October 14th, 2010

Dr. Andrew Rawicz
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Re: Functional Specification for the Portable Filtering System

Dear Dr. Rawicz,

The document presented here outlines the functional specifications for our Portable Filtering System (PFS). We are aiming to design a reusable, durable and easy-to-use solution to the ever-present problem of clean water in rural areas of developing countries. By creating a self-powered portable filter we feel that we will, if not accomplish our goal, definitely take a huge step in the right direction.

The functional specifications described here within provide details of our functionality as well as details of its high level performance. Additionally, this document will serve as a route marker for our team during our development and testing phases to ensure that levels of performance and final user features are in keeping with our original vision.

The AquaQuick team, which is comprised of Vaibhav Mal, Shivam Mathur, Adam Tanabouz and Jie Gu, can be contacted via the email address or phone number listed below and are more than happy to answer any questions you may have.

Regards,

Vaibhav Mal

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Functional Specification for Portable Filtering System

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Issued Date: October 14th, 2010

Executive Summary

Water, it is all around us. Two- thirds of our planet is covered by it. Seventy percent of our own bodies are made up of water. Almost all living creatures require water to survive including humans who also use it for various other purposes including cleaning, bathing, cooking etc. to name a few. Given this, it is seems almost unbelievable that there are people who have to walk miles every day just so they can have access to water that is not even suitable for their consumption. With the AquaQuick Portable Filtering System (PFS) the user will not only be able to transport the water with much more ease the water will also be filtered during the transportation using the inbuilt, self-powered filtering system.

The PFS is intended to be a durable, reusable and sustainable solution to the problem of clean water. Keeping the rural developing target audience in mind we will also aim to make it as easy to use as possible without requiring any special assembly or know how. Our Proof-Of-Concept model will consist of the following features:

- A physical mesh filter to catch the bigger impurities and particles
- A self powered UV light based filtering system to kill other bacteria/viruses
- A gear system to ensure adequate RPMs are delivered to the motor so that enough power is generated independent of the users walking speed

Apart from the aforementioned features, every PFS posses a robust and sturdy construction so as to withstand the less developed and sometimes non-existent roads that might be encountered in developing areas. Since longevity is of paramount importance we will require our unit to pass rigorous reliability testing at every stage to increase the reliability of the final product as much as possible. Since our main goal is to provide healthy clean water, the water the PFS will deliver will meet the standards set by Health Canada.

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Glossary

User	Any person pulling the PFS is the user of the PFS. If the person pulling switches, the user has switched as well. If someone was to use any other means, such as an animal, to pull the PFS that would be considered the current user.
Developing Countries/ Rural Areas	Any place where running water is not a norm and people have to walk to a source of water either man made or natural to acquire water
UV	Ultraviolet Light used to kill bacteria and filter the water

Introduction

The PFS is a filtering device for users specifically for people who have to walk large distances in order to access water. The PFS allows the user greater ease while transporting the water due to being on wheels and also filters the water while it is being transported. Being powered by its own motion it saves energy and is a perfect fit for developing countries. This document provides the requirements for the PFS.

1.1 SCOPE

This document describes the functional requirements that every PFS unit will meet. It will describe all features that will be found in the Proof-Of-Concept model and also detail the production device. References to these specifications will be found in future documents and will also serve as guidelines while designing our working prototype.

1.2 INTENDED AUDIENCE

The guidelines and specifications detailed here within are for use by all members of AquaQuick. It will serve as a go-to whenever any member is unsure of the direction his part of the project is to go in. During testing and debugging this document will make sure the performance and features are in keeping with what we set out to do.

1.3 CLASSIFICATION

To help better organize this document the following scheme is used to classify our specifications:

RX – Y [Functional Specification]

X denotes the specification number and Y assigns to it a priority. The priorities can be

A – Proof-Of-Concept only
B – Proof-Of-Concept and Final production system
C – Final production system only

System Overview

This section covers the general requirements of our PFS. The specific subsystems are covered in later sections.

2.1 SYSTEM OVERVIEW

Figure 2.1 shows the basic overview of how our system.

Our Proof-Of-Concept model will be a fully functional device but will have a motor driving the wheels to simulate the distance traveled by the user in the real world. Once the user pours unfiltered water into the container, it first encounters the mesh on the mouth of the container that catches any large impurities. After the container is completely filled the user seals the top and starts "walking" (in the Proof-Of-Concept model this entails switching on the wheels). The wheels are attached to a motor through a series of wheels (Figure 2.2) to ensure that adequate RPMs are achieved independent of the speed of the walker (this can be simulated by increasing or decreasing the speed of the wheels). The rotation then powers a motor that in turn powers on a series of bulbs that emit UV light that kills all bacteria and viruses present in the water.

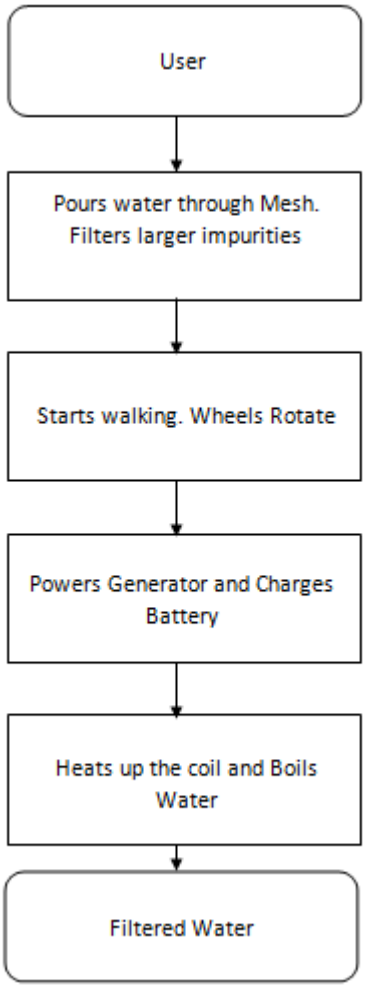

Figure 2.1: System Overview

Once the user has reached its destination, clean water can be easily obtained through a conveniently located tap at the bottom of the container.

The following figure 2.1 shows how our gear system will work in order to achieve higher RPMs at driven gear (G2), utilizing concept of gear ratio.

The permanent magnet motor works as a generator to convert mechanical energy into electrical and will charge a battery for later use by the UV bulbs.

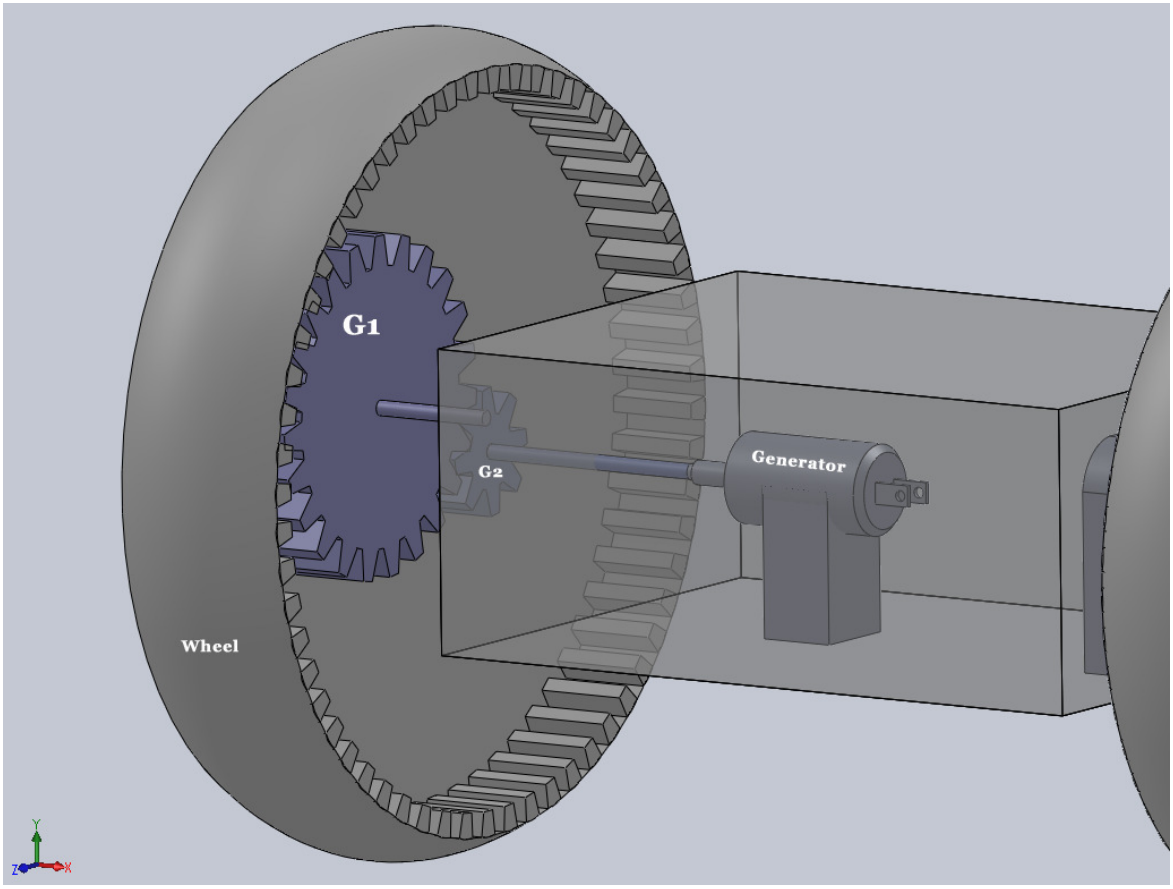

Figure 2.2: Gear System and Generator Overview

Since our product performs only one basic function i.e filtering, we will not have well defined development phases. We will first focus on getting the filter to perform as we require it to, and then the rest of the time will be spent on making the device as user friendly and durable as possible.

Overall System Requirements

3.1. General Requirements

[R1-B] Two sturdy wheels shall be required for any road condition.
[R2-B] PFS shall be efficient to kill most bacteria.
[R3-B] Two large containers shall be required for carrying enough water at once.
[R4-B] The retail price of PFS shall be under CDN$200.
[R5-B] PFS shall be constructed by hand crack generator, gear system, electrical circuit and water treatment module.

3.2. Physical Requirements

[R6-C] PFS shall have a maximum sum of height, width and length less 250cm.
[R7-C] The diameter of wheel shall be no larger than 46cm.
[R8-C] PFS shall not exceed 15 kilograms, not including the weight of water.
[R9-B] The wavelength of UV light shall be 254nm.

3.3. Electrical Requirements

[R10-A] The power of UV light bulb in water treatment module shall be 9W.
[R11-A] The output voltage from the generator shall be between 0V and 20V.
[R12-C] The generator and battery shall be easily accessible for replacement.
[R13-C] The battery shall be operational for at least 6 years before requiring replacement.
[R14-C] The generator shall be operational for at least 8 years before requiring replacement.
[R15-B] PFS shall have a battery to charge the electricity from generator and then supply power to water treatment module.

3.4. Mechanical Requirements

[R16-B] PFS must not have sharp edges, corners, etc.
[R17-C] All parts of PFS shall be adjustable by tools, for example, screw driver.
[R18-C] The generator, gear system and battery shall not be noticeable.

3.5. Environmental Requirements

[R19-B] PFS shall be able to operate at temperatures between 0 degrees Celsius and 60 degrees Celsius.
[R20-B] PFS shall be able to operate at humidity between 10% and 80%.
[R21-B] PFS shall be able to operate at altitude up to 2500m.
[R22-B] PFS shall be used both outdoors and indoors.

3.6. Standards

[R23-B] PFS shall conform to CGSB-44.232-2002 standards. (Ref 1)
[R24-B] PFS shall conform to ANSI standards.
[R25-B] PFS shall conform to CSA-ISO 9241-5-00. (Ref 2)
[R26-B] PFS shall conform to BIFMA standards.
[R27-B] PFS shall conform to IEC 61000.

3.7. Reliability and Durability

[R28-B] PFS shall be able to work properly day by day.
[R29-B] PFS shall be resistant to mechanical crash damage caused by users.
[R30-C] PFS shall be serviceable by majority.
[R31-B] The life hours of UV light bulb in water treatment module shall be no less than 10000 hrs.
[R32-B] The life hours of wheels in gear system shall be no less than 10000000 hrs.

3.8. Safety Requirements

[R33-B] PFS shall be no bodily harm to the users.
[R34-B] PFS shall not be inflammable and explosive.
[R35-C] The electronic components and ports shall be enclosed.
[R36-B] PFS shall be no negative effect to the quality of water.
[R37-C] PFS shall be able to detect electrical failure and the system will alarm once there is an error.

3.9. Performance Requirements

[R38-B] PFS shall be able to kill over 90% bacteria in water.
[R39-B] PFS shall be able to transport water in most road conditions.
[R40-B] The total time of water treatment shall be no longer than 1 hour.

3.10. Usability Requirements

[R41-C] Each component of PFS shall be changeable and upgradeable by majority.
[R42-B] The UV light from water treatment module shall not affect the taste of water.
[R43-B] The water container shall be rust-proof.

The Generator

The generator provides the power required to feed the ultra violet bulbs. The mechanical energy of the wheels will be used to rotate the rotor of the generator through the gear module. A permanent magnet DC motor will be used as a generator. The voltage and power of the generator should be enough to feed the UV bulbs with the current needed. The cart will be dragged by hand which makes the RPM of the wheels relatively slow. So, the generator is chosen carefully to generate the required voltage at low RPM.

4.1. Safety Requirements

[R44-B]	RPMs of the generator should not take the generated output above the c current limit in order not to overheat the generator.
[R45-B]	RPM shall not generate voltage more than 12 DC voltage in order to not shorten battery life.
[R46-C]	Motor should be well placed to be protected from outdoor conditions.
[R47-B]	Wiring connector of the motor should be insulated and protected from weather conditions.

4.2. Electrical Requirements

[R48-B]	The wattage of the permanent magnet DC motor shall be higher than the wattage needed for UV bulbs for safety.
[R49-B]	12 v DC 80 watt permanent magnet motor will be used to generate 11 V to 13 V to charge a lead acid deep cycle battery and to feed the 12 V bulbs
[R50-B]	Maximum current should not exceed 6 A, the nominal rate of 80 watt 12 volt DC motor.

Transmission Module

The gearing of the product is to transmit the rotation of the wheels to the rotor of the generator. Also, it is so important to increase the RPM of the generator to the required rotation speed. By changing the diameter ratio of gears, we can change the generator speed which will increase the amount of the generated voltage and current.

5.1 General requirements

[R51-B] The diameter ratio of gears will be calculated according to the required RPM of the generator and will be between 11 to 13 voltages.

[R52-B] Average speed of the wheels is an important factor to calculate the diameter ratio of gears.

5.2 Physical requirement

[R53-B] Gears will be fixed between the wheels shaft and the generator.

[R54-B] Gears module will consist of 3 gears. The rotation will be transferred from wheel shaft gear to generator gear through a third gear.

Water Treatment Module

Ultra violate bulbs will be used to disinfect water. UV is 20,000 times more efficient than boiling the water because of many features. UV is effective for all types of microorganisms. UV is safe and not harmful for environment. In addition, UV has no impact on taste, odor, and color of the water. To kill microorganisms, the UV energy penetrates the cell, and disrupts its DNA, preventing reproduction. Then, after disinfecting the Water using UV, the water can be used directly.

6.1 General Requirements

[R55-B]	We will use UV bulbs radiate at 254 nm to be able to destruct all kind of Organisms (μWs/cm2 at 254 nanometer).
[R56-B]	The container should be cleaned periodically
[R57-C]	When the UV bulb efficiency reduces to 60%, the bulb should be replaced.
[R58-C]	The bulbs will be isolated from water, it will be in glass sleeve or it will be attached to a transparent container.

6.2 Physical Requirement

[R59-B]	Before applying UV waves, the water will pass through a filter to remove giardia spores and other larger organisms.
[R60-C]	There will be cover for the container and warning sign on the container not to open the cover when UV bulbs on.
[R61-C]	There will be a 4 mm thick viewing window on the container to check the bulbs.

Electrical circuit requirement

The electric circuit of the generated electricity shall be safe to protect the load and generator and safe for people. There are some precautions to build a safe electric circuit to protect the generator, the load and the user.

7.1 General Requirements

[R62-B] All electrical components will be complying with (IEEE) standard.
[R63-C] All components should be protected from outdoor weather condition.
[R64-B] The thickness of wires shall be longer than needed for more safety in case of high current.

7.2 Electrical Requirements

[R65-B] 12V 33AH Deep Cycle Sealed Battery will be used to store the energy and to stabilize the Dc voltage supplied to the UV bulbs.
[R66-B] Blocking diode shall be used (rated for 6A) to prevent reverse current from flowing back into the generator from the battery.
[R67-C] Charger controller will be used to protect the load and battery from overcharging when the wheels rotation increased.
[R68-B] 1.5 A Fuse should be used to protect the battery from high current.
[R69-C] There should be a switch for the circuit to isolate the load from the circuit.

Documentation and Manuals

[R70-B] The detailed user documentation should consist of a user manual as well as a setup guide.

[R71-B] Both the user manual and the setup guide will be available on the company website.

[R72-B] All documentation shall be available in different languages and will be translated into new ones as required.

[R73-B] All documentation will be written while keeping our audience in mind and will have minimum technical details.

[R74-B] The manual will have minimal text and will be focused on pictures to convey the message.

System Test Plan

This section will describe the testing process that each device will go under to prove that it meets the specifications. In addition to visually inspecting each component, following additional tests will be done.

9.1 Component Testing

Before integrating individual components to the system, each component will be individually tested to ensure that it is not faulty or damaged.

Generator Test

The generator used to convert mechanical energy to electrical energy will be tested by manually rotating the mechanical side and measuring the voltage using digital millimeter to ensure the expected voltage output is produced.

Battery Test

Each battery will be tested by being plugged into the outlet and let it charge fully. Once it is charged, the time it took will be compared the expected time. We will then use the digital millimeter to ensure the expected output is produced.

Wheels and Gear test

Before integrating the gear system and the wheels to the system, we will ensure the gear ratio is within the expected limits. This will be done using a Tachometer to measure RPMs on the small gear and the RPMs of the wheel and calculate the ratio.

UV Bulbs

Each UV bulb will be tested individually. This will be done by simply putting the bulb in a simple circuit with a 9V source and visually ensure that the bulb will light up.

Sand Filter Testing

This is the first component where water is filtered initially to filter the larger impurities in water. This will be done by physically passing relatively dirty water and visually inspecting the water on the other side for clarity.

9.2 Integrated Testing

In addition to the testing of individual components, a recursive integration testing will be done after completion of assembly. A complete simulation of the product will be done to ensure product does what it is intended to. Each complete system with wheels will be simulated on a belt while the top is held so only the wheels rotate.

Firstly, impure water will be tested using a water testing device to ensure bacteria are present in water. Water will be poured into the containers through the sand filter and will be visually inspected that larger impurities are removed. Once the container is filled, the belt will start rotating the wheels which will go through the generator and charge the battery. Within minutes, all the UV bulbs will be visually inspected to see if they are lit up. After the cart has "travelled" enough distance (calculated using wheel's RPMs and time), water will be tested using the same water testing device to ensure that bacteria and other microorganisms have been killed.

In addition, we will also do sub component testing of the generator and the battery to ensure they work together and are producing the expected energy.

Conclusion

This function specification lays out the requirements and capabilities that are to be expected from the Portable Filtering System. We are currently developing and testing our filtering system and hope to have a final working product by December 15th 2010.

References

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