aquaflo
WATERMAKER

MDES Project Report: Watermakers – Desalination and Hydration at Sea

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ABSTRACT

In this exegesis the term Watermaker has been used to describe a survival product that creates fresh potable drinking water from saltwater.

Of all the water on the earth ninety seven percent of it is saltwater. Of that three percent that is fresh water only point five percent is of a quality safe enough for drinking (Kim, Hee Ko, Kang, & Han. 2010).

When a person is stranded on a life vessel or in a situation where freshwater is not readily available, a survival product that produces fresh water has the possibility of prolonging the life of that person. Designing a product that provides fresh water and thus preventing the dehydration of someone in a survival situation was the aim of this project.

The final product meets the design criteria of being energy efficient and easy to use. By achieving this, the end user is provided with a product that is immediately usable and requires a low expenditure of energy when in use. Product testing and usability studies were carried out during development to ensure that the design criteria were fulfilled.

Research revealed that there is a need for a product of this kind that sits in the more affordable end of the market. Design challenges involved creating a product that requires minimal parts and keeps manufacturing costs low. Achieving this resulted in a more affordable option to the consumer, with the intention of making them more inclined to purchase the product that may some day save their life. Furthermore, low cost can open up opportunities in markets that would otherwise have been precluded by price sensitivity, such as in developing nations.

Of the two main desalination processes in use today (reverse osmosis and distillation), distillation was chosen as it offered more affordable design options and production methods. This product is unique in its function of using the sun's energy to gather water through condensation. Utilising the suns energy to generate fresh water made this product more suited for warmer climates; however testing showed it was still productive in cooler climates.

A product of this nature could be used in any situation where fresh, potable water is required – not just survival circumstances. With water shortage and quality becoming a global concern this product offers a low cost, easy to use option for producing drinking water. Over 80% of the global third world population is situated within the tropics. The low cost of this product coupled with the warmer temperatures found in the tropics means this product is ideally suited for use in developing nations.

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1.0 INTRODUCTION

A Watermaker is a survival product designed to produce fresh water in situations when it is not available. They are used on both coastal and offshore vessels and are stored as an emergency product. The importance of having such a product gives the users peace of mind that if something were to happen they would have an increased chance of survival.

The aim of this project was to develop a survival product that can produce fresh water while on life rafts or in situations where fresh drinkable water is not available. The product has a focus on the marine environment and helping prevent dehydration among individuals in survival situations. It was to use either reverse osmosis or distillation as a desalination process the end result offering an alternative solution to existing contemporary products.

This exegesis documents the research and design exploration carried out to fulfil the aim. The research begins with an emphasis on the importance of hydration and the effects of dehydration. The marine environment and potential ocean conditions are then discussed to give a greater appreciation for the products environment.

A research question was created to help provide direction for this project. The question states**:** How can we create a more effective and affordable survival product that aids the rehydration of people in situations where drinking water quality and quantity are an issue? The question was addressed by the research and design components. The focus of the research was intended to provide information that would lead to the development of design criteria that could satisfy this question.

A review of existing literature was carried out to understand the effects of chronic dehydration on an individual. There were discussions and conclusions that suggest how each piece of research could be considered when developing the initial concepts. The other literature consisted of a new desalination process currently in the development phase. Application of new technology was looked to for direction for some concepts making it important to review these in detail.

Products of this nature may be purchased and never used. Convincing the consumer to invest in a product they believe they will never use is a challenge. Offering a more affordable option to the consumer is a possibility, finding ways to make a product of this kind more affordable required research into the existing technologies and different methods of desalination. A review of the leading contemporary products by Katadyn and Aquamate is a key part of the research component. Analysis of the technology and design features highlighted the strengths and weaknesses of these products, with the findings helping direct the concept and development phase of the project.

A state of the art review was also completed on the leading contemporary product Katadyn Survivor06. With a focus on usability studies, product tests showed the strengths and weaknesses in this area.

Concepts were generated based off the developed design criteria established from the research component. The aim of the concept phase was to produce ideas that are unique and appear to have enough merit to develop further. Sketches and three-dimensional mock ups provided direction while working prototypes helped test ideas and theories generated in the concept phase.

Development of the strongest concepts addressed the problem in their own unique manner. Concept development was aided by further prototype testing as well as focus groups that provided feedback on the developed concepts.

Prototypes played an important role in the development process. Having a physical representation of a concept raised issues that may not have been considered otherwise.

The end result is a product that reflects the research component and fulfils the research question. The design satisfies the design criteria and represents a thorough development phase. The product offers the consumer a new exciting alternative to existing solutions.

2.0 Background

The following chapter will discuss issues based around this project highlighting the importance of hydration and the effects of dehydration on an individual. It will touch on the potential users of watermakers and the environments these products will be used in. Technologies of desalination methods will be discussed to help better understand potential processes that could be applied to product concepts. An interview with a member of the coastguard also gives insight into boating safety in New Zealand and the importance of safety equipment of small and large vessels.

2.1 Importance of Hydration

Avoiding dehydration is vital when in a survival situation. Water is the most important nutrient for the human body (besides oxygen) as your body can only survive a fraction of the time without water that it can without food (Kottusch, Pueschel, & Tillmann, 2009).

When a person starts using energy (walking, running sweating) they begin using water from their body that needs to be replaced, if they are using more water than they replace dehydration will occur. (Survival Topics, N.D.) This makes it important for people in survival situations to rest and use as little energy as possible to reduce the rate of dehydration.

Two thirds of an individuals body weight is water. When dehydration occurs the body will lose its efficiency “2.5% loss of body weight from water loss will result in 25% loss of efficiency” (Survival Topics, N.D.) This shows how critical it is to stay hydrated to ensure there are no poor judgements and irrational decisions that may put that person and others at risk. As a person succumbs to the effects of dehydration their blood becomes thicker and loses volume. This puts the heart under more pressure and causes it to work harder resulting in more energy loss.

Table 2.0: Survival Length in Shade – Water Quantity/ Temperature

Max Temp	No Water	.95L	1.9L	3.79L	9.46L	18.9L
48.9oC	2	2	2	2.5	3	4.5
32.2 oC	7	8	9	10.5	15	23
21.1 oC	10	11	12	14	20.5	32
10 oC	10	11	12	14.5	21	32

Severe dehydration puts the body under immense stress and strain however the victims will not suffer any long-term ill effects even with a loss of up to ten percent of the individual’s body weight. Once fluids are replaced the victims will recover very quickly. This chart reveals that there are many variables surrounding survival situations. The amount of water needed each day by an individual depends on various aspects regarding weather conditions and climate. This chart represents how much water an individual will need each day in the specified temperatures whilst resting in the shade. (Survival Topics, N.D.)

General Water Requirements

As hydration is so important it is useful to know what amount of water is required to reach a person’s optimal hydration level. Unfortunately general water requirements are highly variable and complex. Grandjean states that “because the water requirement is the amount necessary to balance the insensible losses (which can vary markedly) and maintain a tolerable solute load for the kidneys (which may vary with dietary composition and other factors), it is impossible to set a general water requirement" (2004).

The Food and Nutrition Board also explains that "there is not a single level of water intake that would ensure adequate hydration and optimal health for half of all apparently healthy persons in all environmental conditions". They go on to discuss how they are unable to provide an Estimated Average Requirement (EAR) or a Recommended Dietary Allowance (RDA) instead establishing an Adequate Intake (AI) intended to advise on the healthy intake of water for U.S and Canadian individuals (2004).

Adequate Intake of Water			
0 – 6 months	0.7 L/day of water, assumed to be from human milk.		
7 – 12 months	0.8 L/day of water, assumed to be from human milk and complementary foods and beverages		
1 – 3 years	1.3L/day		
3 – 8 years	1.7 L/day		
9 – 13 years	**Boys** 2.4 L/day	**Girls** 2.1 L/day	
14 – 18 years	**Boys** 3.3 L/day	**Girls** 2.3 L/day	
19 – 70+	**Men** 3.7 L/day	**Women** 2.7 L/day	

(Food and Nutrition Board. 2004)

From this information it can be seen that it is impossible to foresee how much water a person will require to survive. The table's suggestions are rough guidelines that do not guarantee adequate hydration. However any amount of fresh water will help to prolong an individual's life through rehydration.

Survival without Food

To ensure well being when in survival situations it is vital to eat to maintain good health. As with water, without food an individual may make irrational decisions that may jeopardise their survival. Some side effects after missing only a few meals include irritability, physical weakness, confusion, disorientation, poor judgement, weakened immune system and an inability to maintain body temperature which can lead to hypothermia, heat exhaustion or even heat stroke, (Survival Topics, n.d.).

Eating the wrong foods can also work against anyone in a survival situation. Meats and salty foods require a lot of water to digest, causing an individual to lose even more bodily fluids. (Survival Topics, n.d.)

Factors which influence survival times of individuals suffering from starvation include muscle mass, initial heath, body fat, metabolism and the temperature of the environment. It is believed that obese people can last from 3 weeks to 25 weeks depending on their initial heath. Doctors generally say that on average a healthy individual can last between 4 and 6 weeks. (Survival Topics, n.d.)

Will to Survive

When put in a survival situation a factor that keeps a person alive is their "determination to live" also known as "will to survive". Having a strong "will to survive" can in some cases help the individual overcome situations and adverse conditions that others would not survive due to their determination and desire to live. It is believed that the will can add several days or even a week to the length of survival without food or water. (Survival Topics. n.d).

2.2 Conditions at Sea

The following section will look at potential conditions sailors and offshore vessels could experience at sea. Understanding these conditions is necessary to help better appreciate and understand the environment the product will be used in. This knowledge will influence design choices and decisions.

Figure 2.0 Photograph – Ocean Conditions, Liferaft at sea. Adapted from "www.deskboss.blogspot.com". 23/10/2010.

Wind and Waves

There are only two main influencing factors that affect a vessel. These are wind and waves which are interrelated, "Waves are created by the transfer of energy from wind to water" (Toghill, 1994, p65). Waves are generated as the wind pushes across the oceans surface. This generates friction, or drag, that results in waves being produced. The sizes of the waves are dependent on the strength of the wind. The stronger the wind the more drag on the ocean surface, resulting in larger waves.

Another influencing factor to the size of the waves is the fetch. Fetch is "the distance over the water that the wind blows" (Toghill, 1994, p65). The further the distance the wind blows across, the larger the waves will be. A maximum wave height will eventually be reached which is determined by the strength of the wind and depth of the water. Lager waves can be generated by lighter winds if they are blowing across a greater distance.

It is not the size of the waves that creates problems for vessels at sea it is the shape of the waves. Small steep spilling waves can be more dangerous than large rolling waves. Waves will spill or break in a depth that is half the height of the wave. This makes oceans with shallow waters or coastlines dangerous for vessels in turbulent sea conditions. (Toghill, 1994, p.69).

One of the most dangerous passages of water is Cape Horn. This is due to the continental shelf that runs along the southern tip of South America. It is the shallow waters in the area that create such dangerous sea conditions for vessels passing through. It is the shallow waters that create spilling waves, making it "highly dangerous even to giant ships, let alone small yachts" (Toghill, 1994, p69).

Most well built vessels and small craft are entirely capable of sailing through heavy seas and gale force winds. If the vessels were to encounter extreme weather conditions such as cyclones and hurricanes the vessels

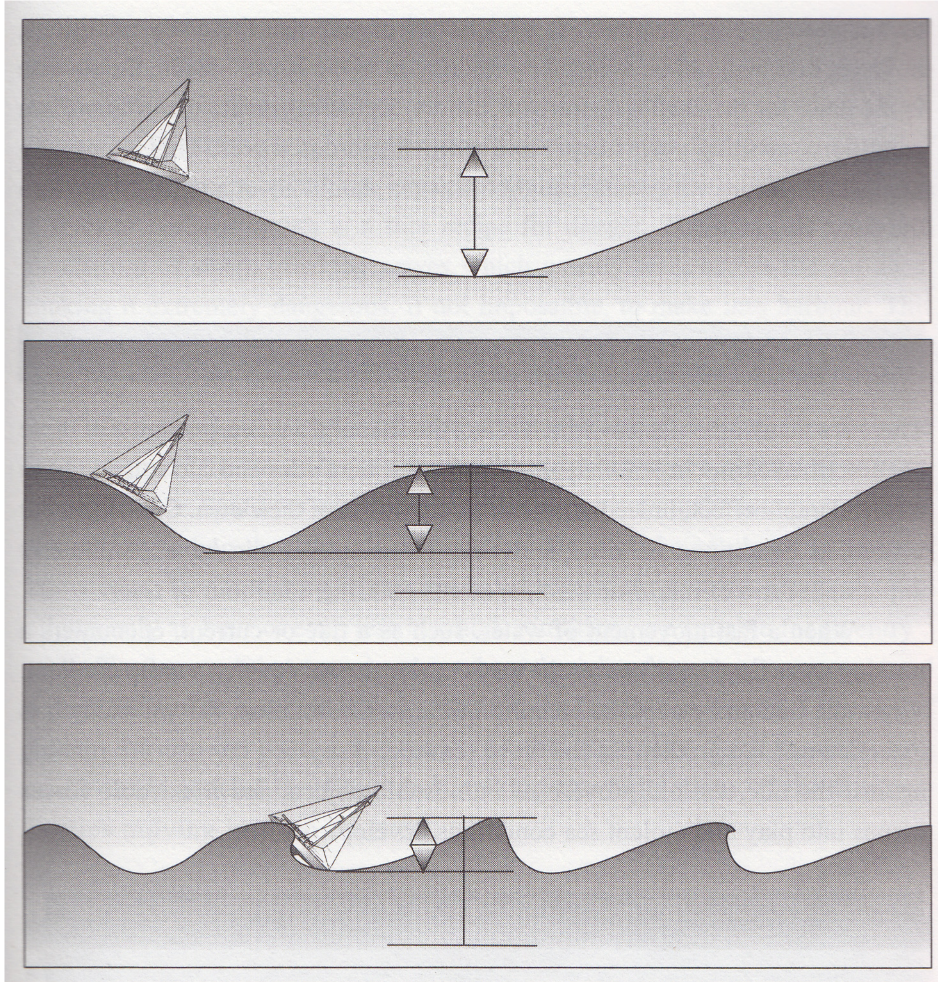


Figure 2.1 Illustration – Showing the danger of different waves and their shape. Adapted from, Toghill, J. (1994). *A manual of heavy weather sailing*, pg 69.

may be overwhelmed. (Toghill, 1994, p68). It is in these situations where sailors or individuals may have to abandon ship and board a life vessel.

High and Low pressure Systems

High-pressure systems also know as anticyclones are generally termed "fair weather systems". High pressure generally brings stable fine weather patterns. The systems spread over a wide area and will bring light to moderate winds at sea and pleasant weather conditions. It is very rare that these pressure systems will bring severe winds. (Toghill, 1994, p80).

Table 2.1 Wind Speed Chart – Showing the maritime descriptions and speeds. Adapted from, Pardey, L., & Padey, L. (2008). *Storm Tactics Handbook* pg 10.

Wind-Speed Chart

Beaufort Scale	Speed in knots (measured at 33 feet)	Meters per Second	Maritime Description
Force 0	less than 1	.5	Calm
Force 1	1-3	.5-1.5	Light air
Force 2	4-6	2-3	Light breeze
Force 3	7-10	3.5-5	Gentle breeze
Force 4	11-16	5.5-8	Moderate Breeze
Force 5	17-21	9-10.5	Fresh Breeze
Force 6	22-27	11-13	Strong Breeze
Force 7	28-33	14-16	Near Gale
Force 8	34-40	17.5-20	Gale
Force 9	41-47	21-24	Strong Gale
Force 10	48-55	25-28	Storm
Force 11	56-63	29-32	Violent Storm
Force 12	64 plus	33 plus	Hurricane

High pressure systems would be more desirable when stranded on a life raft. However large high pressure systems in the tropics could also result in clear skies and very hot weather conditions. Stranded in a life vessel in such conditions would cause a faster rate of dehydration for the individuals.

Low pressure systems are considered "dirty" systems. They are associated with unstable and unpleasant weather conditions including strong winds and turbulent waters. They have seasonal trends and can be more unpredictable and problematic in the right season. Vessels could experience gale force winds and pressure systems that can potentially develop into tropical storms (Cyclones, Hurricanes and Typhoons). Tropical storms are the most feared weather conditions for offshore and inshore vessels. (Toghill, 1994, p80-81).

Low pressure systems would cause the most concern for people stranded on a life raft of damaged vessel, as they would have little or no control over there raft or vessel and there is the possibility of it turning into a Tropical Revolving Storm which have low survival rates.

Tropical Revolving Storms

Storms, Hurricanes or Typhoons are correctly known as tropical revolving storms and occur in low pressure systems. These are the most feared of all storms at sea with "Yachts and small craft rarely surviving a passage through one" (Toghill, 1994, p91). They are confined to the tropical ad sub tropical belt and will lose their severity when they move out of the region.

Tropical revolving storms are a large low/depression system. They are capable of radiating over four hundred kilometres with winds reaching speeds of up to 250 kilometres per hour. The waves and phenomenal winds these storms bring are what can be so devastating. Chances of surviving such conditions on a vessel or life raft are considered extremely minimal. (Toghill, 1994, p91).

Tropical storms are seasonal and occur at different times of the year in different oceans. The following chart displays the different storm types, seasons and locations they occur.

Type	Season	Location
Hurricanes	July – November	North Atlantic (Western)
Typhoons	July – November	North Pacific (Western)
Cyclones	June – November	Bay of Bengal, Arabian Sea
	November – April	South Pacific (Western)
	November – April	South Indian Ocean (Eastern)

(Toghill, 1994, p93)

Storms or gales only represent a very small percentage of sailing time for offshore vessels. Pardey & Pardey back this up explaining that of all their hours at sea (10,600 approx) only 300 hours were spent in such conditions with gale force winds with a "force 8" rating. That equates to only 3.5 percent of his time at sea. (2008, p.27)

Although the reason for being stranded on a life raft or damaged vessel may be due to a storm the chances of experiencing multiple storms and such conditions at sea for a prolonged period of time is very unlikely.

Large storms are a major threat to small and large vessels. However it is of greater concern to offshore vessels as there is generally little time to avoid an incoming storm.

2.3 The Life Raft

The following passage will look into the life raft and its qualities. Understanding the different rafts will give a greater appreciation for the conditions and environment on board a life raft. It also helps establish a set of design criteria regarding usability and functionality for the developed product.

Figure 2.2 Photograph – A photograph of a coastal life raft. "www.iboats.com/reverecoastalcompactliferafts" 22/10/2010

Features

The majority of life rafts come with mandatory safety equipment including flairs, safety blankets, bailers, water and some basic foods. Some designs also have a canopy to protect the users from the harsh sun. An increase in cost will most likely result in better material, and more safety equipment. (www.safetyatsea.co.nz, n.d.)

Most life rafts are a circular or hexagonal type shape. They either consist of a single or double walled pontoon. Double walled pontoons offer greater stability in rough conditions and are also more reliable. However they do cost more to purchase due to the extra cost in materials and labour. Double walled life rafts are more suited for offshore vessels and single walled rafts for coastal situations. (www.safetyatsea.co.nz, n.d.) Life rafts come in a range of sizes. The number of people it can hold determines the rafts size and specifications. Common sizes are 4-6 man life rafts for offshore yachts and coastal vessels. Bigger rafts are available for large ocean going ships with capabilities for over 50 people.

Figure 2.3 Photograph – A photograph of an offshore life raft. "www.tcschandlery.co.uk/waypointoffshoreliferaft" 22/10/2010

Materials

Life Rafts are made from a range of materials. There are rubber based rafts and PVC based rafts. Rubber based rafts are made from cloth material, rubber and neoprene. These types of rafts have been used sine the 1940's and have been proven reliable over the years. This type of construction is more costly to produce, as they are handmade. (www.safetyatsea.co.nz, n.d.)

PVC liferafts are made with cloth based PVC or urethane material on both sides. The seams are heat welded making them less costly to produce. They have an outer shell to protect an inner tube made from rubber/polyurethane. (www.safetyatsea.co.nz, n.d.)

Costs

The purchase of a life raft is similar to that of a Watermaker. Both products are expensive and will most likely never be used. Prices start at around $1000.00 (New Zealand Dollars) for a 4-man and can reach over $4000.00 (New Zealand Dollars) for an 8-man life raft. Inflatable life rafts have a lifespan of ten to fifteen years and will require a service every 1-2 years. Which is an additional cost.

The interview with Neil Murray (New Zealand coastguard) revealed that most people are not prepared to spend large amounts of money on a product that they will never use. Life Rafts are expensive products however they are made to be as affordable as possible. He continued to explain that because of this, life rafts are made of cheap materials and are not something that you would want to be stuck on for a long period of time. If they were made of similar materials to inflatable runabout boats the cost of a life raft would be too expensive and people would not purchase them.

Conclusion

Each situation and scenario will be different due to varying ocean conditions, locations, weather patterns and the individual's life rafts. As there is a range available to consumers it will be unknown what type each vessel will be carrying. So the size and designs will be unknown. Each share similarities and it can be assumed that the life raft consists of inflatable pontoons. The life rafts are designed to be as durable as possible however a sharp object or open flame could potentially puncture a pontoon and putting the people in even more danger. It is important not to design something that could put the individuals in even more danger.

The users will most likely be wet from waves that spill over the sidewall. Depending on the location the people may be cold and suffering from the effects of prolonged exposure to such conditions resulting in hypothermia and depending on the number of people on board space may be limited. All those contributing factors take a toll on the mental condition of the people on the life raft. The mental state of people in such survival situations is very fragile which is reinforced by the review of the book "Treading Water" by Rob Hewitt in the literature review section of this report. After just 24 hours without water Rob was having hallucinations and struggling to understand what is real and what is not.

Hydration will be another contributing factor to the mental state of the people on board. As mentioned earlier people start to loose 25% of their efficiency with 2.5% body weight loss through dehydration.

The final design must acknowledge all those factors. The design must be easy to use and require little interaction to function allowing the users to rest and reserve valuable energy to prolong their survival.

2.4 New Zealand Context

New Zealand has a coastline of over 15000km. This is the 10th longest of all countries in the world. No matter where you live in New Zealand, within a few hours you can reach the ocean. It is this exposure to water and water activities that sets New Zealand up as an ideal candidate for this type of project.

Every year there are over 100 offshore boating accidents in New Zealand waters. Eighteen percent of all drowning in New Zealand take place offshore, with ninety two percent of the victims being male. Statistics show the further from the shore the accident takes place, the smaller the chance of survival. (Water Safety New Zealand, n.d)

2.5 Users

Potential users for this product are any person who may find themselves in a boat offshore while the purchasers are more likely to be boat owners and enthusiasts that regularly take part in recreational boating activities.

In the initial stages this project will look to primarily target the users in the boating market and secondly for use in areas that are suffering from water shortage due to non-potable fresh water.

Varying from youth to the elderly, the user demographic mainly consists of males. This is due to earlier research revealing that of all offshore drowning within New Zealand ninety two percent of the victims were male. (Water Safety New Zealand, n.d).

To ensure a larger potential market this product needs to cater for many marine environments and activities. This means that the product could be used in smaller craft such as runabouts to offshore vessels, which are considered to be around ten to twenty feet in size. Marketing the product towards smaller vessels opens up a new potential consumer. With the high cost of existing products they are more targeted at larger offshore boats. A more affordable option to smaller craft may be enough to convince the consumer to purchase such a product.

Other potential users and markets are for areas that suffer water shortages due to poor water quality. The developed concept could be used to purify the dirty water into a suitable condition for drinking.

2.6 Technologies

Desalinisation

"Desalinisation is the processing of seawater to obtain pure water through the separation of dissolved saline components" (The encyclopaedia of Science and Technology, D, pg 338)

With 40 years of intensive research and development in saltwater desalinisation only two processes have reached large-scale commercial success. These are the distillation and reverse osmosis processes. There are three types of commercial desalinisation plants. Two used distillation while the other one reverse osmosis.

Distillation

Multistage Flash distillation and Multiple-effect distillation are the two commercial plants. They use a very similar process with the only significant difference being the productiveness and energy efficiency. Multiple effect distillation works by heating seawater to evaporate pure water that has become condensed through the distillation process. The heating is driven by low-temperature steam as a heat source.

Reverse Osmosis

The other commercial plant design uses Reverse Osmosis which works by using a filtration process with a semi permeable membrane. The membrane is generally composed of a polymer and consists of spiral-wound and hollow fibre modules.

All solutions have a specific osmotic pressure. When this pressure is reversed through a membrane a filtration process at a molecular-ionic level will take place removing salt from the solution. In practice the membrane will remove approximately 98.4% of the salt from the solution. This process is the most commonly used with current hydration products. (Kupitz, J, 2002).

In a natural environment "osmosis works by water passing through a membrane from pure water or from a dilute solution into a more concentrated solution" (Kupitz, J, 2002).

2.7 Interview

This interview is with the New Zealand Coastguard, Neil Murray. Neil has a vast amount of experience surrounding boating and safety on vessels in New Zealand and Internationally. Having skippered a yacht in the BT Global Challenge around the world race, Neil is someone that has the potential to give great insight into this project.

It has been completed in three sections. Personal: where an understanding of Neil and his boating experience is gained, Boating/ Ocean safety, and Watermakers and Survival equipment.

The documentation of this interview includes excerpts of direct quotes from the interviewee as well as summarising some of the key issues discussed.

Personal

How long have you been working for the coastguard and what does your role consist of?

"Seven years as the Training and Development Manager". He then stated that coastguard is responsible for issuing over 10 000 certificates every year for training in boating activity. There are approx 11 employees for the coastguard and the rest are volunteers (over 12 000) across New Zealand.

What kind of boating experience have you had?

Neil has been boating all his life. With an impressive portfolio consisting of skippering a yacht in the famous around the world yacht race BT Global Challenge. Neil has sailed in various climates and conditions.

Have you ever experienced a boating accident/survival situation?

After I asked this question Neil paused and said that he was involved in a serious boating accident that occurred on a "reef off the coast of Africa". (I did not pursue this question any further as this was potentially a very personal and sensitive subject)

Later in the interview he did mention that he had not been on a boat that had completely sunk in mid ocean.

What is the most valuable thing you have learnt while working for the New Zealand coast guard?

"The importance of a flotation and communication device" The response to this question diverted a little and we began to talk about how "trailer power boats are the most popular craft in New Zealand" Thus why they are responsible for the majority of fatalities across the country.

Boating/ocean safety

How do you rate New Zealand conditions in regards to boating safety? (i.e. Unpredictable)

In response to this question Neil said that "it is no worse than other countries". He went on to talk about how there is a preconception about New Zealand being unpredictable and dangerous, however he believes that it is no more dangerous than any other country. Much of the risk comes from inexperience when conditions change.

Do you believe that the New Zealand boating public is well educated about these conditions and boating safety within our country?

"It's getting much better" he continued and mentioned how there is approx 400 000 boats in New Zealand and that 1.3 million New Zealanders go boating in some form every year. If they can educate just a portion of all those people then they are doing their job.

What do you believe would help reduce boating accidents in New Zealand?

"Education", the use of life jackets and communication devices such as epirb radios.
(An epirb radio is a portable safety device that sends an emergency signal via satellite when activated, giving an exact location of the device)

Is there a need for formal training and education required before an individual purchases a boat in New Zealand?

Neil stated that this is the big debate at the moment within the industry. The question is by having a license will there be reduced fatalities? His belief is that if a license were to be put in place there would be regulations on a specific size of the boat and engine. However the most common accidents occur in small craft with small engines (approx 12 feet with 15 hp motor) which would probably not require a boating license to operate. Later he did conclude that "yes" a license would probably be a good idea if it were going to save lives.

How many boating accidents occur in NZ waters every year?

There are on average "10 fatalities every year" this fluctuates. Neil mentioned how it had been as low as 6 per year. However last year there were more than 12 fatalities.

How many (or percentage) of them are in the Auckland region?

"A vast majority are in Auckland", he said that 50% of New Zealand boating activity occurs in the Auckland region. We then talked about how the coastguard works. Neil said that in the Auckland region the coastguard works like an "AA car membership" and will respond when boats run out of fuel and have flat batteries. However in areas such as Gisborne they will only respond to an accident that involves injury or vessel damage.

How many accidents do the coastguard respond to ever year in New Zealand?

About 10 responses per day on average Neil suggested.

How many of these accidents are serious?

This question diverted a little and we discussed about how Maritime New Zealand categorises boating accidents. They have a "technical definition" of an accident. An accident suggests a serious injury has occurred or consists of serious vessel damage that may result in injury. The classification of an incident is a less serious situation where there has been minor damage to a vessel that may result in injury to the crew.

Approximately what percentage of the call outs are during the summer period?

The majority as the summer period is the most active season for boating.

What particular areas of New Zealand waters are the most dangerous for vessels?

"The west coast and the harbour bars" he added that the more exposed you are the better equipped the boats should be.

Do you believe New Zealanders are generally well prepared for an accident when boating?

Neil said that it all comes down to education and that we are educated about boating safety however there was still room for improvement.

What is the number one cause of boating accidents, weather, collision, equipment failure etc?

"Lack of knowledge" (This question overlapped a little with previous ones so was not discussed in depth)

What percentage of boating accidents are inshore opposed to offshore?

Neil stated that the majority occur inshore due to the majority of boating taking place inshore.

Watermakers and Survival Equipment

What do you believe are the most important safety products boats should carry?

"Life jackets and an effective communication device" (this topic was brought up previously due to another question and was not talked about for long)

What safety products are most important for run about and small sailing craft?

This question again overlaps and was not asked as the response would have been the same as the previous question.

What safety equipment do you believe is most important for offshore vessels?

"It's hard to point to one" Neil added that depending on what situation may eventuate would depend on the importance of the safety equipment. We discussed how there is a term used called "the big three" this is referring to the three most likely scenarios on a boat. These are fire, flood and a man overboard. If a fire were to occur a fire extinguisher would be the best piece of equipment. If flooding were to occur (this represents sinking), a life raft would be essential. If there happened to be a man overboard a life ring (flotation device) would be the most valuable piece of equipment. This is also the most common scenario out of the three.

Later Neil suggested that his personal opinion is that an Epirb is probably overall the most important piece of equipment.

Do you believe that there is a need for a Watermaker on every boat?

We deviated from this question very quickly however Neil believed that the boats that would most likely need a watermaker would be offshore vessels. However there could be a potential market for solar desalinators in the islands where they go out in boats without any form of safety equipment.

What features do you believe would be most beneficial if I were to design a new innovative Watermaker for survival situations?

"Something that is reliable…efficient…functional"

How would you rank the importance of a Watermaker on an offshore vessel?

Neil believed that there is a need for watermakers on offshore vessels however said its "lowish but important". We went on to discuss that he had experienced times in offshore sailing where his generator on the yacht broke down. The generator would power an automatic desalinator, so without the generator working there would be a need for a manual Watermaker.

Do you believe that if a cheaper alternative Watermaker was in the market they would be purchased for smaller craft?

"Definitely…price is a factor" Neil believes that a cheaper alternative would attract many potential buyers as being a product that people believe they will never have to use they will often go for a cheaper alternative. We discussed that the quality and craftsmanship of an actual life raft is "terrible". This is due to that same reason. So life rafts are generally inexpensive for what they are. If they were to be made to the same quality of inflatable boats they would be far too expensive.

Do you believe that the price is a factor in whether someone chooses to purchase a Watermaker?

"Yes" This question overlaps the previous thus was not discussed much further.

Thoughts

Neil mentioned in this interview that there is another potential market for my product. He believes that in places like Fiji in the pacific islands many of the boats are underequipped. Neil suggested that an affordable solar still could possibly be donated to these boats offering some form of safety equipment should they run into any trouble. There have been occasions when boats have gone out for an evening fish and have not returned due to engine failure, the boats may be floating around for a day or two before they are found.

3.0 Literature Review

This chapter reviews several pieces of literature. The first piece reviews a survival story that occurred in New Zealand waters. It provides insight into the mental state of an individual in a survival situation and the effects of chronic dehydration. The second piece of literature is discussing research into a new technology for desalination and potential applications in the future.

Treading Water

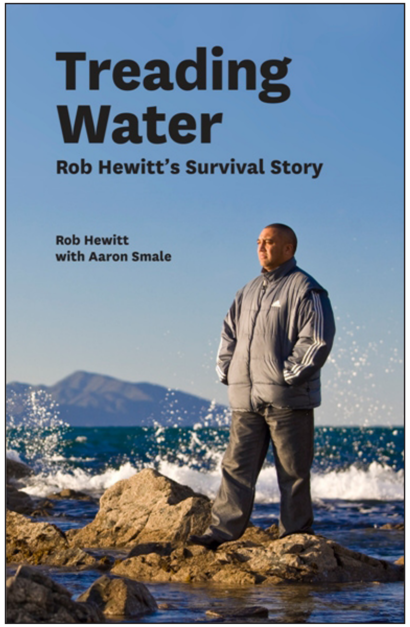


Figure 3.0 Treading water book cover

This is a unique survival story that occurred in New Zealand waters. Rob Hewitt was diving off shore and was separated from his boat due to underwater sea currents. When he arose from diving he estimated that he was several kilometres away from the boat and drifting further. He spent four days and three nights floating at sea with no food or water for aid. This book documents his background and his experiences during that time at sea.

Although this survival story is not situated on a life raft it is an extraordinary story of human survival that occurred in New Zealand waters. This story had a lot of media attention partly due to Rob being a brother of former All Black Norm Hewitt. Rob was an experienced Navy Diver and it is believed that the skills and knowledge he obtained as a navy diver are the only reason he lived to tell his story.

3.1 Literature Review 1

Body

Rob Hewitt's mental state changes dramatically within a very short period of time. His experience as a Navy diver for nearly twenty years has taught him how to deal with situations like these at sea. Staying positive and the will to survive are two key reasons for his survival along with his Navy experience. In saying this no amount of experience can prevent the effects of chronic dehydration and hypothermia.

For the first day and night Rob has a good mental state of mind considering the situation he is experiencing. He knew his experience, as a Navy diver would aid him in survival. He watched the search helicopters fly overhead and knew they were searching in the wrong direction. Rob was certain that he would be found on the second day.

"He had watched the sun disappear and now it was coming back up again. And he was filled with hope. He had made it through the night and today he would be found. He prayed and thanked God" (Hewitt & Smale, 2007, p.72).

This belief was nearly his undoing. With him from the first day he had a catch bag with 4 Kina (sea eggs) and a crayfish. Later this day he would eat all his kina and the crayfish believing that he would be found. However he still had two nights and two days left at sea. Had he rationed the kina he may have kept a better mental state through his experience. Throughout this experience Rob has many thoughts of God although not being a religious person himself. **"He began yelling in frustration to God to have him rescued"** (Hewitt & Smale, 2007, p.80).

Early throughout his experience Rob would talk to a crayfish in his catch bag. He believed that it helped him through the night knowing that there was something living close to him. He named the crayfish Tama. **"I remember saying to the crayfish, kia ora, there's only the two of us out here in this situation and it looks like we're in a bit of shit"** (Hewitt & Smale, 2007, p.78).

"If Rob's body was starting to disintegrate, on the second night his mind started to fall apart" (Hewitt & Smale, 2007, p.88). This night is when he experienced the first vivid hallucination. **"…it was these power-poles. They were about 30 metres away and the lines disappeared into the distance. I was trying to swim towards them to climb up and get as high out of the water as possible"** (Hewitt & Smale, 2007, p.88).

Through the night he had drifted within 3km of an island however suffering from extreme exhaustion he had no energy to swim there. He had several attempts at swimming, suffering from exhaustion he kept blacking out so had to give up. **"I started swimming and I started blacking out. I liken it to hyperventilating."** (Hewitt & Smale, 2007, p.90).

During the third day Rob believes he has reached his lowest point when he contemplates suicide. He attempted to drown himself however during this attempt it is thoughts of his children that change his mind. **"The first thing that comes into my mind was, you selfish prick. Why are you doing this. You've got people to live for. I looked at the kids"** (Hewitt & Smale, 2007, p.91).

By the third night Rob's mental state was rapidly declining. Hallucinations were becoming more frequent as his body was starting to die due to the effects of dehydration. He still knew the hallucinations were not real but **"at night these things would play mind games with you"** (Hewitt & Smale, 2007, p.105).

Rob started to lose his equipment during these hallucinations. **"He woke up and felt for his mask. It was no longer on his head. He panicked again, flapping around in the water trying to find it."** (Hewitt & Smale, 2007, p.107).

"On Wednesday morning Rob awoke in astonishment to see daylight." (Hewitt & Smale, 2007, p.109). Rob was amazed he had survived another night. During the fourth day he gave himself little jobs to keep his mind busy to avoid more hallucinations. He kept systematically checking his dive equipment over and over.

Rob's body starts to become hypothermic and suffer from chronic dehydration this is when Rob's mental state took an even more rapid decline. **"By the afternoon on Wednesday, Rob couldn't tell reality from hallucination."** (Hewitt & Smale, 2007, p.111). The severity of the dehydration was also compounded from his direct exposure to the salt water. His body fluids were slowly being replaced with salt water through his skin by an osmosis process. To give an understanding of Rob's condition, 98% of the body is made up of water **"By the time they pulled me out of the water 65 percent of the water in my body had traces of salt"** (Hewitt & Smale, 2007, p.110). Seventy-two percent is the tipping point when your organs start to fail. Rob was also suffering from extreme sunburn and his skin was starting to die from the prolonged exposure to the salt water.

Rob was found on the fourth day in a terrible condition. He was still hallucinating when pulled from the water and his body was in even worse condition. It was covered in boils, his flesh was decaying and the dehydration had caused him to lose over 9kg.

Conclusion

The writing begins with introducing Rob Hewitt and touches on his childhood and events leading up to the incident. Research has been done on the effects of dehydration and exhaustion and what it does to the body, however hearing about these effects from someone who has experienced them gives a whole new awareness into this area and is why this piece of literature is so important to this projects research.

Reading how quickly Rob deteriorated from lack of fluids was astonishing. Rob succumbed to the effects of dehydration much faster than someone in a life raft would have due to him being in the water the whole time. The water in his body was absorbing the salts and rapidly increasing the rate of dehydration. The serious effects of dehydration started on the second night, this was not much longer than 24hours after the incident.

The literature gave an insight into an individuals experience in a survival situation and understanding of the rapid deterioration of an individual suffering from extreme dehydration and exhaustion. This knowledge will help refine design criteria based around the physical capabilities of people who may be using the end product.

It emphasised the importance of usability and efficiency. A product that requires a large output of energy for little reward is something that will be useless to an individual in a situation like Hewitt's.

3.2 Literature review 2

Article 1: Direct seawater desalination by ion concentration polarization.
Date: Published online 21st March 2010
Authors: Sung Jae Kim, Sung Hee Ko, Kwan Hyoung Kang and Jongyoon Han

Article 2: New water desalination approach could lead to portable units for disaster relief or remote locations
Author: Darren Quick
Date: 00:31 March 29, 2010
Source: Gizmag (online magazine) – Research Watch

The two articles are linked. Article 2 was written in response to the research carried out in article 1. The subject is an innovative approach to saltwater desalination. The new technique could potentially be applied to medium sized devices to allow water relief in areas of need due to natural disasters or lack of potable water. Article one provides insight into this new process and illustrates testing results and methods involved. Article two discusses this new research and how this new technology could be applied.

Body
This research introduces an innovative approach to saltwater desalination. The most common process for desalination is distillation however in recent years newer processes such as reverse osmosis have been applied to create more efficient methods. These methods require high-energy consumption and have a high rejection rate making them less efficient.

The new method is called Ion Concentration Polarisation, where a continuous stream of saltwater is divided into desalted and concentrated streams by ion concentration polarisation. It is a "phenomenon that occurs when an ion current is passed through ion-selective membranes" (Kim, Ko, Kang & Han, 2010, p.298). This process works by running an electrical current through the stream where negatively charged salt molecules are then directed through a nanomembrane. The negatively charged molecules, particles are then redirected at a nanojunction to flow into the salted reservoir. The salt rejection rate is 99%, which is higher than the reverse osmosis method.

After many tests the flow channels and junction remain free from debris, where reverse osmosis can clog and foul due to micro particles containing bacteria and pathogens.

The researchers see this new process applied to smaller scale devices rather than large scale desalination pants, as large scale plants are unfeasible in areas that currently experience water shortage and sanitation issues. The potential device could possibly be driven by a battery making it ideal for third world countries and applicable for disaster relief.

Research mentioned in the literature discussed the current water shortage issues experienced by 0.35 billion worldwide (affecting 25 different countries). It is estimated that this number would grow to 3.9 billion by 2025 affecting 52 countries. It was mentioned that 97% of the total water on earth is seawater and that only .5% of freshwater is potable, reinforcing the importance of research and development of methods like ion concentration polarisation.

The testing carried out for these articles used pre-filtered water to remove any large debris like sand and seaweed etc. As most microorganisms, biomolecules, and micro particles have a negative charge they will be processed the same as the salts and exit the junction in the salted stream. After further tests the channels were still free from debris. The ionic concentration of the seawater in the desalted stream was significantly lower than the original concentration. Further tests resulted in water with a salinity rating less than the minimum standard for potable drinking water.

The article concluded with potential devices and applications for this method of desalination. It was mentioned that solar power would be enough to power a device using this method. A gravity feed would be the best option for flow transfer. The testing suggested that the flow rate output would be greater than current household gravity fed purification systems.

Conclusion

The two articles were very insightful pieces of literature, giving greater understanding into current and future methods of desalination and their advantages. The first article “Direct seawater desalination by ion concentration polarization” was very technical and outlined the research and testing regarding this method. Whereas the second article “New water desalination approach could lead to portable units for disaster relief or remote locations, Darren Quick” which reviewed the potential of this process, simplified and summarized the research article to make it more accessible to your average reader. This complemented the original article and gave a better understanding of the more technical aspects of the first article.

Concluding on the findings, this method of desalination is still very primitive and requires significant research and development before any form of product could apply this technique of desalination.

This method will not play a part in any of the concept generation as it requires a source of power that will not be practical in survival situations experienced at sea. However the method of ion concentration desalination, once developed, has the potential to play a significant role in survival products for fresh water production.

These pieces of literature have helped refine the design criteria to support only natural and physical energies for the production and desalination process of saltwater. This directly limited the methods of desalination to distillation and reverse osmosis membranes.

4.0 Product Reviews

The following chapter looks into the current leading desalination products available to consumers. Product placement charts reveal how these existing products perform under a set of assigned criteria, also displaying where a competitive product would sit against these existing products. A state of the art review is carried out on the leading contemporary product. The key part of the review is based around product usability and function. Focus groups and tests were carried out to rate the usability of the product and to obtain feedback on the product aesthetics and signal functions.

4.1 Existing Products

Katadyn Survivor 35 Manual Watermaker

Figure 4.0 Photograph – PUR Survivor 35 Manual Watermaker. (Landfall Navigation, N.D.)

This design is one of the most widely used watermakers on the market. The Survivor 35 is capable of making up to 4.5 L of water per hour. This is enough water for a multiple person life raft as approved by the US coastguard. The water is generated by manually pumping the product to force the salt water through a reverse osmosis membrane that filters it to a potable standard. This product will cost you around $3000.00 NZD.

The Survivor 35 is not a small product. Its measurements are 55.9cm (length) x14cm (width) x 8.9cm (depth), with a reverse osmosis membrane measuring 20cm. It is targeted at larger vessels where more storage space would be available. It weighs 3.2kg which is relatively light considering the length of the product.

The large size is due to the handle/crank on the product which is designed to make the product more efficient as larger strokes can be achieved with a longer handle resulting in more water being pushed through the membrane. (Katadyn, 2010)

It uses reverse osmosis to filter the salt water. This is a newer technology and is mentioned in chapter two. The reverse osmosis filter results in a 98.4% on average rejection rate of the salts from sea water. (Katadyn, 2010) The rejection rate can be influenced by water quality or pressure applied to the pump.

Most of the components are made from stainless steel and injection moulded parts. The stainless steel was most likely used to provide a strong crank for the product it also will not be affected by corrosion in the harsh marine environment.

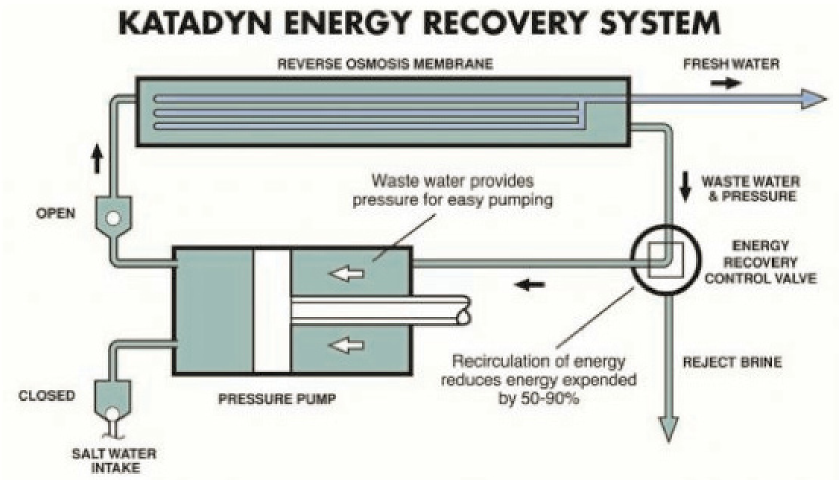


Figure 4.1 Diagram – Showing the patented energy recovery system. Adapted from "www.katadyn.com/caen/katadyn-products/". 3/10/2010.

This product also has a patented design feature. It is an energy recovery system. The system takes advantage of stored energy within the reject water and is used to aid the next stroke. This can be seen in the diagram shown below. (Katadyn, 2010)

Conclusion: The Survivor 35 is a well designed product that uses new technology. The product has an extremely high output rate. However the cost of this product is very expensive due to the technology involved. Reverse osmosis membranes are very costly and directly influence the cost of the product to the consumer, as well as having the potential to cause some issues if they are not cared for properly. This product also requires servicing every two years adding another expense to the overall cost of the product.

Katadyn Survivor 06 Manual Watermaker.

Figure 4.2 Photograph – PUR survivor 06 Manual Watermaker. (Landfall Navigation, N.D.)

This design is another leading watermaker produced by the same company as the Survivor 35. It uses the same technologies as the previous design however was developed to be smaller to suit situations where space and weight is an issue. It is a hand-operated product that forces seawater through a reverse osmosis membrane.

The product has less output than the Survivor35, producing only .89L per hour when averaging forty pumps per minute. Weighing approximately 2.5 pounds this is one of the lightest and most compact desalinating products available. This product costs around $1500.00 NZD. (Katadyn, 2010)

The benefit the Survivor 06 of using the reverse osmosis technology is that it allows a high output rate of fresh water. However the membranes require maintenance and special care. If the membrane has not been looked after correctly when stored the product may not function.

The energy recovery system mentioned in the Katadyn Survivor 35 review has also been used with this design. The patented technology will help reduce the energy input required to pump the product.

The scale of this product compact, with measurements of, 20.3cm (length) x 12.7cm (width) x 6.4cm (depth). This makes the product suitable for smaller vessels where space and storage is a concern. The smaller scale of the product means a smaller output however it is still sufficient to supply potable water for up to six people per day.

The components are made from stainless steel and injection moulded plastic parts. The housing for the membrane is made from injection moulded nylon. Nylon is a strong plastic with excellent wear resistance that will provide a solid protection for the membrane. The stainless steel components are not corrosive in the marine environment.

Conclusion: The Katadyn Survivor 06 is a more affordable option to the consumer compared to the companies other product Survivor 35. However the product is still expensive and requires maintenance on the membrane. If this is neglected the product could potentially be of no use in a survival situation. The energy input into the product claims to be minimal however someone in poor health may struggle to operate the product due to the timely manual operation this product requires.

Aquamate Solar Still

Figure 4.3 Photograph – Solar Still Aquamate. (Landfall Navigation, N.D.)

This Aquamate is an inflatable solar still that uses a distillation process to generate fresh water in survival situations. This process takes longer to produce fresh water compared to a reverse osmosis based product and is dependent on suitable weather conditions.

It works by storing seawater on a black dish that is heated by the sun. The water evaporates and rises as water vapour. The vapour collects on the upper surface of the product and runs down the outer edges to be collected and stored in a separate reservoir. This process has been used for a long time, with products like this having been available for approximately 40 years and used in the army for a similar duration. This product costs around $400.00 NZD.

It requires no human interaction or energy input to generate the fresh water. This allows the user to reserve their energy and rest while the product works to produce fresh water. This could be an important feature if the users are not in good condition.

The Aquamate Solar Still is made from PVC plastic also known as Polyvinylchloride. This is an ideal material for inflatable products. PVC is a durable thermoplastic. The plastic can be made more flexible and malleable by the addition of plasticisers. This material is commonly used for inflatable products. The edges can easily be heat welded to seal the products. The disadvantage of using PVC is that the soft material can be punctured by sharp objects. This would directly affect the reliability of the product.

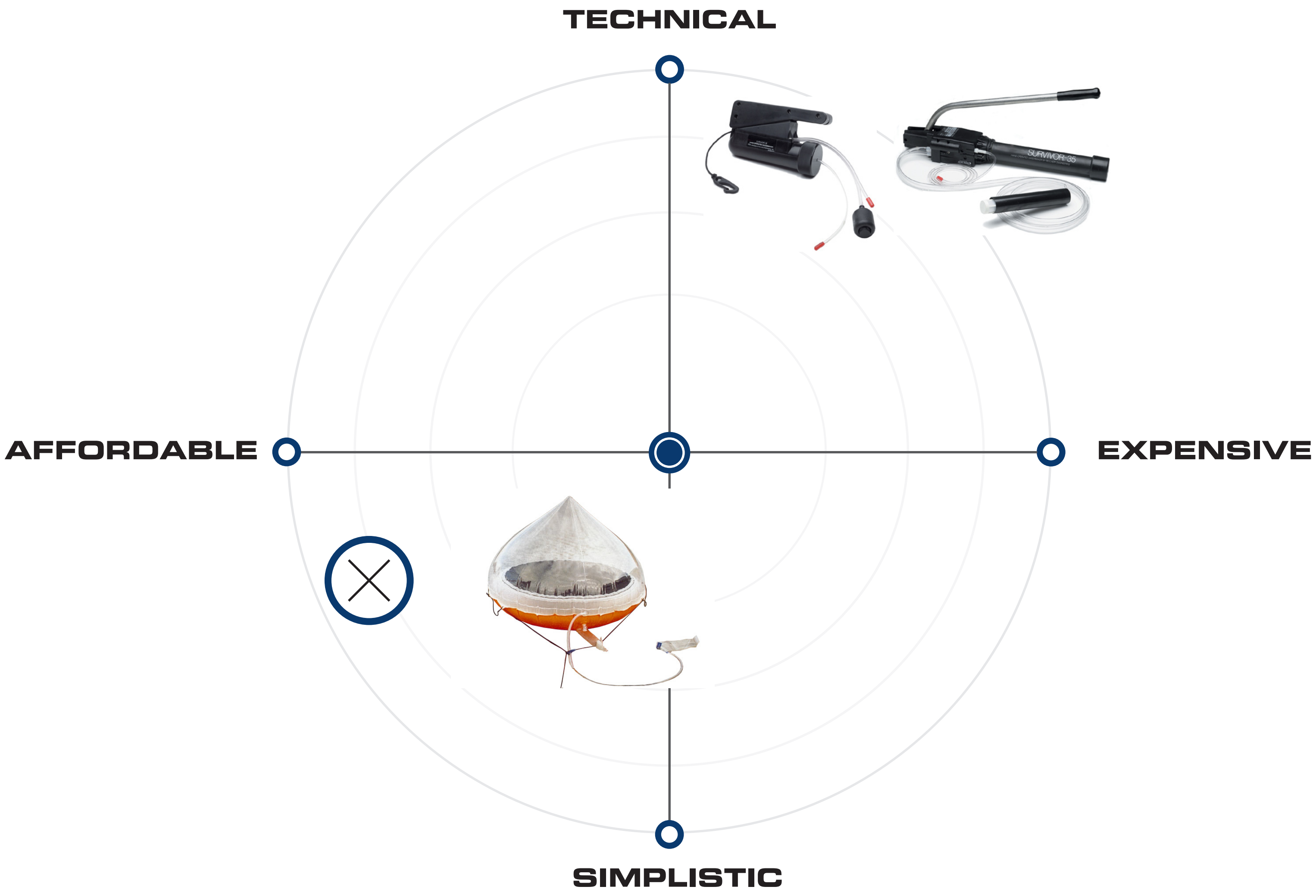
It can be folded up to a smaller size when deflated. The measurements of a deflated product are 26cm (length) x 23cm (width) x 7 cm (depth). When inflated the product is a dome shape with a diameter of approximately 60cm.

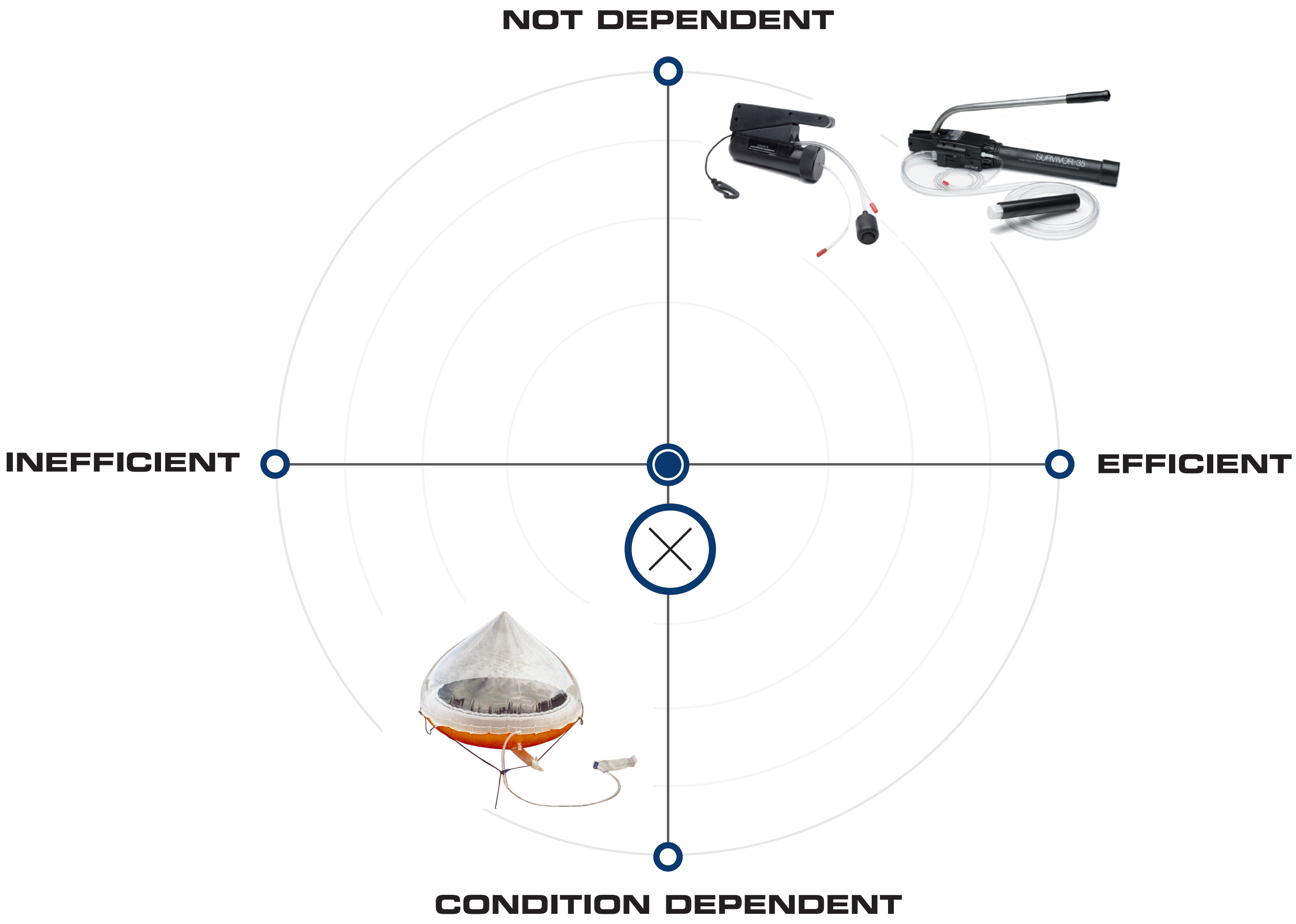
Conclusion: Due to the way in which the seawater is stored this product would not perform well in choppy or turbulent sea conditions. The seawater would spill over into the freshwater reservoir contaminating the supply. This is a serious flaw in the product design as sea conditions can often be turbulent even in fine weather when this product is most suited.

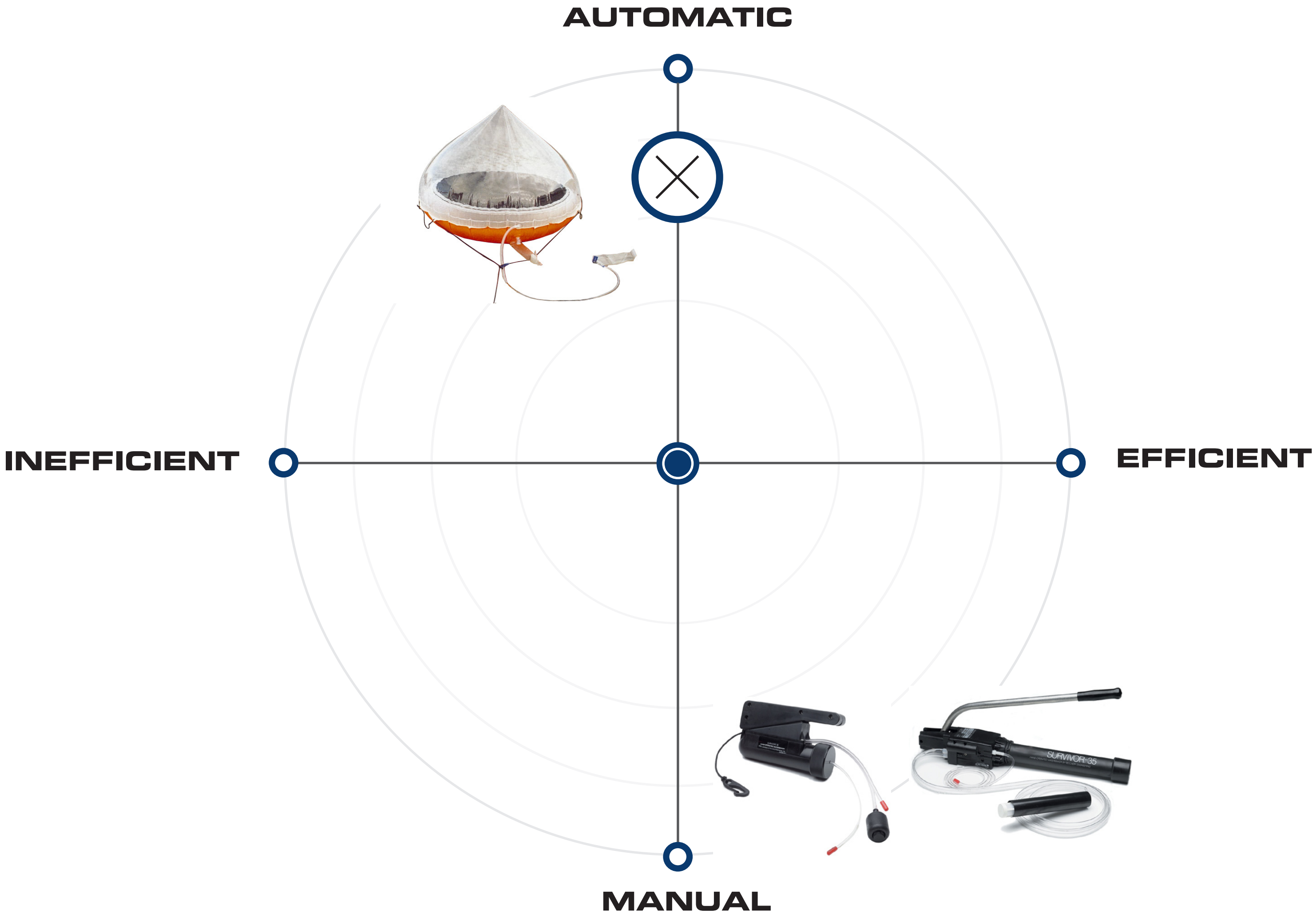
This product is a more affordable option to the consumer. The simplicity of the product and affordable materials make it a great product for people who are not prepared to spend large amounts of money on a watermaker. The fact that this product requires no energy input is definitely a strong asset. However the compromise is that this product is condition dependent and suited for warmer climates limiting the potential market.

4.2 Product Placement Charts

The following charts illustrate how the watermaker will rate against the leading contemporary products across comparable sets of criteria. The focus of the charts is to compare efficiency, cost, and ease of use, weather dependency and simplicity. The purpose of this is to show how each set of criteria influences another. The cost of a product will increase with the addition of technical features and components. The efficiency of the product will be affected by the amount of user interaction.


TECHNICAL
AFFORDABLE
EXPENSIVE
SIMPLISTIC


NOT DEPENDENT
INEFFICIENT
EFFICIENT
CONDITION DEPENDENT


AUTOMATIC
INEFFICIENT
EFFICIENT
MANUAL

4.3 State Of The Art Review

The Katadyn Survivor 06 is the one of the more preeminent products in this niche market. It has a high production rate and is recommended by many books as the ideal product for a grab bag (survival bag) on a vessel and is considered the most technologically innovative product in this area.

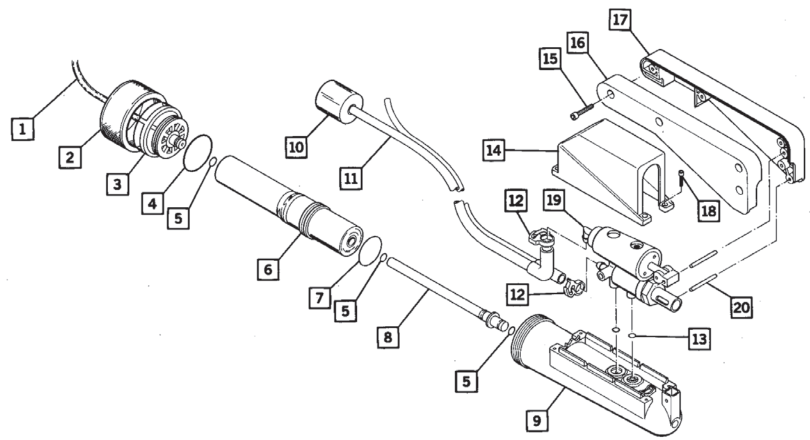
By reviewing the Katadyn Survivor 06 a greater understanding will be gained on a product using the reverse osmosis process for desalination. Knowing the areas this product excels in and its weaknesses will offer great insight when developing concepts.

This product will also be reviewed through observational tests, interactive tests, surveys and ergonomic analysis.

Product Technologies and materials

The Katadyn Survivor 06 is a combination of advanced product development and engineering. The product uses a reverse osmosis membrane to filter the salts from seawater and to generate fresh water as a result. The salt water has to be forced through a semi permeable membrane at over 400 psi to filter the salts from the seawater.

The product is made up of over 20 unique parts. The base is an injection-moulded thermo plastic and the handle attachment is a powder coated pressed stainless steel bracket. The internal mechanisms mainly consist of a pump body and membrane housing components. The exploded view reveals the internal components and the sound engineering that this product possesses.



1. Product Hose (8013208)
2. Cap membrane housing (8013198)
3. End plug membrane housing (8013161)
4. O-ring (8013190)
5. O-ring (qty: 4, 8013239)
6. Membrane module (8013165)
7. O-ring, brine seal already installed
8. Plug (8013193)
9. Membrane Housing (8013156)
10. Weight and strainer (8013287/8013197)
11. Intake/Reject Hose (8013284)
12. Clamps (8013246/8013203)
13. Two different O-rings (8013243/8013244) and one seal (8013011)
14. Pump Body Cover (8013160)
15. Screw, handle (qty. 4, 8013019)
16. Left handle (8013164)
17. Right handle (8013163)
18. Screw, cover (qty: 4, 8013200)
19. Pump Body (8013153)
20. Handle pin (qty: 2, 8013188)

Figure 4.4 Illustration – PUR Survivor 06 exploded view. Adapted from "www.katadynwatermakers.co.uk". 08/05/2010.

Product Feedback

A set of questions were constructed to gain knowledge on peoples initial views and observations on the Katadyn Survivor 06 to. This tested the products affordances/signal functions, aesthetics, ergonomics and general observations. Surveys and in-group and individual meetings were then used to gain a few different perspectives.

Conclusion of surveys

One of the tests included in the survey was to show people the product not telling them what it was and to ask them if they knew the product and its function. (There were over 10 people involved ranging from designers to working professionals and young adults). No one knew what the product was when it was shown to them, with the common response "No not at all". This suggests that the product signal functions are poor.

The interviewee was then asked how much they thought the product was worth. They were given price brackets ranging from $100-500 and $1500-2000. The product sits between $1500 and $2000 New Zealand dollars. Everyone picked the product to sit in the lower end of the scale, suggesting the product looks cheap despite it costing over $1500. This may relate to poor aesthetics or the interviewees' general lack of familiarity with a specialist product such as this.

Other issues that arose were the ergonomics of the product. For a product that requires an individual to pump it for over an hour to generate enough water for a day there is very little attention to ergonomics. Over 80% of the people involved in the survey rated them between poor and average.

Ergonomic and Usability Studies

A user test survey was then completed on two people. This involved the user taking the product with no clear instruction and watching them pump the Katadyn Survivor 06 for 30 minutes. The method of operation for this product requires the user to pump a handle up and down to force water through the reverse osmosis membrane. A standard set of questions were asked every five minutes to see how they were feeling, what parts of their body were sore and how they found the general operation of the product. The final record was of how much water had been generated.

This testing revealed a lot about the function of the product. Little after five minutes both users were starting to feel uncomfortable and parts of their body were beginning to ache. Both users were tested in the evening and both sitting in a similar position to what you would expect in a life raft.

Considering that both users were fit, strong and were not suffering from dehydration or fatigue, it would be fair to question the function of this product when used by someone experiencing those symptoms. Both users predicted that they could not maintain that pumping method for much more than 30 mins after the test.

The outputs of fresh water generated from the tests were surprising. Both users generated much more water than predicted. User 1 generated 750ml of water and user 2 generated 680 ml of water. The amount of water generated was not a realistic indication of the amount someone would generate on a life raft as both users knew the duration was only 30 minutes and paced themselves accordingly.

Figure 4.5 Photographs – User testing for Katadyn Survivor 06 Manual Watermaker. 02/09/2009.

Conclusion of Reviews

The product performed very well in terms of output and function. There was a large amount of water generated for a short period of input. However this method of operation requires the user to pump a handle up and down to force water through the reverse osmosis membrane. It is this method of operation that could be improved. In a survival situation with someone suffering from exhaustion and dehydration it is unlikely that they would have sufficient energy to operate this product for a long period of time.

Other areas that this product did not perform well in were its aesthetics and signal functions. The product does not sell itself to the user. It is an engineered looking product and does not reflect its environment very well. Many of the people tested had no idea what the product was.

This product rates poorly with aesthetics and ergonomics however it excels with its function and output. To build a product to compete with this one the design and development would need to address the aesthetics and ergonomics rather than the function. It is highly possible that a person trapped in a life raft will not know what a reverse osmosis pump is or what it would look like. To every extent possible, it is important that the product communicates through aesthetics what its intended use is.

5.0 Initial Ideas

This chapter introduces the set of design criteria that was established based off the research component of this exegesis. The first concepts are documented in this chapter. Some concepts are raw ideas while others are more developed concepts.

5.1 Design Criteria/Specifications

The initial concepts that follow are based on the following design criteria/specifications.

From the initial research a set of design criteria and specifications have been established. The initial concepts are focused around these, however they allow for a few creative concepts that may not completely fulfil all aspects.

Functionality
The design should be functional. As found in the research component people in survival situations are under immense stress and have poor judgement. This product should be simple and easy to use. There are two main areas of functionality for this product, functional for the user and functional in terms of output.

Concepts should use either distillation or reverse osmosis as a method of desalination. Research revealed that users might be suffering from metal fatigue making minimum interaction with the product a key design challenge. Reliability is also a heavy influence when looking at functionality. It must be reliable and dependable for the user.

Innovation
Applying new technology to concepts is a way of fulfilling the innovation section of criteria. Although the two methods of desalination are currently being used concepts could incorporate new approaches to these methods by using new materials and technology to better improve the method.

Ergonomics
Depending on the concept ergonomics may rank high in the set of criteria. If the product requires a lot of human interaction then ergonomics will play an important role in the design and development phase.

Hand operated concepts will require attention to grips and mechanical operation. The designs must offer the best ergonomic solution to the method of operation. The users will most likely be in poor condition so the product must be as comfortable and ergonomic as possible.

If the concept uses reverse osmosis as a method for desalination ergonomics will play an important and necessary role in the development of the design. However if the concept uses distillation as the process for desalination ergonomics will not be a primary focus as the concept will most likely be using the suns energy to produce the water requiring little interaction with the user.

Sustainability
All design concepts should pay attention to sustainability and be environmentally conscious. The purpose of sustainable design is to minimise the negative environmental impact manufacturing and the product itself will have on the planet. Concepts can pay attention to sustainability by using materials that have a minimal effect on the environment. Product longevity and lifespan should be considered when selecting the materials. As the product needs to be durable, there may be

a trade off between product longevity and eco friendly materials.

Affordance
Concepts should suit their environment and purpose. Affordance for concepts could be achieved by using safety and marine colours. It is the designer's responsibility to make the product fit into its intended environment. The consumer must be convinced that the product belongs in the marine environment.

Safety
Design concepts need to be designed to acknowledge their environment and users safety. The concepts should not pose a potential risk or hazard to the users in any way. If the concepts pose a threat to the safety of the users they will not be developed further.

Aesthetics /Desirability
Once the product function has been developed it is then the responsibility of the designer to make the product attractive and suit its intended environment. With this product it is the safety/marine theme and environment as well as the function that will influence the aesthetics of the product. The challenge is to design around these features to make the product desirable and appealing to the user.

Other influences to the aesthetics will come from ergonomic issues and reliability. A product of this nature will have a heavy focus on function, as it is one of the primary pieces of design criteria. Aesthetics is secondary but still plays a role in the concept and development phase, as the product needs to be appealing and desirable to the consumer.

Ease of Use
People in survival situations need to have a product that won't let them down and is simple to use. The more complex the product is to use, the more mental pressures and stress the survivors will have to endure. Earlier research revealed that an individual suffering from just minor dehydration can potentially make irrational decisions that could jeopardise the safety of others. It must be assumed that the users could be suffering from injury or dehydration. The easier the product is to use the smaller the chance something can go wrong.

Reliability/Durability
The design should boast both reliable and durable features. For a product that people may rely on with their life it has to be sound and well refined. Concepts can also fulfil this piece of design criteria by using robust materials and reliable technology.

Not only must the product be reliable in terms of function it is just as important that the product looks reliable. This will ensure that the potential consumers can trust the product. Consumers will not want to purchase a product that looks like it could potentially fail.

Cost-to-benefit relation
As this is a product that people will most likely never use it has to sell itself to the end user. The cost of the product needs to be at the lower end of the scale as research has indicated that people are not always willing to spend big money on a product they believe they will never use. Making this product more affordable to the end user makes it a more appealing option for someone purchasing this kind of product.

Summary of Criteria
The criteria descriptions listed previously show there is still a wide brief to work from. Concepts should focus on the specifications that were rated the highest in the ranking chart. These are function, reliability/durability

and ease of use. The concepts that abide by those criteria will be the strongest.

Table 5.0
Design Criteria for Initial Concepts – on a scale of one to ten.

Design Criteria for Initial Concepts										
Criteria	**Ranking of Importance**									
	1	2	3	4	5	6	7	8	9	10
Functionality	■	■	■	■	■	■	■	■	■	
Innovation	■	■	■	■	■	■	■	■	■	
Ergonomics	■	■	■	■	■	■	■			
Sustainability	■	■	■	■	■	■	■			
Affordance	■	■	■	■	■	■	■			
Safety	■	■	■	■	■	■	■	■		
Aesthetics /Desirability	■	■	■	■	■	■	■	■		
Ease of Use	■	■	■	■	■	■	■	■	■	
Reliability/Durability	■	■	■	■	■	■	■	■	■	
Cost-to-benefit	■	■	■	■	■	■	■			

5.2 Initial Concepts

Life Jacket/Desalinator

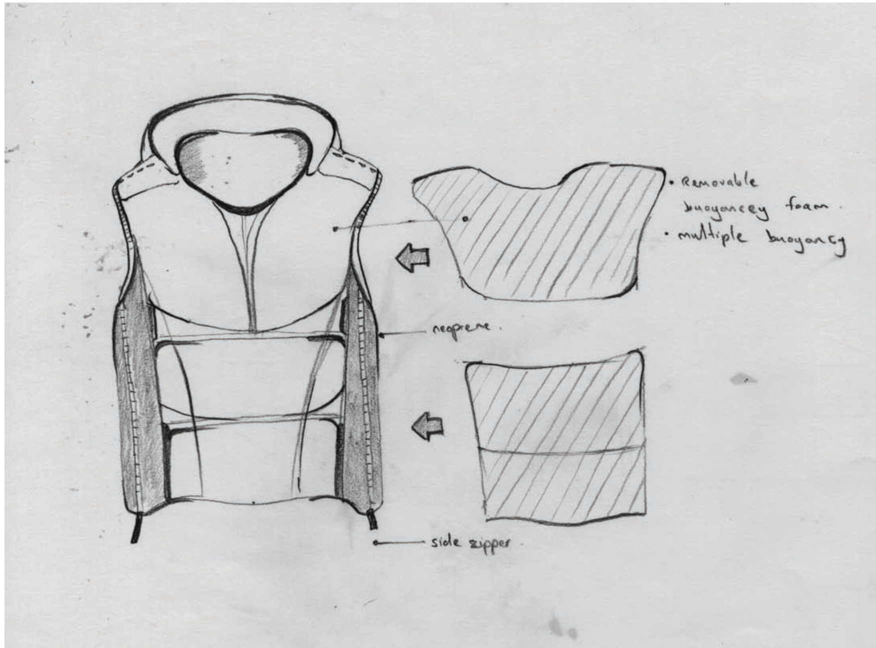


Figure 5.0 Sketch – Buoyancy control life jacket. 09/11/2009

How it works

The idea for this concept was driven from research surrounding offshore sailing. It is designed to aid the sailor with an industry standard buoyancy vest inclusive with built in thermal insulation.

A titanium coated neoprene core ensures the sailor remains warm in cooler climates thus reducing the chances of hypothermia if swept off the yacht. Another feature that this concept hosts is a built in reverse osmosis membrane. The small hand pump forces the salt water through the membrane to supply the user with fresh water.

Results

The concept is a strong one however it was not developed further as it was moving too far away from a watermaker and towards a lifejacket design project.

Figure 5.1 Sketches – Reverse osmosis life jacket concepts. 09/11/2009

Water Catcher

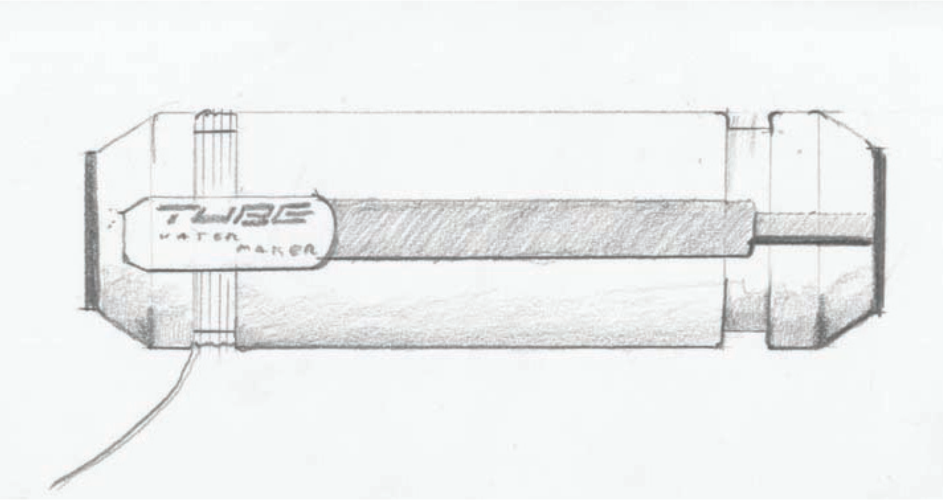


Figure 5.2 Sketch – Side view of the water catcher. 15/11/2009

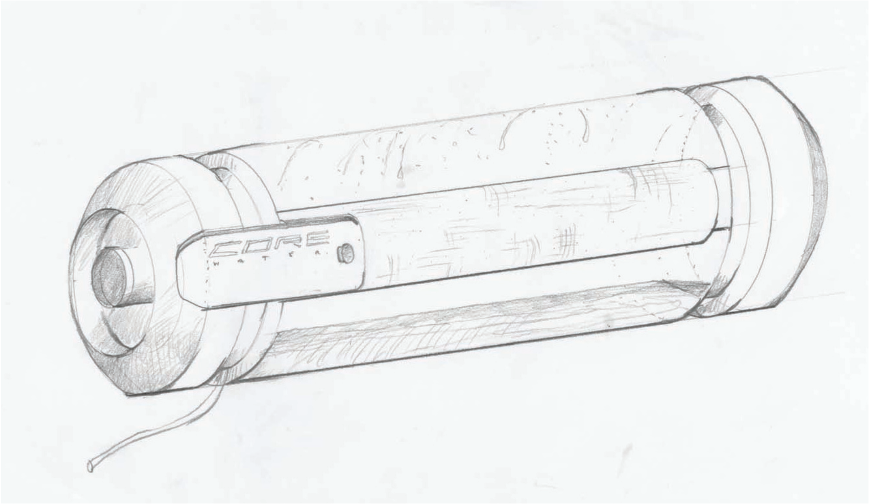


Figure 5.3 Sketch – Perspective view of the water catcher. 15/11/2009.

How it works

Using the suns energy to produce fresh water, this product works by collecting salt water in a sponge that is suspended on a gimbal system in the middle of the cylinder. The sun heats the black sponge and the water vapour rises and condensates on the surface of the cylinder. It then runs down the surface and collects on the bottom. This product would suit warmer climates and would not perform well on colder days.

Results

This concepts ranks highly in regard to addressing the design criteria, as it is easy to use and requires little energy to operate.

Friction Powered boiler

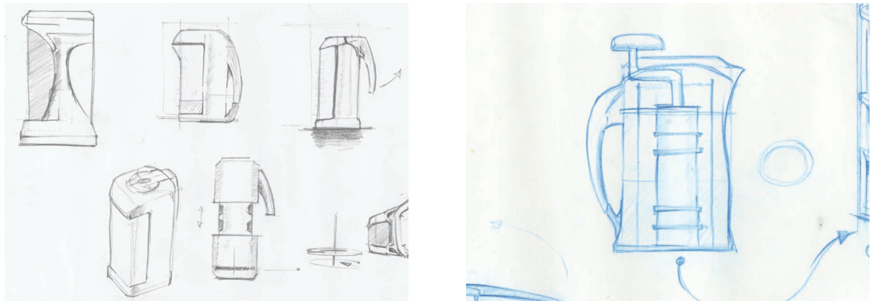


Figure 5.4 Sketches – Friction powered boiler. 09/10/2009.

How it works

The idea behind this design is that the water is heated by rotating a metal plate against another fixed plate. With the use of heat conducting metals such as copper and stainless steel the water is heated enough to start a condensation process. The water vapour would rise and condensate on the top canopy, then follow the contour into a separate reservoir where the fresh water is collected.

Condensation will occur when the internal temperature is greater than the outer temperature. Water vapour then accumulates on the inner surface (condensation).

Results

This is another strong concept however further development was not carried out due to the potential of there being too much research involved with proving this method of water production. Tests and prototypes would need to be developed just to see if the concept would even work and the project would suffer as a result.

Water Boiler/collector

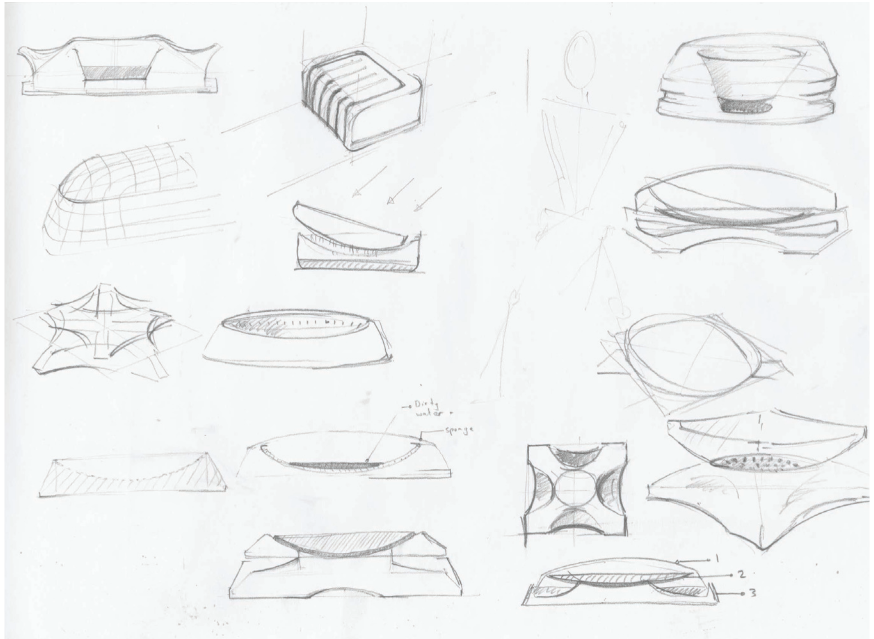


Figure 5.5 Sketches – Assorted quick sketches for the water boiler collector. 14/09/2009.

How it works

This design works by heating the salt or dirty water up to boiling temperature. This is done by a supplied accelerant being lit under the saltwater reservoir. The salt water heats up and boils releasing loads of water vapour. There is a curved canopy where the rising vapour would reach, water droplets would form on this canopy and follow the contour of the structure to be collected in a separate chamber. This water is fresh as the salts are left in the saltwater container.

This process could be a very fast way of generating fresh water in survival situations. However it is probably more suited for tramping and land based activities as having a product that gets extremely hot and is powered by flammable products would not be practical on a life raft.

Results

This design was not developed further as it did not fulfil an important piece of criteria, safety. The design uses a flame to heat the salt water, if the product were to fail it could jeopardise the safety of the people using the product. This concept would be more suited to a tramping environment.

Figure 5.6 Photographs – Water boiler/collector concept. 160/09/2009.

Rotational Pump Reverse Osmosis Watermaker

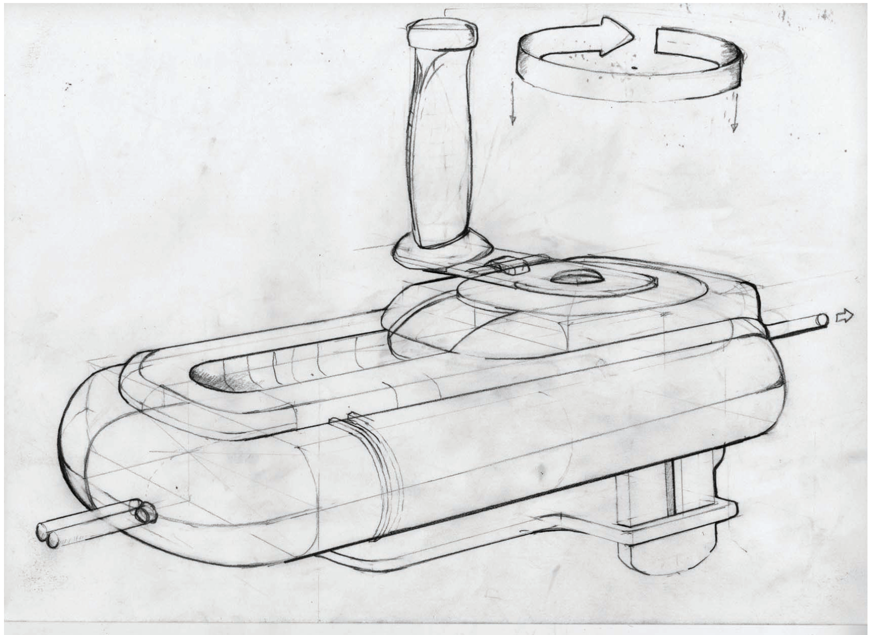


Figure 5.7 Sketch – Rotational pump/Reverse osmosis Watermaker. 20/09/2009.

How it works

The unique approach to this concept is the pumping mechanism. Instead of pumping up and down, a rotational pump has been incorporated. Using a rotational pump requires less effort from the user and is a much more ergonomic method of pumping.

Looking at different pump systems, there were two possible options for the rotational pump method. One was a vane pump and the other was a screw pump. The screw pump initially looked the best option however it was unknown whether these types of pumps could generate enough

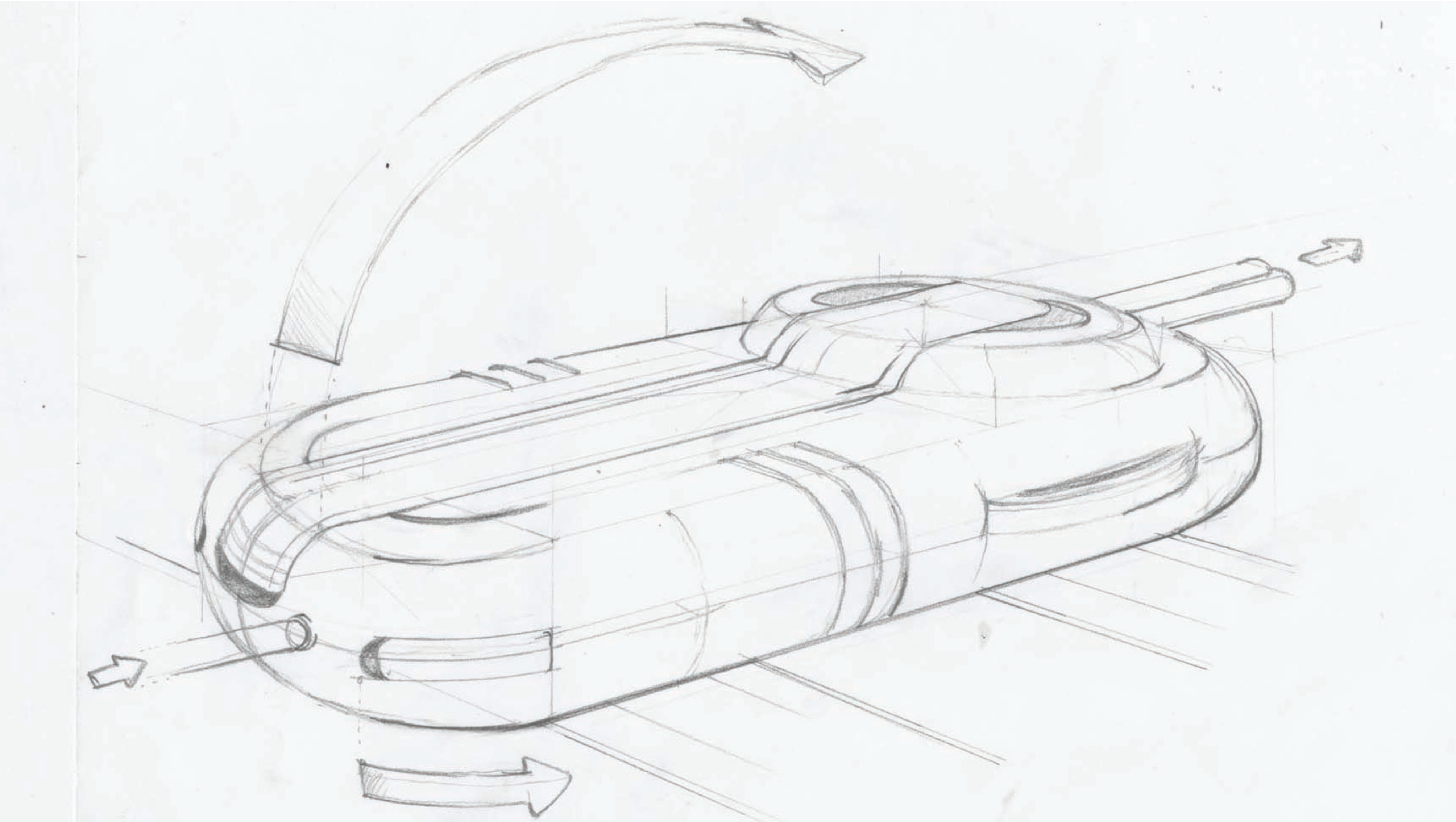


Figure 5.8 Sketch – Rotational pump/Reverse osmosis Watermaker (closed). 20/09/2009.

pressure, when being driven by hand, to force the water through the reverse osmosis membrane filter.

After brief talks with an engineer it was agreed that a vane pump would be the best option for this concept as it could generate the required pressure, whereas a screw pump would not.

Results

This concept would offer the opportunity to redesign an existing product (Katadyn Survivor 06). When developing this concept there could be many limitations with the design as the shape of the reverse osmosis membrane is predetermined. The finer details would still need a lot of attention however it still has the possibility of being a suitable design project to follow through with.

Figure 5.9 Photographs – Cardboard mock-ups for rotational pump concept. 21/09/2009.

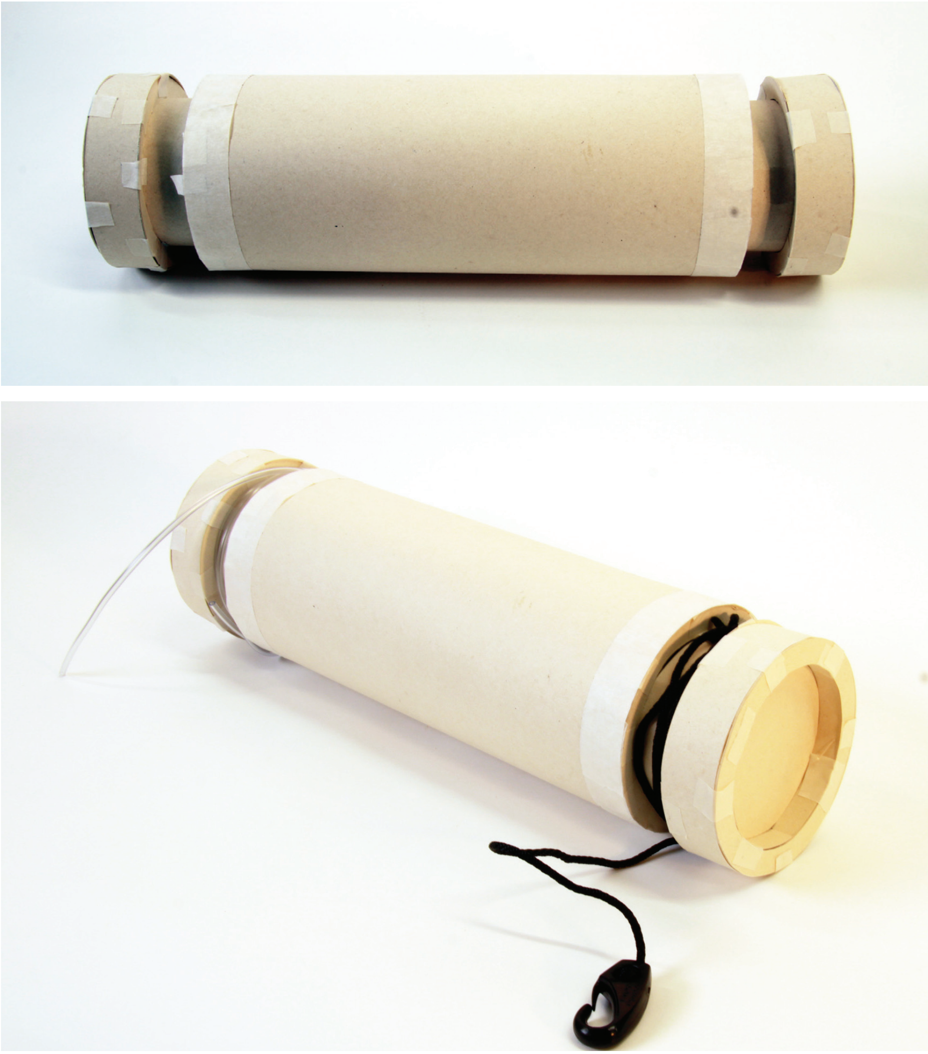


Figure 5.10 Photographs – Cardboard mock-ups for water catcher solar still. 19/11/2009.

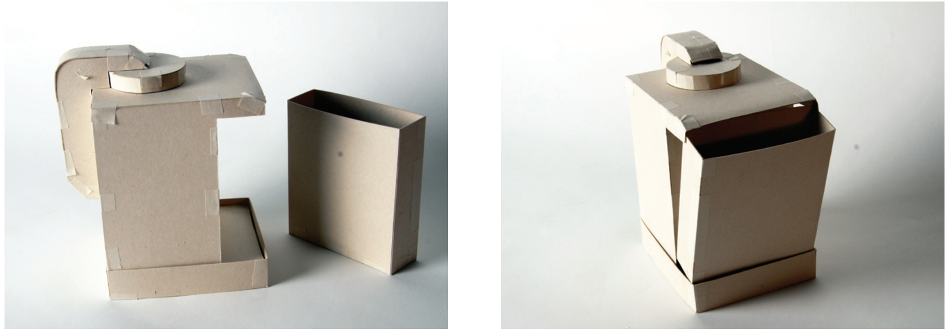


Figure 5.11 Photographs – Cardboard mock-ups for friction powered water boiler. 12/10/2009.

5.3 Conclusion of Concepts

The results have concluded with three strong concepts each using different methods for production.

Highest Ranking Concepts

Water Catcher

This concept appears to be inexpensive to manufacture, easy to use and requires no energy to operate. The only negative with a product like this is that it is condition dependent relying on sunny weather. Other than that this product best reflects the design criteria.

Friction Powered Boiler

There has been limited time researching into whether this process would generate enough heat to boil the saltwater. However if this could be developed to work the concept could offer a new way of sterilising water and generating fresh water from salt water. There would be huge potential with its application. Spending time developing this concept would be very risky, as it would consume valuable time that could be spent developing a more feasible concept.

Rotational Pump Reverse Osmosis Watermaker

This is a concept that is looking at improvements in operation that could be applied to current manual reverse osmosis filters. Using a rotational system it could be a very functional product that addresses the design criteria. However there is some concern that developing this concept would offer little freedom in design and concept development, as it is making improvements to an existing product.

5.4 Chosen Concept

Water Catcher

This product best reflects the design criteria and offers the most potential for development. The affordability factor also was an influence in pursuing this concept as it could be developed as a cheap alternative to the expensive products currently on the market.

The concept has much potential and with the development of key design features the end result will offer something new and innovative to the consumer. Storing the saltwater within a sponge is an innovation not seen with existing products. Allowing the product to rotate in the waves also makes this concept unique.

The concept uses distillation to generate fresh water. Using this process requires more time to generate fresh water however it requires no energy input from the user. This is seen as a valuable as a valuable asset as it will preserve the energy of the user. With all the strengths listed it reinforces the potential of this concept and why it was chosen to develop.

6.0 Chosen Concept Development

This chapter shows the development of the chosen concept. Sketches and three-dimensional mock-ups aid development through this process. Configuration of the components and different ways of increasing surface area, generate a range of unique developed concepts are also presented in this chapter.

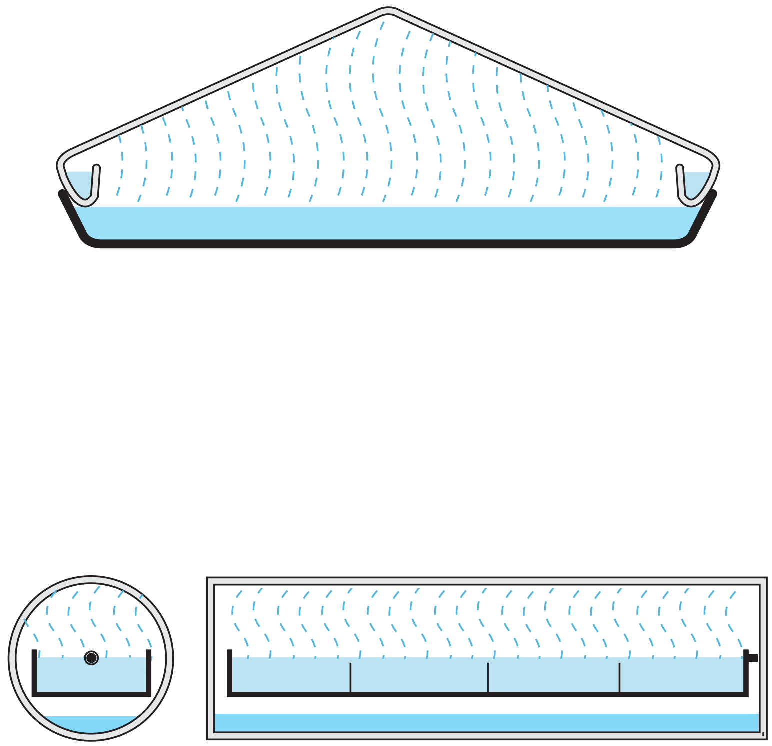


Figure 6.0 Illustrations – Showing the function of a traditional dome solar still compared to a cylindrical concept. 02/09/2009.

The diagram in the image section shows a traditional solar still in comparison with the developed concept. Traditional solar stills are usually a cone shape allowing more surface area and a steep enough gradient for the condensate water to run down. The problem with that design is it takes up a lot of space. The cylinder design is a more compact design and has a steeper gradient allowing the water to run down the inner surface much quicker.

6.1 Refined Design Specifications

After some product reviews, initial concept development and testing a refined set of criteria has been established. This is in addition to the criteria specified in chapter four.

The design will-

- Use minimal parts, keeping production costs to a minimum.
- Be easy to use.
- Not allow seawater to contaminate the freshwater.
- Have a maximised surface area.
- Be durable and reliable.
- Have an aesthetic that fits into the marine environment.
- Produce a satisfactory amount of water for one person to survive.
- Possibly be used as disaster relief or for areas lacking potable water.

6.2 Developed Concepts

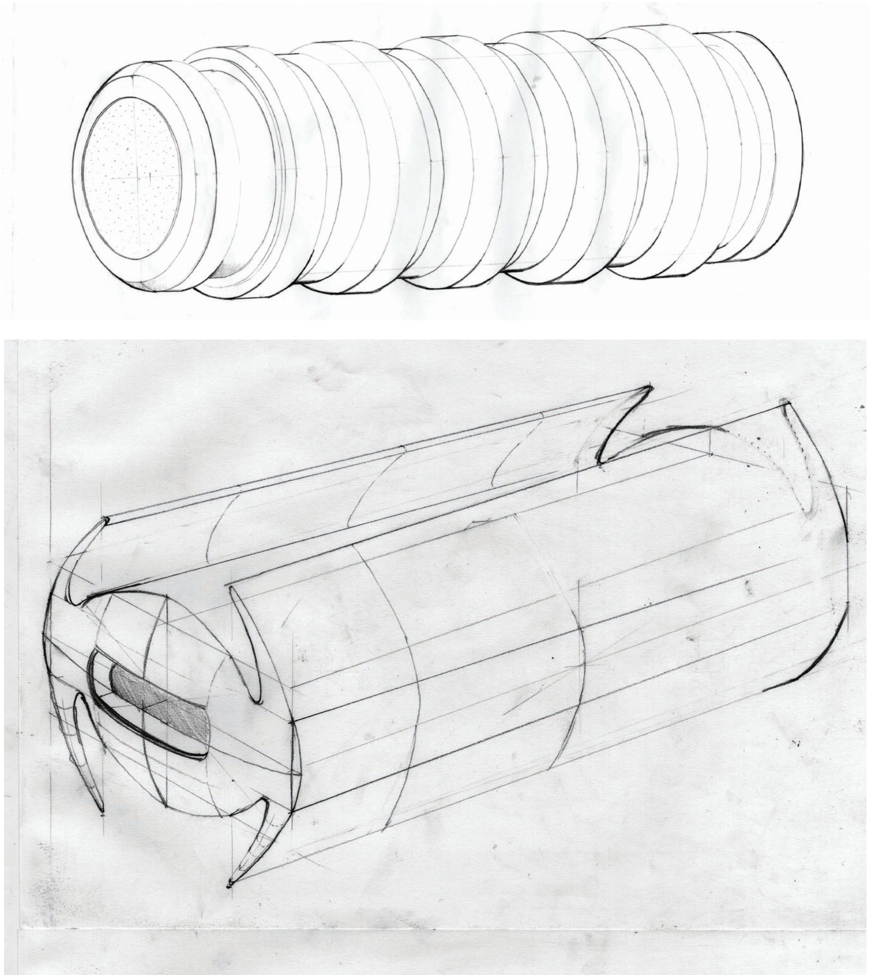


Figure 6.1 Sketches – Initial concepts looking at ways to increase the surface area of the solar still. 02/12/2009.

The following are developed concepts based off the chosen design. Each developed concept is an attempt at increasing the surface area of the base. This is to maximise the amount of area on the product for condensation.

Maximising Surface Area

This concept is a result of talks with an engineer (Timothy Gough, Designer/Engineer for Flotech). After looking at earlier concepts and suggesting that the size of the product may be too small to generate enough water new ways to generate more surface area on the product were discussed.

Due to one of the design specifications being compatibility the size of the product needs to be kept to a minimum, however the smaller the product the smaller the output of fresh water. One way of increasing the output is by increasing the surface area of the cylinder. These concepts show variations in the contours of the product to increase the surface area. By having the ribs running down the product the surface is nearly doubled which provides more surface area for the water to condensate on.

Telescopic Design

This design is also attempting to maximise the surface area of the product whilst still trying to keep the product to a minimal size. It is moving away from the preferred cylindrical shape and towards an oval profile.

The oval shape gives the Watermaker a point of orientation. It can be flipped and will level on one of the longer profiles, giving sufficient time for the water vapour to rise and condensate on the upper surface. If the product is perfectly round the wind may cause it to spin and not enough time would be available for the water to condensate on the upper surface above the sponge.

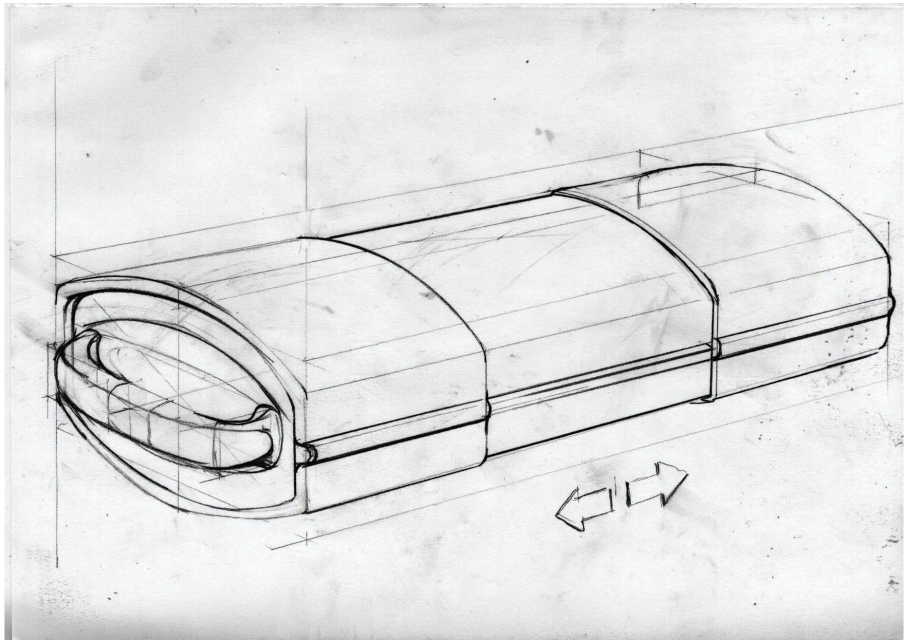


Figure 6.2 Sketch – Developed concept to increase the surface area of the solar still, Telescopic design. 13/02/2010.

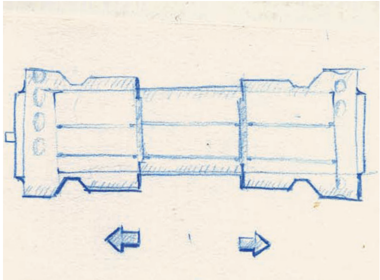


Figure 6.3 Sketch – Side view of a telescopic cylinder concept. 13/02/2010.

Rotational Semicircle Design

This design once again tries to maximise the surface area of the product while trying to minimise the overall size. It has a different approach, where the previous design boasted a ribbed surface that increased the total surface area this design uses a mechanical technique.

The design has two halves, one is slightly smaller than the other so it can rotate 180 degrees and sit flush with the other half. This would allow another Watermaker to connect to the closed design to form a cylinder again, resulting in two Watermakers with the same storage space as one would have

Unfortunately there appeared to be too many issues trying to make this design watertight so this concept was not developed any further.

Flat Packed Design

The idea for this concept arose due to concerns over the size of initial prototypes not generating enough water. Early prototypes were cylindrical in shape with a diameter of 13cm and a length of 35cm. A resolve was needed to make the product bigger but not take up as much space; which has been the driving factor for the majority of the concepts generated.

The basis of this new design is around the solid structure being able to be dissembled and packed flat to a height of no more than 5cm. The mid section of the product is a flat sheet of clear plastic that is kept in its cylinder shape by the end caps. The mid section could be made in two different ways: 1) The base being extruded into a cylindrical shape, or 2) The other being two flat sheets of plastic that are fluid sealed down two edges. Whatever the method the base cylinder forms the core structure and is one of the strong points of this design.

As the mid section of the product can be packed flat it reduces the storage space dramatically. This also allows the Watermaker to be much bigger and therefore have a larger internal surface area when assembled, thus allowing it to generate more fresh water.

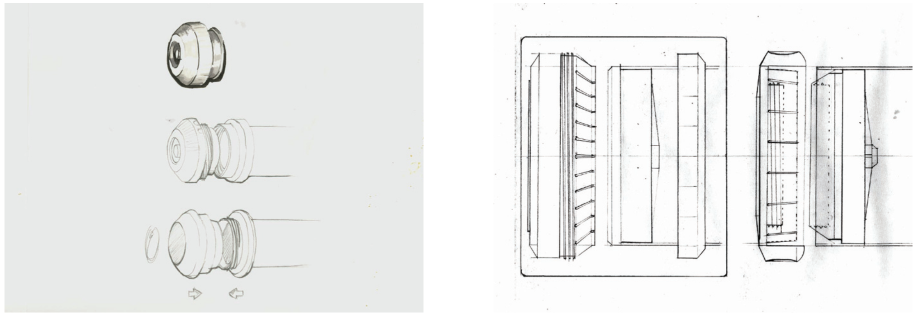


Figure 6.4 Sketch – Showing different was of sealing the end of the flat pack concept. 25/03/2010.

The major challenge with this concept is trying to design two end caps to form a watertight seal that is robust and 100% leak proof. Two parts screwing into each other, with the base sandwiched in the middle, could generate a suitable seal. But an additional part needed to be generated to hold the tray. With many attempts to try and incorporate this into one of the end caps it appeared very difficult to achieve. No solution was found that did not result in an extra part being necessary.

6.3 3D Mock-Ups

Some of the design concepts were created into cardboard mock-ups to look at size and scale. Seeing the concepts in three dimensions highlighted something's that needed addressing, with a few designs looking better on paper than in three dimensions.

Figure 6.5 Photograph – Cardboard mock-up of the cylinder design for the solar still. 06/02/2010.

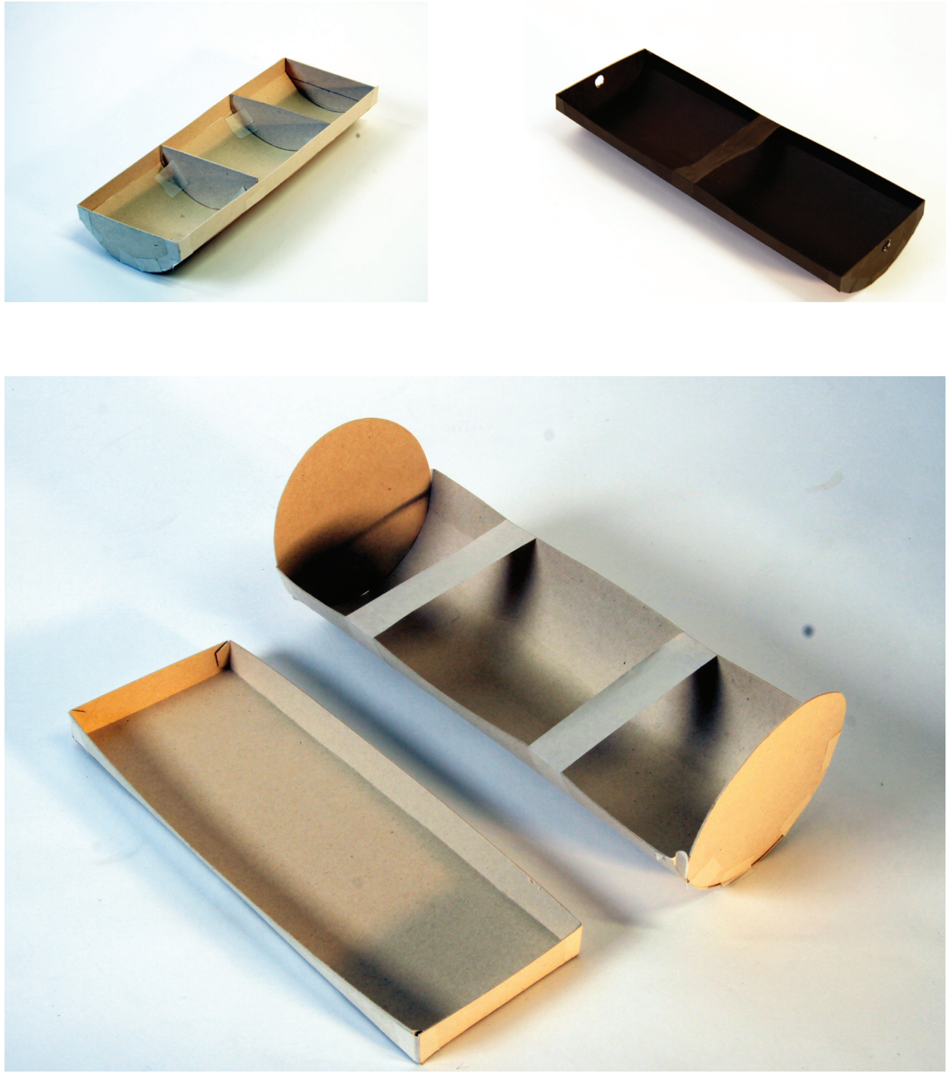


Figure 6.6 Photographs – Cardboard mock-ups for different internal trays. The trays hold the saltwater. 06/02/2010.

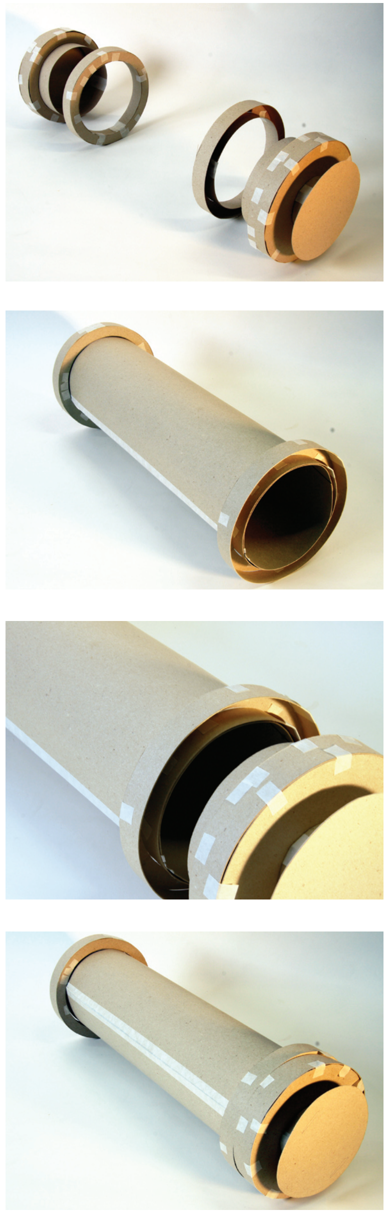



Figure 6.7 Photographs – Cardboard mock-ups for the flat packed concept. Showing the assembly of the design. 30/03/2010.

6.4 Feedback

The blow moulded surface area design appeared to be the design to best fulfil the design criteria and offer the best solution to the problem. It allows the overall product size to be smaller while still meeting the need to increase the surface area, the larger the surface area the more space for condensation to occur. This will result in a higher water output.

7.0 Prototypes and Testing

The following chapter will document the testing of the first working prototypes. The prototypes start off as simple models and develop into fully functional working designs. Cross comparisons are done to find ways to improve the output of the concepts. Simple changes reveal surprising increases in water production.

Much of the prototype testing was carried out during the development of the original concept. The tests were carried out to prove that the concept works and to find ways of potentially increasing the productiveness of the design. This was done by testing the aspects of increasing surface area, changing colours and incorporating metal objects to increase internal temperatures.

7.1 Bottle Tubes

Figure 7.0 Photographs – First small scale working prototypes. 10/12/2009.

The bottle tube design was the first working prototype created. The original idea was sparked by seeing a bottle that was sitting out in the sun. The contents of the bottle had started to condensate on the upper canopy and were running down back into the contents of the bottle. So the early designs very much resemble a 1.5L soft drink bottle.

The bottle tube prototypes are made from two 1.5L bottles. The middle section of the bottle was cut out and fixed to one another. The bottom of the bottle (punt) was used from both bottles as an end cap to seal the tube and to also act as an axis for the tray to rotate on.

The tray was constructed by a net shape designed to fit inside the bottle, a simple rectangle with sidewalls to contain the sponge that holds the saltwater. The tray is made from a black sheet of polypropylene.
It sits on two screws on the centre axis of the bottle to give the prototype the gimbals feature that was incorporated into the early concepts.

Figure 7.1 Photographs –Prototypes Bottle Tubes dissembled and perspective shots. 11/12/2009.

7.2 Prototype Testing - Bottle Tubes

Hypothesis

It was thought that the early bottle tubes would not collect a huge amount of water, as they are not to full scale. They are approximately 1/3 of the preferred size for the Watermaker. By being smaller they could have increased their internal temperature much faster than the larger prototypes and start working in a fraction of the time, but the output may slow down once the optimum temperature has been reached.

The first bottle tube prototype was been made with a yellow sponge to hold the salt water. There was no scientific reason for this other than that this is the colour the sponge was purchased in. There was a possibility that a black sponge could draw more heat so a cross comparison was carried out with two identical bottle tubes, one with a yellow sponge and the other with a black sponge.

Tables 7.0

Prototype testing results for the first concepts - Bottle Tubes.

Date: 26/01/2010	**Test No:** 005	
Prototype/s: 001 Yellow bottle, 002 Black Bottle		
Temperature: 20°C		
General Conditions: Cloudy day with patches of sunshine. Strong NE winds.		
Duration: 7hours		
Start: 10:30 am	**Finish:** 5:30 pm	
Results		
Prototype No:	**#001**	**#002**
Water Produced: (L)	40ml	60ml

Date: 27/01/2010	**Test No:** 006	
Prototype/s: 001 Yellow bottle, 002 Black Bottle		
Temperature: 20°C		
General Conditions: Mostly sunny with occasional clouds. Strong NE winds.		
Duration: 7hours		
Start: 11:30 am	**Finish:** 5:00 pm	
Results		
Prototype No:	**#001**	**#002**
Water Produced: (L)	40ml	55ml

Date: 2/02/2010	**Test No:** 007	
Prototype/s: 001 Yellow bottle, 002 Black Bottle		
Temperature: 23°C (approx)		
General Conditions: Mostly sunny.		
Duration: 8 hours		
Start: 9:30 am	**Finish:** 5:30 pm	
Results		
Prototype No:	**#001**	**#002**
Water Produced: (L)	55ml	70ml

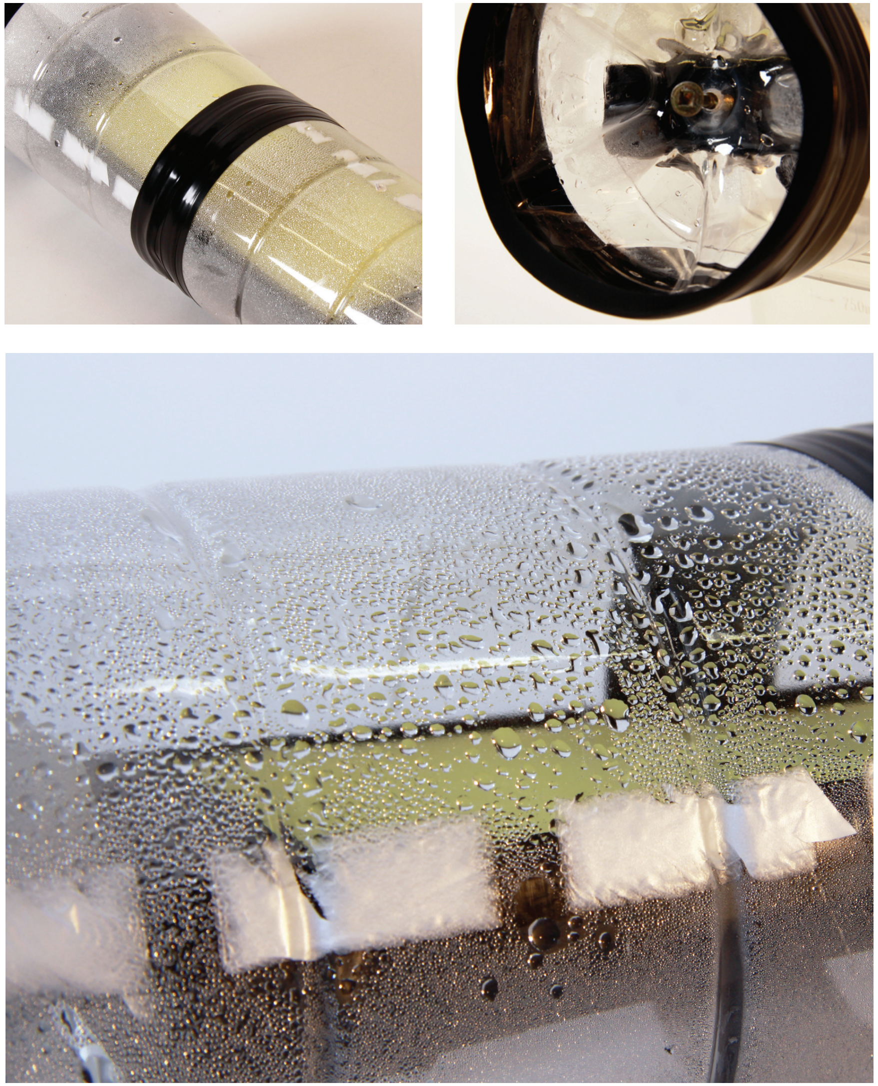


Figure 7.2 Photographs – Close up shots of the first working prototypes. 11/12/2009.

7.3 Testing and Cross Comparisons

The first bottle tube was tested approximately 10 times before some cross comparisons were done. The tests were only using fresh water on the sponge rather than saltwater and had very positive results, generating a surprising amount of water in the bottom of the bottle. On a sunny day the bottle would generate about 40ml of water. This is not enough water to survive on in a life raft but for an early prototype it is a good result.

Once the bottle tube prototype had been proven to work, an identical prototype was assembled for some comparative testing using a black sponge. The dimensions and tray sizes were the same and the same amount of water was placed onto the sponges. The only difference between the two prototypes was the colour of the sponge that sat on the tray.

The two prototypes were placed out in a range of conditions to see if any variables in weather conditions would affect the results.

From the first test it was evident that the black sponge made a significant difference. Over the first day it produced nearly twice the amount of water as the yellow sponge. Further tests were carried out to see if this was due to optimum conditions or some unforeseen reason. The tests only revealed that the prototype with the black sponge continued to be much more efficient and this was due to the black surface absorbing more sunlight, therefore generating more heat.

7.4 Vacuum Formed Prototypes

After the success of the first prototypes, larger scale prototypes were made for the purpose of further comparative testing. A mould was made from a PVC pipe to vacuum form the base of the new mock-ups. A tray was constructed out of corrugated plastic that contained a sponge holding the salt water.

The moulded halves were sealed with a foam strip that ran down the edge. A spine also ran down both edges to form the seal. It was not perfect as some water was lost when it would meet this seal and run down the outside of the prototype. I estimate that possibly as much as 10-20% of the water generated was lost.

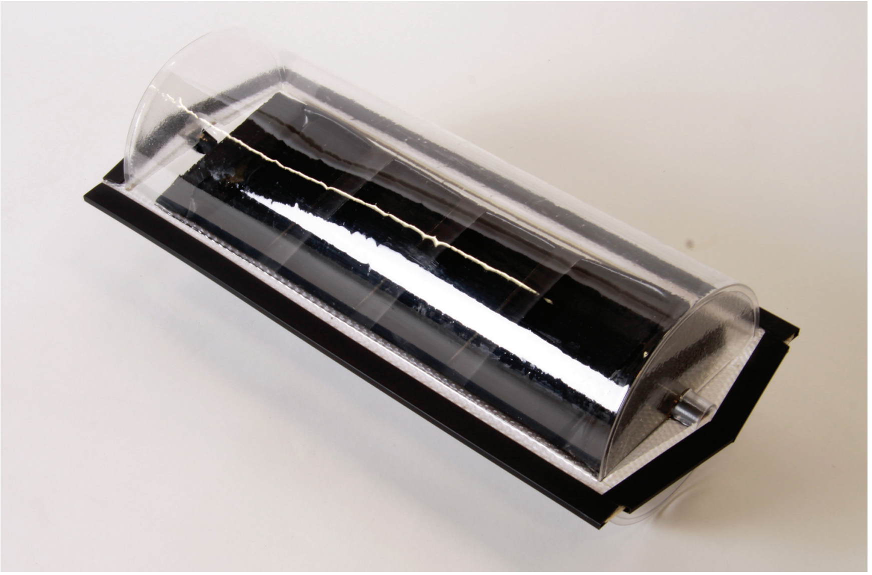


Figure 7.3 Photograph – Perspective view of the larger scale-working prototype – Vac Formed Prototypes. 20/01/2010.

Two of these prototypes were also made. The only visual difference between the two was the shape of the flange that ran along the edge of the prototype. This was only for identification between the prototypes and offered no advantage with testing.

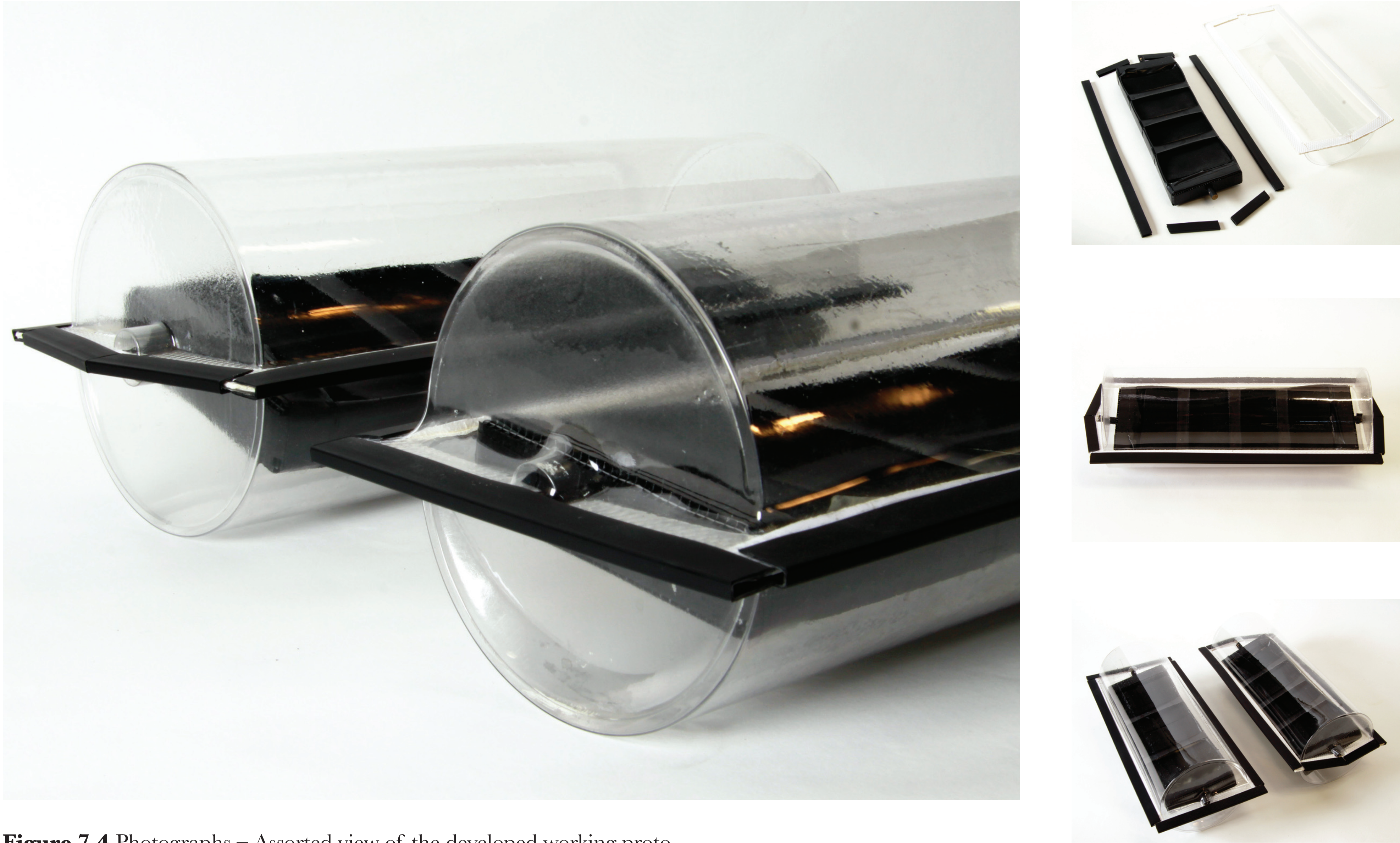


Figure 7.4 Photographs – Assorted view of the developed working prototypes. Built for comparative testing. 20/01/2010.

7.5 Prototype Testing – Vacuum Formed

The first tests with the new prototypes were very positive. The results can be seen in the chart below.
The testing was carried out during mid to late summer. This gave a better indication of the performance in the ideal climates. Initially one of the prototypes leaked the majority of its water down one edge of the seal. This was quickly fixed and testing resumed.

Figure 7.5 Photograph – Close up shot of a Vac Formed Prototype working. 20/01/2010.

Some tests were carried out on a lake to see how the product performed in rough conditions. The testing revealed that the product would sometimes spin when a larger wave struck the cylinder shaped prototype. This led to the quick development of an over design to stop the product being flipped.

Tables 7.1
Prototype testing results for the second concepts – Vac Formed Prototypes.

Date: 2010	**Test No:** 007	
Prototype/s: 003 Vac One, 004 Vac Two		
Temperature: 22°C		
General Conditions: Mostly sunny with occasional clouds. Not much wind.		
Duration: 7hours		
Start: 10:30 am	**Finish:** 5:30 pm	
Results		
Prototype No:	**#003**	**#004**
Water Produced: (L)	150ml	155ml

Date: 2010	**Test No:** 008	
Prototype/s: 003 Vac One, 004 Vac Two		
Temperature: 25°C		
General Conditions: Mostly sunny with occasional clouds. Moderate NW winds.		
Duration: 9.5 hours		
Start: 10:30 am	**Finish:** 8:00 pm	
Results		
Prototype No:	**#003**	**#004**
Water Produced: (L)	230ml	240ml

7.6 Variations for Comparison

Further testing was carried out with the vacuum formed prototypes. Some theories suggested by engineer Timothy Gough were tried. This was to use a silver reflective sheet of aluminium on the bottom surface to reflect the suns rays and heat throughout the prototype. This could potentially speed up the rate of evaporation and condensation.

This test was to be purely a visual observational test where the two prototypes were used. One had the silver sheet insert and the other without. This was tested several times in varying conditions. There was no obvious advantage or increased output with the insert.

7.7 Oval Prototype

Another working prototype was made to test a new oval design. This trial product was to test how varying wall gradient would affect the performance and if the increased surface area would help with the amount of water produced.

The prototype was also vacuumed in two pieces and sealed the same way. The insert tray was the same size as in the smaller cylindrical designs to ensure consistent testing criteria. This design was unfortunately created in autumn and conditions for testing were poor. The prototype did have an advantage over the cylinder designs, which was put down to the increased surface area allowing for more condensation.

This design also boasted the new testing feature of two black aluminium inserts. These inserts can be seen on the on the prototype photos to the left on the outside of the central tray. Tests were carried out with and with out them. The theory was that the aluminium rods would attract more heat and increase the internal temperature thus speeding up the rate of condensation.

Tests concluded that the rods had no significant advantage and did not increase the production at all. Due to local conditions rapidly deteriorating this theory was not able to be tested in depth. This idea could increase the productiveness however testing revealed no significant increase so this feature was not developed further.

Figure 7.6 Photograph – Perspective shot of the Oval concept. 16/02/2010.

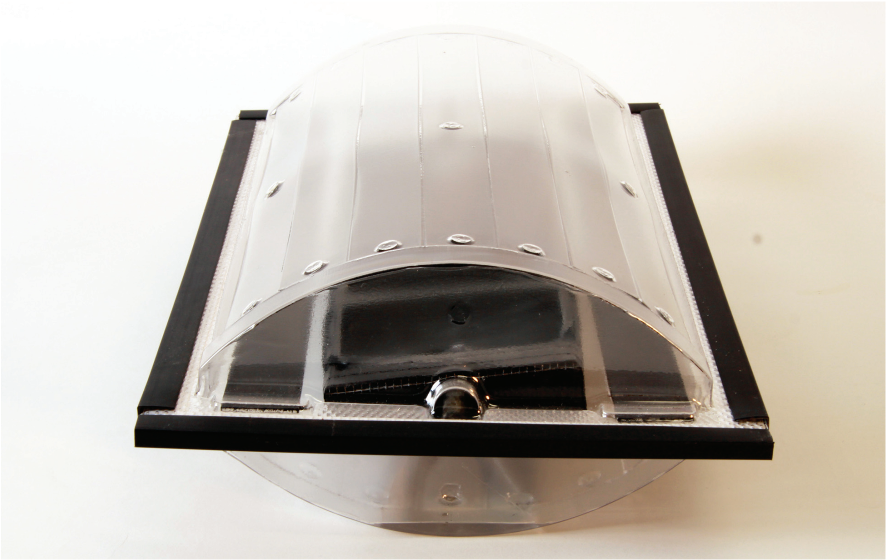


Figure 7.7 Photographs – Showing the simplicity of the Prototypes. Front view to show the profile of the design. 16/02/2010.

7.8 Prototype Results and Conclusions

Overall the prototypes proved vital to help progress with further development. The smaller bottle tube prototypes had a surprising output for their size. The significance of having the sponge black was the greatest finding within the testing phase. The trials that did not have a significant effect in increasing production were the silver reflector insert in the vacuum formed cylinder and the rods used in the oval design. Both tests were to try and increase internal temperatures to speed up the condensation process however nothing was conclusive with the tests that were carried out.

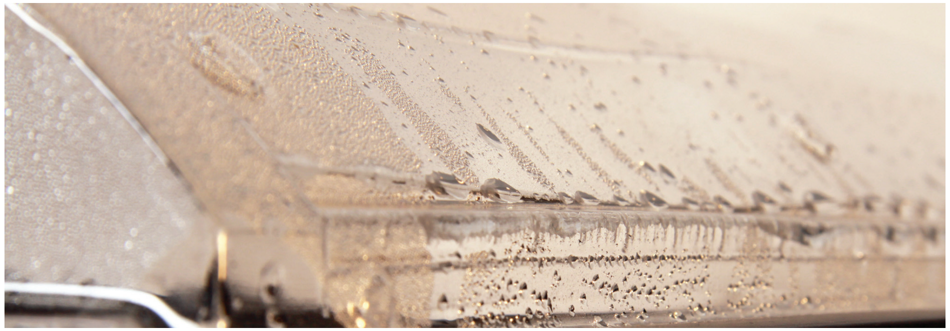


Figure 7.8 Photograph – Close up perspective shot. Showing the build up of condensation on the inner surface. 16/02/2010.

Figure 7.9 Photograph – Another close up perspective shot. Showing the build up of condensation on the inner surface and how it tracks down the inner surface. 16/02/2010.

7.9 Development based on results

Based on the results from the prototype testing, the design will not incorporate large scale ribs. The attempts to try and speed up the condensation process with internal metal components were inconclusive and will not be applied to the final design. Keeping the sponge black and the tray on a gimbal system are crucial as testing proved that a black sponge was much more productive than a lighter colour and the gimbal system will allow the product to rotate in the surf, encouraging water production.

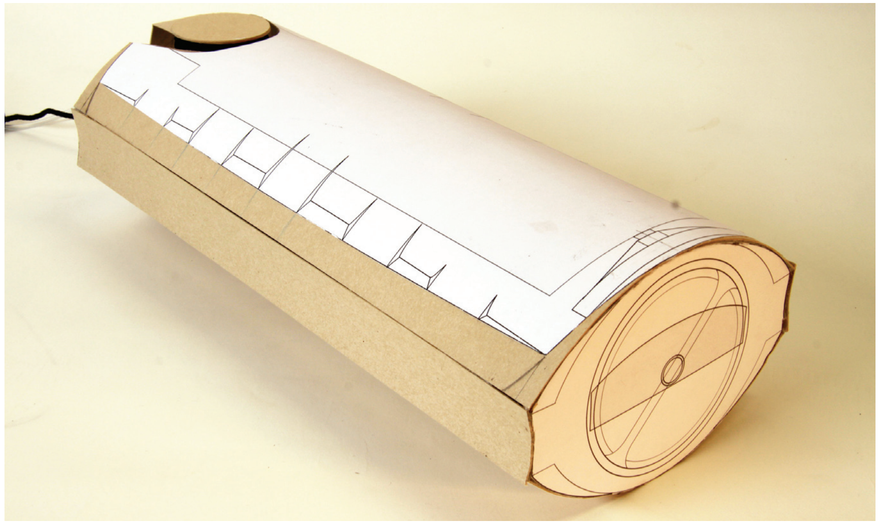
8.0 Refinement and Manufacturing

This chapter documents the refinement of the watermaker. Changes are made based on product testing and prototypes. Final adjustments are made to the design with the help of industry professionals. A brief explanation for each part is included. As well as Focus groups and interviews to gain critical feedback on the final design.

8.1 Chosen Manufacturing Technique

During the refinement phase the design shifted across three versions with different manufacturing techniques. There was a blow-moulded design that would be economical in high production numbers. There was an Extrusion moulded design that would have a reduced footprint to save space. The final design was Vacuum formed and could be stacked in one another to save space. Each concept was developed to a high level with many strong attributes.

An interview was arranged with a manufacturing industry specialist to show them the gather their opinion on which design to was the most beneficial to advance with.



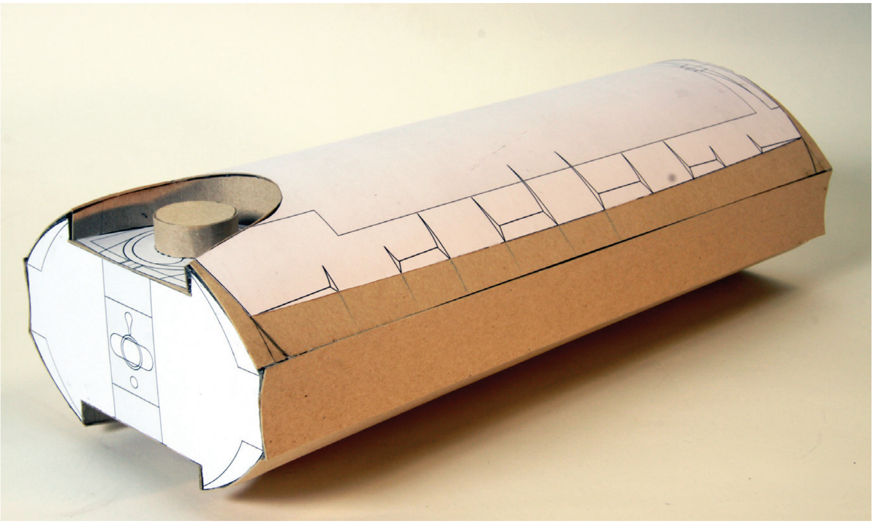
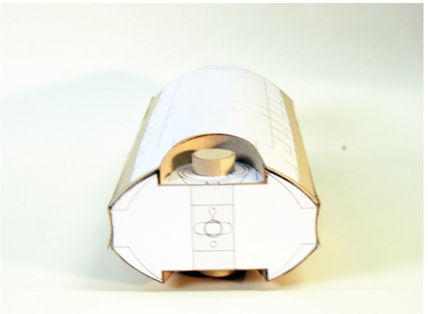
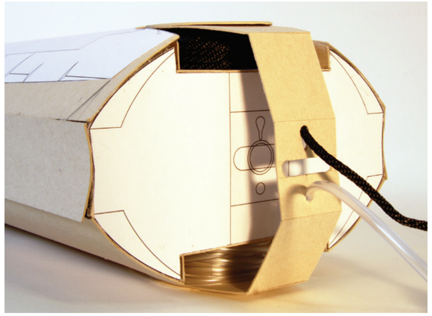


Figure 8.0 Photographs – Cardboard Mock up of the final design, front and rear perspective views. 21/04/2010.





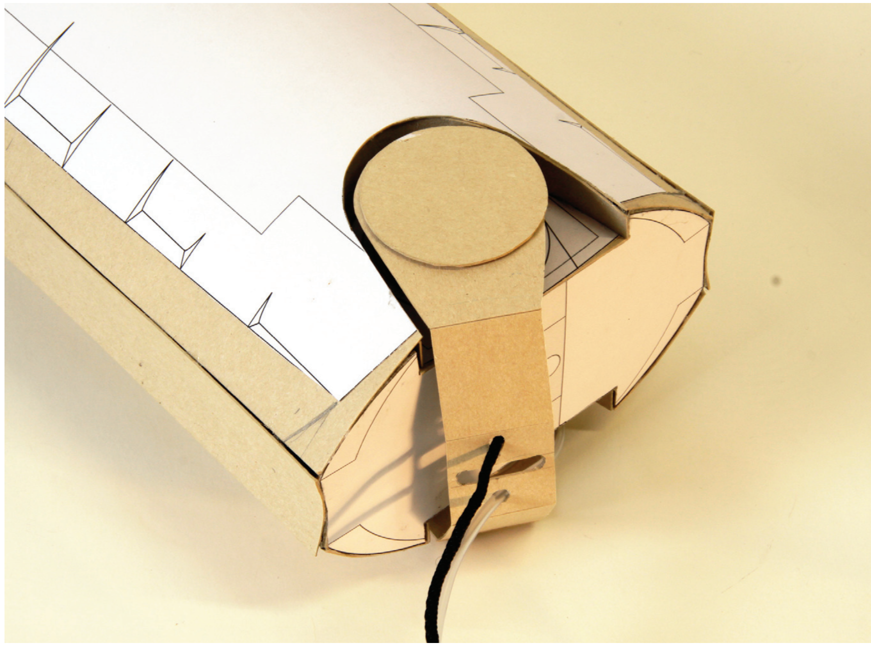


Figure 8.1 Photographs – Cardboard Mock up of the final design, assorted views to show the front bracket components. 21/04/2010.

Meeting with Brien PDT (Plastic Design Technologies) 14/5/10

Brien O'Brien, who runs a SLA rapid prototyping business in Silverdale, Auckland has a vast knowledge in manufacturing and what he passed on in the meeting proved to be invaluable.

Three different concepts were presented and discussed with Brien,

1) Blow-Moulded Design
2) Extrusion Moulded Design

3) Vac Formed Design

This was to find out what design features had the most potential and which manufacturing technique is most suited for production.

The designs that appealed to Brien the most were the blow-moulded design and the vacuum formed concepts. On a small scale production vacuum forming is a more affordable process as tooling is cheaper, and the process is more automated than it used to be. The blow-moulded design is better suited for large-scale production and he believed that using this technique would make a very affordable product.

As a result of the meeting with O'Brien the blow moulded design was chosen as the concept that will be further developed. Using this technique will have more expensive tooling, however once set up it will be more affordable to do large volume runs. Using blow moulding for the base will provide a watertight durable product. The plastic used in this process will be the same as used in translucent bottles: PET (Polyethylene terephthalate). Its qualities are durability and strong resistance to UV light which are both important for the intended use of the product.

Figure 8.2 CAD Renderings – Front and rear views of the final design.
10/07/2010.

8.2 Components and Materials

Front bracket
Designed to bring the front components together. The top and bottom caps both clip into this component connecting these three parts. The rejuvenating feed, supply hose and lead all pass through the front bracket. This part is made from High Density Polyethylene (HDPE) plastic.

Top Cap
Clips into the front bracket and was designed as a reel for the products lead. This component can swivel so the lead could be reeled in or pulled out. It was the most suitable way for storing the lead. This part is made from High Density Polyethylene (HDPE) plastic.

Bottom Cap
Clips onto the front bracket and was designed to allow the feed hose to be wrapped around it. The bottom cap has a pressure tight fit onto the base and does not need to pivot like the top cap. This part is made from High Density Polyethylene (HDPE) plastic.

Plugs
Used to form seals at the front of the product for the supply hose and rejuvenating sponge feed. Both are made from silicone rubber.

Tray
Its sole function is to hold the sponge that contains the salt water. It rests on a gimbal system to allow the tray to flip if the product is tipped by a wave. This part is made from High Density Polyethylene (HDPE) plastic.

Internal Sponge
Its function is to hold the seawater. Having the seawater contained in a sponge stops any chance of it spilling into the fresh water that is generated. The sponge is black to attract more heat making the process much faster. Heated seawater evaporates and rises as water vapour. The external sponge connects to the internal sponge allowing a constant supply of fresh source water. Both sponges are made from super absorbent Polyvinyl Alcohol (PVA) Sponge.

Base
Designed to give a clear canopy over the internal components containing the saltwater, the oval shape minimises the chance of this product flipping. The ribs add strength to the shape. It is made by injection blow moulding and uses clear polyethylene (PET) plastic.

Insert cap
Designed as an insert to hold the tray; having this insert allows the user to easily insert the tray back inside the product before they screw the end cap back on. This part is made from High Density Polyethylene (HDPE) plastic.

End Cap
Designed as a seal at the end of the base, it has an internal thread and screws onto the thread on the base. This part is made from High Density Polyethylene (HDPE) plastic.

External Sponge
The saltwater is pulled up the tubular sponge by a capillary action to feed the internal sponge. The water tracks around the outside of the internal sponge before working its way inwards. The internal sponge is replenished at a slow rate allowing the existing water to heat up and

rise as water vapour. This method of self-replenishing gives this product a unique feature. Once the product is placed into the water it will automatically start working.

Lead

This lead is connects to the product so it can be secured to a life vessel or object. The clip is attached to the end of the lead that also has a connection point for the supply hose. The lead is wound onto the top cap when the product is not being used.

Supply hose

This is a hollow silicon tube that runs inside the product. The end is connected to the insert cap and runs outside of the product and is wrapped around the bottom cap. The fresh water produced by this product can be drunk directly from the supply hose. There is a connection point on the clip attached the lead to fit the hose into when the user is not drinking from the product.

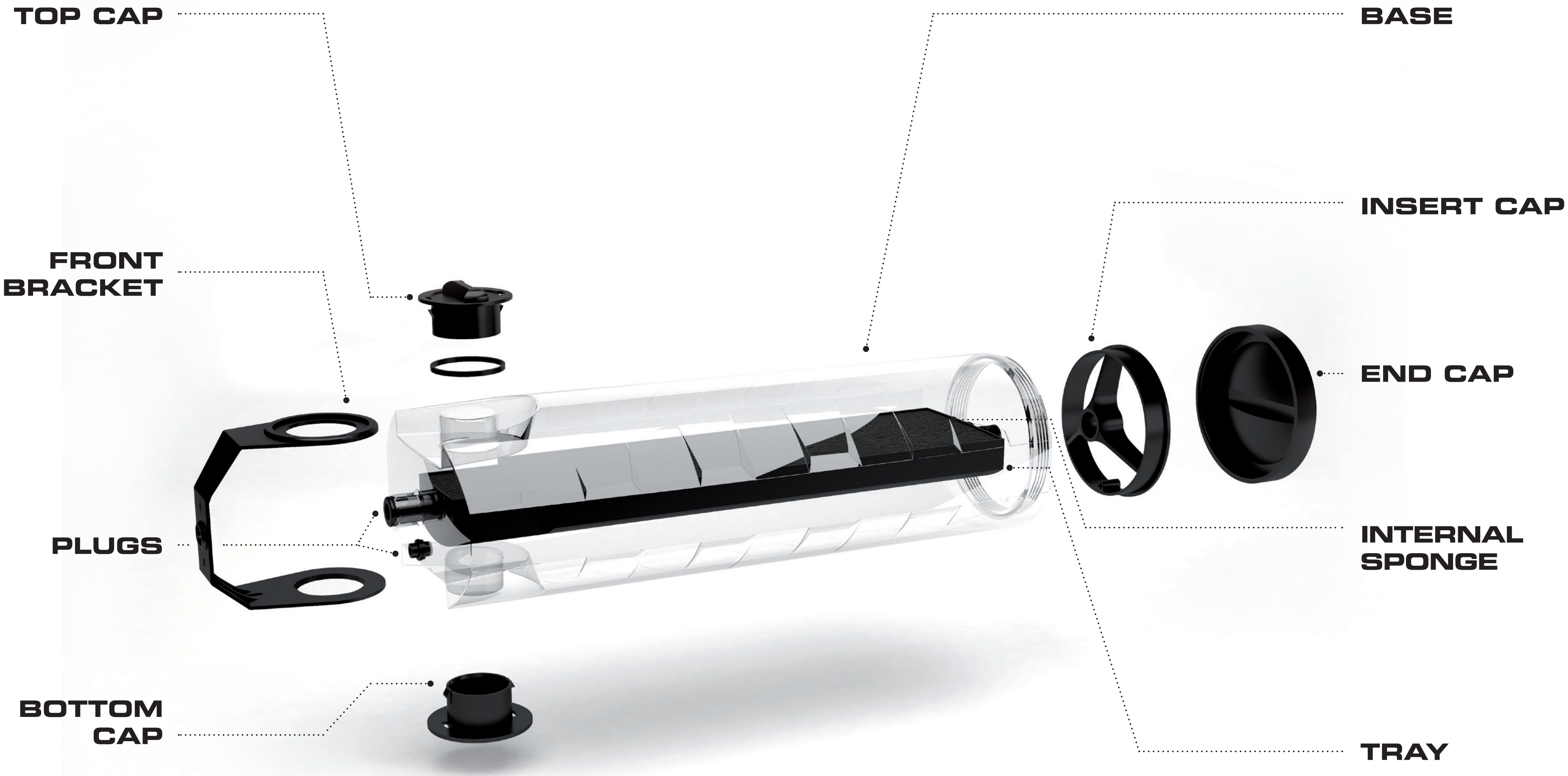


Figure 8.3 CAD Rendering – Exploded view showing the main parts.
10/07/2010.

8.3 Existing Products Colour Branding Evaluation

There are very few Watermakers on the market. Research into their branding and colour revealed that little effort was exerted in this area. The Aquamate inflatable solar still has an orange base but this is on the underside of the product offering little advantage in visibility for searches. The Katadyn Survivor 06 also had little attention to graphics or colour to give the product a safety look. However there was little need, as this product would be kept inside the life raft.

Figure 8.4 Illustrations – Concept generation for the Aquaflo logo. 7/04/2010.

Figure 8.5 Illustrations – Final design for the Aquaflo logo displayed in two colour options. 21/04/2010.

8.4 Overall form and Styling

The original concept was a simple cylinder leading much of the later concepts being fixated on this cylindrical shape. Other developments were made to try and make a new innovative shape however nothing was as efficient as the cylinder.

Product tests revealed that the cylinder would spin in the water easily from wind and waves and the resolve of an oval design was the best solution to this issue.

The Aquaflo's aesthetics were very much determined by the function of the product. Because water vapour forms on the inner surface of the product it was important that the product had a large surface area. It was also important that the product did not take up a lot of space. This made the cylinder an ideal shape for the product as a cylinder has a large surface area in relation to its volume. Development saw the cylinder design evolve into an oval shape. This was to keep the product from spinning around on the water. Product testing revealed that the cylindrical design would roll over in windy conditions. This could slow the condensation process down, as it would cool the internal temperature of the product resulting in less output. The oval design resolved this issue as it was more stable.

The ribs on the side of the base were designed to increase the surface area of the product resulting in a greater output. Earlier designs had much larger ribs however the product proved to be efficient enough without the larger ribs so they were scaled down. An unintentional feature of the ribs is they provide strength and rigidity to the product.

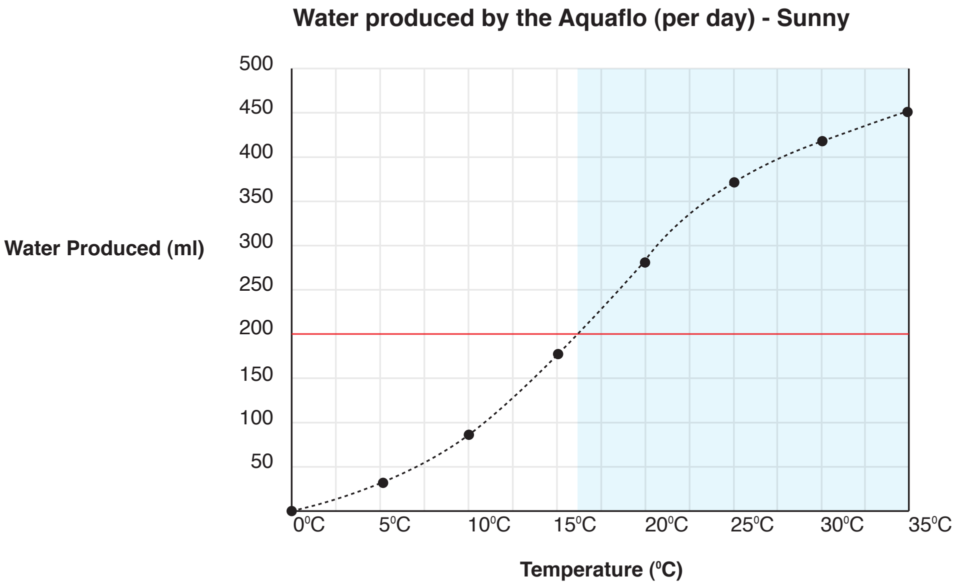
The internal tray was designed to have the maximum footprint possible. This provides more area for the sponge to be exposed to the sunlight resulting in more saltwater being evaporated. This will also make the product more efficient.

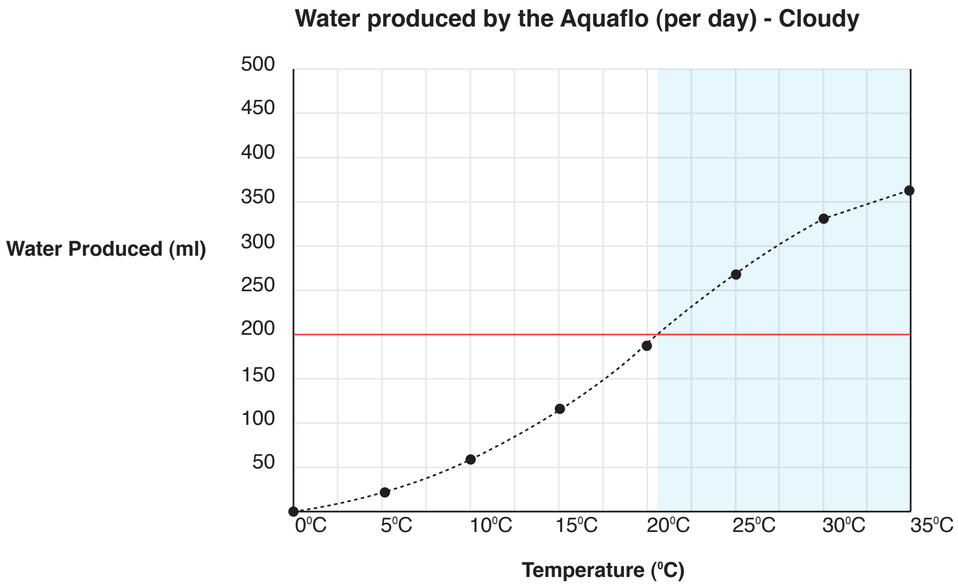
Figure 8.6 CAD – Renderings to show possible colour variations. 10/07/2010.

8.5 Estimated Water Production of the Aquaflo

The following graphs show estimates for water production of the Aquaflo based on earlier product testing. The two charts show the expected water production on both sunny and cloudy days.

Tables 8.0
Water Prediction graphs – Displaying the estimated water quantities per day in a range of temperatures, for both sunny and cloudy days. 22/8/2010.





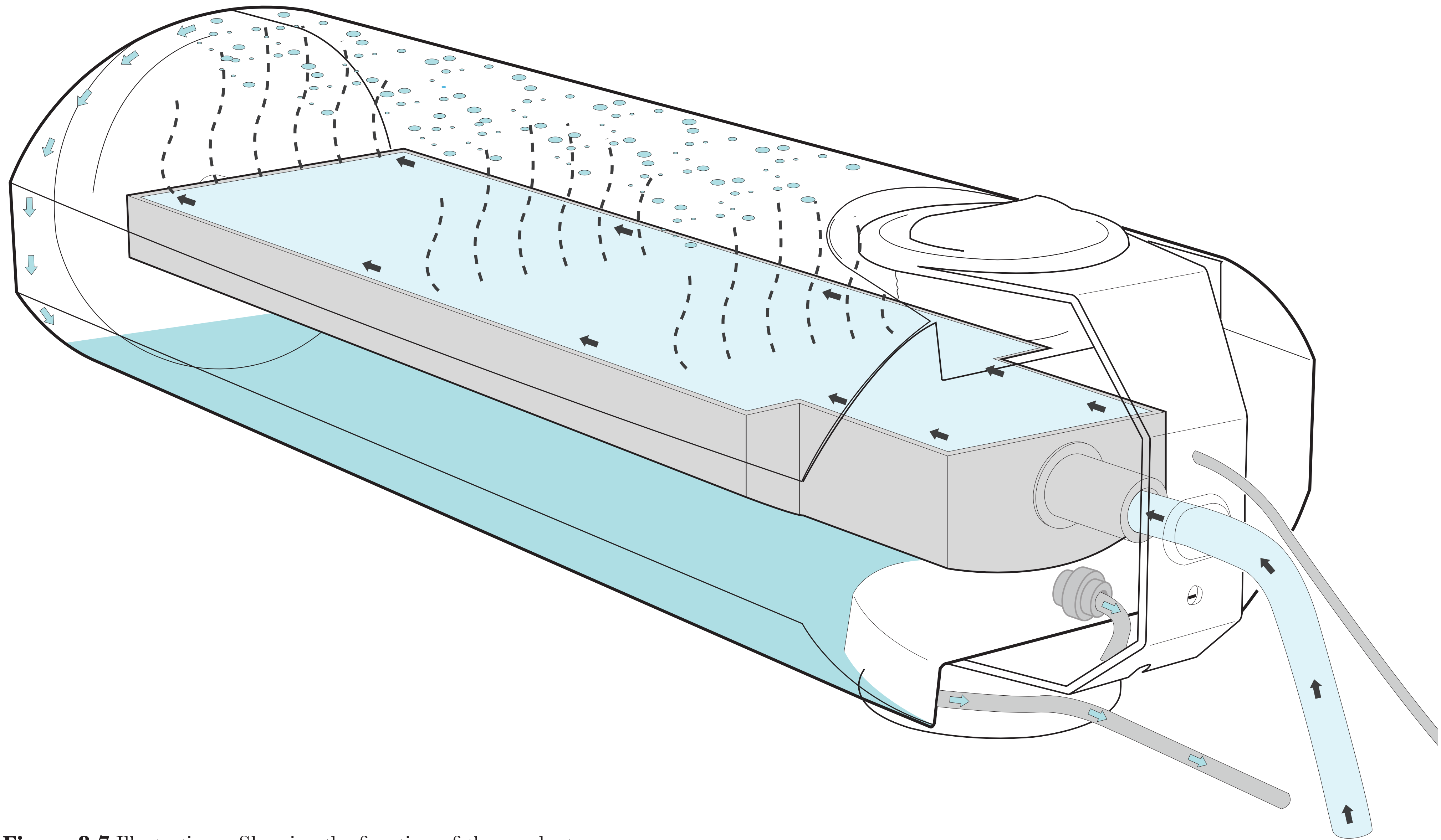


Figure 8.7 Illustration – Showing the function of the product. 20/07/2010.

8.6 Product Ergonomics

A product of this nature may be stored on a vessel and often never used. It is only in survival situations that this product will be needed. The final design is simple to operate and easy to use. Unlike the leading Watermaker Survivor 06 the Aquaflo requires no energy input to generate water. Whereas manual hand pumped products would have required thorough ergonomic development and attention.

Once the Aquaflo is placed on the water it works automatically, the only interaction the user will have after that is to disconnect the hose from the clip to drink from the product. Three basic steps would get the product working.

1. Unravel the supply hose and pull the lead from the spool.
2. Clip the end of the lead to something secure on the life raft/vessel.
3. Place the product on the water.

The rejuvenating sponge was developed into the product so the user does not need to refill the saltwater on the sponge. This again minimises the interaction the user has with the product simplifying the process even more.

The areas that required ergonomic attention were the end cap and front bracket clips. These areas would be handled by the user on a minimal scale. The end cap has a thread and screws onto the base and was designed to allow the user enough surface area to grip the cap and unscrew it from the base. The diameter of the cap was kept to a scale that allowed a larger percentage of the users to grip the cap.

One of the clips on the front bracket has the product lead wrapped around it. The clip has a small handle on it to allow the user to retrieve the product lead. This area of the product was designed so that the user does not need to manually unwind the product lead. It sits on a loose spool and can be pulled from the product. It is only once the user has finished with the product that this handle would need to be used to retrieve the product lead.

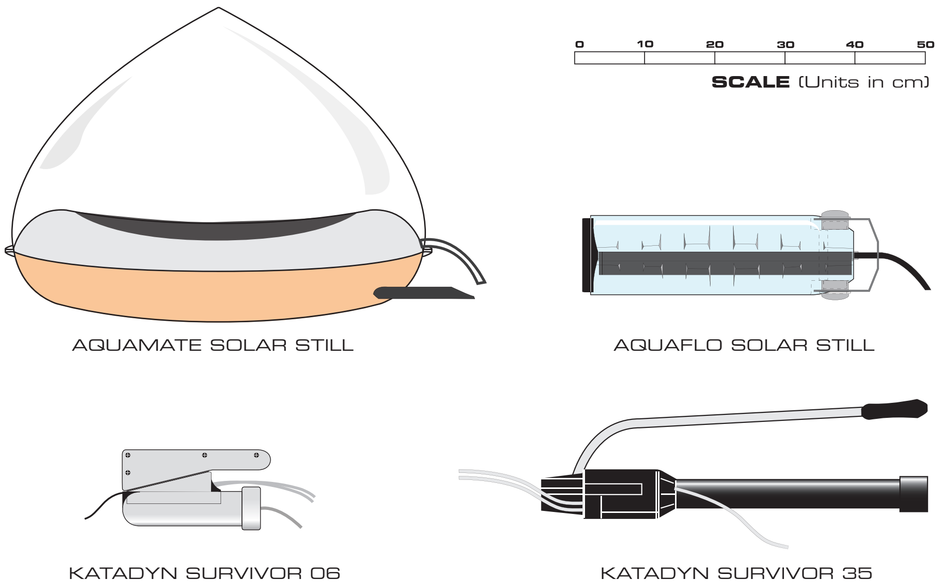


Figure 8.8 Illustrations – Showing the scale of the leading contemporary products against the Aquaflo.

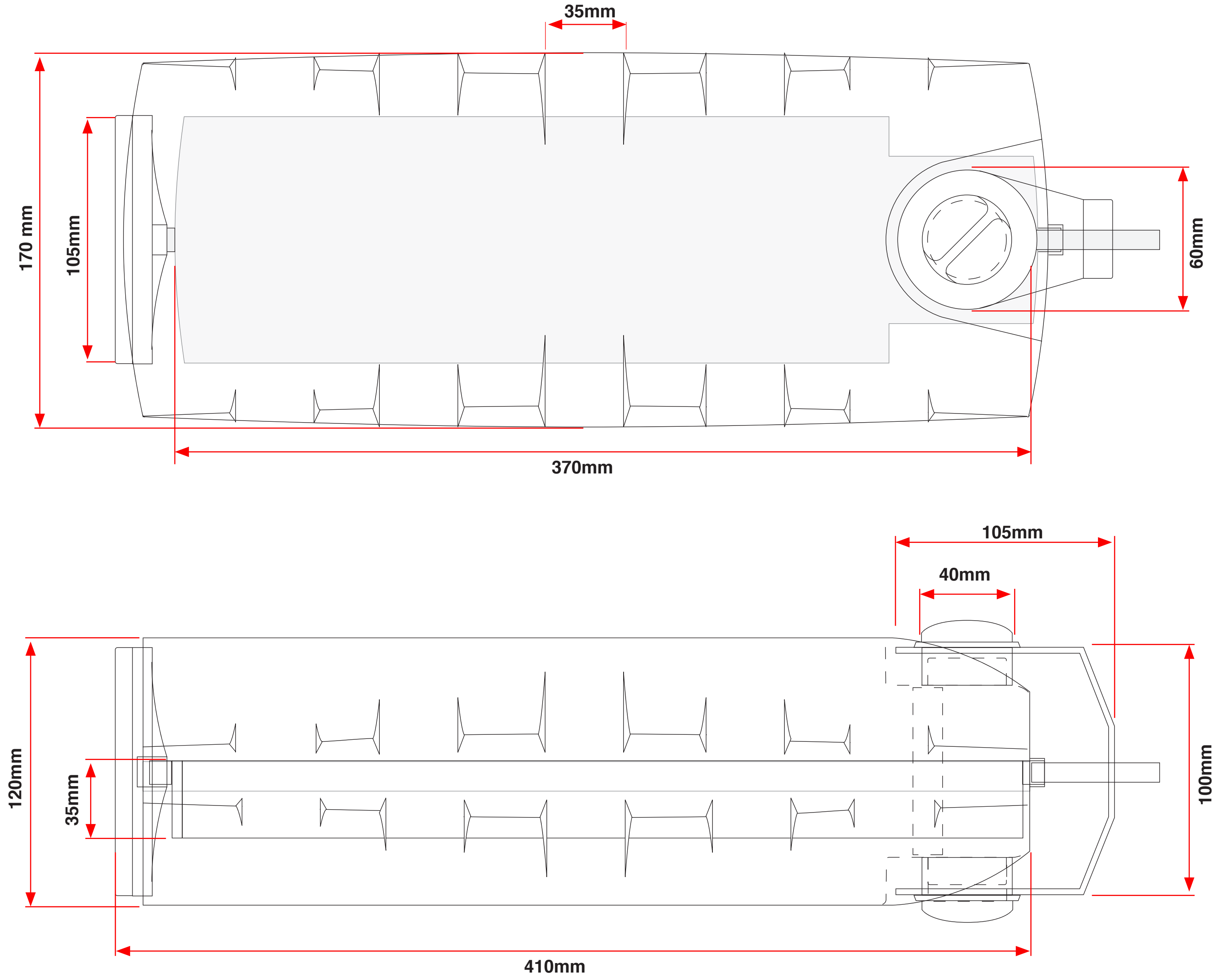


Figure 8.9 Illustrations – Basic dimensions of the Aquaflo.

8.7 Focus Group and Product Feedback

The following passage contains a summary from a focus group and interview that were held to obtain feedback on the final design. Both the interview and focus group were set up to gain feedback on product function, aesthetics, usability and innovation. The people included in the focus group consisted of potential users who all have boating experience. The interview is with a sailing enthusiast whom has various areas a speciality and experience that are relevant to this project.

Interview

The interviewee is Chris Kitchen who has had much experience in the marine industry in New Zealand and internationally. He is currently a designer and joint owner of Weta Marine. Weta has designed and developed a 4.4m trimaran that is gaining interest from around the world. There are now dedicated championships for the Trimarans where Chris was involved with the development of a boat. He studied mechanical engineering at Auckland University and it is this technical knowledge that will provide valuable feedback of the product.

Chris has represented New Zealand in the junior world championships for the Hobie 16 class dinghy where he placed an impressive second. He has also had a lot of experience in other classes of inshore dinghy sailing and has also been involved in several coastal classic races. The Coastal Classic is a yacht race from Devonport wharf in Auckland to Russel. The race involves New Zealand's premier fleet of yachts.

Section One

The following questions were established to gain some knowledge about Chris and his understanding of watermakers.

What boating experience do you have?
It was discussed that Chris has had a lot of experience with inshore dinghy racing. Much of the experience is with multi hull craft such as the Hobie cats (twin hull). He has also competed in larger vessels such as the Coastal Classic race in New Zealand. Later in the interview it also arose that he had much experience in recreational cruising, mostly off the east coast of New Zealand.

Are you aware of current and existing watermakers? (if so which ones)
It was discussed that Chris was aware of some products available for survival situations and "grab bags" (survival packs on board a vessel). He could not think of any of the specific product names but mentioned the few he was aware of. He knew of the Katadyn Survivor 06 manual water maker and the Aquamate inflatable solar stills.

Have you ever been in any boating accident or situation where a watermaker was or could have been used?
"One time we had a broken propeller off Rangitoto Island": which is a volcanic island in the Hauraki Gulf of Auckland, New Zealand. We discussed that he and his crew were not too concerned as they were not isolated or vulnerable to hazardous ocean conditions. They were in a sheltered bay and had enough food and water to last a week. Due to no wind they could not sail back to make repairs. After a few days the wind picked up enough to sail back to the marina.

Section Two

Chris was shown the Aquaflo Watermaker however nothing about the product was explained or suggested. This is to gain initial observational preconceptions, views and opinions of the final design.

How do you think this product functions?
Chris looked at the product and said that he believed that it was a solar still and worked by collecting water through a condensation process. He stated that he had seen product before that use the same method.

Do you believe that you could get this product working without any instructional information?
Chris believed that he would have very little trouble understanding how the product worked. He said instructional information is always helpful and can be beneficial if people were to be in a serious situation. We discussed that it would be necessary to have the instructions on the side of the product. Image based instructions with a short description was believed would be the best option.

What are your initial thoughts and opinion on the products aesthetics?
He thought it looked "pretty straight forward". He believed that the product looked "clean" and did not look overly complex. Chris did mentioned that the front of the product did look "kind of busy" but added that it was not necessarily a bad thing as it cleaned up the rear of the product. He said that there was nothing about the product that was unpleasant and went on to mentioned that it was not the type of product he would expect to be heavily focused on looks and appearance.

How important would the aesthetics of the product be for you when purchasing a watermaker?
Chris stated that "it is of low importance". Having an engineering background he suggested that "reliability and cost" would be the decisive factors when purchasing a watermaker. The importance of reliability was discussed with such a product and that the aesthetics should be focused around this. Chris said that people would need to trust the product and that if the product looks durable and solid it would suggest to the consumer that the product is reliable.

What are your thoughts and opinions on the product colour and branding?
Without explanation Chris was able to identify that the components on the prototype were black to attract more heat to the product. It was discussed how the product could be manufactured in safety colours to better represent it as a survival product. Chris was asked if he thought this was a good idea "it depends if colour would affect the function of the product". It was mentioned that the internal components needed to remain black to attract the heat however the external components could be any colour and not affect the function of the product. He suggested that due to the small scale of the product it "probably wouldn't need to be a safety colour". However it would be beneficial so that people could recognise that it is a safety product and make it easier to find in emergency situations.

Section Three
The third set of questions is to get an honest critical opinion about the product once I have explained all the design functions and features.

Now that you have a better understanding on how the product works and functions is it any different than you imagined?
Chris stated "No not really" and added that using the sponge to store the salt water was "innovative" and the rejuvenating feed was also a great idea.

Do you think you or people in survival situations would have trouble operating this product?
He replied, "No I don't think so, it is a simple product to operate". It was discussed that due to the minimal user interaction with the product it would not be a very difficult product to operate. Chris believed users

would have little trouble setting up and operating the product.

Do you think the product size and scale is appropriate?
He explained that it was important to "try and compact it as much as possible, space is a big consideration in boats" Chris asked if the scale of the product was relative to the output. It was explained that the scale was appropriate to generate enough water for one person per day in the right conditions.

What market do you believe this product would be best suited for?
"Third world countries and small coastal vessels" Chris believed that due to the affordability of the product it would be suited to third world countries and as an option to smaller recreational craft.

Is there anything about this product that you would be concerned about in the marine environment?
Chris noticed that "all the components appear to be plastic" and used no materials that would be of great concern in the marine environment. He asked about the type of sponge used on the product and mentioned that he wondered if it were to be left damp could it deteriorate? It was then explained that the product would be sealed until required for use and this should not be an issue. He added that the only other issue would be the space the product would take up. In larger vessels it would not be much concern however in smaller craft every bit of space is valuable.

What improvements do you believe would be beneficial to this product?
Chris said that while the features at the front of the product were well designed making everything flush would optimise the size of the product. He suggested that having smooth surfaces in the marine environment makes it much easier to clean.

Other thoughts?
Chris said that due to the product being weather dependent it should be marketed mainly in warm climates. He said the watermaker had "huge potential" in the right markets. We discussed how the design could also be adapted as an aid product after natural disasters.

Conclusion
The interview with Chris Kitchen proved to be very beneficial. Chris's experience as a designer in the marine industry showed as he offered constructive feedback throughout the interview. He suggested ways in which the product could be improved to better function in such an environment. Chris saw the potential of the product due to the low manufacturing costs involved in production.

Focus Group
A focus group was held to gain feedback on a few key areas of the product. The people involved in the focus group were primarily male with boating experience. This was to ensure that the information gathered was from potential users and consumers of the product. They were asked to rate the product in a few key areas. Usability (ease of use), Functionality, Aesthetics and Innovation are the four areas the focus group is based around. The group was asked to give the product a rating between one and ten for each of the categories. The results were then put together to give the product an overall rating in those four areas. The results are listed below.

Conclusion
The results highlighted the strengths of the product. Innovation proved to be the best performer. The group was then asked why innovation was ranked so highly. The response suggested that this was mainly due to the rejuvenating feed and how the saltwater was stored in the sponge. The

response to the products aesthetics was good however it was suggested that colour could be used to make it look more like a safety product. (This was due to the prototype being painted black). The focus group provided valuable feedback from potential users. With the most interesting finding being that the function of the product were rated so highly.

Table 8.1
Tables – Showing results from the focus group questionnaire.

Usability									
1	2	3	4	5	6	7	8	9	10

Function									
1	2	3	4	5	6	7	8	9	10

Aesthetics									
1	2	3	4	5	6	7	8	9	10

Innovation									
1	2	3	4	5	6	7	8	9	10

8.8 Storage and Accessibility

The Aquaflo watermaker would be stored in different places depending on the type of vessel the product was on. It would be marketed towards smaller recreational craft and yachts, as there is not currently an affordable product targeted towards this type of vessel. The product would still be marketed towards larger vessels however the emphasis would be on smaller craft, as this is believed to have the most potential. The following passages explain how the product would be stored and accessed in emergency situations.

Small Craft/ Runabouts (8-18 feet)

On smaller vessels within this size range the Aquaflo would be stored in the front of the vessel. Most boats over 12 feet have storage space down the sidewalls. Most commonly a gutter runs from the front of the vessel to the rear of the boat. It is used to store fishing rods and other equipment. In many cases the watermaker would be stored in this gutter making it accessible in emergency situations.

Smaller craft around 8-12 feet do not have the gutter storage space as seen on the larger vessels. A caging/bracket for the product could be designed to mount to the sidewall of these smaller craft. It would allow the user to mount the bracket at the front of the boat where the product was accessible yet out of the way to conserve space.

Medium Sized Craft 18+ feet

Most boats over this size will have allocated storage space. This is commonly found under seats and on the sidewalls of the vessel. There is usually storage at the very front of boats, as it is narrow and impractical for anything other than storage. The most ideal place to store the product on boats this size would be with any other emergency equipment. Smaller yachts may have a grab bag for emergencies, if there is space in the bag the product would be encouraged to be placed there. If not the product should be stored with any other emergency and first aid equipment. Boats in this size bracket could also use a mounting bracket for the product and place it in the most accessible place.

In an Emergency

Each emergency situation will be different due to variables such as the time of the emergency, ocean conditions, number of people on board and cause of the problem. People can make irrational decisions in such circumstances. If there is a fire or major structural damage to the vessel the occupants may have little time to abandon ship. If an emergency "grab bag" is pre packed this gives less chance of leaving anything that may help their chances of survival at sea. Alternatively it should be in a place where it is easy to see so that it is remembered and can be picked up with ease and taken overboard.

8.9 Final Design and Justification

The final design is a reflection of the design process and refinement phase. The product testing aspect of this project helped prove that the desalination process would work and is viable within this product. The many cardboard mock-ups provided a good perspective on scale and aesthetic qualities.

Each unit was designed to produce enough water for a single person per day. As this product relies on the suns energy to produce water its performance is condition dependent. On cooler days it will produce less water however the survivors will require less water on cooler days. The product will excel on hotter days when the user requires more water. As the temperature increases so will the output of the product.

The final Watermaker has been named "Aquaflo". The branding and logo are both simple and can be applied to the product on specific parts. A sticker has been made to place on the side of the product and therefore avoids interfering with the function of the Aquaflo. The sticker is made from a foil adhesive and will reflect the suns rays constantly as it floats in the ocean, as well as potentially signalling to searchers. It also contains instructional information and warnings about using the product.

The final outcome for this project has significant features that existing watermakers do not adhere to or possess. Firstly the Aquaflo does not require setup or input energy to produce water, giving survivors suffering from exhaustion a source of fluid for no effort. The self-rejuvenating sponge feature pulls the salt water from the ocean at a slow rate replacing the water that evaporates from the tray. Again this feature requires no interaction from the user and can be left to work continuously.
The final Watermaker has been named "Aquaflo". The branding and logo are both simple and can be applied to the product on specific parts.

A sticker has been made to place on the side of the product and therefore avoids interfering with the function of the Aquaflo. The sticker is made from a foil adhesive and will reflect the suns rays constantly as it floats in the ocean, as well as potentially signalling to searchers. It also contains instructional information and warnings about using the product.

The Aquaflo reflects the design specifications and offers something new to this niche market.

8.10 Future Development and Applications

The Aquaflo Watermaker can potentially be developed to further increase its efficiency and output. Testing of potential ways to speed up the water production has been done with some results increasing speed and others being inconclusive. Emphasizing the ribs to increase the surface area would most probably result in more condensation thus producing more water.

Much of the research and development was to make the product best suited for survival situations on boats or life rafts. The product testing carried out was limited by New Zealand conditions and seasonal changes making it was hard to determine an accurate scale for the product for worldwide conditions. A range of sizes could be made to suit specific conditions. Smaller products could be manufactured for warmer climates and larger scaled products for the cooler climates.

As previously mentioned the concept has the possibility of being applied to aid countries or areas where the water is not potable or at a standard suitable to drink.

It could be implemented on lakes or rivers in a system that connects the hose ends together to pull the water from the products. They are cheap to manufacture could be simplified to make it even more affordable. This could be done by reducing the total number of parts to three making it well suited for these poorer areas affected by water shortages and quality issues.

9.0 Conclusion

This exegesis aimed to develop a survival product that could produce fresh water while on life rafts or where fresh potable water is not available. The product itself was focused around the marine environment with the task of helping prevent dehydration among individuals in survival situations.

At the beginning of this project the question was asked: How can we create a more effective and affordable survival product that aids the rehydration of people in situations where drinking water quality and quantity are an issue? This can be broken down into three sections, rehydration using fresh water, affordability and effectiveness, each having been thoroughly researched.

The research component started with a look into the importance of hydration and the effects of dehydration, as well as the characteristics of the marine environment and potential users of the product. All of which shed light onto information relevant to the development of design criteria.

Research into technologies identified two possible solutions of how to rehydrate people using fresh water. These were the desalination processes of reverse osmosis and distillation. Initial concepts were developed using both processes however it was distillation that was chosen as it provided effective water production with little energy expenditure, as well as being the most affordable process. This was due to the absence of a reverse osmosis membrane which was found to increase the cost of manufacturing immensely.

The final concept chosen was the "watercatcher" which was later named Aquaflo. In theory this design found a solution to the research question however it was necessary to complete prototype testing to ensure that the most effective option was found, the tests trialled various prototypes each with different shapes and features and it was found that by using a black sponge to retain salt water, a gimbal system for the tray and an oval shaped base, the product could produce great results without contaminating the fresh water or being affected by ocean conditions.

Once the refined concept was built focus groups and an interview were carried out. In response it was suggested that the products external components could be made flush to make it easier to clean and minimise used space. The interviewees also thought it would be beneficial to have the product made in safety colours as the final design was shown in black to better highlight the product aesthetics. The colour of the product can easily be changed during manufacturing to match safety colours. In terms of the redesigning of the shape, this is a suggestion that would be worthwhile developing at a later date.

Overall they were impressed with the product, saying that it would be easy to use and how it was innovative in the way it used a rejuvenating feed with saltwater being stored in the sponge. The product proved effective in selling itself to the potential customer. Its sleek yet sturdy look as described by Chris Kitchen makes it appeal to customers as they see it as reliability and money well spent.

The cost of this product is hard to determine due to the varying tooling costs. However through discussions with industry specialists and the use of affordable PET plastics, the Aquaflo has the potential to be a fraction of the cost of any current product in this market.

The Aquaflo has successfully resolved the question at hand. It is effective in its ability to produce water in varying conditions as well as being able to sell itself to the customer as a worthwhile product to own. It is made affordable by using cost effective materials and manufacturing processes and most importantly it is able to aid in the rehydration of individuals in a survival situation.

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