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Mech 525

MediCleanse

Final Report

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Submitted To:

Professor Samir Mustapha

Table of Contents

List of Figures

Introduction

This report introduces MediCleanse, a new device engineered to sterilize medical equipment, responding to the critical need for stringent cleanliness in healthcare settings. MediCleanse leverages modern sterilization techniques to ensure high levels of disinfection, thereby assisting in the reduction of infection risks associated with medical care. The report details the technical development process, from concept to final design, and evaluates the device's performance in practical scenarios. It also addresses the technical challenges encountered, such as ensuring effective sterilization across a range of equipment and maintaining user-friendliness for healthcare professionals. Moreover, the report outlines the feedback integration from prototypes and its influence on the iterative design improvements. In addressing these technical aspects, the report underscores MediCleanse’s potential to improve operational efficiency and maintain high sterilization standards in medical environments.

Opportunity Identification

The opportunity of MediCleanse was recognized after identifying the inefficiencies faced by Lebanese Red Cross volunteers when manually sterilizing medical equipment in emergency situations or the necessity to return to base stations for such procedures. These practices significantly slow down the response effectiveness of Emergency Medical Technicians (EMTs) during critical missions. This prompted the development of a portable medical washer. Such an apparatus would facilitate the sterilization process through automation, conform to the spatial constraints of an ambulance, and consequently increase the EMTs' operational efficiency in urgent care scenarios. For detailed insights, refer to the appendix, which includes a survey conducted with EMTs from the Gemayzeh Emergency Medical Services sector.

List of customer needs

Our foldable washing machine is designed to meet the specific needs of emergency medical professionals, addressing critical requirements.

- **Explicit needs:**

  Portability: Create a solution that is easily transportable, allowing EMTs to maintain hygiene standards even in mobile or diverse emergency settings.

  Efficiency: Develop a washing and sterilization process that is rapid and effective, enabling quick turnaround times for medical equipment needed in urgent situations.

  Compatibility: Ensure compatibility with a variety of medical equipment, with a particular focus on items like cervical collars, to accommodate the diverse needs of emergency medical services.

  User-Friendly Design: Create an intuitive and user-friendly interface to facilitate the washing and sterilization process, minimizing the need for extensive training and allowing for efficient use in high-pressure situations.

- **Latent needs:**

  Reliability: Build a durable product that can withstand the rigors of emergency environments, ensuring consistent performance over time.

By addressing these specific needs, our foldable washing machine aims to provide a tailored and indispensable solution for emergency medical services.

Mission statement

After conducting interviews with EMTs at the Red Cross in Gemayze, it became evident that there were significant challenges associated with cleaning medical equipment quickly and effectively post-emergencies. This observation led to a comprehensive market analysis to understand the availability and limitations of current solutions. Our research uncovered several portable washing machines, such as the GRINCHAT washing machine (1) and the SUPER DEAL compact mini washing machine (2) which were primarily designed for laundering clothes rather than sterilizing medical tools.

To address this gap, we conceptualized MediCleanse, a pioneering product tailored specifically for the sanitation needs of medical equipment including cervical collars and immobilization

straps. This concept was further validated through a survey distributed among Red Cross volunteers.

MediCleanse aims to elevate the efficiency of EMT operations by providing a compact, effective solution for the sterilization of essential tools like cervical collars. Our mission is to assure that EMTs have access to consistently clean equipment, optimizing their readiness for life-saving interventions and safeguarding the health of both medical professionals and patients.

Product Description	A washer that cleans medical equipment in emergency vehicles in 15 minutes.
Benefit proposition	1. First in the market 2. Friendly user interface 3. Compact and portable
Business goals	1. Launch by May 2024 2. Develop a product that is cost and time efficient
Primary market	Lebanese Red Cross and Civil Defense
Secondary market	1. Red Cross and Red Crescent in other countries 2. Any organization that operates ambulances 3. Hospitals
Assumptions	1. Compatible with the disinfectant EMTs use. 2. Its design will be compatible for ambulance vehicles to keep them stable during driving
Stakeholders	Internal: Investors, manufacturers, partners. External: NGOs, Hospitals, EMTs.

Table 1. Mission statement

Specifications

Disinfection Capacity: The product holds 1.5 liters of disinfectant to accommodate a range of cleaning needs.

Compact and Space-Efficient Design: Given the limited space available in emergency vehicles, customers need a washer with dimensions that fit seamlessly. MediCleanse is optimized for ambulance use with dimensions of 70 cm in length, 40 cm in height and 30 cm width (70x30x40 cm).

Compatibility with Emergency Vehicle Power Supply: Customers expect the washer to operate efficiently within the emergency vehicle's power constraints. Therefore, the operating voltage is 12 Volts, which matches the battery/alternator voltage from the ambulance.

Portability and Easy Installation: The washer is free-standing to facilitate portability. Customers need a product that can be easily moved and positioned as needed.

Manageable Weight: The washer weighs 15 Kg which satisfies the need for handling and transport.

Efficient Cleaning Cycles: Customers value time efficiency. The washer offers quick cleaning cycles lasting 10 minutes, meeting the disinfection requirements outlined in the Infection Prevention guidelines.

Robust and Leak-Proof Construction: Customers expect the washer to withstand the rigors of emergency situations. By adhering to the IP67 standard, which ensures water and dust resistance, the product is both dustproof and leakage-proof.

Concept generation and selection

In terms of concept sketches, we generated about 8 concepts, which we then combined and narrowed down to one sketch with all the favorable features from each individual sketch.

Sketch 1:

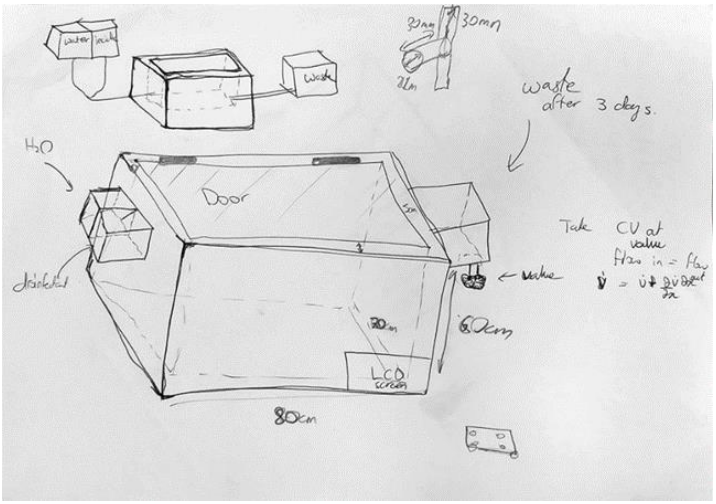


Figure 1. Sketch 1

This design includes a simplified disinfectant delivery system which relies on gravity. Also, it includes a waste storage tank to store discarded disinfectant. This model includes a top side door, to make placing items into it easier.
We chose to discard this model and the gravity feeding system because gravity cannot provide enough pressure to clean up heavy stains. Also, it is preferred to mount the tanks on the bottom to lower the center of gravity to make the appliance more stable.

Sketch 2:

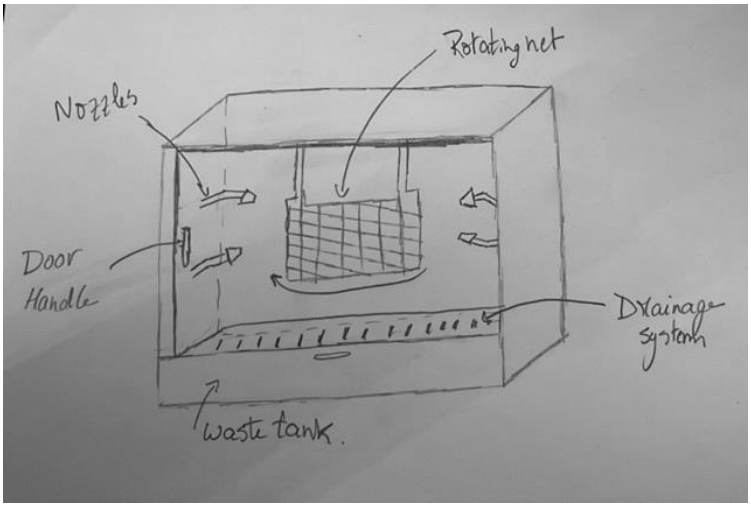


Figure 2. Sketch 2

This sketch includes a rotating net configuration, inspired by portable clothes washing machines commonly sold on Amazon. This setup includes a rotating net and nozzles that spray pressurized water on the items placed into the net while it rotates. This setup was discarded since imbalance may arise from the rotating net since the items placed inside will not be placed in the net in any order, which will cause vibrations and instability. Also, the net would severely limit the size of objects we can place into the washer, as it needs room to rotate.

Sketch 3:

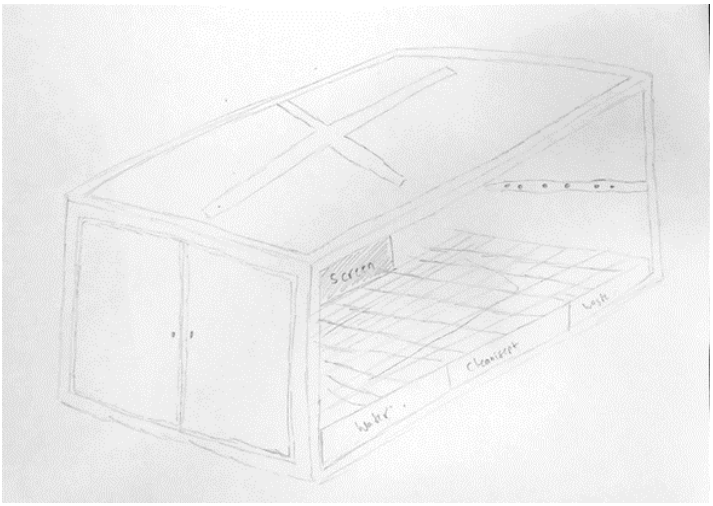


Figure 3. Sketch 3

Sketch 3 includes an oven-style washer with a rack in the middle and two nozzles, one on the top and one on the bottom, to spray the items and clean them properly. The door is top-mounted in this sketch. This idea forms the basis for our final iteration, with a few modifications.

Sketch 4:

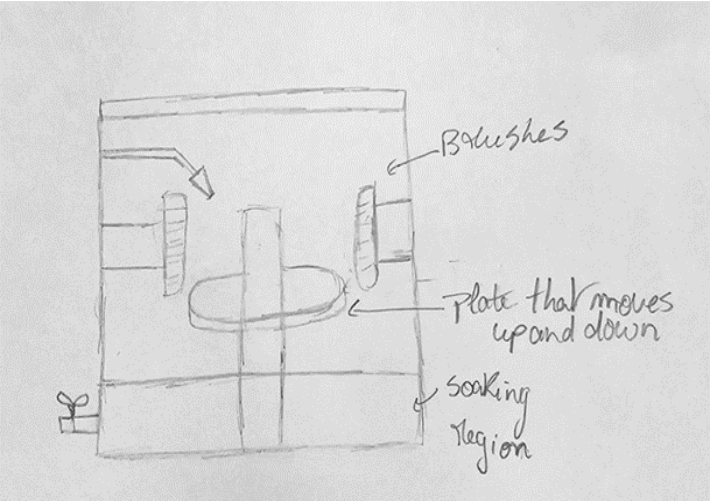


Figure 4. Sketch 4

Includes a rotating assembly in the middle which moves up and down, and two stationary brushes which rub against the items placed on the rotating assembly, while being sprayed with disinfectant. We chose to disregard this design due to space limitation and the size of objects we can place in the washer, and because the brushes will not be able to clean all the surfaces of the objects placed in the washer.

Sketch 5

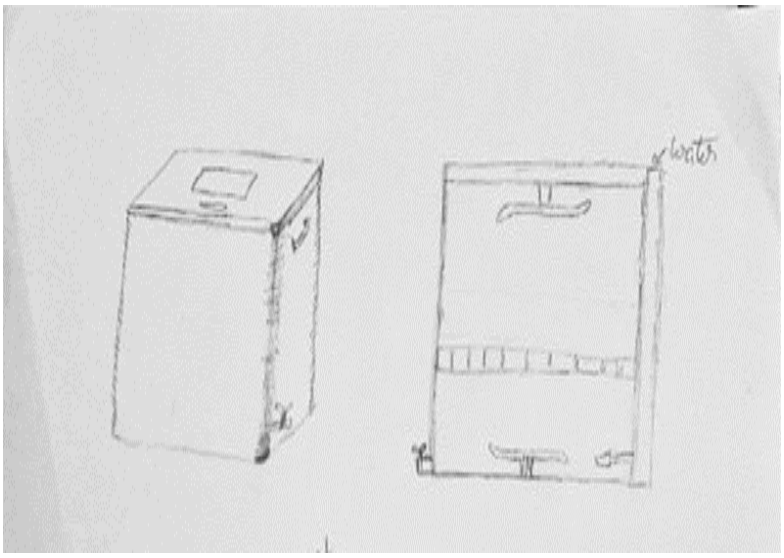


Figure 5. Sketch 5

Sketch 5 is the same as Sketch 3, with the difference of a side-mounted door, as opposed to a top-mounted door. We neglected this design due to waterproofing concerns with a side-mounted door.

Sketch 6

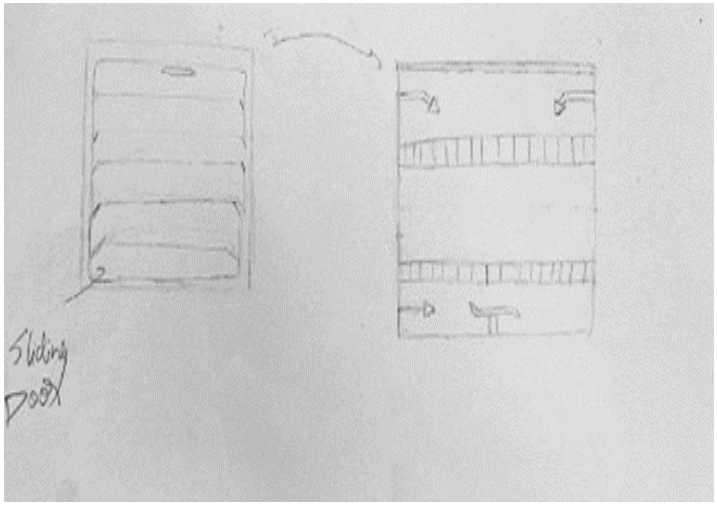


Figure 6. Sketch 6

Sketch 6 is another take on the rack approach which resembles an oven, with top and bottom-mounted nozzles. This iteration includes bottom-mounted tanks, with separate cleanisept and water tanks and a tank for storing the waste. Another added feature of this design is a screen to display the remaining time of the wash cycle.

Sketch 7

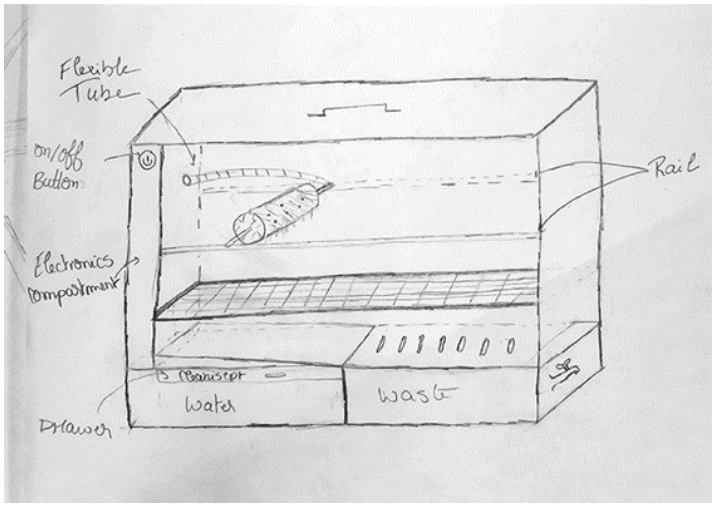


Figure 7. Sketch 7

This concept includes bits and pieces from all the previous iterations, with a few new features. First, we chose top-mounted doors to address the waterproofing concern we had. We also chose the rack approach which resembles an oven, to place the items onto it. A new feature we thought of is a linear rail, that can be adjusted up and down to accommodate larger items, with a rotating scrubber that moves across the items placed on the rack. This scrubber will spray disinfectant at the same time, to efficiently clean the items.
We also chose to reduce the number of tanks to two. One for water, to which we will add the prescribed amount of disinfectant for one wash cycle (very much like a washing machine), and a tank for the waste disinfectant that will be discarded.

Sketch 8

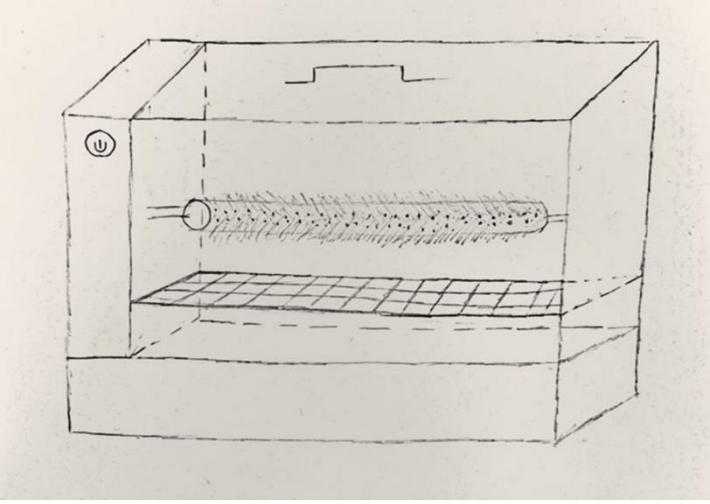


Figure 8. Sketch 8

This concept is similar to concept 8, however, the cleaning brush is fixed and does not slide along a rail.

Final concept selection

Alternative	Effectiveness of Sterilization	Size and Fit	Manufacturing Feasibility	Durability	Total
Brush mechanism	1.0	1.0	0.8	0.7	0.875
Rotating Net mechanism	0.3	0.4	0.5	0.6	0.450
Pressurized water mechanism	0.6	1.0	1.0	0.8	0.850

Table 2. Decision Matrix

The Brush mechanism has the highest total score of 0.875, followed closely by the Pressurized water mechanism with a score of 0.850, and the Rotating Net mechanism has the lowest score of 0.450.

Starting with the effectiveness of sterilization, the brush mechanism is highly reliable in ensuring thorough cleaning of medical equipment. It achieves this by actively scrubbing the equipment while simultaneously spraying water and disinfectant. On the other hand, the rotating net and the pressurized water systems do not provide the same assurance for removing stubborn stains, as they lack the mechanical action provided by the brushes.

Regarding the size and fit criteria, the brush mechanism and the pressurized water mechanism are designed to accommodate larger equipment, providing enough space for placement. However, the rotating net mechanism imposes limitations on space, restricting the size of equipment that can be handled.

In terms of manufacturing feasibility, the pressurized water mechanism is the simplest to construct as it primarily necessitates a high-quality pump. In contrast, the brush mechanism demands a more complex assembly that includes integrating brushes with the washing unit and the piping system. The most challenging to manufacture is the rotating net mechanism, which presents the additional complication of managing system vibrations.

Regarding durability, the pressurized water mechanism stands out as the most robust option since its design lacks components prone to wear and tear. In contrast, the brush mechanism may face deterioration over time due to the abrasion from scrubbing. Similarly, the durability of the rotating net is compromised due to the continuous stress exerted by vibrations.

Initially, we chose a top-opening door for our washer due to its advantages in effective waterproofing. This design greatly simplifies the sealing process when compared to side-opening or sliding doors, which are more challenging to seal against water. However, a top-opening design requires that the brush mechanism be removable to allow items to be placed on the rack. This requirement adds complexity to the system. To prioritize ease of use and simplicity, we decided to switch to a front-opening door. We plan to use silicone to seal this door, ensuring it meets waterproofing standards.

As our product is first to the market, direct benchmarking against existing products wasn't possible. However, we drew inspiration from established mechanisms: the brush system mirrors that of car washes, and the nozzle arrangement resembles those found in dishwashers. Additionally, the method of incorporating disinfectant into the water system is similar to how detergent is dispensed in conventional washing machines.

Prototype

Figure 9. Prototype

Our alpha prototype was primarily constructed from cardboard pieces and featured a paper tube serving as the cleaning brush. This prototype was neither built to scale nor intended to be functional; rather, it was designed to assess the feasibility of our initial ideas and identify necessary improvements.

Initially, the alpha prototype included a single brush. However, we determined that this was insufficient for thoroughly cleaning the entire surface of the medical equipment. Consequently, we shifted to a two-brush design to increase coverage. Although initially intended to be removable, we found that this feature added unnecessary complexity and reduced reliability. Therefore, we opted for a fixed brush configuration instead.

We added a side access port to the design to facilitate the insertion and removal of medical equipment that needs to be washed. Given the limited space within an ambulance, this approach proved to be the most practical for accessibility.

Material Selection

After reviewing articles on washing machines, we have decided to use the following materials for our portable medical washer:

1) Stainless Steel: This will be used for the washing chamber, net, and rails due to its rust and corrosion resistance (4).

2) Plexiglass: This will be used for the washer's door, allowing visibility of the entire washing process.

3) Silicone: This will be used to seal the edges and corners, aiding in the waterproofing of the washer. (5)

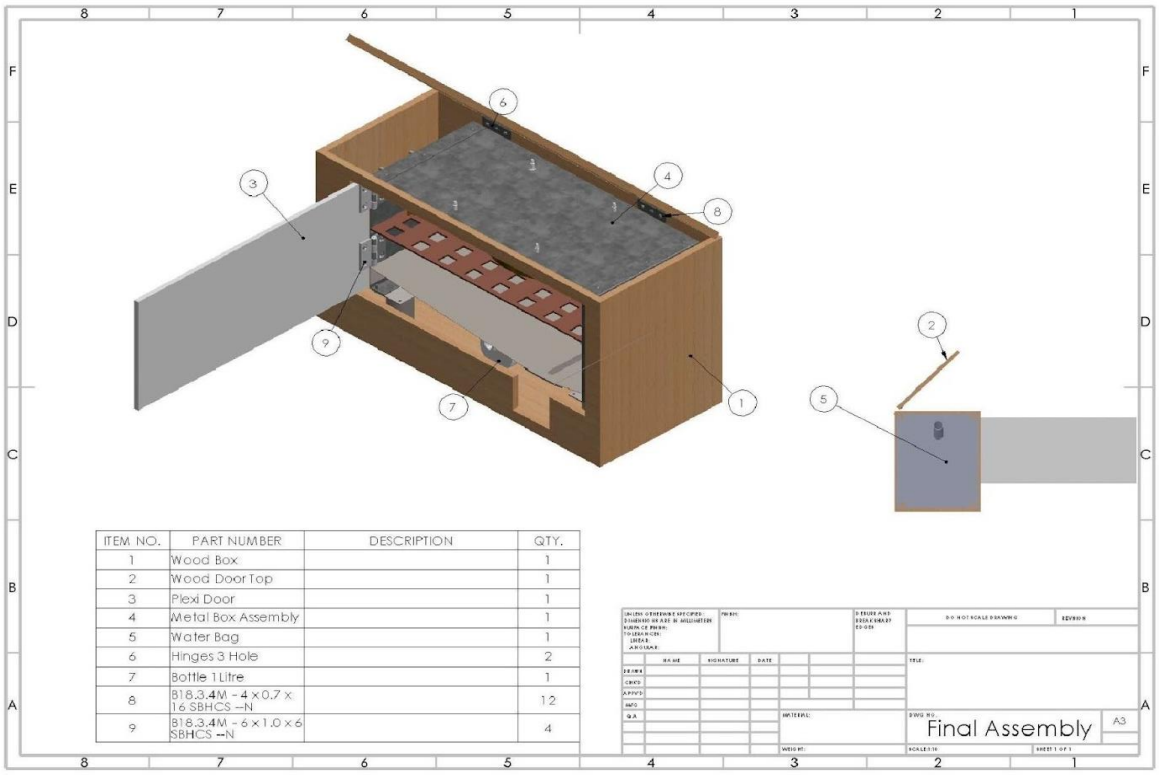
4) Anti-Slip Rubber: This will be used to prevent the washer from sliding when the ambulance is in motion.

5)PLA Plastic: For control panel housing or other interface components, ABS plastic is strong, impact-resistant, and easy to shape. (6)

6)Neoprene or Nitrile Rubber: For hoses or connections that may need to be flexible and chemical-resistant.

7)Aluminum: For framing, aluminum offers strength without adding significant weight. (7)

CAD Drawings and Manufacturing Process



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Wood Box		1
2	Wood Door Top		1
3	Plexi Door		1
4	Metal Box Assembly		1
5	Water Bag		1
6	Hinges 3 Hole		2
7	Bottle 1 Litre		1
8	818.3.4M - 4 x 0.7 x 16 SBHCS --N		12
9	818.3.4M - 6 x 1.0 x 6 SBHCS --N		4

Figure 10. Final Assembly

The washer is encased within a wooden box (Item 1), constructed to provide a sturdy exterior with a natural finish. This box is equipped with a top door (Item 2), crafted from wood, and hinged (Item 6), allowing for easy access to the interior mechanisms. The pieces of wood are cut using a band saw, and held together using wood screws at the corners.

Inside the wooden enclosure lies the primary operational assembly, manufactured corrosion-resistant galvanized steel (Item 4). This inner metal box is engineered to contain the cleaning mechanism, which consists of strategically placed brushes and nozzles, driven by an electric motor for automated cleaning cycles. The assembly is designed to support multiple medical equipment.

To manufacture the metal box, we started with 2mm galvanized steel, cut into 3 sheets using the guillotine cutter. Two sides and the top and back of the box. Once bent into shape using a press brake, a 1mm aluminum sheet was cut and bent into shape for the bottom of the box. All joints of the metal boxes were held together using 4 mm blind rivets after having 4 mm holes drilled. The joints of the metal box were then made water-tight by adding silicon sealant.

For secure and precise construction, various fasteners such as three-hole hinges (Item 6) and bolts (Items 8-9) are detailed, ensuring the structural integrity and functionality of the moving parts. The diagram to the right side of the main image shows the hinged door in the open position, indicating the entry point for medical equipment.

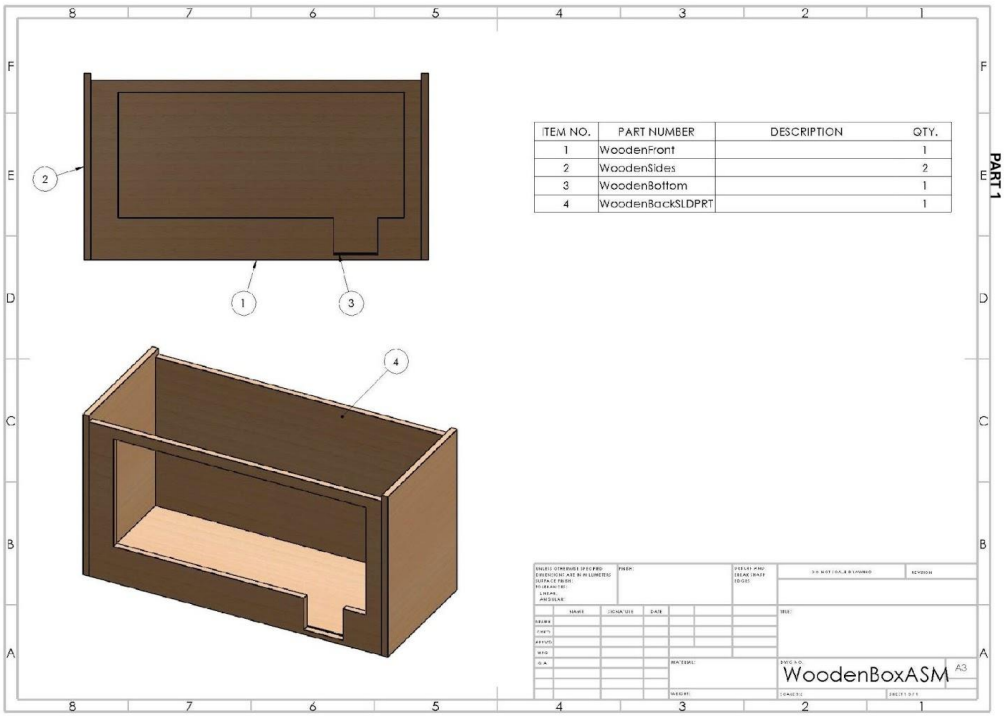


Figure 11. Complete Wood Assembly

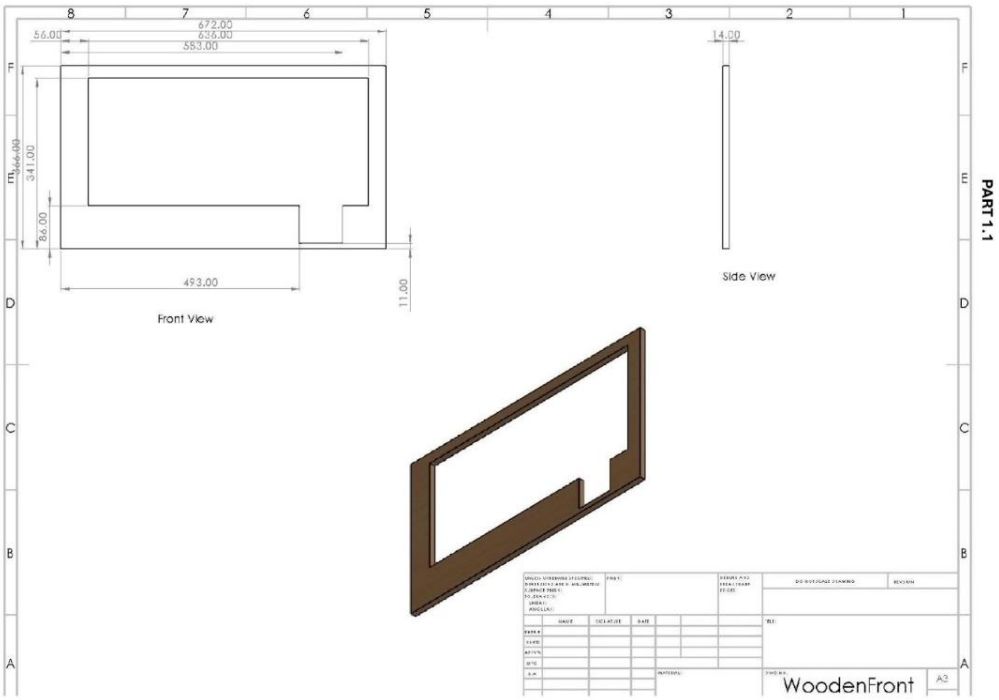


Figure 12. Wood Front Panel

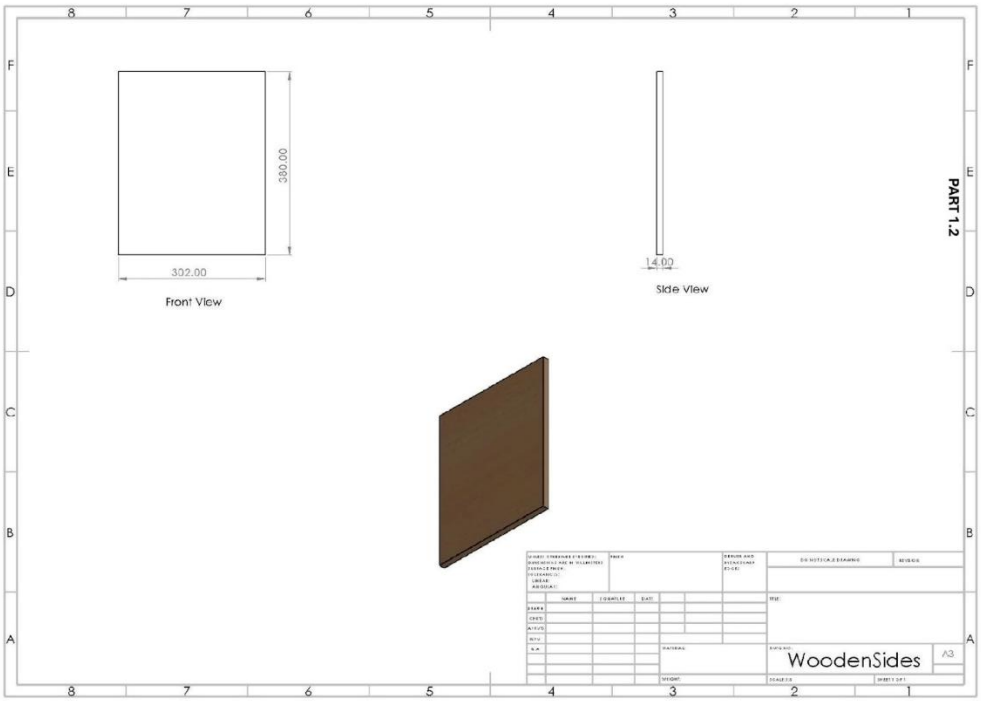


Figure 13. Wood Side Panel

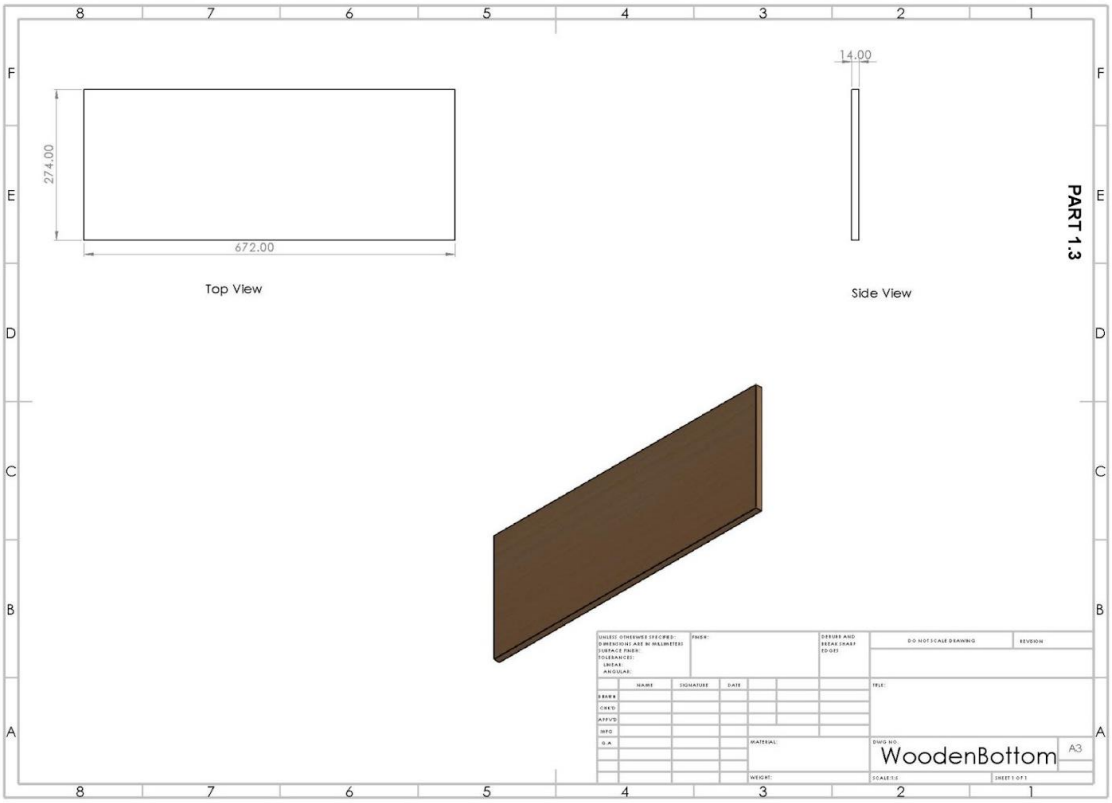


Figure 14. Wood Bottom Panel

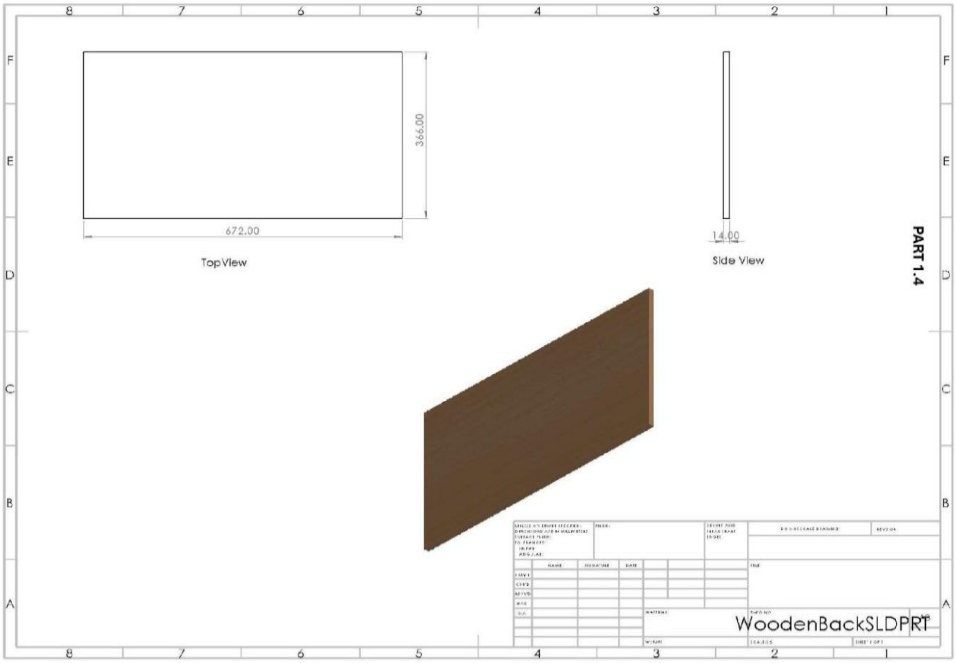


Figure 15. Wood Back Panel

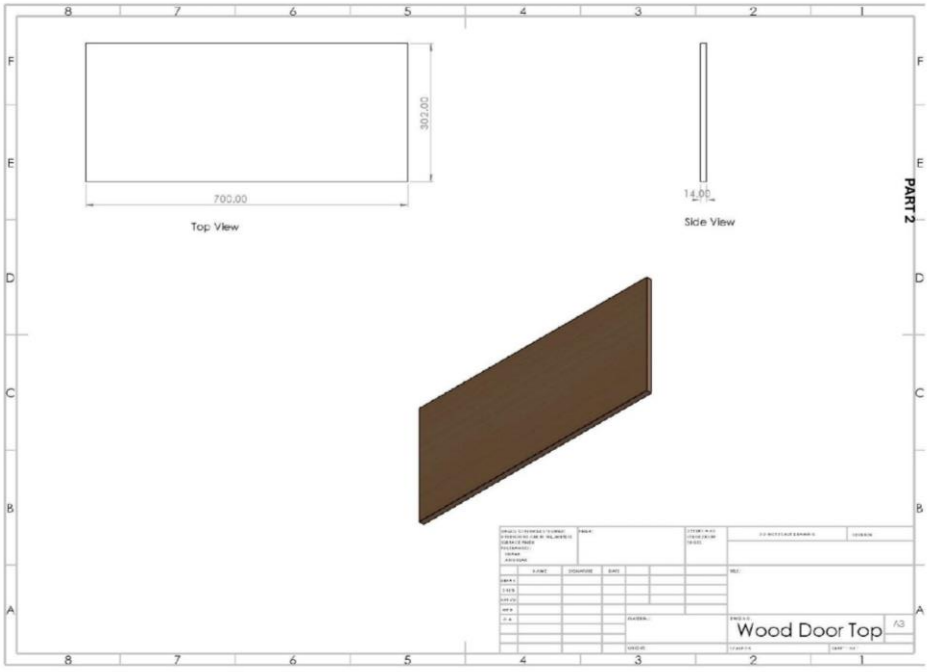


Figure 16. Wood Top Panel

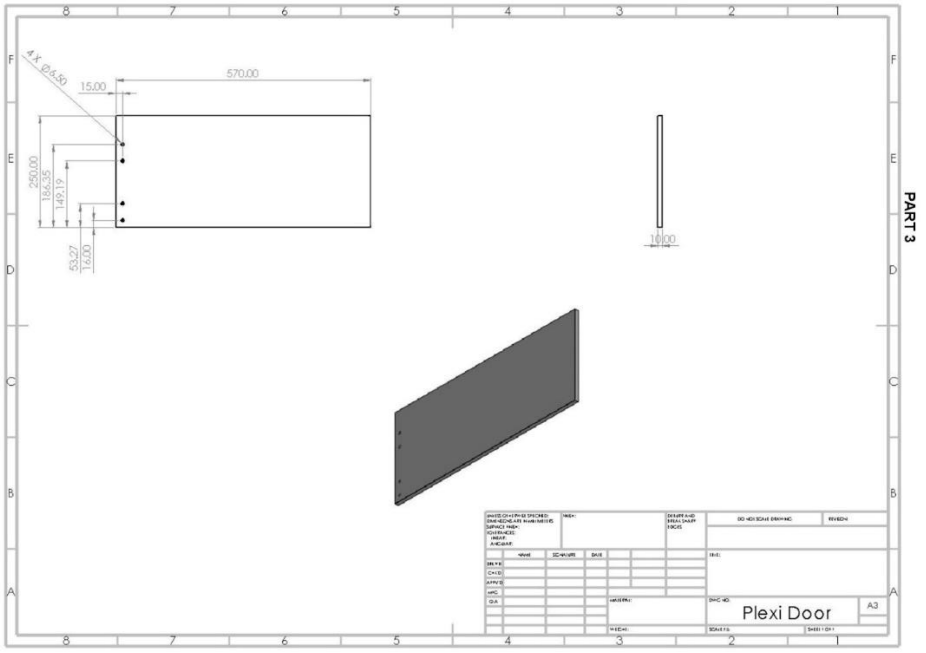


Figure 17. Plexi Door

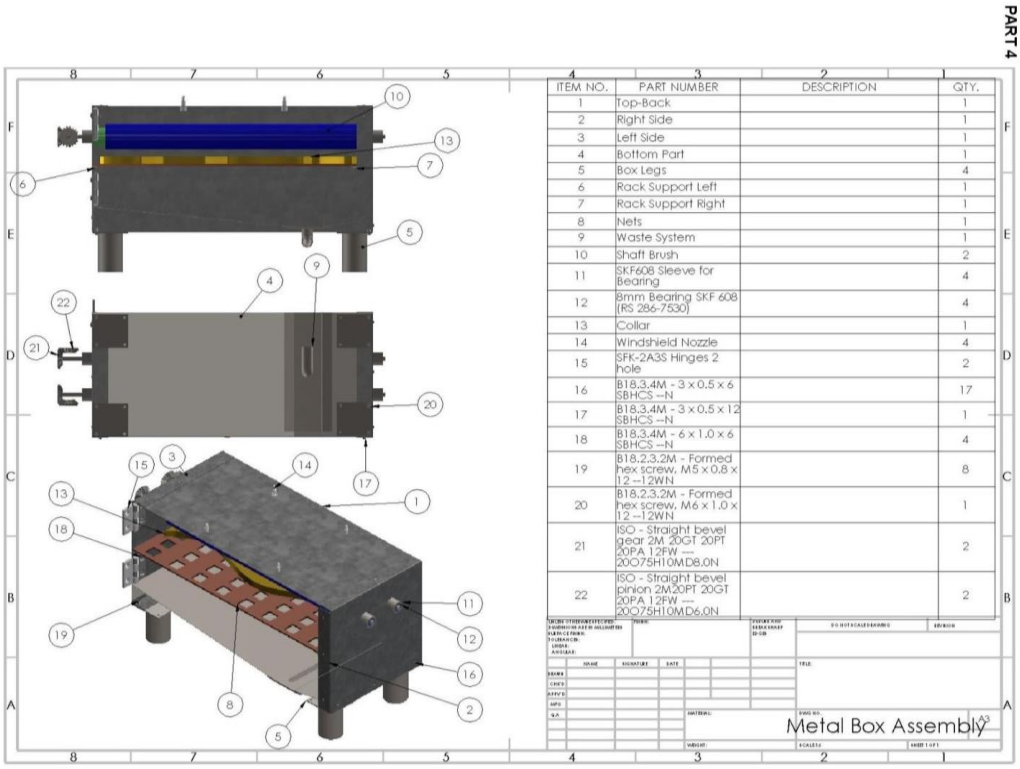


Figure 18. Metal Box Assembly

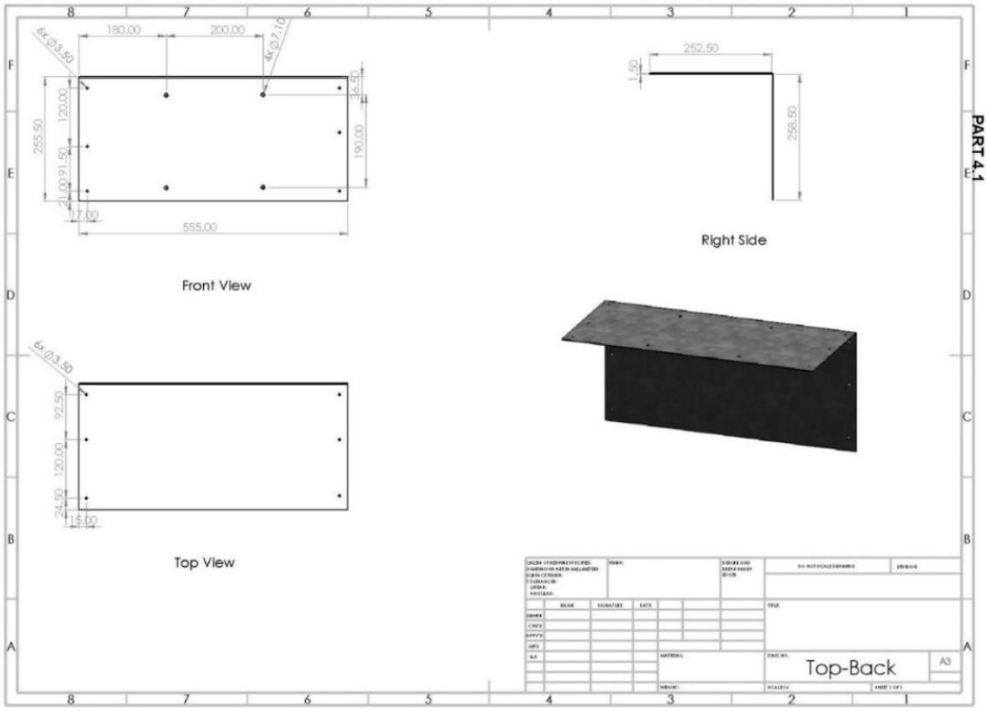


Figure 19. Metal Top-Back

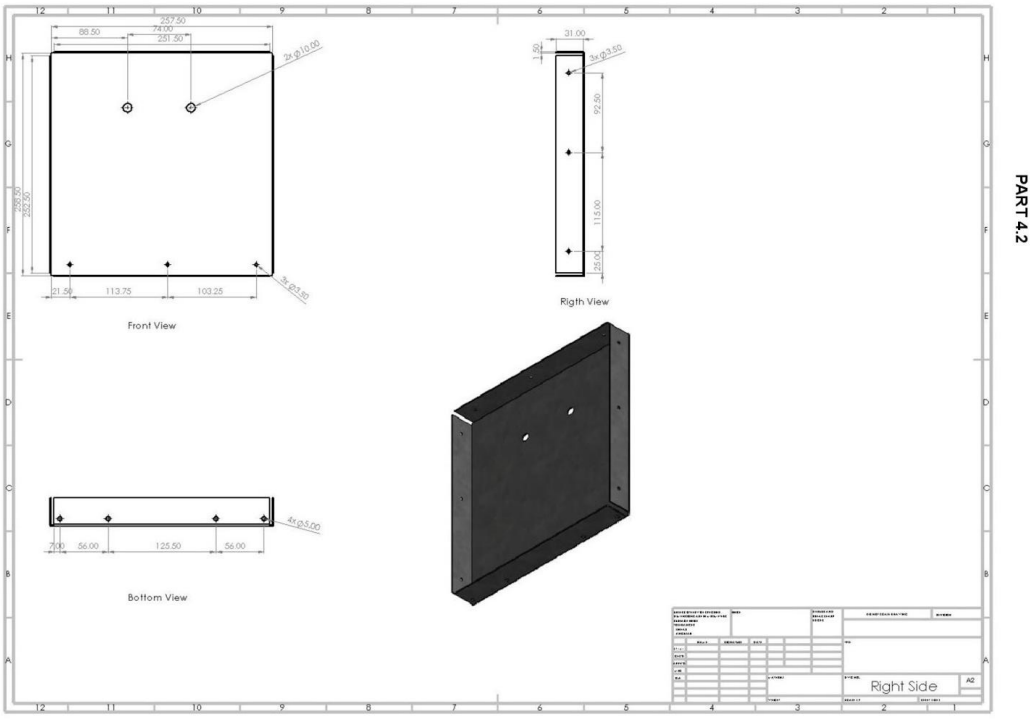


Figure 20. Metal Right Side Panel

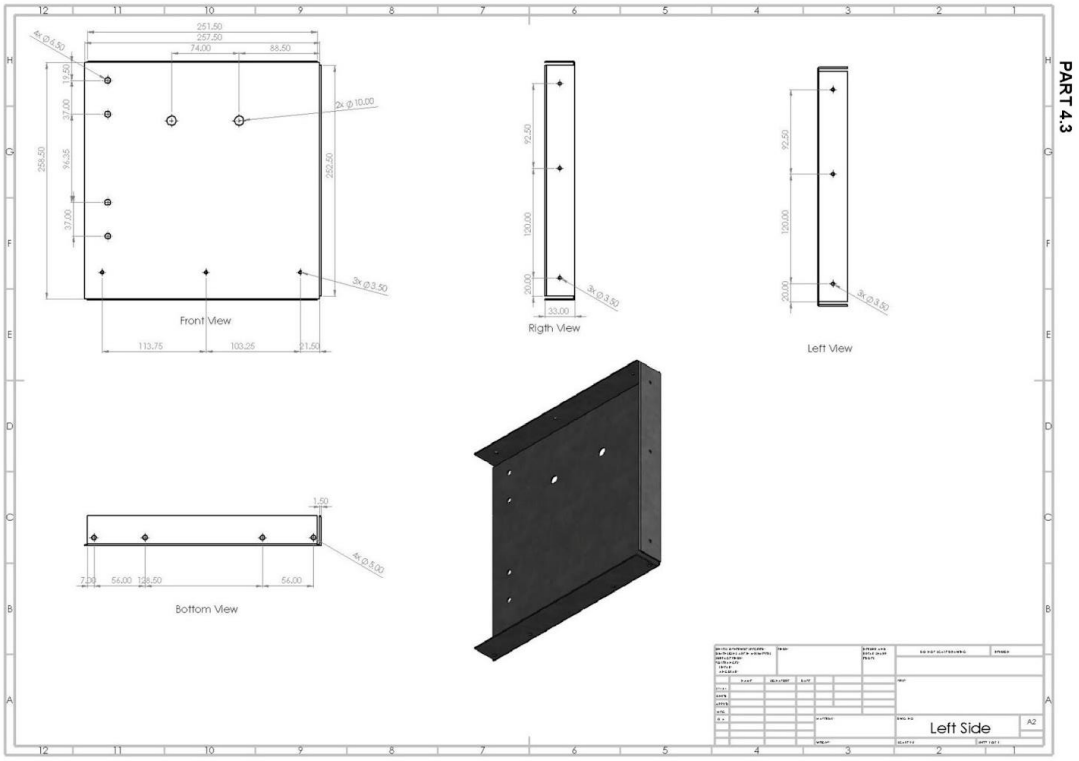


Figure 21. Metal Lest Side Panel

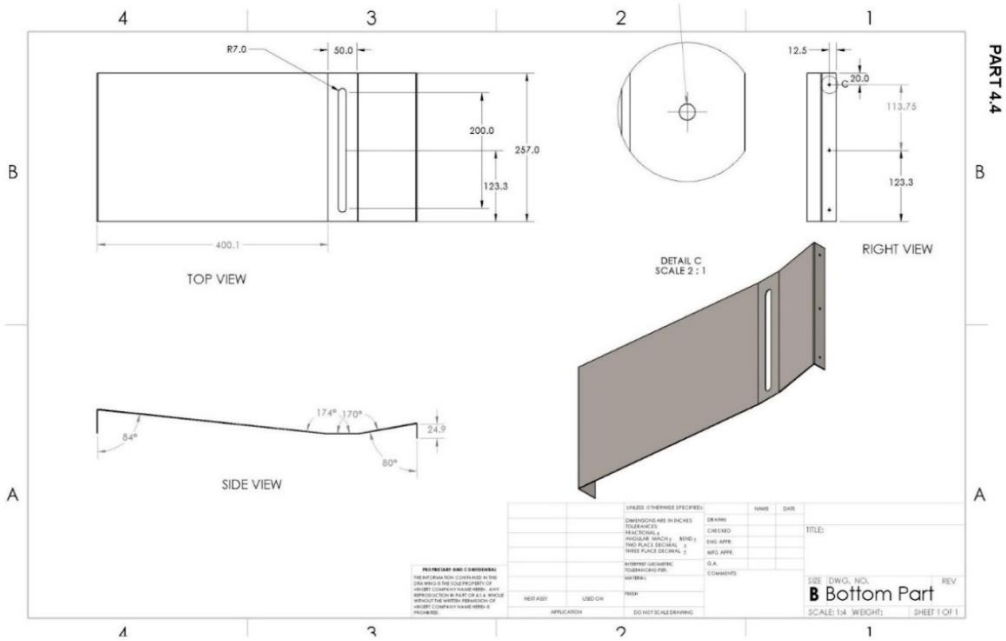


Figure 22. Metal Bottom Part

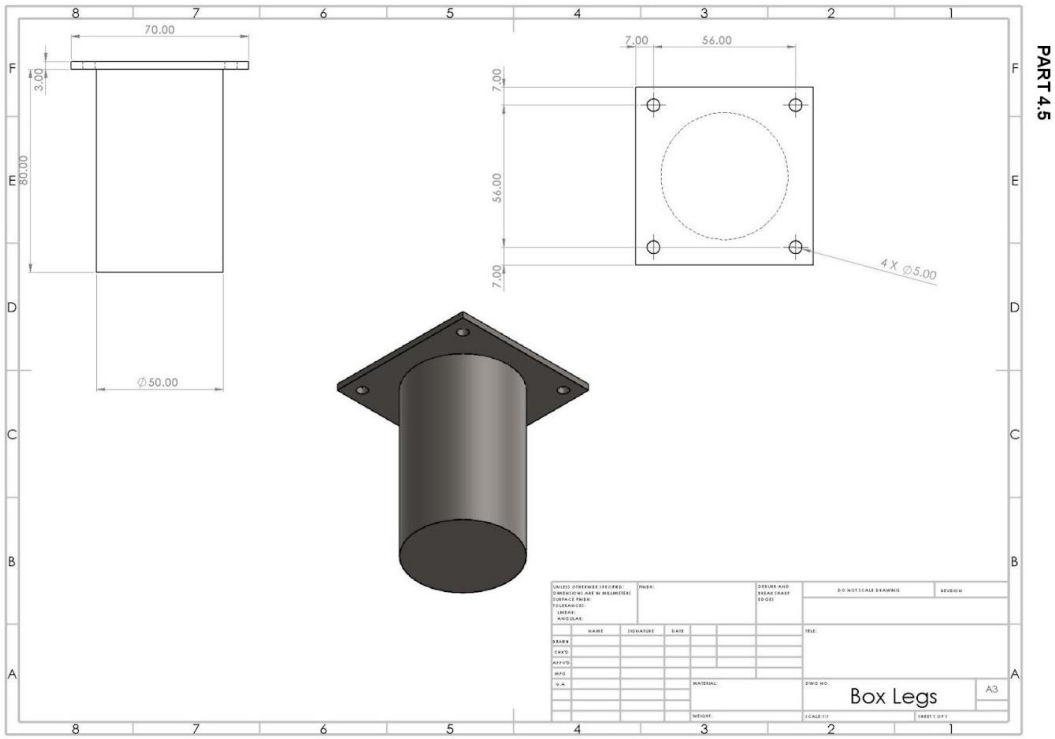


Figure 23. Box Legs

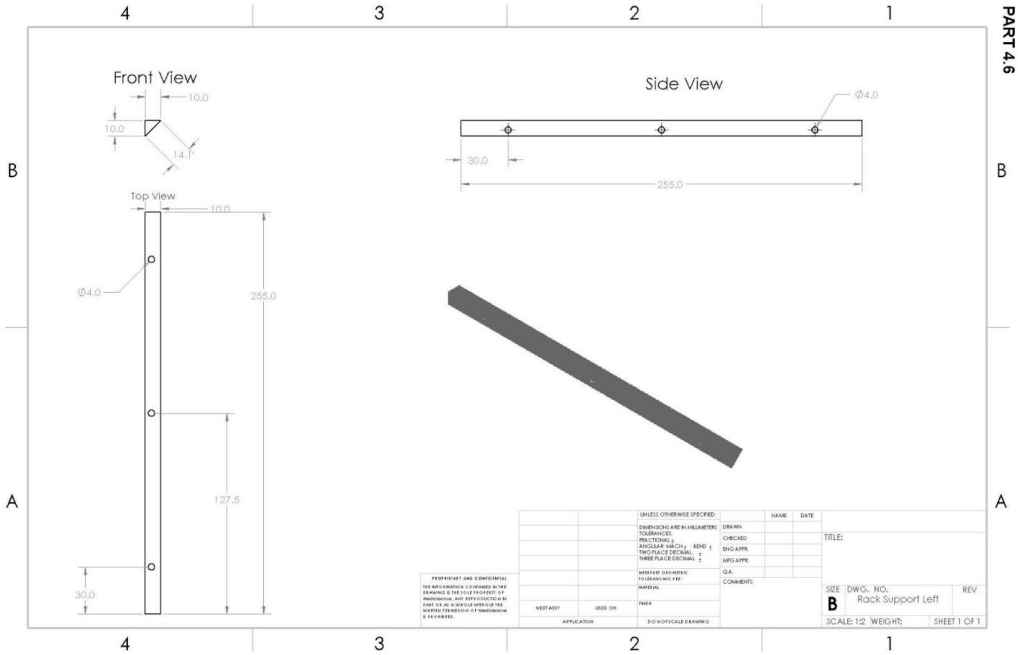


Figure 24. Rack Support Left

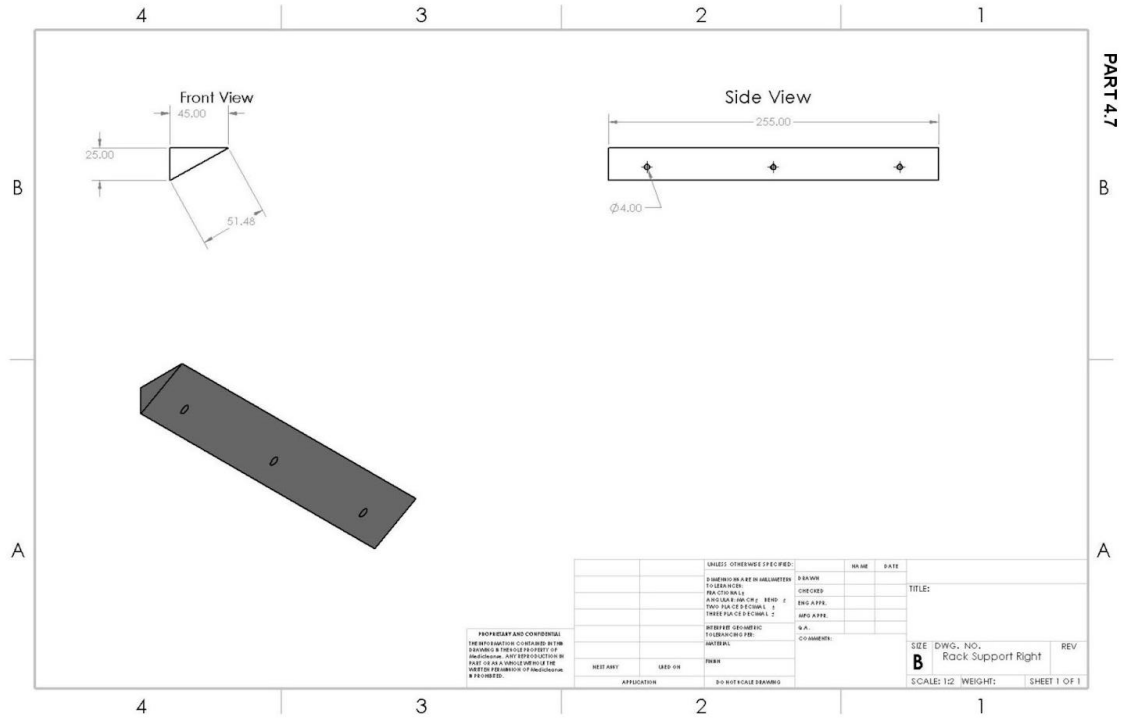


Figure 25. Rack Support Right

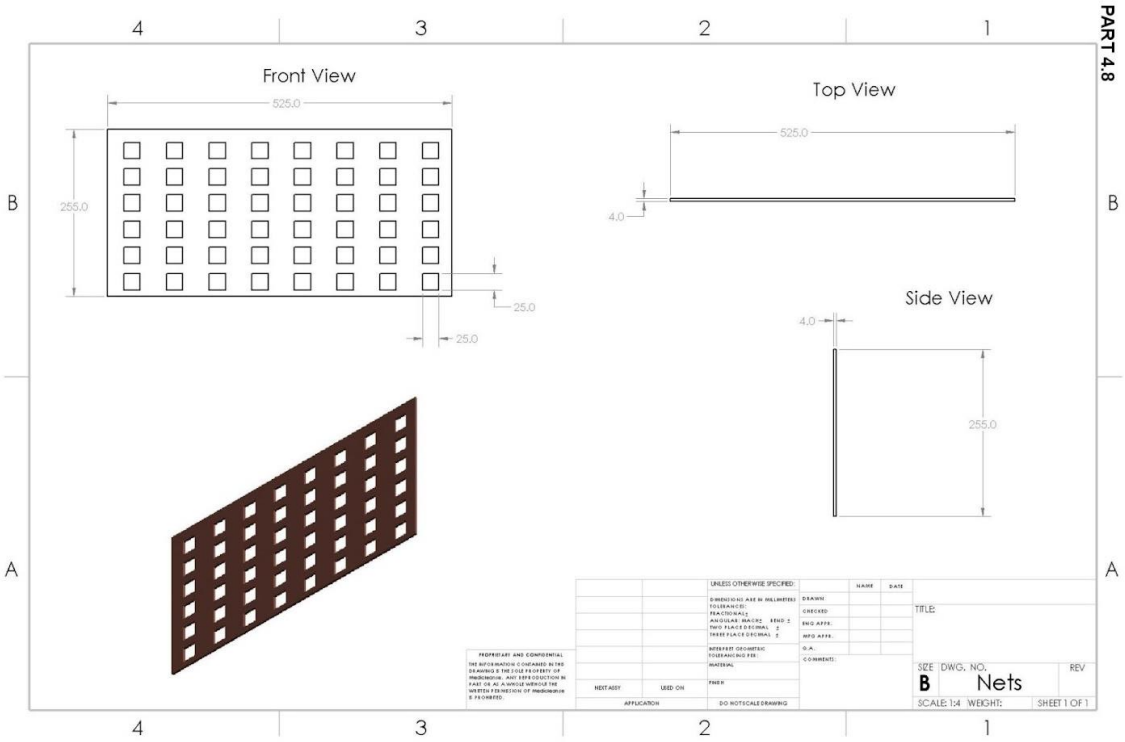


Figure 26. Rack

PART 4.9

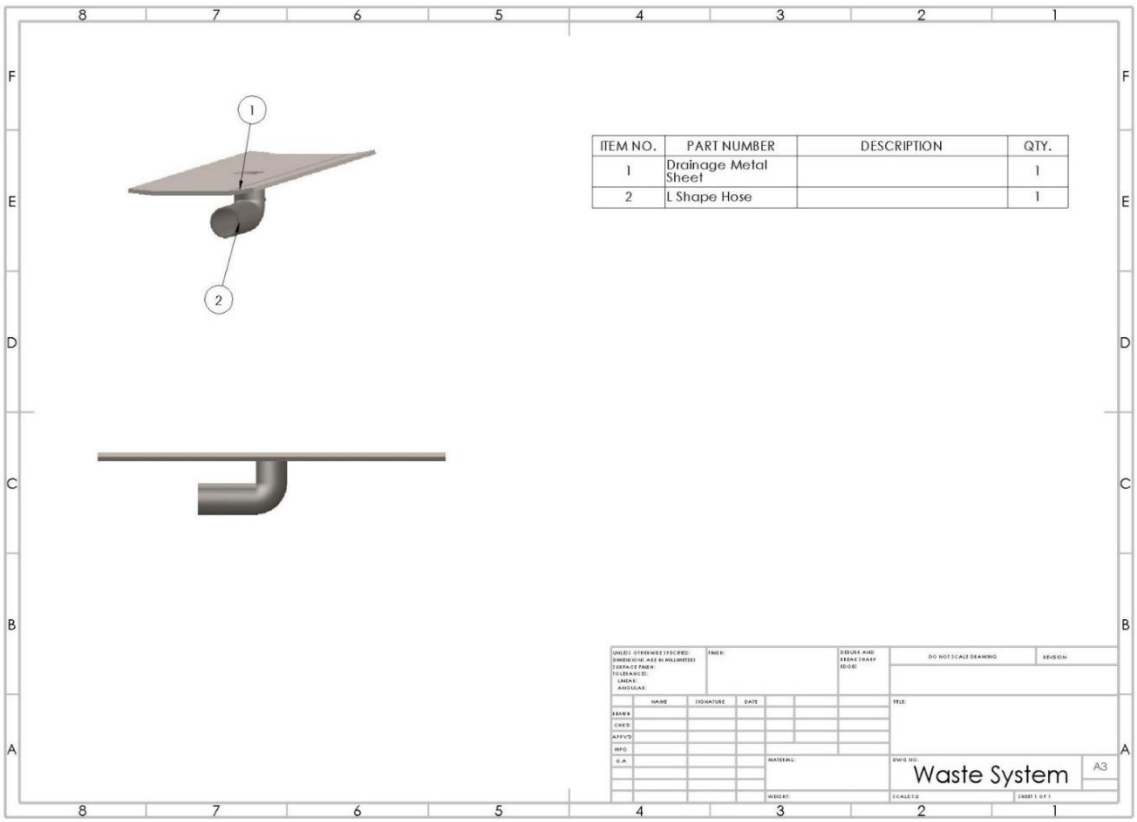


Figure 27. Waste System

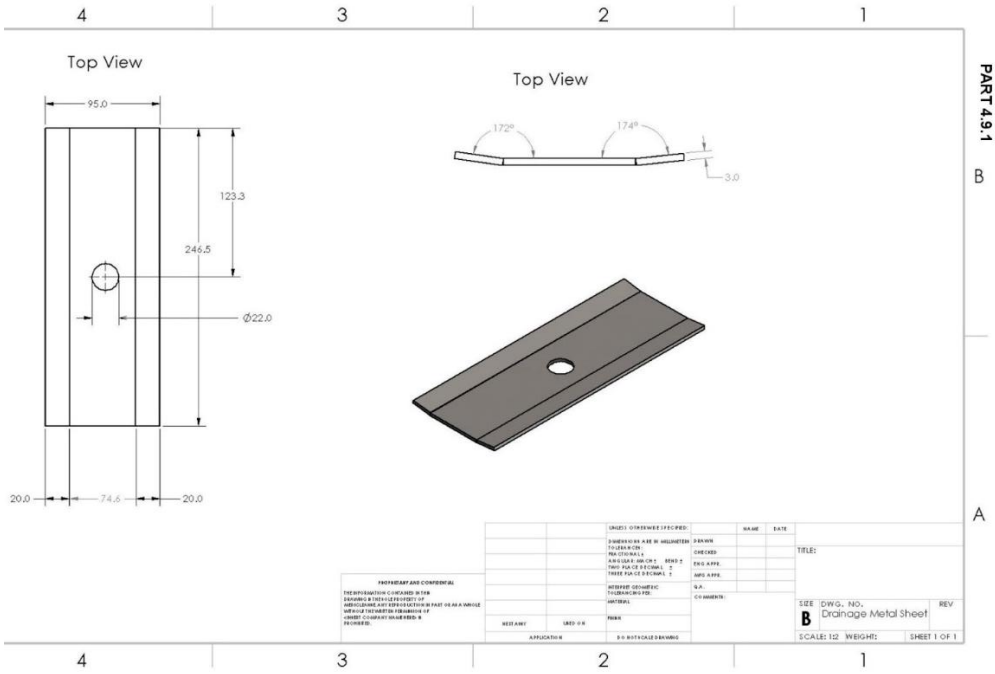


Figure 28. Drainage Metal Sheet

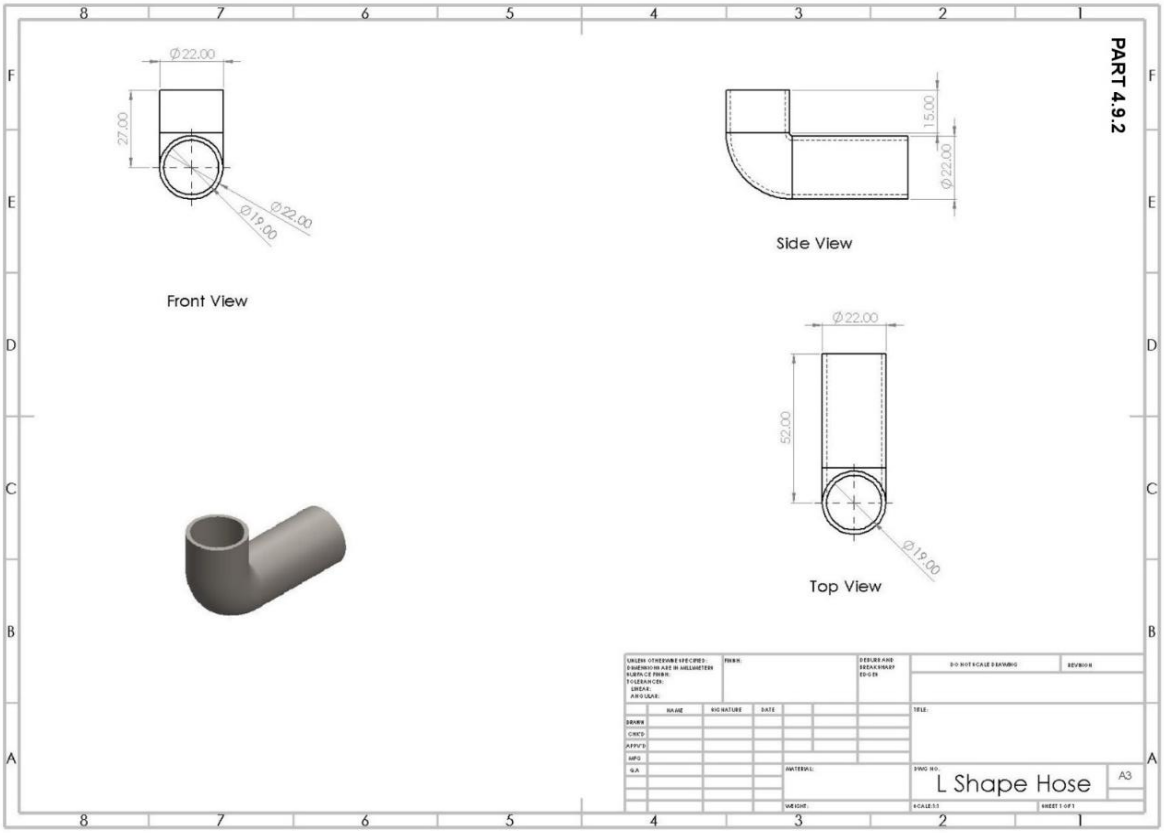


Figure 29. L shape Hose

PART 4.10

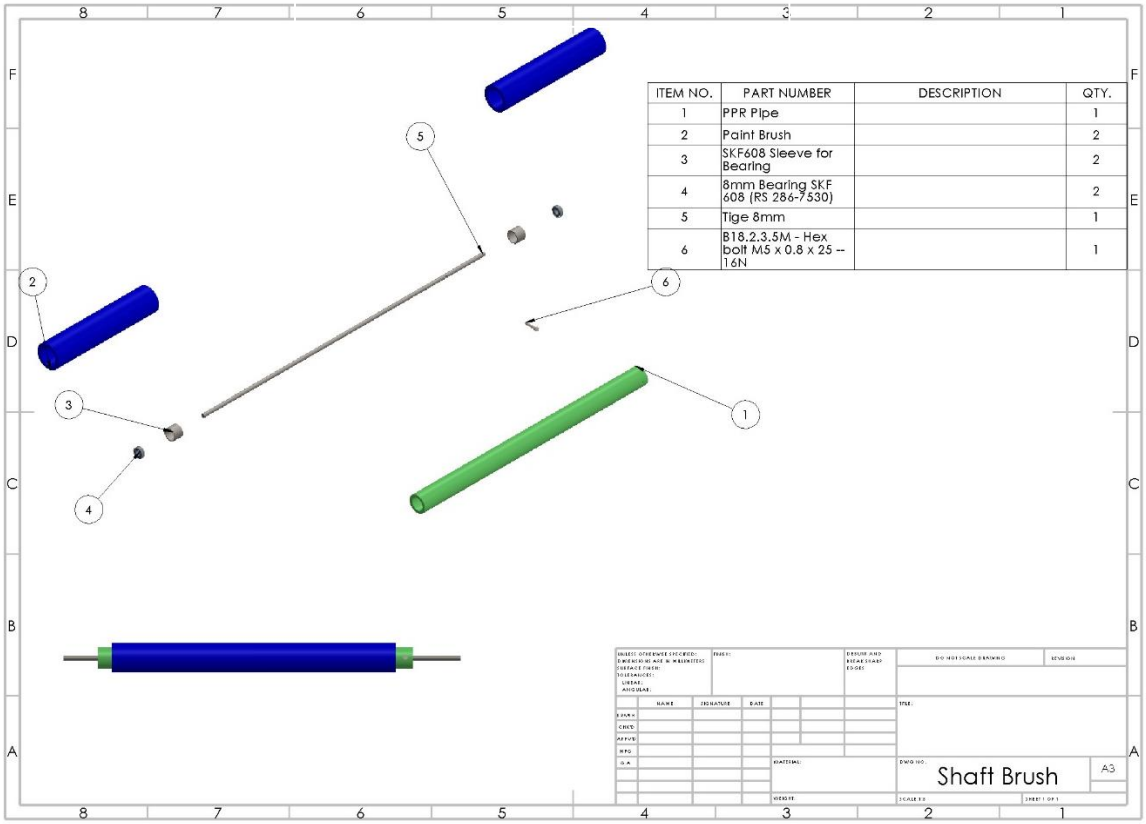


Figure 30. Shaft Brush

PART 4.10.1

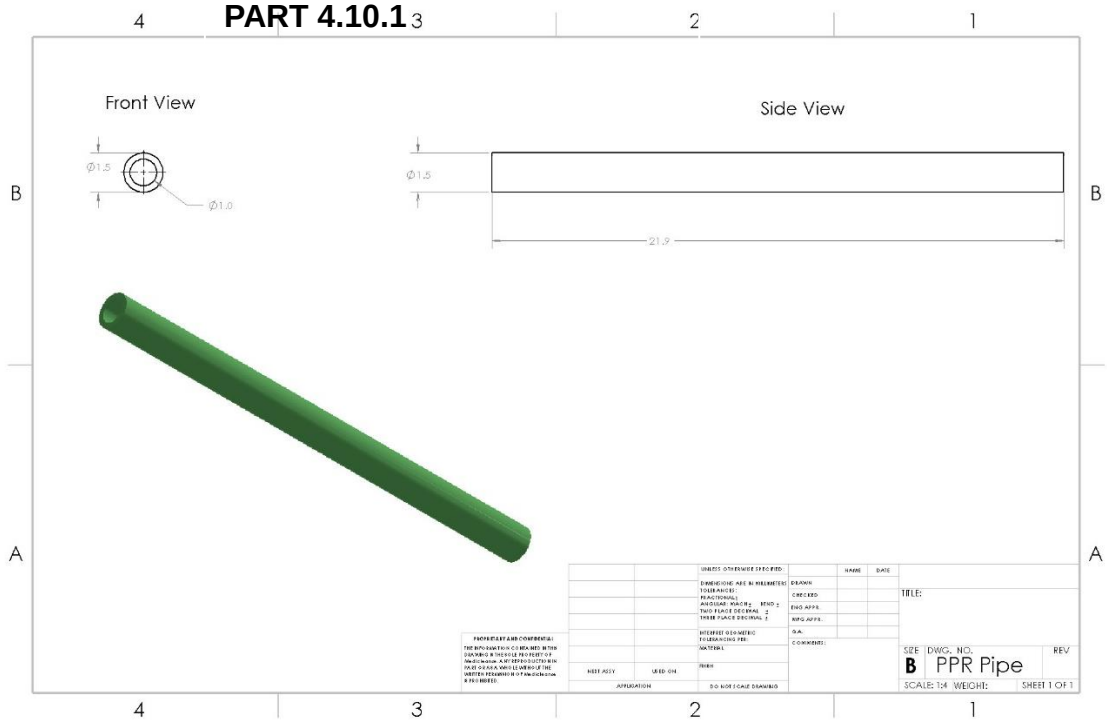


Figure 31. PPR Pipe

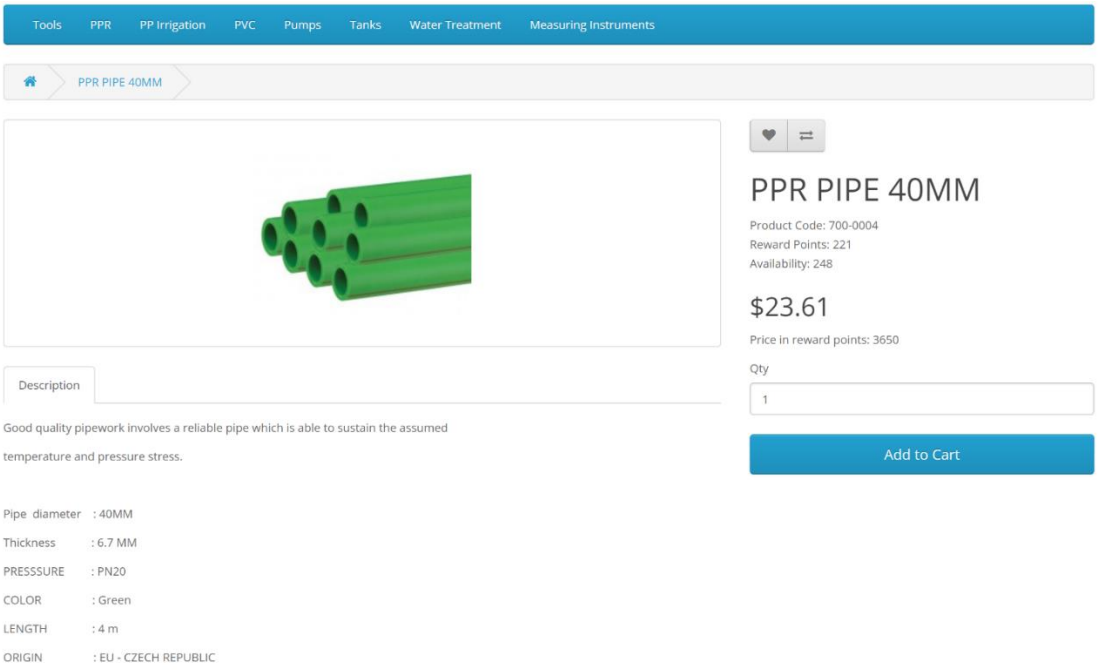


Figure 32. PPR Pipe standard

PART 4.10.2

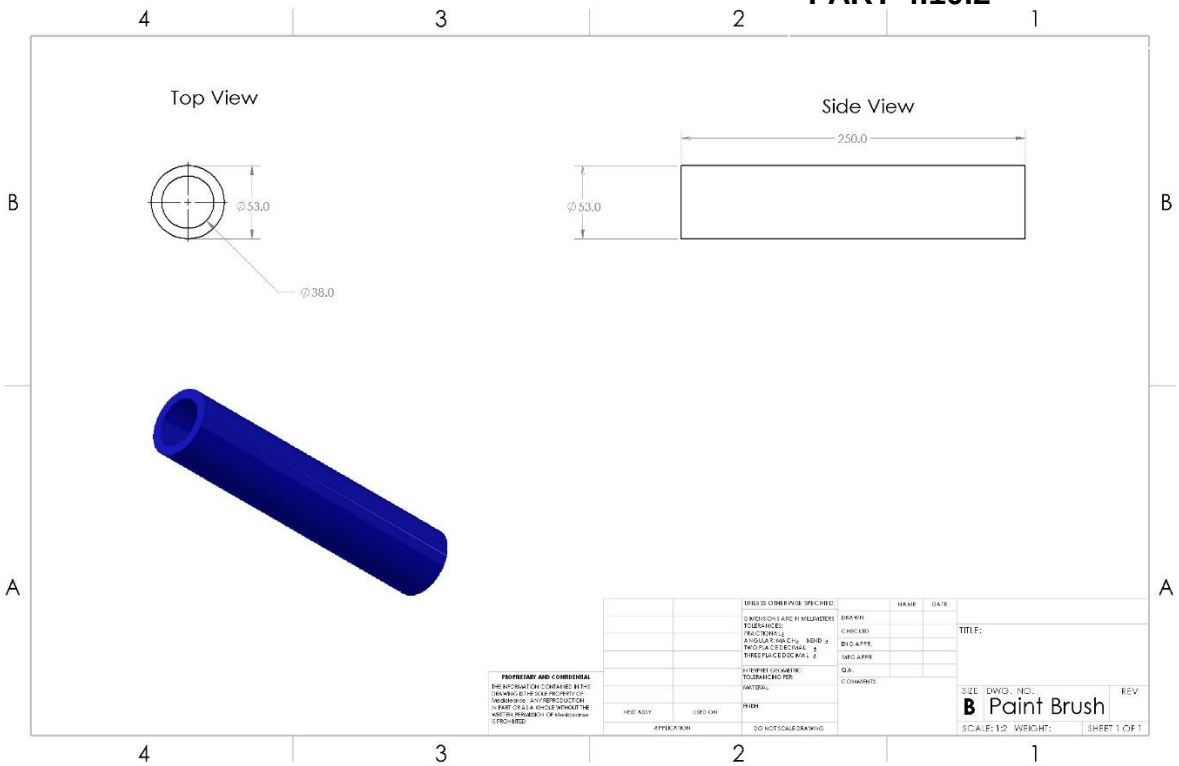


Figure 33. Cleaning Brush

PART 4.10.3 / 4.11

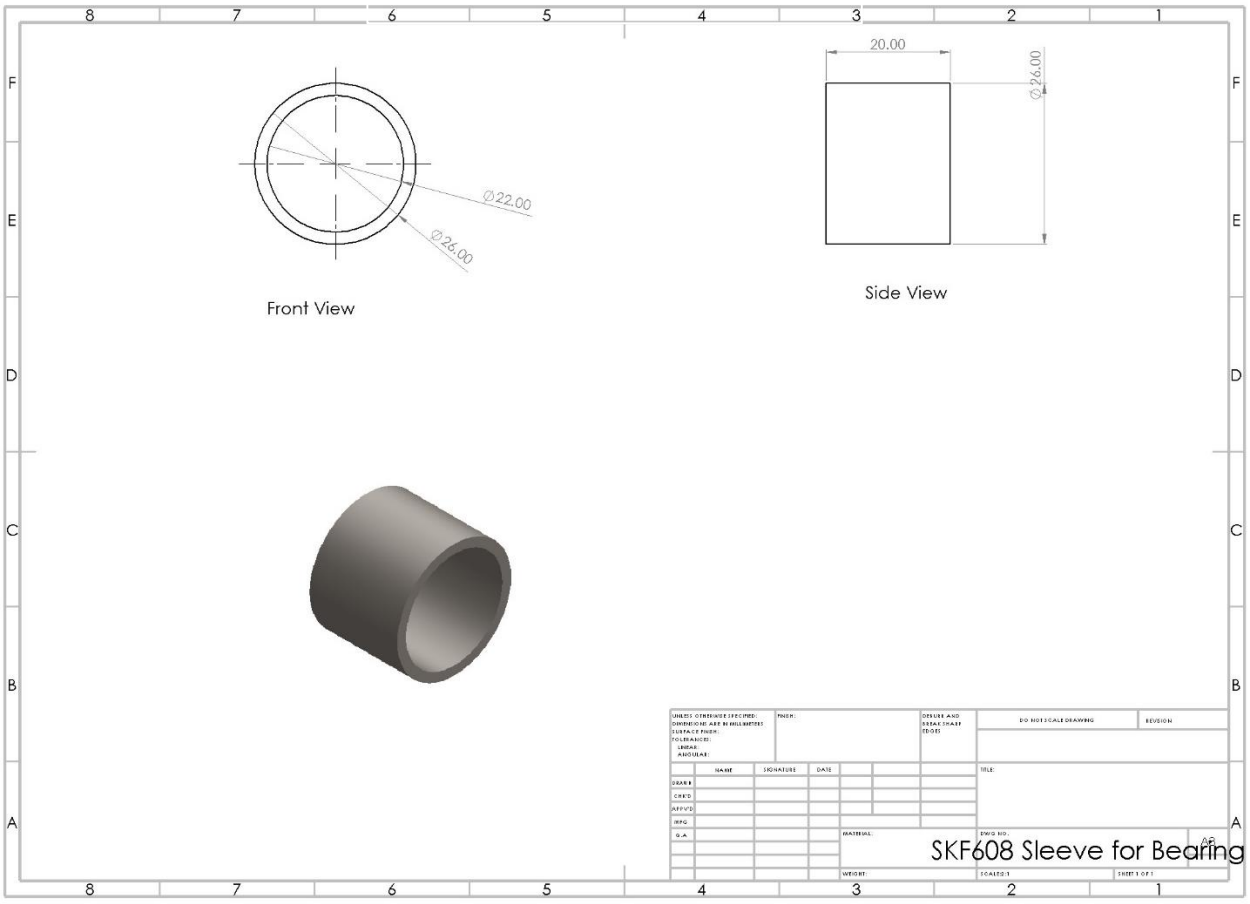


Figure 34. Sleeve for bearing

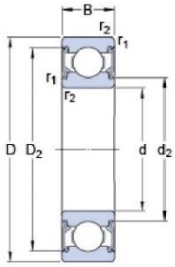
SKF

PART 4.10.4 / 4.12

608 - 2 RSH

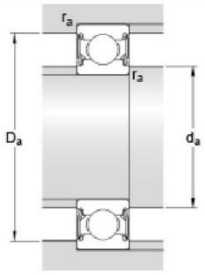
SKF Explorer

Dimensions



d		8	mm
D		22	mm
B		7	mm
d_2	≈	10.55	mm
D_2	≈	19.2	mm
$r_{1,2}$	min.	0.3	mm

Abutment dimensions



d_a	min.	10	mm
d_a	max.	10.5	mm
D_a	max.	20	mm
r_a	max.	0.3	mm

Calculation data

Basic dynamic load rating	C	3.45	kN
Basic static load rating	C_0	1.37	kN
Fatigue load limit	P_u	0.057	kN
Limiting speed		22000	r/min
Calculation factor	k_r	0.025	
Calculation factor	f_0	12	

Mass

Mass bearing		0.012	kg

https://www.skf.com/id/products/rolling-bearings/ball-bearings/deep-groove-ball-bearings/productid-608

Figure 35. Bearing standard

PART 4.10.5

Note that the rod is 8x650mm

ENGLISH

Datasheet

RS Pro 300mm x 8mm Diameter Stainless Steel Rod

RS Stock No: **786-6015**

Product Details

RS Pro stainless steel rod measures 300 mm x 8 mm. This tube can be used to fit into your structural systems and should be used with the MSM clamps.

Features and Benefits

- MSM connecting tubes
- Stainless steel construction

RS, Professionally Approved Products, gives you professional quality parts across all products categories. Our range has been testified by engineers as giving comparable quality to that of the leading brands without paying a premium price.

https://uk.rs-online.com/web/p/metal-bars-metal-rods/7866015

Figure 36. stainless steel rod

Note this Rod was 8x650

PART 4.10.6

METRIC (MM)	PART NUMBER	THREAD SIZE (METRIC)	GRIP RANGE	LENGTH +/-.4	HEAD DIA +/- .25	HEAD HEIGHT +/-.1	BODY DIA. MAX.	HOLE SIZE +.05/-0
	.30C1IRR	M3	0.50 - 1.50	8.70	5.40	0.30	4.92	5.10
	.40C1IRR	M4	0.50 - 2.00	10.40	6.70	0.30	6.30	6.40
	.50C1IRR	M5	0.50 - 3.00	11.50	7.90	0.40	7.10	7.20
	.60C1IRR	M6	0.70 - 3.00	14.50	10.20	0.40	9.50	9.60
	.80C1IRR	M8	0.80 - 4.50	16.00	11.30	0.40	10.50	10.60

LONGER GRIP RANGES AND CLOSED END PARTS ARE AVAILABLE UPON REQUEST

Figure 37. screw standards

PART 4.13

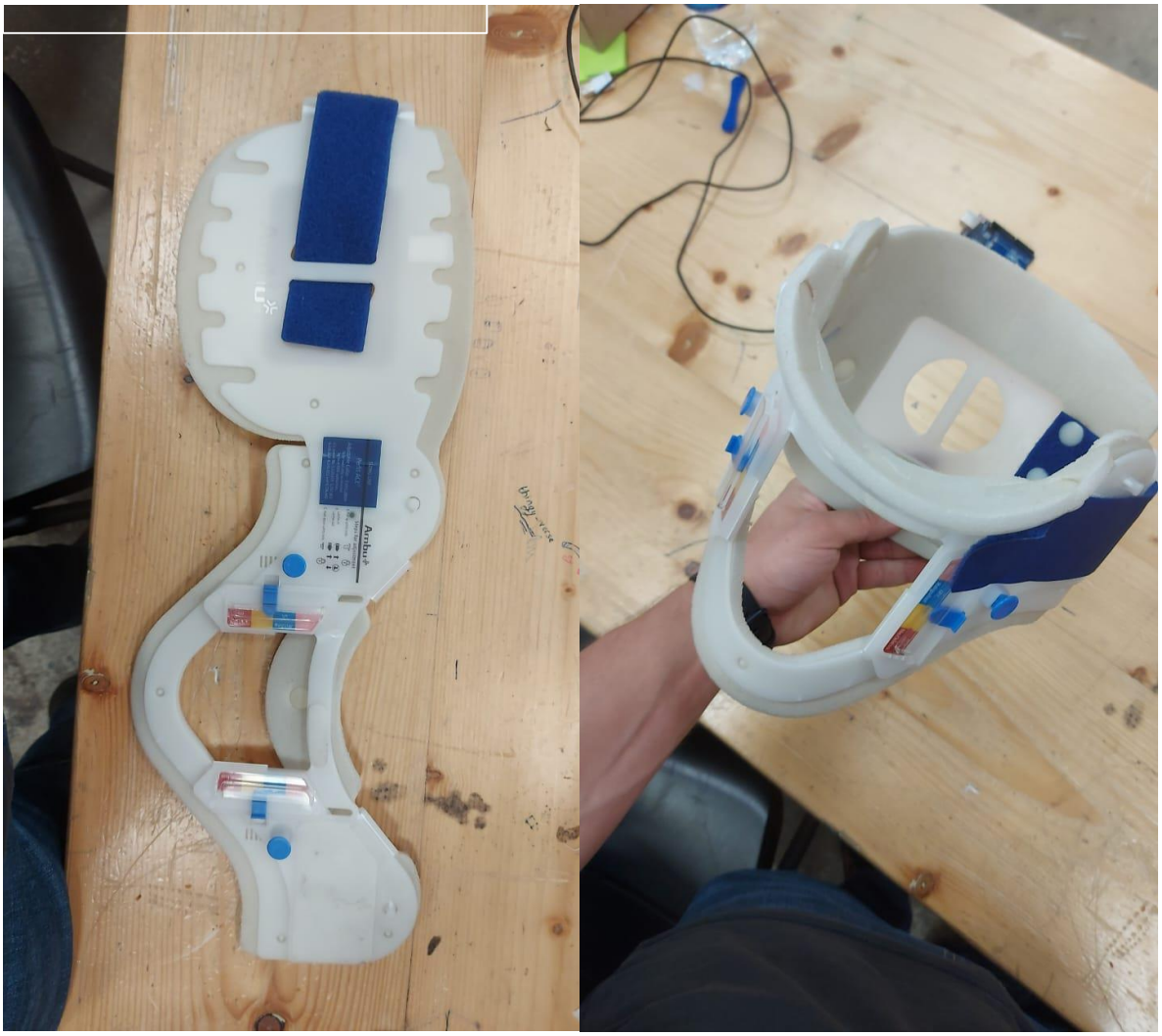


Figure 38. Colar

From this standard we used the M5x0.8x2

PART 4.14

Figure 39. Spray Nozzle

PART 4.15

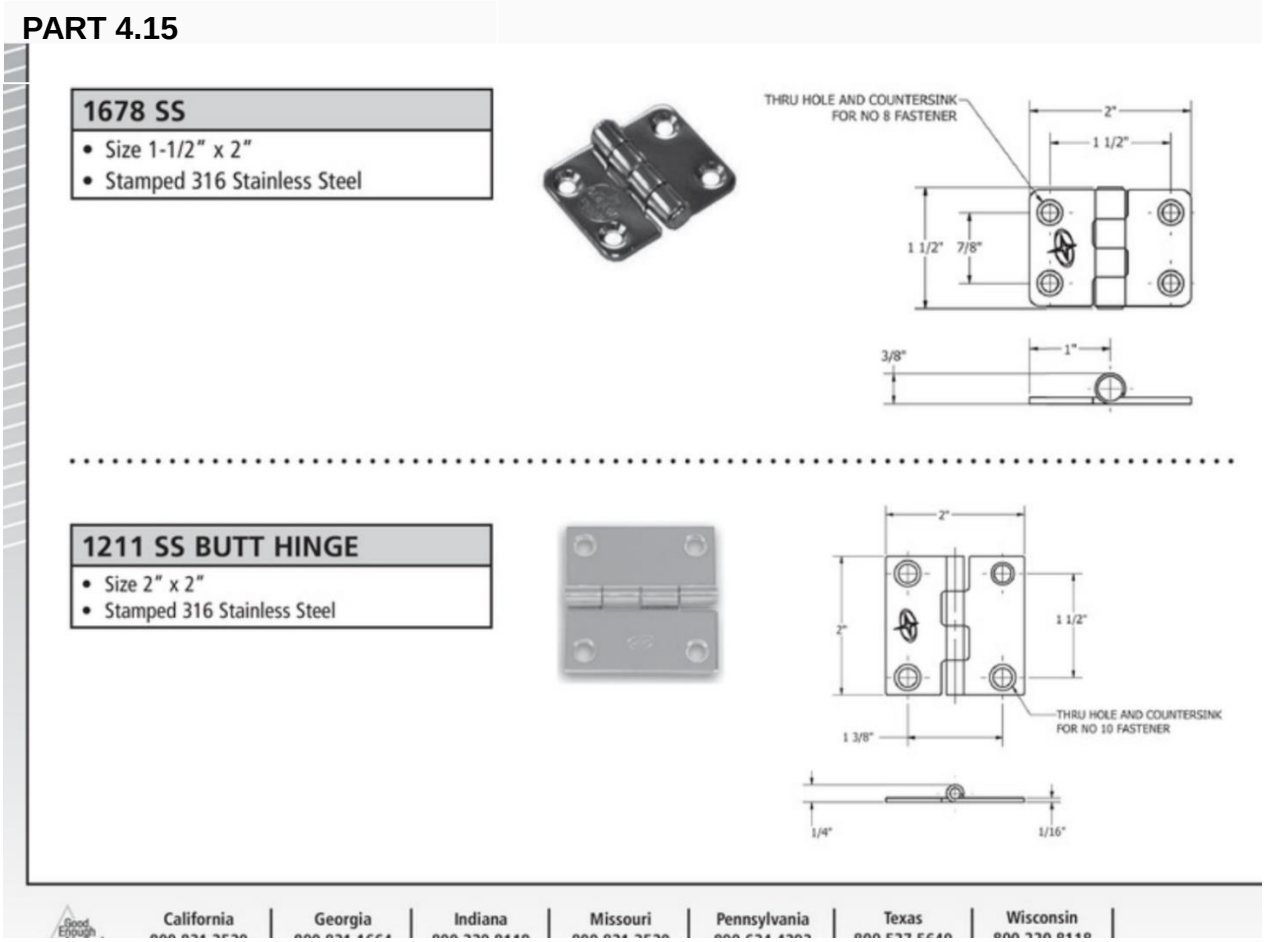


Figure 40. Hinges

PART 4.16 / 17 / 18

	PART NUMBER	THREAD SIZE (METRIC)	GRIP RANGE	LENGTH +/-.4	HEAD DIA +/- .25	HEAD HEIGHT +/-.1	BODY DIA. MAX.	HOLE SIZE +.05/-0
METRIC (MM)	.30C1IRR	M3	0.50 - 1.50	8.70	5.40	0.30	4.92	5.10
	.40C1IRR	M4	0.50 - 2.00	10.40	6.70	0.30	6.30	6.40
	.50C1IRR	M5	0.50 - 3.00	11.50	7.90	0.40	7.10	7.20
	.60C1IRR	M6	0.70 - 3.00	14.50	10.20	0.40	9.50	9.60
	.80C1IRR	M8	0.80 - 4.50	16.00	11.30	0.40	10.50	10.60

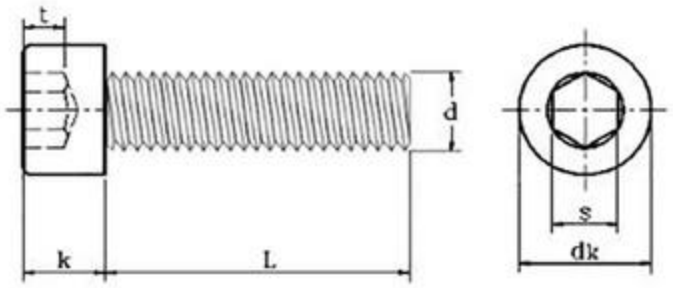
LONGER GRIP RANGES AND CLOSED END PARTS ARE AVAILABLE UPON REQUEST

Figure 41. screw standards

From this standard we used the M3x0.5x6 and M3x0.5x12 and M6x1x6

PART 4.19 / 20 From this standard we used M5x0.8x12 and M6x1x12.

PART 8 / 9 From this standard we uses M4X0.7X16 and M6x1.0x6.



Unit: mm

Thread Diameter	Thread Pitch	dk		k		s		t min
		max	min	max	min	max	min	
M1.4	0.3	2.74	2.46	1.4	1.26	1.36	1.32	0.6
M1.6	0.35	3.14	2.86	1.6	1.46	1.56	1.52	0.7
M2	0.4	3.98	3.62	2	1.86	1.56	1.52	1
M2.5	0.45	4.68	4.32	2.5	2.36	2.06	2.02	1.1
M3	0.5	5.68	5.32	3	2.86	2.58	2.52	1.3
M4	0.7	7.22	6.78	4	3.82	3.08	3.02	2
M5	0.8	8.72	8.28	5	4.82	4.095	4.02	2.5
M6	1	10.22	9.78	6	5.7	5.14	5.02	3
M8	1.25	13.27	12.73	8	7.64	6.14	6.02	4
M10	1.5	16.27	15.73	10	9.64	8.175	8.025	5
M12	1.75	18.27	17.73	12	11.57	10.18	10.025	6
M14	2	21.33	20.67	14	12.57	12.21	12.032	7
M16	2	24.33	23.67	16	15.57	14.21	14.032	8
M18	2.5	27.33	26.67	18	17.57	14.21	14.032	9
M20	2.5	30.33	19.67	20	19.48	17.23	17.05	10
M22	2.5	33.39	32.61	22	21.48	17.23	17.05	11
M24	3	36.36	35.61	24	23.48	19.28	19.065	12

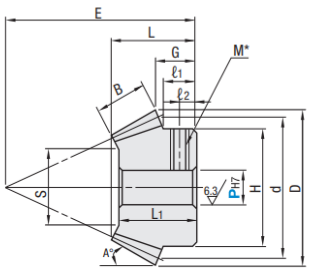
Figure 38. Knot and screw standards

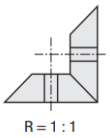
PART 4.21 / 22

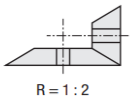
Bevel Gears –
Pressure Angle 20°,
Straight / Spiral Type
Module 1.0, 1.5, 2.0

RoHS10

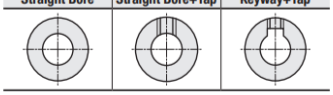
Type					Material	Surface Treatment	Accessories
Straight Type			Spiral Type				
Straight Bore	Straight Bore + Tap	Keyed Bore + Tap	Straight Bore + Tap	Keyed Bore + Tap			
KGEASH	KGEAST	KGEASK	KGEAPT	KGEAPK	1045 Carbon Steel or Equivalent	—	Set Screw (4137 Alloy Steel or Equivalent Black Oxide)
KGEASHB	KGEASTB	KGEASKB	KGEAPTB	KGEAPKB		Black Oxide	
KGEASHG	KGEASTG	KGEASKG	KGEAPTG	KGEAPKG		Electroless Nickel Plating	
KGHS	KGTS	KGKS	—	—	304 Stainless Steel	—	Set Screw (304 Stainless Steel)







Shaft Bore Specifications



- Keyway Dimension Details P.1469.
- Positioning of keyway and teeth are not fixed.

*Straight Bore Type does not have tapped holes.

- Set Screw is not included in Non-tapped Type products.

Accuracy JIS B 1702 (Class 4)

Straight Type

Part Number Type	Module	Nominal	Shaft Bore Dia. P_{H7} 1 mm Increment: Straight Bore Straight Bore + Tap	Shaft Bore Dia. P_{H7} 1 mm Increment: Keyway + Tap	No. of Teeth	R Gear Ratio	Mating Gear Number	B	H	d	D	S	E	L	G	ℓ1	ℓ2	L1	A°	M (Coarse)
Straight Bore KGEASH KGEASHB KGEASHG KGHS	1.0	2020	6, 8	8	20	1:1	2020	4.3	16	20	21.41	11.8	21	14.53	11.71	9	4.5	13	49°3′	M4
		2525	6, 8, 10	8, 10	25		2525	5.3	20	25	26.41	15	23	14.7	11.21	8	4	13	48°51′	M4
		3030	8, 10, 12	8, 10, 12	30		3030	6.2	22	30	31.41	19.4	26	15.89	11.71	8.9	4.5	14.5	47°42′	M4 (M5)
		2040	6, 8	8	20	1:2	4020	5.7	16	20	21.79	12.1	29.6	15.03	10.05	8.6	4	14	29°8′	M4
		4020	8, 10, 12	8, 10, 12	40		2040	5.7	25	40	40.89	28.4	21.8	15.02	12.69	8	4	13	66°0′	M4 (M5)
Straight Bore + Tap KGEAST KGEASTB KGEASTG KGTS	1.5	2020	10, 12	10, 12	20	1:1	2020	6.8	24	30	32.12	17.7	28	18.53	14.06	10	5	16.5	49°3′	M4
		2525	10–14	10–14	25		2525	7.5	30	37.5	39.62	23.7	34	21.26	16.31	11.5	5	19	48°51′	M4
		3030	12–16	12–16	30		3030	9.3	33	45	47.12	29.6	38	22.83	16.56	12.34	6	21	47°42′	M5
		1836	8, 10, 12	8	18	1:2	3618	9.8	22	27	29.68	12.2(12.1)	40.74	22.96	14.41	12.5	6	21	29°25′	M4
		3618	10–15	10–15	36		1836	9.8	30	54	55.34	34.3	26.75	18.54	14.59	10	5	15.5	66°17′	M5
Keyway Bore + Tap KGEASK KGEASKB KGEASKG KGKS	2.0	2020	12–14	12–14	20	1:1	2020	8.5	34	40	41.32	23.9	37	24	18.41	14	7	21	49°3′	M5
		*2525			25		2525	10.5	42	50	51.33	32.3	40	23.34	16.41	10.99	5	21	48°51′	M5
		3030	16–18	16–18	30		3030	12.4	44	60	61.36	38.9	51	30.77	22.41	16.79	8	28	47°42′	M6
		1836	10	10	18	1:2	3618	12.6	28	36	37.81	19.1	53.12	29	18.01	15.12	7	27	29°25′	M4
		3618	12–14	12–14	36		1836	12.6	36	72	72.15	47.6	35.21	24.07	19	13	6.5	21	66°17′	M5

- * marked sizes not available for Stainless Steel products
- Sizes in ( ) are for 304 Stainless Steel.
- Module 1.0 is not available for KGHS (Round Shaft Bore of 304 Stainless Steel)
- Spiral bevel gears from different manufacturers may not match correctly. Always select mating sets from MISUMI.
- Note: The gears are sold in each piece quantity, not as sets.
- Select 10K as P dimension if you request keyway width of 4.0 mm (height 1.8 mm) for Keyway+Tap with shaft bore diameter of 10. P.1469

Spiral Type (Spiral Angle 35°)

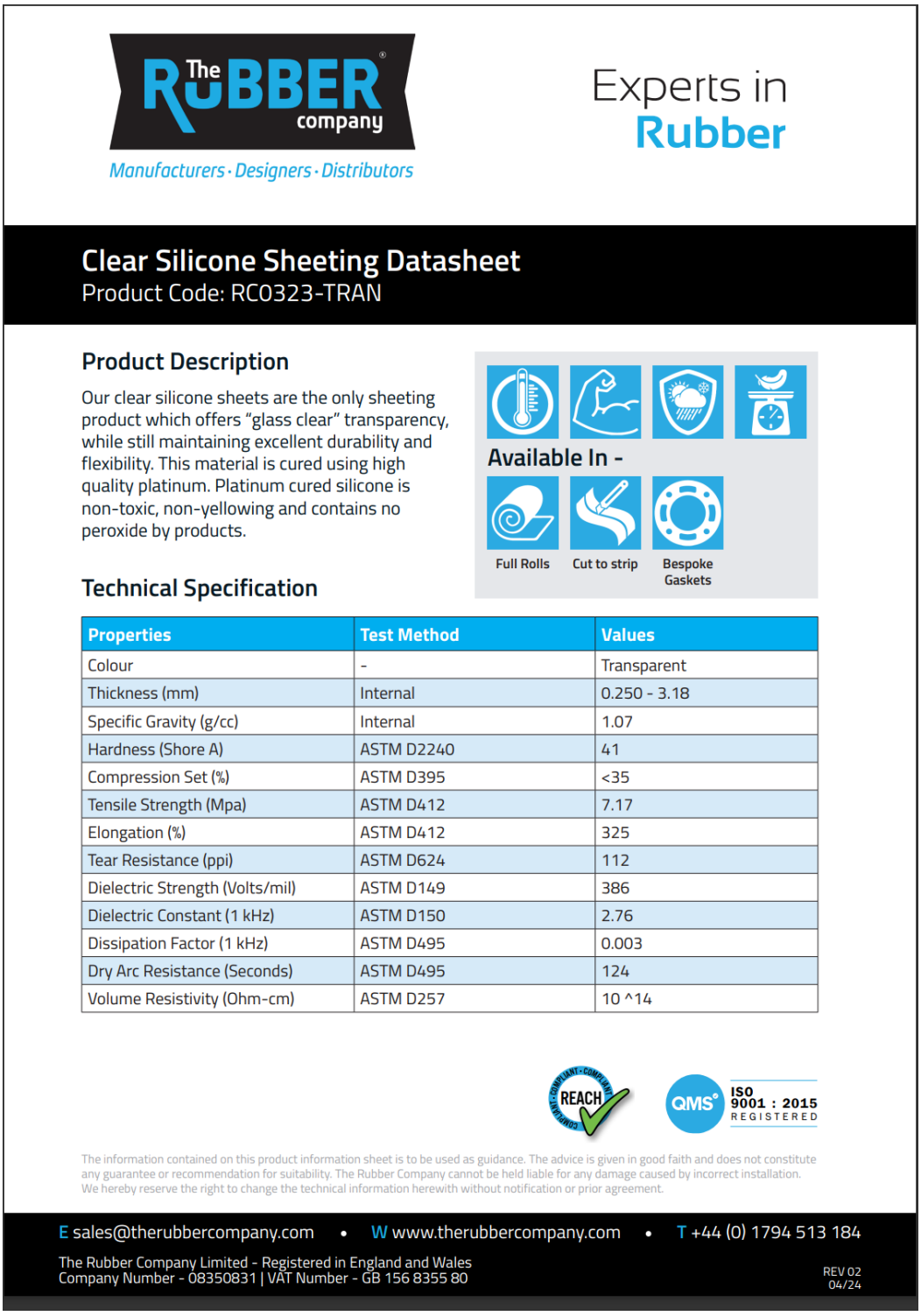
Part Number Type	Module	Nominal	Shaft Bore Dia. P_{H7} 1 mm Increment: Straight Bore + Tap	Shaft Bore Dia. P_{H7} 1 mm Increment: Keyway + Tap	Twisting Direction	No. of Teeth	R Gear Ratio	Mating Gear Number	B	H	d	D	S	E	L	G	ℓ1	ℓ2	L1	A°	M (Coarse)
Straight Bore + Tap KGEAPT KGEAPTB KGEAPTG	1.0	2020	6, 8	8	L R	20	1:1	2020	4.5	16	20	21.12	11.3	21	14.43	11.56	9	4.5	13	50°31′	M4
		3030	10, 12	10, 12	(Left) (Right)	30		3030	6.2	22	30	31.09	19.4	26	15.67	11.54	9	4.5	14.5	48°21′	M5
		2040	8, 10, 12	8	L (Left)	20	1:2	4020	5.7	16	20	21.87	12.1	29.6	15	10.07	8.6	4	14	30°13′	M4
		4020	10, 12	10, 12	R (Right)	40		2040	5.7	25	40	40.41	28.4	21.8	14.57	12.21	8	4	13	65°36′	M5
Keyway + Tap KGEAPK KGEAPKB KGEAPKG	1.5	2020	10, 12	10, 12	(Left) (Right)	20	1:1	2020	7	24	30	31.85	17.2	28	18.44	13.93	10	5	16.5	50°5′	M4
		3030	12–16	12–16	L R	30		3030	9.3	33	45	46.79	29.7	38	22.64	16.4	12	6	21	47°54′	M5
		1836	8, 10, 12	8	L (Left)	18	1:2	3618	9.8	22	27	30.09	12.2	40.74	22.96	14.51	12.49	6	21	30°44′	M4
		3618	10–15	10–15	R (Right)	36		1836	9.8	30	54	54.76	34.3	26.75	18.01	14.01	9	4.5	15.5	65°57′	M5

- Use Spiral Type in L and R sets.
- Spiral bevel gears from different manufacturers may not match correctly. Always select mating sets from MISUMI.
- Note: The gears are sold in each piece quantity, not as sets.
- Select 10K as P dimension if you request keyway width of 4.0 mm (height 1.8 mm) for Keyed Bore + Tap with shaft bore diameter of 10. P.1469

https://sg.misumi-ec.com/vona2/detail/110300429650/

Figure 43. Bevel Gears

From this standard we used module 2 with number of teeth=20, number of pinions teeth=20, pressure Angle =20, and Face Width =12



The Rubber company

Manufacturers · Designers · Distributors

Experts in Rubber

Clear Silicone Sheeting Datasheet

Product Code: RC0323-TRAN

Product Description

Our clear silicone sheets are the only sheeting product which offers "glass clear" transparency, while still maintaining excellent durability and flexibility. This material is cured using high quality platinum. Platinum cured silicone is non-toxic, non-yellowing and contains no peroxide by products.

Available In -

Full Rolls | Cut to strip | Bespoke Gaskets

Technical Specification

Properties	Test Method	Values
Colour	-	Transparent
Thickness (mm)	Internal	0.250 - 3.18
Specific Gravity (g/cc)	Internal	1.07
Hardness (Shore A)	ASTM D2240	41
Compression Set (%)	ASTM D395	<35
Tensile Strength (Mpa)	ASTM D412	7.17
Elongation (%)	ASTM D412	325
Tear Resistance (ppi)	ASTM D624	112
Dielectric Strength (Volts/mil)	ASTM D149	386
Dielectric Constant (1 kHz)	ASTM D150	2.76
Dissipation Factor (1 kHz)	ASTM D495	0.003
Dry Arc Resistance (Seconds)	ASTM D495	124
Volume Resistivity (Ohm-cm)	ASTM D257	10 ^14

REACH COMPLIANT · COMPLIANT

QMS ISO 9001 : 2015 REGISTERED

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Company Number - 08350831 | VAT Number - GB 156 8355 80

REV 02
04/24

https://therubbercompany.com/wp-content/uploads/2013/05/RC0307-60-Nitrile-BS2751-Rubber-Sheeting-Datasheet.pdf

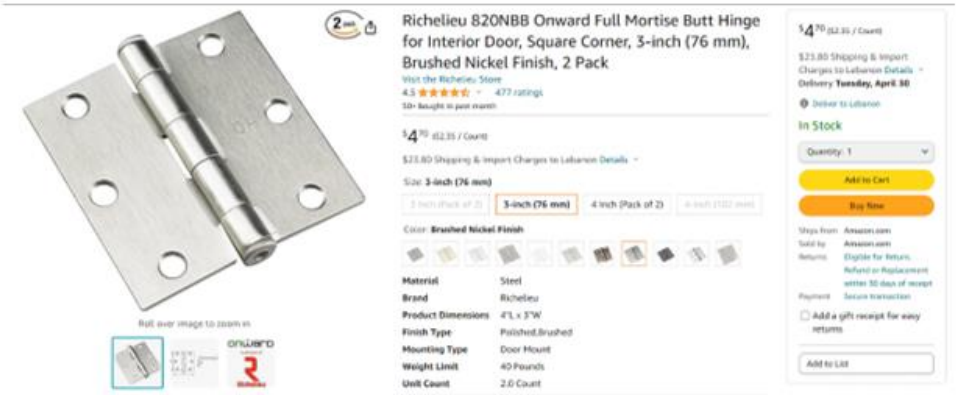
Figure 44. Silicone seal

For sealing, we used the sealant in figure 44.

PART 5

Figure 45. Water Tank

PART 6



Technical Details

Material	Steel
Brand	Richelieu
Product Dimensions	4"L x 3"W
Finish Type	Polished,Brushed
Mounting Type	Door Mount
Weight Limit	40 Pounds
Unit Count	2.0 Count
Manufacturer	Richelieu
Part Number	820NBB
Item Weight	7.2 ounces
Country of Origin	China
Item model number	820NBB
Size	3-inch (76 mm)
Color	Brushed Nickel Finish
Style	Square
Finish	Polished,Brushed
Item Package Quantity	1
Number Of Pieces	2
Maximum Weight Capacity	40 Pounds
Included Components	Box of 2 hinges, screws/nails
Batteries Required?	No

Figure 46. Hinge 3 holes

Testing Phase

During the testing phase of MediCleanse, several unexpected issues arose that required immediate adjustments.

- **Nozzle Positioning:** The nozzles weren't effectively spraying the collar and brush. We corrected this by changing the angles to increase the spray coverage.
- **Electrical Connections:** The pins and wires in the electrical/control system were not securely connected. We resolved this by soldering them to ensure stability and prevent disconnections.
- **Rack Positioning:** The rack holding the medical equipment was too low, causing it to miss the brushes. We adjusted the height of the rack to ensure proper cleaning.
- **Gear Friction:** There was noticeable friction in the gears' meshing. To fix this, we applied a lubricant, which allowed for smoother shaft rotation.

These adjustments were necessary to improve MediCleanse's functionality, ensuring it worked efficiently and as intended.

Final Product:

We put together the final version of our medical washer by carefully fitting the steel cleaning tank into its wooden case. To make sure we had solid electrical connections that wouldn’t come loose, we soldered all the wiring securely. We also added an LCD screen with a power switch to make it easy for users to turn the machine on and off. The last touch was painting the wooden box black, which looks good and doesn't show dust easily – practical for the kind of environments it will be used in.

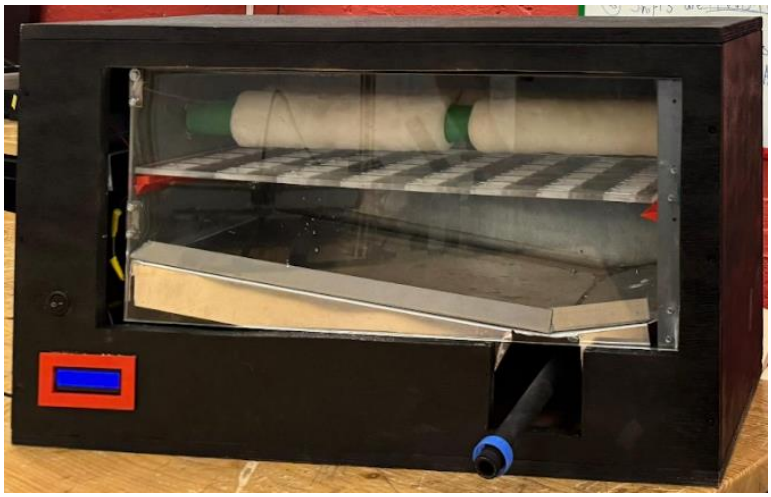


Figure 39. Final Product

Figure 40. Top view of Medicleanse on the inside

MediCleanse complies with the hygiene standards for medical equipment set by the Lebanese Red Cross and Civil Defense. The design also aligns with international standards (2). For waterproofing, we will follow the IP67 standard to guarantee no water leakage (5). Moreover, for the safety standards we will go for IEC 60601-1.

Discussion and Analysis

- Innovative Solution for Critical Needs:

MediCleanse represents a significant innovation in the field of emergency medical services (EMS) by addressing a critical need for efficient and effective cleaning of medical equipment. Traditional methods of manual cleaning not only consume valuable time but also may not ensure thorough sterilization, posing risks to both patients and medical professionals. By introducing a dedicated washing machine tailored for ambulance use, MediCleanse offers a streamlined solution that enhances hygiene standards and optimizes the readiness of EMTs for life-saving interventions.

- Market Potential and Competitive Advantage:

With minimal competition in the market for portable washing machines specifically designed for medical equipment sterilization, MediCleanse enjoys a unique positioning as a first-mover. Its focus on portability, user-friendly design, and compatibility with emergency vehicles gives it a competitive edge over conventional washing machines intended for household use. Moreover, the extensive research conducted to identify customer needs and specifications ensures that MediCleanse is well-aligned with the requirements of its target market, further enhancing its potential for success.

- Impact on Emergency Medical Services:

The introduction of MediCleanse has the potential to revolutionize the way medical equipment is cleaned and sterilized in emergency settings. By significantly reducing the time and effort required for cleaning, EMTs can allocate more resources to patient care, thereby improving overall efficiency and response times. Additionally, the assurance of consistently clean equipment mitigates the risk of cross-contamination and infection transmission, safeguarding the health of both patients and medical professionals. In essence, MediCleanse not only enhances the operational capabilities of EMS but also contributes to better patient outcomes and overall healthcare quality.

- Challenges and Future Considerations:

While the concept of MediCleanse holds immense promise, several challenges and considerations lie ahead. Ensuring widespread adoption and acceptance among EMS organizations and healthcare facilities will be crucial for its success. Effective marketing strategies, partnerships with key stakeholders, and demonstration of tangible benefits will play vital roles in overcoming initial skepticism and driving adoption. Furthermore, continuous innovation and adaptation to evolving technological and regulatory landscapes will be essential to maintain MediCleanse's competitive edge and relevance in the market.

In conclusion, MediCleanse represents a groundbreaking innovation in the realm of emergency medical services, offering a tailored solution to address a critical need for efficient equipment sterilization. With its potential to enhance operational efficiency, improve patient outcomes, and elevate hygiene standards in emergency settings, MediCleanse has the capacity to make a significant impact on the healthcare industry, reaffirming its status as a pioneering product in the field of medical equipment sanitation.

References

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Amazon.com: Super deal compact mini twin tub washing machine 13lbs capacity portable washer wash and spin cycle combo, built-in gravity drain for camping, apartments, dorms, college, RV's and small spaces : Appliances. (n.d.-b). https://www.amazon.com/SUPER-DEAL-Portable-Apartments-Delicates/dp/B07B94ZR74

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Appendix

Surveys

Survey 1

We carried out a survey within the Gemayze department of the Red Cross, collecting 20 responses. The survey's objective was to assess the feasibility of our product and to identify the specifications deemed most essential by users.
The questions posed were designed to delve deeper into the necessity for the washer and to pinpoint the specifications that would make it truly beneficial.

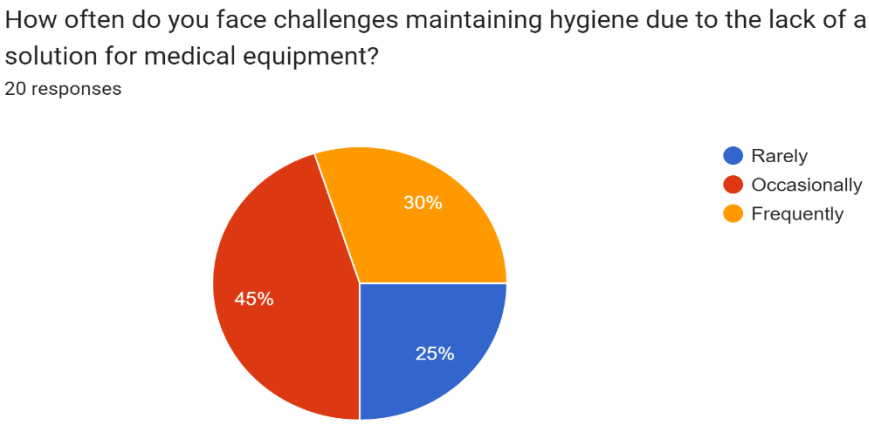

Figure 41. Data from the survey showing the percentage of EMTs struggling to clean medical equipment

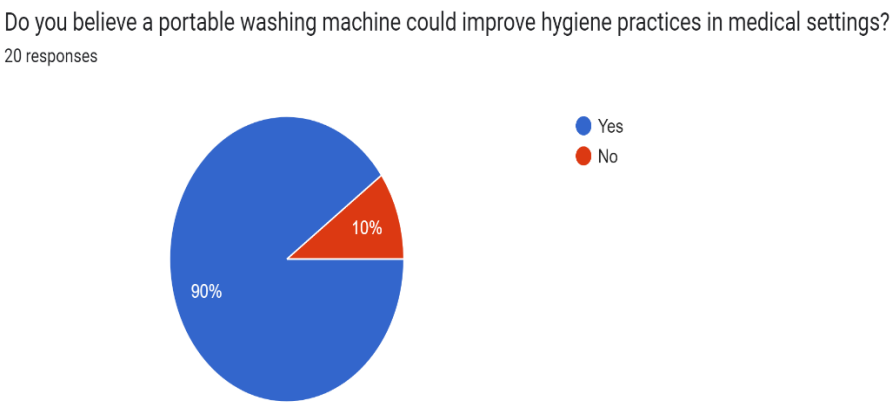

Figure 42. Data from the survey showing the need for the washer

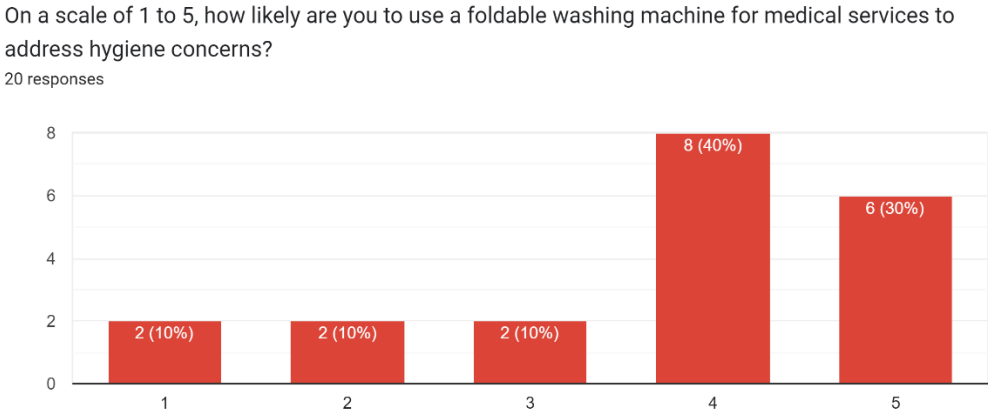

Figure 43. Data from the survey showing the likelihood of purchasing the washer

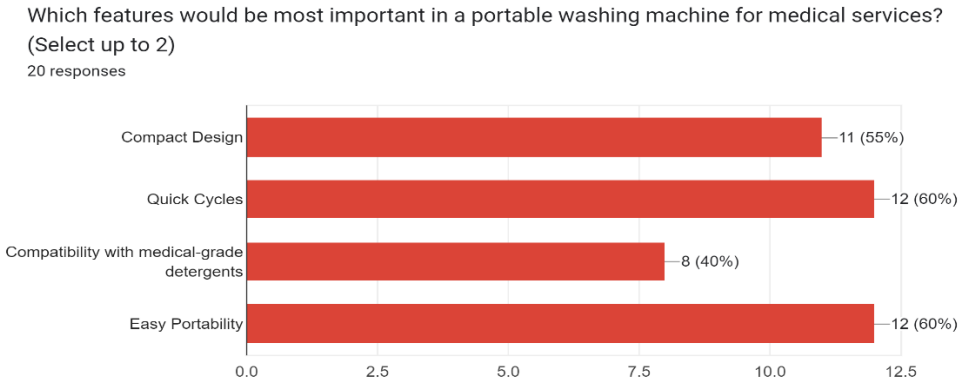

Figure 44. Data from the survey showing customer needs

Based on surveys we determined the two main specifications that we will be focusing on.

- The washer is easy to move around

The washer is compact and easily portable. (Primary need)
The washer installation can be easily done with no prior experience needed. (Primary need)
The washer is light in weight. (Secondary need)

- The washer quickly washes the equipment

The washer should have short cycles. (Primary need)
The washer should incorporate pre-programmed wash cycles tailored specifically for different types of equipment. (Secondary need)

- Unfulfilled need:
- Our washer does not have the capability to measure cleanliness automatically. Therefore, EMTs are required to manually inspect the equipment after each wash cycle to ensure it meets cleanliness standards before releasing it for use.
- Ensuring water and energy efficiency won't be feasible if our primary focus is on achieving quick washing cycles.

Survey 2

After building the alpha prototype we conducted a second survey among EMTs to get feedback.

1. How would you rate the overall design of the portable washer prototype?

More Details Insights

Excellent	2
Good	7
Fair	2
Poor	0
Very good	0

Figure 45. Protype rating

2. Does the prototype seem visually appealing to you?

More Details

Yes	11
No	0
Other	0

Figure 46. Feedback to the washer's design

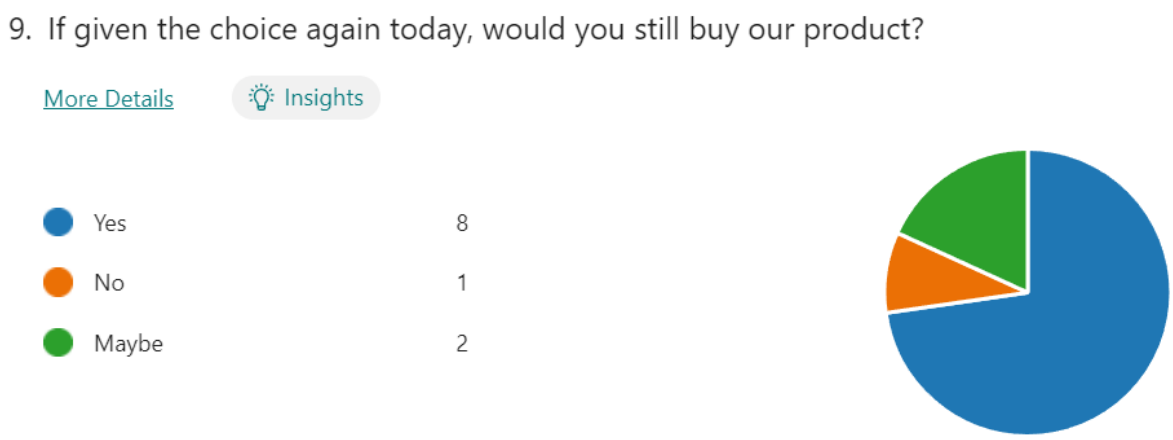

Figure 47. Data showing the likelihood of the washer's purchase

Based on the survey responses, here's a summary of the feedback on the focused prototype of the portable washer:

- **Overall Design Rating:** 70% of respondents rated the design as "Good," 20% as "Excellent," and 10% as "Fair."
- **Visual Appeal:** 100% of respondents found the prototype visually appealing.
- **Intuitiveness:** 60% of respondents found the interaction with the prototype to be "Somewhat intuitive," while 40% found it "Very intuitive."
- **Fit Within Ambulance:** 80% of respondents believe that the prototype would fit well within an ambulance, while 20% had concerns about its fit.
- **Ease of Handling and Storage:** 60% of respondents rated the ease of handling and storage as "Somewhat easy," and 40% rated it as "Very easy."
-

This feedback suggests that the prototype has been well-received in terms of its design and visual appeal. However, there are areas for improvement in intuitiveness and ease of handling and storage to ensure better fit and functionality within an ambulance.

The creation of this visual prototype represents the initial step in a user-centered design process. It's an opportunity to align the product's physical presence with the users' needs and preferences.

Approach to getting organized and identifying customer needs

We first started off by identifying a problem: EMTs expend considerable effort cleaning their equipment manually, a process that is both time-consuming and ineffective.

Subsequently, we conducted market research and found minimal competition, indicating an unexplored market opportunity. This gap in the market motivated us to pursue the development of a solution.

We chose to develop a washer specific for ambulance use to make the lives of EMTs easier.

After evaluating market interest, we conducted surveys with our target audience—EMTs—and

discovered that 90% of respondents expressed interest in such a product. We also included a section dedicated for them to specify their needs.
Next, our plan involves identifying the specifications of our product and the materials required by researching those compatible with the disinfectants used by EMTs. Additionally, we will design the product, conduct testing, and create a prototype.

Benchmark

Since our product was first to market we weren't able to properly benchmark it against existing products however we were inspired by the following product for certain features in our medical washer:

1. Grinchat mini washing machine

Figure 48. Grinchat mini washing machine

Technical Details

Brand Name	GRINCHAT
Model Info	X-1
Item Weight	3.63 pounds
Product Dimensions	12.2 x 12.2 x 13.39 inches
Item model number	X-1
Efficiency	High Efficiency
Capacity	11 Liters
Max Spin Speed	1500 rpw
Noise	40 dB
Installation Type	Freestanding
Part Number	12345
Special Features	Adjustable Leveling Legs
Color	Purple
Control Console	Touch
Standard Cycles	5000
Access Location	Top Load
Voltage	110 Volts (AC)
Wattage	36 Watt-hours
Crispers/Drawers	1
Material Type	Plastic
Included Components	Power Cord, Mini Washing Machine, Drain Hose
Batteries Included?	No
Batteries Required?	No

Figure 49. Grinchat mini washing machine specifications

2. SereneLife mini washing machine

Figure 50. SereneLife mini washing machine

Brand Name	SereneLife
Model Info	PUCWM44
Item Weight	7.54 pounds
Product Dimensions	14.76 x 5.12 x 12.6 inches
Country of Origin	China
Item model number	PUCWM44
Efficiency	Energy Efficiency
Capacity	0.8 Kilograms
Part Number	PUCWM44
Special Features	Portable, Lightweight
Control Console	Push Button
Standard Cycles	1
Access Location	Top Load
Included Components	Cover
Batteries Required?	No

Figure 51. SereneLife mini washing machine specifications

Meeting Minutes

Meeting #1		
Date: 26/01/2024	Time: from 4PM till 5PM	Location: Red Room
Meeting called by	Team members	
Attendees	Celine Issa, Elie Daou, Assad Georges, Kevin Ibrahim, Tommy Hajjar	
Minutes taker	Kevin Ibrahim	
Agenda Item: Introduction to the MediCleanse project		
Discussion	**a new device designed for sterilizing medical equipment**	
The team introduced the MediCleanse project, a new device designed for sterilizing medical equipment. Initial sketches and designs were presented and discussed.		
Conclusions		
▪ Agree on pursuing further research into design feasibility and market needs.		

Action Items	Person Responsible	Deadline
Discussed the efficacy of the product.	Team	By next meeting
Discussed with Elie Daou an active red cross member about our product	Team	By next meeting

Meeting #2		
Date: 03/02/2024	Time: from 6:00PM till 7:00PM	Location: Red Room
Meeting called by	Team members	
Attendees	Celine Issa, Elie Daou, Assad Georges, Kevin Ibrahim, Tommy Hajjar	
Minutes taker	Kevin Ibrahim	

Agenda Item: Discuss feedback from initial concept presentation	
Discussion	

Feedback from class and professor on initial concepts was discussed, highlighting the need for portability and efficiency.

Conclusions	

- Agree on pursuing further research into design feasibility and market needs.

Action Items	**Person Responsible**	**Deadline**
Conduct market analysis and gather more data on customer requirements	Team	By next meeting
Find benchmarking criteria	Team	By next meeting

Meeting #3		
Date: 28/02/2024	Time: from 8PM till 10PM	Location: OXY
Meeting called by	Team members	
Attendees	Celine Issa, Elie Daou, Assad Georges, Kevin Ibrahim, Tommy Hajjar	
Minutes taker	Kevin Ibrahim	

Agenda Item: Present redesigned product concepts	
Discussion	

Redesigned product concepts were presented. The team finalized the list of features, emphasizing user-friendliness and compatibility with medical equipment.

Conclusions	

- Approve the features list and move forward with prototype development.

Action Items	**Person Responsible**	**Deadline**
Drew our concept sketches	Team	By next meeting
Sent a survey to the Lebanese red cross approving our sketches	Team	By next meeting

Meeting #4		
Date: 28/02/2024	Time: from 11PM till 12:00PM	Location: BDH
Meeting called by	Team members	
Attendees	Celine Issa, Elie Daou, Assad Georges, Kevin Ibrahim, Tommy Hajjar	
Minutes taker	Kevin Ibrahim	
Agenda Item: Discuss initial testing plans		
Discussion		
Progress on the prototype was shared. Initial testing plans were outlined, focusing on sterilization effectiveness and operational efficiency		
Conclusions		

- Continue with the development and start preparing for initial tests

Action Items	Person Responsible	Deadline
	Team	By next meeting

Meeting #5		
Date: 3/03/2024	Time: from 8:00PM till 10:00PM	Location: Red Room
Meeting called by	Team members	
Attendees	Celine Issa, Elie Daou, Assad Georges, Kevin Ibrahim, Tommy Hajjar	
Minutes taker	Kevin Ibrahim	
Agenda Item: The low-resolution prototype		
Discussion		

The initial concept sketch was selected, and there was discussion about developing a low-resolution prototype.

Conclusions	

- We must determine how to execute the low-resolution prototype and initiate its development.

Action Items	**Person Responsible**	**Deadline**
Decide on material used for the low-resultion prototype	Team	By next meeting
Begin building the low resolution prototype	Team	By next meeting

Meeting #6		
Date: 16/03/2024	Time: from 8:00PM till 10:00PM	Location: Red Room
Meeting called by	Team members	
Attendees	Celine Issa, Elie Daou, Assad Georges, Kevin Ibrahim, Tommy Hajjar	

Minutes taker	Kevin Ibrahim
Agenda Item: The low-resolution prototype	
Discussion	
Built our low-resolution prototype	
Conclusions	
▪ We must take it to the red cross for a survey about the design	

Action Items	Person Responsible	Deadline
Surveyed the Redcross	Team	By next meeting

Meeting #7		
Date: 23/03/2024	Time: from 6:00PM till 8:00PM	Location: Red Room
Meeting called by	Team members	
Attendees	Celine Issa, Elie Daou, Assad Georges, Kevin Ibrahim, Tommy Hajjar	
Minutes taker	Kevin Ibrahim	
Agenda Item: our final product		
Discussion		
Begin discussing about how to manufacture our prototype Decided what electronics and components will be used		
Conclusions		

- We must start manufacturing the prototype

Action Items	Person Responsible	Deadline
Decided on material used for the prototype	Team	By next meeting
Begin manufacturing our prototype	Team	By next meeting

Meeting #8		
Date: 3/03/2024	Time: from 6:00PM till 8:00PM	Location: Red Room
Meeting called by	Team members	
Attendees	Celine Issa, Elie Daou, Assad Georges, Kevin Ibrahim, Tommy Hajjar	
Minutes taker	Kevin Ibrahim	
Agenda Item: shaft rotation mechanism		
Discussion		

Did a research on shaft rotation and gears

Conclusions

- Used gears to rotate our shafts due to dimension constictions

Action Items	Person Responsible	Deadline
Built our gear box and final product	Team	By next meeting