix the sheet in the rectangular metal profile are Stainless Steel 410 self drilling hex washer head with the following features:

- Termination: Stainless steel.
- Applications: To fix roofing sheets or metal structure in corrosive environments (marine, mining and industrial).
- Diameter size: 12 mm.
- Length: ¾ inches.
- Metal structure up to 5 mm.

6.5. Electrical installation

6.5.1. Electrical installation proposal

- The installation will be made in such a way that it can be connected to the public distribution.
- Solar panels can be placed to help with the electrical supply but they cannot be relied on to be the sole source of power.
- There will be a generator set for supply failures or in case of impossibility of connection to the power grid.

6.5.2. Primary Health Center supply

Because the nature of the primary power source of the health center can vary from location to location, it will initially be assumed that the source is a single-phase source that may come from the local network or a low voltage generator set.

6.5.3. Wires

The cable sections necessary for which installation have been calculated in ANNEX II. Below are the characteristics of the cables chosen.

General Power Line

RZ1-K(AS) CPR - Cables RCT

- Section: 3G10 mm^2.
- Nominal voltage: 0.6 / 1 kV.

- Test voltage: 3500 V AC.
- Insulation: Crosslinked polyethylene (XLPE) type DIX 3 according to UNE 21123, HD 603 S1 and IEC 60502-.
- Maximum temperature in the conductor: 90ºC.
- Cover: Thermoplastic polyolefin type DMZ-E according to UNE 21123 and UNE-HD 603-1 and ST8 according to IEC 60502-1.
- Standards of reference: UNE21123 and HD603S1

Indoor installations or receivers

Circuit	Space	Length (mm)	Section (mm^2)	Line (mm^2)
Subpanel 1	Hospital	6,00	2,50	2,5x2+2,5TT
Subpanel 2	ACS	1,00	2,50	2,5x2+2,5TT
C.1.1	E. Current	6,00	2,50	2,5x2+2,5TT
C.1.2	Lights	5,00	1,50	1,25x2+1,25TT

Table 9. Indoor installations

RZ1-K(AS) CPR - Cables RCT

- Nominal voltage: 0.6 / 1 kV.
- Test voltage: 3500 V AC.
- Insulation: Crosslinked polyethylene (XLPE) type DIX 3 according to UNE-21123, HD 603 S1 and IEC 60502-.
- Maximum temperature in the conductor: 90ºC.
- Cover: Thermoplastic polyolefin type DMZ-E according to UNE 21123 and UNE-HD 603-1 and ST8 according to IEC 60502-1.
- Standards of reference: UNE-21123 and HD603S1

6.5.4. Electric conduits

General Power Line

GG22RJ1K tube:

- Curved PVC corrugated pipe.
- 80 mm nominal diameter.
- Insulating and non-flame propagator.
- Impact resistance of 12 J.
- Compression resistance of 250 N.

Indoor installations or receivers

Halogen-free corrugated tube of 20 mm.

- For public places.
- Diameter: 20mm.

- Built according to UNE EN 61386-1, UNE EN 61386-22 and ITC-BT-28.
- Compressive strength: 320 N.
- Impact resistance: > 2 Jules.
- Temperatures of use: from -5ºC to 90ºC.
- Non flame propagator.

Halogen-free corrugated tube of 16 mm

- For public places.
- Diameter: 16 mm.
- Built according to UNE EN 61386-1, UNE EN 61386-22 and ITC-BT-28.
- Compressive strength: 320 N.
- Impact resistance:> 2J.
- Temperatures of use: from -5º to 90ºC.
- Non flame propagator.

6.5.5. Indoor installations

The general system electrical panel is the device in which all the cables of the installation come together. It organizes the electrical system and protects the electrical appliances and mechanisms from power surges and other incidents.

General system electrical panel

- Number of elements to install: 1.
- 8 elements.
- Degree of protection against penetration of solid and liquid objects: IP - 65.
- Degree of protection against impacts: IK - 08.
- Material: Halogen-free.
- Hermetic closure with plastic handle.
- External dimensions (width x height x depth): 215 x 200 x 115 mm

Subpanel

- Number of elements to install: 1.
- 4 elements.
- Degree of protection against penetration of solid and liquid objects: IP - 65.
- Degree of protection against impacts: IK - 08.
- Material: Halogen-free.
- Hermetic closure with plastic handle.
- External dimensions (width x height x depth): 120 x 200 x 115 mm.

Differential Switch 25 A

- ABB FH 200 AC type.

- Number of elements to install: 4.
- Nº of poles: 2.
- Type AC.
- Nominal fault current: 30mA.
- Built according to IEC/EN 61008 standard.

Miniature circuit breaker 25 A

- ABB S202-C25.
- Number of elements to install: 1.
- System M Pro.
- Number of poles: 2.
- Tripping characteristic: C.
- Rated short-circuit capacity: 6 kA.
- Built according to IEC/EN 60898-1, IEC/EN 60947-2, UL 1077, CSA 22.2 Nº 235 standard.
- Weight: 1,3 kg.

Miniature circuit breaker 20 A

- ABB S202-C20.
- Number of elements to install: 1.
- System M Pro.
- Number of poles: 2.
- Tripping characteristic: C.
- Rated short-circuit capacity: 6 kA.
- Built according to IEC/EN 60898-1, IEC/EN 60947-2, UL 1077, CSA 22.2 Nº 235 standard.
- Weight: 1,3 kg.

Miniature circuit breaker 10 A

- ABB S202-C10.
- Number of elements to install: 1.
- System M Pro.
- Number of poles: 2.
- Tripping characteristic: C.
- Rated short-circuit capacity: 6 kA.
- Built according to IEC/EN 60898-1, IEC/EN 60947-2, UL 1077, CSA 22.2 Nº 235 standard.
- Weight: 1,3 kg.

Isolation transformer

The isolation transformer will be in accordance with the total installed power, 5,20 kW, 6,12 kVA. The most economic transformer covering the following needs has been chosen:

- Torytrans CNB08 single phase isolation transformer.
- Power: 8 kVA.

- Thermal class F (155ºC).
- Degree of protection: IP - 00, IP - 23.
- Room temperature: 30ºC.

Bypass

There will be 3 possible electrical power sources: the Public Electrical Grid, the generator set or the group of installed batteries.

The bypass will be responsible for changing the primary power source, either from the public grid or from the generator set to the emergency power source in a quickly and safely way. It will also regulate the supply while the batteries are discharged, to feed them while giving supply to the rest of the hospital block.

The ATyS ™ SOCOMEC 004 has been chosen. It will perform the following functions:

- Supervise the voltages and frequencies of the power supplies.
- Provide low voltage supervision of power supplies.
- Allow customer scheduling.
- Show chronological and real-time information.
- Allow system testing.
- Provide source status indications on the front plate.

Batteries system

Our installation demands batteries with high depth of discharge, long service life and high efficiency. In the market there are different types of batteries: liquid batteries (aerated), absorbent glass mat battery (AGM), gel cell and Lithium-Ion.

Lithium-Ion batteries have been chosen because of the following advantages over the rest:

- High charging currents (shortens charging time).
- Longer battery life. (Up to 6 times more than a conventional battery).
- High efficiency between charging and discharging (very little energy loss due to heating).

The battery system chosen is a 24V 100Ah Lithium-Ion Battery CYNETIC and its characteristics are as follows:

- Rated voltage: 25,6V.
- Nameplate capacity: 100Ah.
- Rated power: 2560Wh.
- Recommended charging current: 30 A.
- Charging temperature range: 0ºC to 55ºC.
- Discharging temperature range: -10ºC to 60ºC.

A kit containing the inverter, regulator and batteries charger will also be installed. The Axpert VP 2000 - 24V has been chosen, with the characteristics below.

- Output: 2000 VA.
- Pot. Output (W): 2500 W.
- Peak power (W): 6000 W.
- 94% efficiency.
- Charge current 50 A.
- Starting charge current 4 A.
- Protection degree IP - 21.

Generating set

The following generator set has been chosen in order to obtain the maximum capacity of charge in the batteries, and taking into account that it must also be able to feed the entire Primary Health Center and the batteries simultaneously if needed. The DG7500SE ITC POWER SOUNDPROOF GENERATOR has been chosen.

- Frequency: 50 Hz.
- Rated power: 5 kW.
- Maximum power: 5,5 kW.
- Nominal intensity: 27,5 A.
- Sound level: 72 dB.
- Autonomy: 12 h.
- Tank capacity: 30 liters.

Mechanism

All the mechanisms to be installed in the Primary Hospital Center will be from VALENA.

- Bipolar base 16A - 230V
  - Ref: 7 412 20.
  - Number of elements: 6.

- Base cover
  - Ref: 7 410 01.
  - Number of elements: 8.

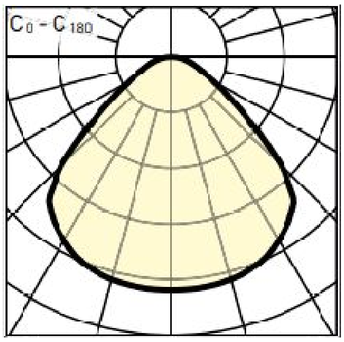
- Switch 10AX - 230V
  - Ref: 7 412 42.
  - Number of elements: 2

6.5.6. Lighting installation

The lighting study was carried out using the Dx Evo tool. Different lighting results were obtained, along with their respective planes and light isolines, and the luminaires were distributed to comply with light levels set by regulation.

Luminaire of the clinical area

In the clinical area, a minimum luminaire of 500 Lux will have to be installed, therefore, the installation of 4 TRILUX ArimoS M48 CDP 01 luminaires has been planned, with a consumption of 46 W and a flow of 4750 lm per lamp.



With an arrangement and light levels of:

- Container height: 2,395 m.
- Mounting height: 2,395 m.
- Values in Lux.
- Scale 1:36.

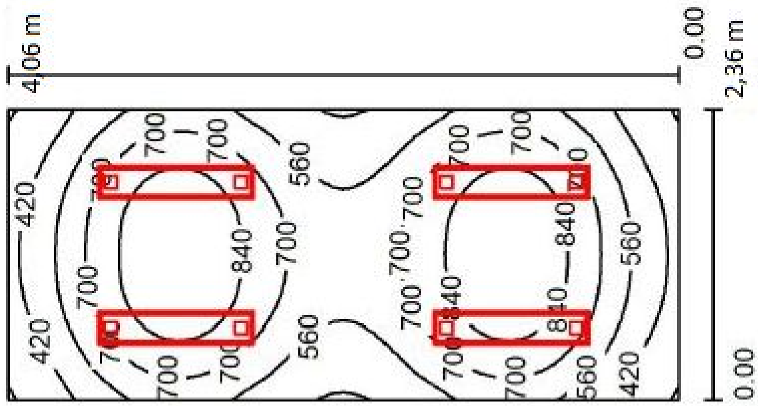
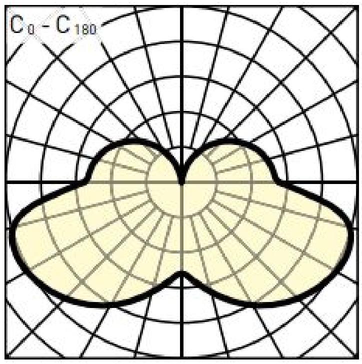


Figure 23. Light isolines diagram of the clinical area

Luminaire of the lobby area

Following the guidelines for the lighting of the lobby area, a lighting fixture with less power has been projected than the previous one, since 400 Lux is considered enough. 2 TRILUX PolaronIQ WD1 830 will provide enough lighting.



Emergency luminaire

NEXTREMA 400 nw Eb3 emergency luminaires have been selected to have 1 for the container. It should be noted that the emergency lamp has its own system for supply failures with an autonomy of 3 hours and will only use the external supply to charge itself.

6.5.7. Characteristics of power lines

Circuit	Volt (V)	Power (W)	Int. (A)	Sec. (mm^2)	Line (mm^2)	Length (m)	MCB (A)
Subpanel 1	230	3990	20,41	2,50	2,5x2+2,5TT	6,00	25,00
Subpanel 2	230	1200	6,14	1,50	1,25x2+1,25TT	1,00	10,00

Table 10. General table electrical calculations

Subpanel 1	Volt (V)	Power (W)	Int. (A)	Sec. (mm^2)	Line (mm^2)	Length (m)	MCB (A)
C.1.1	230	310	1,59	1,50	1,25x2+1,25TT	5,00	10,00
C.1.2	230	3680	18,82	2,50	2,5x2+2,5TT	6,00	20,00

Table 11. Subpanel 1 electrical calculations

6.6. Plumbing installation

Initially the possibility of having a water tank with a pump to provide water to all the taps with adequate flow rate and pressure was explored. At a later stage of planning the possibility of carrying out the installation with a gravity feed arose, avoiding the pump altogether. This provided advantages such as:

- Lower energy expenditure.
- Less difficulty in plumbing maintenance.
- Less complexity in the system

Before determining the definitive system for the Primary Health Center, a series of calculations were run, where the flow and pressure of the water were studied without using a pump, to see if these values were sufficient for the hand washing of health center personnel.

It was decided that the installation in the Primary Health Center would be gravity fed, since the flow values are within normal values. Although the pressure is lower than recommended by the UNE-EN standard (806-3), it still should be enough for proper hand washing, and the advantages of avoiding a pump installation could be retained.

In the sections shown below all materials necessary to carry out the plumbing installation are detailed, and the calculations justifying the choice of gravity system instead of the pump one can be found in ANNEX II.

6.6.1. Water tank

The tank storing the water used by staff hand washing and similar has the following characteristics:

- Manufacturer: Ajover.
- Material: Polyethylene.
- Capacity: 250 liters.
- Bottom diameter: 76 cm.
- Top diameter: 90 cm.
- Height with lid: 47 cm.

6.6.2. Pipe selection

For the entire plumbing installation, a multilayer pipe will be used. It consists of four outer layers of plastic and one of aluminum inside. The characteristics of the chosen pipes are:

- The purpose of the layers is to give greater resistance and malleability, being able to bend the material with the help of a spring.
- They are suitable for heating and for the conduction of cold and hot water installations.
- Their smooth walls prevent sedimentation inside and they are very resistant to both corrosion and chemical aggressions.
- They stand out for its easy installation, only with a wrench and scissors to cut the tube.
- There are accessories with threaded ends that allow the transition to other types of pipe.

The choice of pipe and its specifications are::

- YNSTALIA Multilayer Pex-al-pex.
- 4 m of multilayer pipe.
- External diameter of 26 mm.
- Internal diameter of 20 mm.

6.6.3. Piping connections

Male Elbows

Two YNSTALIA MULTILAYER MALE THREADED ELBOWS will be necessary to install the pipes.

6.6.4. Ball valve

To do the maintenance of the tank and to have an emergency system for the entire installation, a ball valve (Ø ¾ ") will be used at the outlet of tank water, this will go in the multilayer pipe.

The valve is POOLARIA with the next characteristics:

- Sphere type.
- PVC.

6.7. Thermal installation

For the air conditioning installation, it is necessary to perform thermal calculations of the area where it will be installed, in order to choose the one that best adheres to the conditions and surface of the area. The development of these calculations is in ANNEX II.

6.7.1. Choice of air conditioning

After carrying out thermal calculations of the area, the air conditioning selected is a LG WINDOW-MOUNTED AIR CONDITIONER WITH REMOTE CONTROL - W081 cm whose characteristics are:

- Cooling capacity: 8000 BTU/h.
- Power consumption 1,2 Kw.
- Power supply: 115V/60 Hz.
- Elimination of humidity: 1,26 l/h.
- Noise level: Indoor unit 40 dB.

6.8. Interior and exterior coatings

6.8.1. Walls

Plasterboard plates will be used for the walls of the Primary Health Clinic to have a better finish and to make it easier to install and anchor the instruments inside the containers. These plasterboard plates are 15 mm thick , where its components (plaster and cellulose) are of standard composition. These plates have different colours, where the plaster core is white, the face to be painted is colored yellow cream and the opposite, dark gray.

6.8.2. Ceiling

Decor plasterboard plates of 10 mm thick will be used for the ceiling of the center. These plates have a decorative vinyl covering with textures and different colours. They will be used in yellow cream colour to maintain the same colour of the covering the walls.

6.8.3. Material for plasterboard installation

70 x 30 metal profile

For the installation of the plasterboard plates, metal profiles are necessary as they serve as a support to facilitate the screwing of the coating. Omega shape profiles for semi-direct cladding will be used in the walls.

Recordable ceiling profiles

For the installation of Decor plasterboard plates on the ceiling it is necessary to use a recordable ceiling profile which is a range of galvanized steel profile covered by a pre-lacquered sheet on its exposed side. The splice and union between profiles is ensured by its special assembly system. The stitched system carries a punching or "sewn" in the core of the profile that gives it greater resistance.

Angular laminated profile L A 24

The angular profile will be used on the perimeter of the container with a distance of 30 cm from the ceiling of the container for fixing Decor plasterboard.

Hanging piece

L-shaped pieces will be used to make the correct fit in the profiles of recordable ceilings and to suspend the recordable ceilings with a rod threaded.

Screw PM

The anchoring of the plates in the metal profile will be made with self-tapping screws with a nail point and a trumpet head.

Screw MM

The anchoring of the metal profile in the container will be done with screws with drill point and hemispherical head, in cadmium steel.

Drywall tape

To close the small gaps between the plates, kraft paper tape will be used with anti-humidity treatment, micro-perforated.

6.8.4. Floor

The container floor is made of wood (thickness 28 mm). To guarantee better cleaning and hygiene a vinyl will be used, as is common on hospital floors. It is a very tough material, which holds up well against friction, scratches and falls of all kinds of fluids. In addition, it prevents the growth of fungi and bacteria and it is resistant to water and abrasion.

The characteristics of the adhesive floor tile are as follows:

- Tile type.

- Smooth finish.
- Specific material: Vinyl.
- Adhesive installation system.
- Anti-slip.
- Thickness of wear layer: 0.55 mm.
- Total thickness of the slat: 3 mm.
- Dimensions 30.5 x 61 cm (width x length).

6.8.5. Interior painting

On the plasterboard walls and ceiling of the surgical block, a modified, antibacterial, satin vinyl paint by Blatem will be used. It provides a satin, low odor, high stain resistance, thus allowing easy cleaning. This paint is ideal to combat bacteria and fungus formation, and it is especially recommended for application on walls of areas subject to spills of hospital disinfectants such as: pediatric areas, infirmaries or circulation areas.

6.8.6. Exterior coating

The containers will be exposed to the salinity of the sea water, in case of being transported by sea, and to tropical climates which will cause acceleration of container corrosion. That is why, although the container is made of corten steel (anticorrosive), an insulating ceramic paint will be used on the ceiling and on the four walls of the containers to guarantee better protection against corrosion and also obtain other advantages as:

- It is a thermal insulator.
- It has high solar reflectance (87.7%).
- Low thermal conductivity (0.033 W / m ° C).
- It is an acoustic insulator.
- It is waterproof, it does not absorb humidity or liquids.
- It is flexible.
- It stops corrosion of the substrate under insulation.

6.9. Approximate weight of interior load

An empty 20-foot container weighs 2155 kg and supports a load of about 30 tons (30000 kg). Although it is clear that the container can handle the weight of the equipment, an approximate study of the weight of the equipped container has been conducted in order to know what type of transport it needs. On the one hand, the equipment has been taken into account (also a generator, tank, etc.), and on the other hand, the internal structure of the container.

Structure of walls, ceiling and floor	Weight

Metal structure and plasterboard	786 Kg
Floor	243 Kg
Total	1029 Kg

Table 12. Weight of the interior structure of the container

Equipment	Weight
Computer	2 Kg
Fridge	9 Kg
Scale	15 Kg
Negatoscope	1 Kg
Exploration material	25,4 Kg
Examination coach	75 Kg
Stretcher trolley	15 Kg
Step	4 Kg
Stool	4,5 Kg
Rack	2,1 Kg
Main table	20 Kg
Table for exploration material	45 Kg
Instrument cabinet	20 Kg
Chairs	20,7 Kg
Sanitary waste container	1,37 Kg
Waiting chairs	34,5 Kg
Doors	12,4 Kg
Windows	50 Kg
Lights	20 Kg
Water tank	7 Kg
Transformer	66 Kg
Battery system	28 Kg

Inverter	5 Kg
Generator system	168 Kg
Electrical installation	20 Kg
Total	605,97 Kg

Table 13. Weight of the equipment

Therefore, the approximate total weight of the internal cargo of the containers is 1634kg. Adding the weight of an empty container, a total of 3790kg is obtained, so the road transport is of type N2. (Section 3.3.1)

7. MANUALS AND SPECIFICATIONS

7.1. Transport manual

A. Introduction

The following document includes all specifications that must be taken into account to transport the containers to their final destination to make sure they reach their destination in good condition.

B. Destination

The Primary Health Clinic is destined for any underdeveloped country where there is a lack of access to basic medical care. For this reason, the transport of the mobile clinic to developed countries with good medical infrastructure is ruled out unless there is a natural disaster that requires a clinic with these characteristics. Potential destinations are all over the world.

C. Way of transport and its procedure

Containers must reach their destination with the mode of transport that ensures that they arrive as quickly and safely as possible. Land, sea and air routes will be considered. In the event that the destination cannot be reached by any of these three modes, it will be ruled out.

Below the three modes of transport are detailed::

- Maritime

  The containers used for the Primary Health Clinic are standard 20 feet containers. That means they are suitable to be handled by the port infrastructure of any country that has one.

  A high percentage of countries carry container traffic or have a port in which they can be loaded and unloaded. In case it does not have a port, it will be transported to the nearest port and then through a mode of ground transportation to the country that needs it.

- Land

  After or instead of maritime transportation it is expected that the final destination will be reached by land.. There are two possibilities to transport a container by land, either by truck or by train, and the decision will be made according to availability and access of both.

  - Road: It is necessary to use a transport truck for goods, which allows the transport of 20-foot containers. Due to the possibility of transporting on dangerous roads or in poor condition, the accessibility of these must be previously analyzed in case of danger. The necessary road requirements to transport the load are the following:

- On roads with v = 120 km/h the necessary width will rise to 3,75 m and on roads with v = 40 km/h road of 3 m may be admitted.
- In urban areas and may be adopted, justifying them, lower values than those indicated above.
- Additional roads for slow traffic will have a minimum width of 3,00 m.
- In special circumstances it could be transported on roads with a width greater than 2,55 m.

- Railway
  This kind of transport will be used when the country or region has terminals specialized as transshipment centers, guaranteeing the highway-rail integration if they have an integrated network, national or international scale, on which the container block trains.

- Air
  This method of transportation will be largely avoided to transport containers to their destination. Even so, if the situation required it, the container would be transported by crane helicopter to the remote area. In the event that the area does not have a suitable area for its landing, this possibility of air transportation will have to be discarded.

  Products transported by air are generally of high value and extremely perishable, since the cost of air travel is high, although the duration of the journey is an order of hours and not days.

Below are the two possible transport combinations that can be used to transport the container:

- Combined Maritime Transport - Highway
  Merchandise arrives at the seaport in trucks that are transshipped (whole or only the semi-trailer) on the ship, or the goods arrive at the port maritime and its distribution in the interior of the country is done by truck.

- Combined Maritime Transport - Rail
  Merchandise arrives at the port in the railway carriage to be loaded in the ship. Or it arrives at the port on the ship and its internal distribution is carried out by the railway.

Containers can be transported under different modalities, depending on the interests involved: importers, shippers, transporters and exporters.

- Door to door traffic
  It is the most widespread and the one that presents the most advantages to the user. In this type of operation, loading/stowage is the responsibility of the shipper and unloading/rejection is at the expense of the importer. The

exporter transports the container to the place where your goods are deposited, making loading operation and handling the shipment. At the port of destination, the importer transports the container to the warehouse, unloads the container and returns it to the shipowner.

D. Transport safety

a. Gap cover

During the transport of the containers, all the holes or modifications that have been made in the outer structure must be covered. In this case, the sections of the doors and windows must be covered using the same plate as has been cut, anchored by nails to make it strong enough for transportation but to ensure that once it reaches its destination it can be removed without difficulty.

During transport, folding doors that would go into their corresponding gap will be kept inside the container, so that once arrived at the destination, these are installed.

b. Anchorage of the equipment

To avoid damage to the equipment that the clinic contains during its transport, a system has been defined that allows this security, which must be comply by the person in charge of its transport. The system consists of the use of tie down straps, fixed to the wall by buckles and adjustable by ratchets to adjust easily and quickly. The buckles are arranged by the side walls of the clinic, and the elements will be distributed so that it allows its maximum mooring.

The devices that must use this anchoring system, depending on the type of strap it need are the following:

Equipment	Anchoring
Step	Short tie down strap
Stool	Short tie down strap
Sanitary waste container	Short tie down strap
Chairs	Short tie down strap
Stretcher trolley	Long tie down strap
Bag (Inside instrumental cabinet)	Long tie down strap

Table 14. Equipment by anchor specification

It must also be taken into account other elements that must go anchored. The doors and the windows will be held using lashing straps on the examination couch.

It is necessary to be a person in charge to control that everything is anchored in the manner previously described before the transport of the container.

c. Container movement

Both the mobile equipment and the fixed equipment of the container must not be subject to sudden movements, since it is fragile material. For this, it is required that the container does not suffer inclinations greater than 45º during transport, since that would mean the possible displacement of the equipment, their fall or the looseness of the anchors. It is also not recommended that it suffers high frequency vibrations and gross shocks, as it can endanger the state of the container and material.

E. Installation and fixing

Once the container reaches its destination, it must be installed correctly and with the utmost caution so as not to damage the interior or exterior of it. In the event that the destination region has a crane to place the container, these will be made under the indications of the same company provider. Otherwise, the transport truck will have an auto-crane with it and it will be carried out the installation under the carrier's charge, using hydraulic jacks that will allow the elevation of these.

F. Transport trial

To ensure safe transport and that the container reaches the destination complying with the necessary requirements to ensure its correct operation, a first transport test will be carried out to detect possible failures. During this test, the state of the interior will be checked at the end of each mode of transportation, until reaching the destination, recording the results and modifications that occur. At the end of the trial, the report will be reviewed and necessary decisions and modifications will be made according to the result.

7.2. Maintenance manual

A. Container

The frequency with which maintenance will be required will vary depending on the initial condition of the shipping container, the paint used and the weather conditions where the container is located.

It will be necessary to inspect the containers purchased to check that they are free from damage or defects that may affect the safety of the unit or its carrying capacity. Also, by having a temporary application and being built with used containers, the maintenance of the Primary Health Clinic will be performed every time before it is transported to the place where it will be installed. Below are the most common damage to containers and what mode the inspection will be carried out to avoid them.

a. Common damage

- Damage: Structural defects due to impacts or contamination, related to the manipulation or transfer to which it has been exposed.
- Erosion: Deterioration of the physical condition of the unit, which occurs from continuous exposure to elements or during its use such as: oxidation, rubber wear, door seal, or others. All of them are related to the time of use.
- Nonconforming Repairs: Nonconforming repairs are those that, of according to the IICL (Institute of International Container Lessors), which indicate the limits of damage or wear that can be tolerated without repair. If the damage does not comply with this, it must be repaired. However, a series of small damages can make a repair recommended.
- There are technical criteria to determine the time of a repair. A small rayon is often the beginning of an oxidation, therefore no matter the damage is, it is important that it be reviewed, since it can affect the future of the unit.

b. First inspection

<u>**Interior inspection:**</u>

- With the unit empty and properly neat, dry, and odorless, the interior should be inspected, checking the condition of the floor, ceiling, beams and panels.
- Check the sides of the container, with special emphasis in the housings for the nails of the cranes.
- The bottom inspection is carried out at the time that the unit is manipulated, taking advantage that it is raised.
- The floor must not have nails or other protruding structures that are able to cause damage to the load.
- When inspecting an empty container, the tightness should be verified. This is done by closing the doors with the inspector inside to see if there are areas where light enters.

<u>**Exterior inspection:**</u>

- Check if the corners are without any crack or failure.
- The elements of the structure must be straight, to ensure their rigidity.
- The floor, ceiling and side walls must be in good condition to allow the physical isolation of the load and that the dimensions of the unit does not have variations that make its handling complicated.
- The doors are the last to be revised, since they have more components. It will be necessary to review the panels that compose each door, the locking bars, handles, hinges, all plates and their numbers.

B. Water tank and pipes

The maintenance of the water tank and the pipes will be conducted in the same way that the maintenance of drinking water facilities is carried out in houses and buildings.

a. Water tank
The following general rules must be followed:
- Check the tightness, appearance of cracks or other alterations.
- Check the water circulation (inlet and outlet).
- The tank must be emptied and thoroughly cleaned, at least once a year and preferably before summer.
- Wash the wall and bottom surfaces with a mixture of water and bleach following the instructions for use that appear on the label of the bleach. Use suitable protective clothing (gloves, mask, goggles).
- Rinse the walls and bottom very well with plenty of water until removing the totally remnants of bleach. Completely drain the tank.

b. Pipes and other elements
For the correct maintenance of pipes of any type, taps and other elements, as well as for the prevention of legionella infection should be performed periodically the following actions:
- Disassemble faucet diffusers and showers for cleaning and disinfection.
- Remove lime deposits by putting them in vinegar or other products anti-scale.
- Disinfect the diffusers by immersing them for thirty minutes in 1 liter of water with bleach.
- As the use of the taps is low (only for cleaning) it is recommended to let the water run for a few minutes weekly.

C. Generation set

In order to continuously obtain the necessary power the maintenance of the generator set consists of refilling the appliance diesel deposit when needed. This maintenance is performed with the generator set turned off and every 6 days.

D. Air conditioning

To carry out air maintenance, the next steps must be followed:
- Cleaning the indoor unit filter: The indoor unit filter is washable, in order to keep the exchange battery clean and improve the air quality. Depending on the state it is in, it is recommended to clean it or replace it with a new one. There is no periodicity in this operation, since the filter dirt depends on the use of the air conditioning. It is advisable to inspect it yearly to see if it is obstructed or not.
- Cleaning the battery of the outdoor unit: The battery must be cleaned frequently. This cleaning can be done in two forms, either by blowing with pressurized air or with a brush.

- Check the refrigerant gas charge: In the event that the air conditioning leaks refrigerant gas, simply charging gas is not a solutionThe leak has to be found and repaired. This maintenance operation must be done with an authorized maintainer, as tools and knowledge specialized in the subject are required.

7.3. Installation manual

A. Electrical installation

The Primary Health Clinic will be a transportable block, therefore it should follow some guidelines to assembly the entire installation.

- Before proceeding to any assembly of the clinic, it must be verified that all electrical charges are disconnected by themselves and disconnected from the respective panel and sub-panels.
- Check if the connection to the local network is possible or if it is necessary to power the block through the generator set.
- If there is the possibility of connecting to the public network, check if it is suitable to be able to feed the clinic, it must be compulsorily in Low Voltage.
- It will be connected to the electrical network through a connection with the CETAC system from the general panel.
- If there is no possibility of connecting to the public network, will proceed to the commissioning of the generating set.
- The earthing of the block will be installed by the technical personnel who will install the entire block, the obligations set out in the scope statement will be followed.
- Once the clinic is electrically powered from any power supply, supply will be provided inside the block connecting first the general panel and then the sub-panels.

B. Container assembly

In this section we detail the steps to follow from the container's arrival at its destination until it is properly assembled and ready for use.

- Lids made with the same leftover container will be used to cover the gaps that are intended for the installation of the doors and the windows.
- When the container reaches the destination, the covers must be removed, unscrewing them.
- Lids should be stored under the container.
- For the assembly of the windows and doors, it must be perfectly level. For this, the adjustable column shoes help.
- The adjustable column shoes must be located at the four corners of the container and two in the center. With four pillars it would be enough, but if they add two more the resistance of the structure is improved. The column shoes can be adjusted once they are established.
- When the container is perfectly level, the door and window installation will take place. Each door is marked to the hole that needs to be installed.

- The doors and windows are stored on the examination coach.
- For the sections it must follow the next steps:
    1. Make the section in the container using an oxyacetylene welding torch
    2. Weld the metal profiles in the holes. Must be welded by manual metal arc welding with coated electrode (MMAW). The distance between welded points should be 25 cm.
    3. Fix the sheet (The same that was cut from the original container) with hexagonal screws Stainless Steel 410 12mm ¾ to the metal profiles. The distance between screws should be 10 cm.
    4. Verify that all screws are tight. Sheet metal red

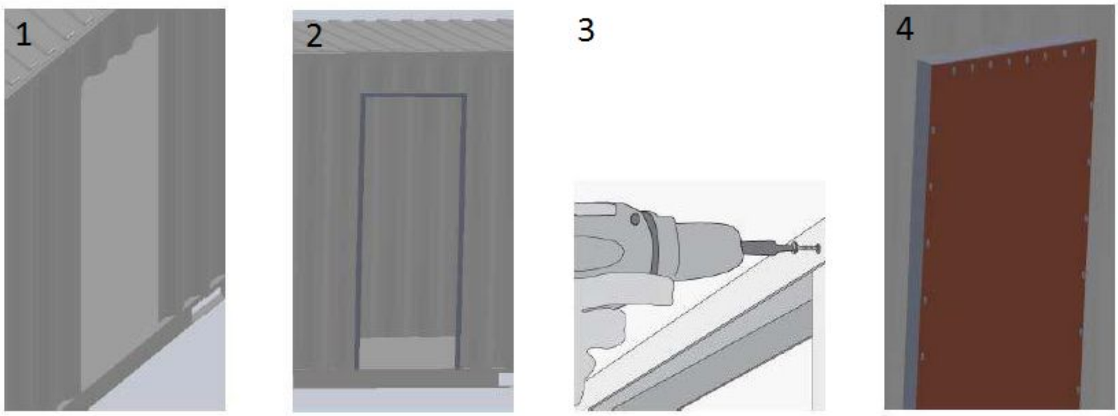


Figure 24. Assembly of the lids

- Once the entire surgical hole is assembled, if the generation set is the power supply that is going to be used, using the mobile ramp, the generator set must be moved outside the machinery area so that it does not influence due to noise, gases and vibrations it generates. Once the working day is done, it should be moved inside again for security.

C. Plasterboard mount

a. Walls

The assembly of the plasterboard covering will be done in the same way as it is done in houses. Below is illustrated how to mount on a brick wall, which in this case will be the corten steel wall. In the lower and upper part of the container, tester profiles will be placed to secure the plane and achieve a perfect finish. For a properly fixing MM screws will be used.

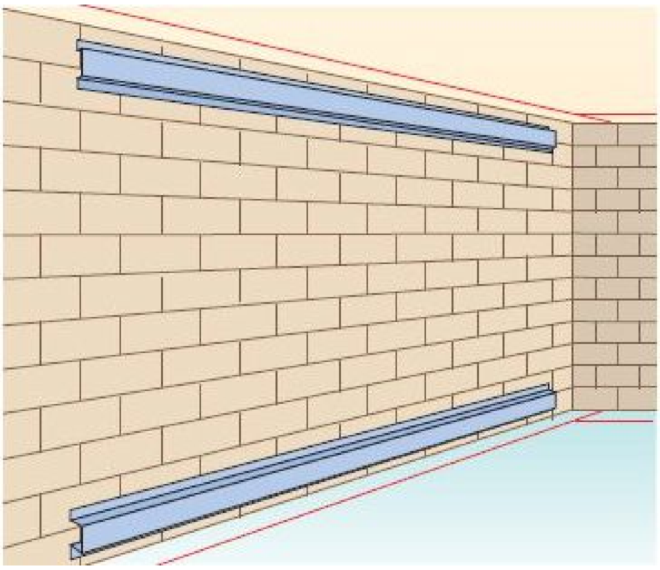


Figure 25. Tester profiles [43]

Then the main profiles will be placed 400 mm apart from each other.

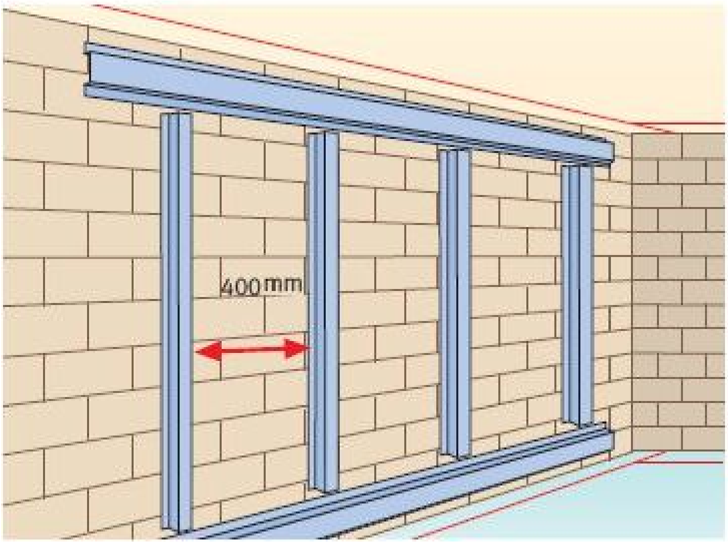


Figure 26. Main profiles [43]

The plasterboard will be screwed to the profile-based structure, with PM screws (every 25 cm), placing it butt with the ceiling, leaving a distance of 1 cm between the ground and the base, being able to help us with chocks.

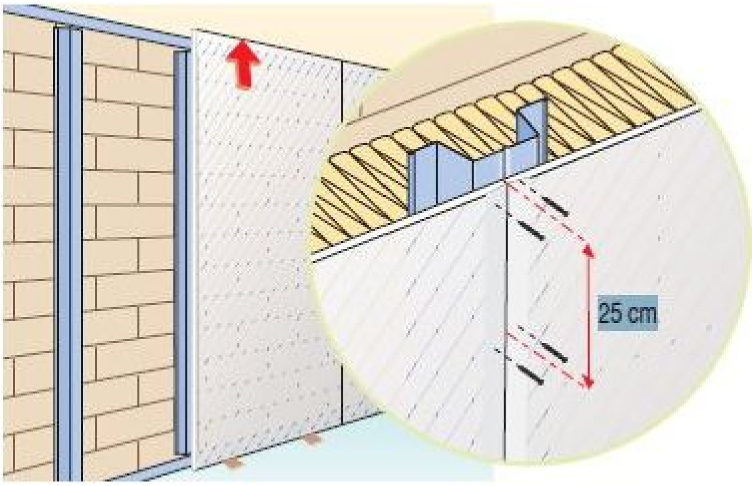


Figure 27. Detail of the screwing [43]

b. Ceiling

Draw a level line on the walls 1 m from the finished floor. This line will serve as a reference for the installation of the plasterboard ceiling. Trace the level of the angular laminated profiles and fix them to the wall every 0,30 m (distance from the corten steel roof to the profile).

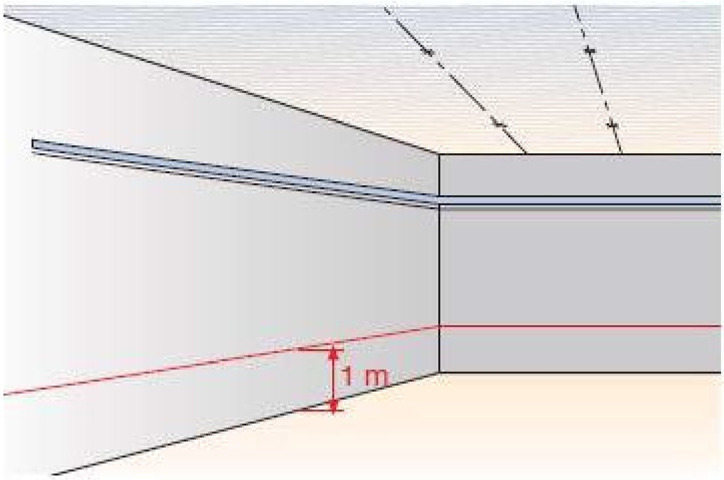


Figure 28. Level line and angular profiles [44]

Outline of the recordable ceiling profiles L A 24 every 1,20 m:

- It is recommended to work in the longest direction of the area.
- As the dimensions of the container are not multiples of 0.60 m (length and width), the profiles will be located so that the main axis of the premises is the central ceiling plate.

Then the points where the anchors for the threaded rods will be placed are marked (each 1.20 m), the threaded rods are cut to the desired size and anchored.

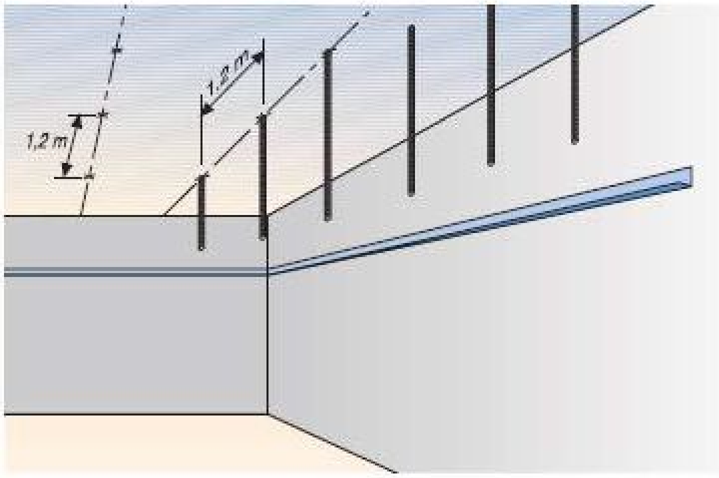


Figure 29. Threaded rods anchor [44]

The suspended recordable profiles (primaries) are placed with the hanging piece TR (for each hanging piece is necessary two nuts to attach it to the rod). The primaries will be cut at the ends taking into account that the plasterboard ceiling must stay in the holes.

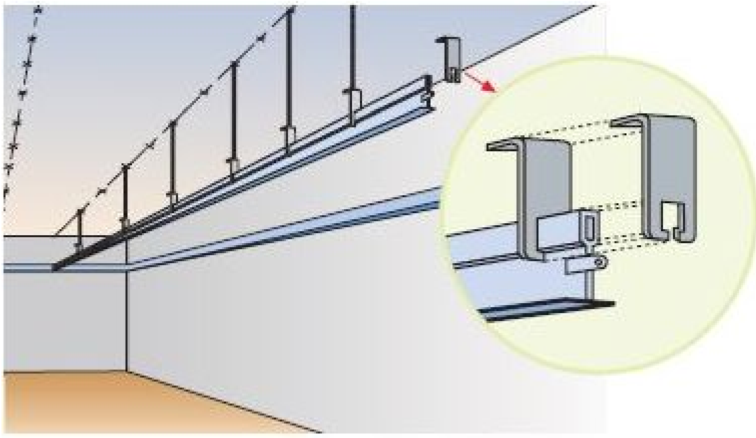


Figure 30. Primary profiles [44]

Plumb in the secondary profiles first the 1200 long ones and after 600 long ones.

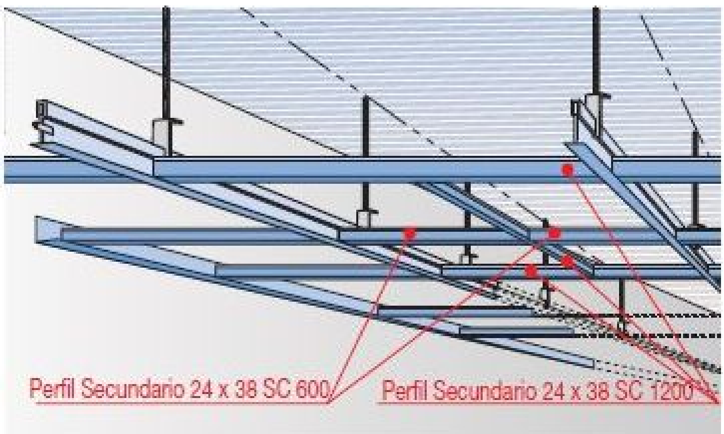


Figure 31. Sample of secondary profiles [44]

Finally, the plasterboard will be installed, starting at the center and ending at the perimeter.

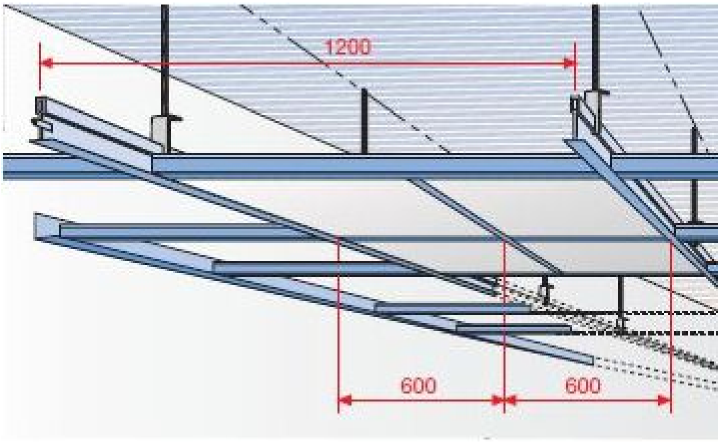


Figure 32. Sample of the plasterboard [44]

7.4. Standards

Field of application	Standard	Description	Compliance
Installations for medical use	REBT ITC BT-28	Installations in premises of public concurrence.	Mandatory
	REBT ITC BT-29	Electrical installations in premises with fire risk or explosion.	Mandatory
	UNE 20460-7-710	Electrical installations in buildings. Section 710: Premises of medical use.	Baseline
Lighting	UNE 2461-1	Workplace lighting.	Baseline
Power generation	REBT ITC BT-40	Low tension generator facilities.	Mandatory
	UNE-EN 60670	Boxes and enclosures for electrical accessories for household and similar fixed electrical installations	Mandatory
	UNE-EN 60439-3	Low-voltage switchgear and controlgear assemblies.	Mandatory
	UNE-EN 60529	Degrees of protection provided by enclosures (IP	Mandatory

Air conditioning	RD 1027	Regulation of thermal installations in buildings.	Mandatory
Fire safety	DB SI	Technical building code	Mandatory
Containers	ISO 668	Freight containers - Classification, dimensions and ratings.	Baseline

Field of application	**Standard**	**Description**	**Compliance**
Electrical installation	REBT ITC BT-06	Overhead network for low voltage distribution	Mandatory
	REBT ITC BT-08	Neutral connection systems.	Mandatory
	REBT ITC BT-10	Forecast of electric charges for supplies in low voltage.	Mandatory
	REBT ITC BT-11	Distribution networks of electric power. Link-ups.	Mandatory
	REBT ITC BT-14	Linking installations. General Power Line.	Mandatory
	REBT ITC BT-18	Installation of grounding strap.	Mandatory
Mechanical installation	AWS E8018-G	Electrode classification	Mandatory
	ISO 2560	Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels.	Mandatory
Plumbing installation	DB HS 4	Water supply from Technical Code of Edification	Baseline
	UNE-EN 806-3	Specifications for installations inside building conveying water for human consumption - Part 3: Pipe sizing - Simplified method	Baseline

Table 15. Regulations of the project

8. ENVIRONMENTAL IMPACT

Contamination has emerged as one of the big challenges society is facing. This section is intended to deal with the impact that this Primary Health Clinic will have into the environment.

Thanks to the fact that recycled containers have been chosen, the environmental impact is very low. The use of recycled containers drastically reduces manufacturing materials, with significant savings in energy and CO_2 emissions into the atmosphere. It was shown that upcycling of a container results in 46 tons of CO_2 eq. as avoided environmental impacts [45]. Furthermore, unlike other modular architecture systems, it is practically maintenance-free, since ocean containers are initially designed to last for many years and manufactured with an insulating layer that, properly treated or adding more, can be totally suitable for the use, saving energy in heating and or cooling.

Apart from that, it is estimated what impact has had the realisation of the project itself. The use of a computer along with the power needed will result in a total consumption of 400W. Throughout the months working on this project, estimated to be equivalent to 400 hours, it makes around 160000 Wh. Using a CO_2 calculator it has been estimated that the generation of CO_2 has been 56 kg of CO_2 that contributes to global warming.

9. CONCLUSIONS

Nowadays, the world is affected by various issues that need addressing, one of the most important being climate change. Global awareness is of vital importance on this issue, in addition to the need to take measures to slow it down in whatever way possible. Moreover, on a global scale it generates other problems such as economic crisis, poverty and wars, contributing to an even bigger gap between developed and underdeveloped countries. It has been observed that the quality of healthcare in underdeveloped countries is low and minimum standards are not met, being the primary healthcare sector's state the most precarious. From this starting point, a product has been developed to help address this lack of access to high-quality primary healthcare. The prototype is capable of being transported to any corner of the world, and is different from what is already on the market, plus it gives an outlet to abandoned containers and thus generates a positive impact against climate change.

A study of containers and primary medical centers has been conducted to gather knowledge on both fronts. It has been difficult to find specific information and regulations on health for this type of product, and therefore it has been quite difficult to find a multipurpose design. However, different possibilities have been studied and a proposal as versatile as possible has been made. Research has been essential when choosing a proposal that best meets the expectations set.

After studying the transport of the containers, and considering that the medical center could be housed within a container, it was found that in order to access complicated roads it was better to choose a shorter container than one of greater length. With this premise, the choice was made to develop a primary health center that didn't include an emergency service, focusing on feasibility and accessibility and ensuring the lower requirements could be met in full.

One of the priorities in terms of installation was to equip the clinic with power autonomy, as it was expected that the product could be deployed in parts of the world with lacking power networks. At first various renewable energy sources such as photovoltaic panels were considered, but for reasons of efficiency and affordability they had to be discarded. Instead, a solution that greatly reduces the dependence on a reliable network was found, in the form of lithium ion batteries that provide the system with up to 12 hours of autonomy, thus protecting the product against intermittent supply failure.

Furthermore, only the necessary equipment for a functioning primary health center was included while leaving out non-essential features, such as a toilet

Finally, because the project has been focused on a possible client who will carry out the entire project from sourcing the container through installation to deployment, a series of manuals have been complied with which the client can proceed to the assembly, transport, use and maintenance of the clinic. It should be mentioned that the study of such a product through a multidisciplinary vision has made me aware of a great number of points of view that have to be taken into account when developing a product. This has led me to progress slowly but thoughtfully, and ultimately to obtain a project of great complexity that fulfills all requirements from many fields.

10. NEXT STEPS

The project duration has limited the final implementation of the system, the possibility of some future works would improve the final result. A SWOT analysis is presented below to detail possible future routes of job. If the product were to be developed further, this table would help focus on improving the weaknesses and avoiding the threats while reinforcing the strengths and exploiting the opportunities.

Strengths	Weaknesses
- Innovation within the market current - Quality equipment - Use of secondhand container - Skills for innovation of products - Advanced research in sectors involved in the project - Mobile clinic unit - High level clinic unit - Air conditioning in the clinical room - Transport of equipment in a safe way safe way to arrive in good conditions. - Product of high social value	- Lack of experience - Lack of natural resources depending on the place of destination - Dependence on various ways of transport - Need of maintenance technicians - High production costs - Small space - Study of amortization of finished product - Reduce lifetime of secondhand container - No tests have been carried out for operation and use
Opportunities	**Threats**
- Possibility of modular growth - Convertible to another type of service - Custom design according to needs	- Transport and assembly time - Need of a technician for installation - Field hospitals invade the marketplace

Table 16. SWOT analysis.

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