21st February 2021

Dr. Craig Scratchely,
School of Engineering Science
Simon Fraser University
8888 University Dr.
Burnaby, B.C., V5A 1S6

RE: ENSC 405W/440 Requirements Specification for *B-Clean*

Dear Dr. Scratchley,

This document has been prepared by SaniTech for ENSC 405W/440 as part of our engineering capstone project. It describes the required specifications for our product, *B-Clean*. Our goal is that *B-Clean* will be a fully integrated basket cleaner system aimed at grocery stores in the lower mainland and in the future, nationwide. *B-Clean* is a product intended to make the shopping experience safer while minimizing human efforts in sanitizing baskets for consumer use.

B-Clean will use a mechanical operation to separate baskets from a stack and direct them to a sanitization section where the basket will be fully cleaned. To this cleaning phase will be added a drying phase before the basket is retrieved from the sanitization station by another mechanical operation which will put the baskets away in a clean stack ready to be used.

The purpose of this document is to outline the functionality of *B-Clean* by providing timelines for proof-of-concept, engineering prototype and the final product. It will also cover the mechanical, electrical, and software requirements for the development of *B-Clean*. Furthermore, it will include safety and sustainability requirements, as well as engineering standards that our product will abide by throughout the entire duration of development.

Our team at SaniTech would like to thank you in advance for taking the time to review our requirement specification document. For further inquiries you can contact our Chief Communications Officer, Mahsa Tahmouresi at mtahmour@sfu.ca.

Sincerely,

Dean Fernandes
Chief Executive Officer
SaniTech

SaniTech

Requirement Specification:

B-Clean

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Abstract

The CoVID-19 pandemic has affected most people and businesses. Grocery stores were one of the select few that were allowed to remain open to help feed millions of Canadians. But to ensure that people didn't get sick while shopping, grocery stores had to implement COVID-19 protocols such as ensuring customers maintain 2 meters distance and sanitize shopping carts/baskets before every use. Managers had to assign more employees to focus on applying COVID-19 protocols than do their regular jobs. This led to increased expenses while still having human errors in cleaning the baskets. Our team at SaniTech is introducing a new technology to address this issue. *B-Clean* is a smart machine that sanitizes the shopping baskets in grocery stores. The device is designed in a way to first recognize baskets sizes as they enter and then while they are given to the machine in a stack form it will rotate them and separate them one by one. Each basket then will get sanitized separately and finally they go through a ramp to come down one by one as a stack like it was given initially. The purpose of this document is to inform the readers about the different requirements of this product.

The paper includes figures and tables to explain detailed constraints and requirements for a market product.

Overall there are three main sections:

- Requirement specifications that let the reader know about the requirements of the system.
- Engineering standards which outlines the engineering rules that applied to our product.
- Proof of concept which includes test plans required to prove the functionality of the product.

The document will conclude by going over the deliverables which is to be shown in mid April 2021.

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Glossary

The following table will explain the terms that are being used throughout the entire document.

Term	**Definition**
B-Clean	Product name for the automated basket sanitizing machine
GUI	Graphical User Interfaces
NEMA	National Electrical Manufacturers Association
ISO	International Organization for Standardization
IEEE	Institute of Electrical and Electronics Engineers

Table 0.1: Table of Glossary

1. Introduction

B-Clean is an automated basket sanitization system that will provide a safe, efficient and a reliable solution for grocery stores looking to enhance their shopping experience. *B-Clean* will evenly clean all surfaces to ensure shopping baskets can be used without any hesitancy from customers.This solution is an alternative to the current manual labour done by either employees spraying unevenly over the surface of a stack of baskets or employees inefficiently wiping individual baskets with a sanitizer cloth. *B-Clean* will be able to take over this routine work to let grocery store employees focus on their regular tasks such as helping customers. This document will help define requirements that will set up the system to the highest standards, ensuring customers will have full confidence in the work done by *B-Clean*.

1.1 Background

The covid-19 pandemic has forced many changes to the usual ordinary life. Extra actions like wearing masks and sanitizing hands are mandatory at most public places to keep the pandemic from spreading. People are paying more attention to all the surfaces they touch, especially handles, door knobs and buttons. Currently, most local shopping markets are required to sanitize their shopping baskets before every use to keep customers safe and keep their stores open. To understand the problem better, SaniTech conducted interviews with local grocery store managers and employees which helped discover that most of them have employees assigned just for the role of sanitizing stacks of baskets for their whole shift.

1.2 Scope

This document outlines the functional specifications and requirements of *B-Clean*. The interviews, company brainstorm meetings, and in-depth research facilitate SaniTech in identifying mechanical, electrical, software, sustainability and safety requirements that will help building the product to provide the efficiency and reliability to meet market needs. This document will also cover some of the important standards that will help define the product as a professional solution.

1.3 Intended Audience

This document is intended to be referenced by the members of SaniTech for design and development purposes. It will also be used to help the potential stakeholders understand the reasoning behind some of our design choices. This document will be reviewed by lecturers and teaching assistants of ENSC 405W/440 offered at Simon Fraser University, Burnaby BC. In the event of requirement modifications, the document will be updated as necessary.

1.4 Requirements Classification

For ease of the reader, the document will use the following convention to identify requirements:

REQ-\<Section\>.\<Subsection1\>.\<Subsection2\>.\<Number\>-\<Priority\>.\<Development Stage\>

The format of the convention is :
- REQ: short form of requirement
- Section: major group of requirements
- Sub-Section 1: sub-group for section
- Sub-Section 2: optional sub-group for sub-section 1
- Number: identification of requirements in sub-section (1 or 2)
- Priority: level of necessity of product, see Table 1.4.1
- Development Stage: approximate due date for requirement, see Table 1.4.2

Priority Encoding	Description
H	High Priority - essential for the product
L	Low Priority - non-essential for the product

Table 1.4.1 - Priority Encoding Look Up Table

Development Stage Encoding	Description	Anticipated Dates
A	Proof of Concept Stage (Alpha Phase)	April 2021
B	Prototype Stage (Beta Phase)	August 2021
F	Production Stage (Final Product)	Future

Table 1.4.2 - Development Stage Encoding Look Up Table

2 System Overview

      B-Clean has been modularized into 3 main stages: the basket preparation module, the sanitization module, and the basket roundup module.

      The basket preparation module is a mechanically focused stage where *B-Clean* will take in a stack of baskets as input and separate them to be processed in the sanitization stage individually. The sanitization module will clean each basket carefully with the highest standards and efficiency. The basket roundup module will then stack the baskets again to return a clean stack of baskets ready to be used.

      All the modules will run on software that will be dedicated to ensuring timing and ease of use for the operators and maintenance staff. The software will help the operator start a sanitization cycle, inform the operator when the cycle is done, help refill the sanitizer when complete and share other relevant information that the operator may need.

      The product will be designed with the best safety and sustainability standards in mind to ensure it is safe for both humans and the environment.
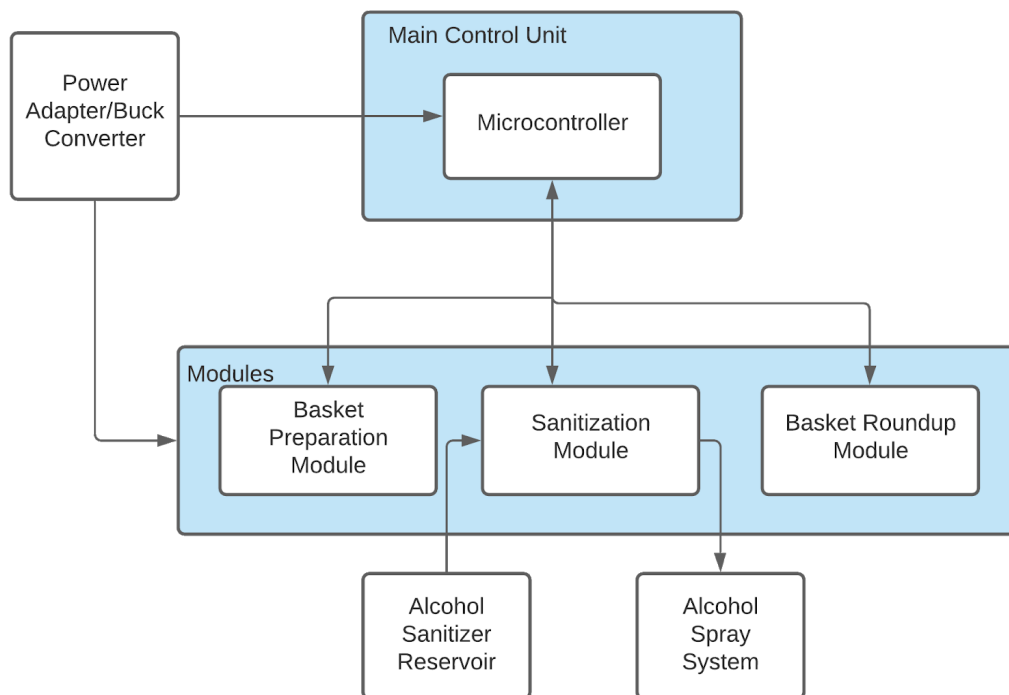

Figure 1.1.1 - Overview block diagram of *B-Clean* System

3 System Requirements

3.1 Mechanical Requirements

Mechanical Requirements are subdivided into five sections, Functional Requirements, Usability Requirements, Material Requirements, Quality Requirements, and Sanitizer Requirements. Functional Requirements section describes physical deliverable functionalities of *B-Clean* system. The Usability Requirements section introduces requirements of mechanical mechanisms relevant to system usability. The Material Requirements section illustrates system material constraints. The Quality Requirements section includes key aspects of mechanical durability and system life span. The Sanitizer Requirements outlines features and characteristics of the sanitizer used in the *B-Clean* system.

3.1.1 Functional Requirements

Requirement ID	Requirement Description
REQ-3.1.1.1-H.B	The system must take a stack of 10 to 20 baskets as an input.
REQ-3.1.1.2-H.A	The system must be able to separate baskets one by one.
REQ-3.1.1.3-H.A	The system must sanitize all the surfaces of the basket.
REQ-3.1.1.4-H.A	The system must sanitize the handles of baskets.
REQ-3.1.1.5-L.B	The system should empty the garbage in the baskets.
REQ-3.1.1.6-L.B	The system should collect and store the garbage in a separate container.
REQ-3.1.1.7-H.B	The system must be able to lift baskets and rotate it upside down.
REQ-3.1.1.8-L.B	The system should be able to rotate it back to the original orientation.
REQ-3.1.1.9-H.B	The system must be able to sanitize different sizes of baskets .
REQ-3.1.1.10-L.B	The system should be able to sanitize different types of handles.
REQ-3.1.1.11-L.B	The system should be able to recycle sanitizer residues.
REQ-3.1.1.12-H.A	The system must stack sanitized baskets as outputs.
REQ-3.1.1.13-H.B	The system must inform the operator when sanitizer is empty.
REQ-3.1.1.14-L.B	The system should inform the operator when the garbage container is full.

| REQ-3.1.1.15-L.B | The system should inform the operator when an error is detected. |

Table 3.1.1 - Functional Requirements

3.1.2 Usability Requirements

Requirement ID	Requirement Description
REQ-3.1.2.1-H.B	The system must be compact.
REQ-3.1.2.2-H.A	The system must have a power on/off button.
REQ-3.1.2.3-L.B	The system should have a start/stop button.
REQ-3.1.2.4-L.B	The system should have a weight sensor or an object detection sensor.
REQ-3.1.2.5-L.B	The system should provide a sound to indicate the completion of the sanitizing process.
REQ-3.1.2.6-H.B	The system must have a convenient way to refill sanitizer.
REQ-3.1.2.7-L.B	The system should have a convenient way to empty the garbage storage.
REQ-3.1.2.8-H.B	The system should sanitize one basket in less than 20 seconds.

Table 3.1.2 - Usability Requirements

3.1.3 Material Requirements

Requirement ID	Requirement Description
REQ-3.1.3.1-H.B	The system should be water resistant since the system uses liquid sanitizer.
REQ-3.1.3.2-H.B	The system should be able to handle the weight of at least 10-20 baskets.(~15Kg)
REQ-3.1.3.3-L.F	The overall material cost required to build the system should be less than 1000 Canadian Dollars.
REQ-3.1.3.4-H.A	The system must stand stable with proper weight distribution.

Table 3.1.3 - Material Requirements

3.1.4 Quality Requirements

Requirement ID	Requirement Description
REQ-3.1.4.1-L.F	The base of the system should not break after 5 years of regular use.
REQ-3.1.4.2-L.F	The frame of the system should not break after 5 years of regular use.
REQ-3.1.4.3-L.F	The spray system should be able to last 2 years or spray 40000 times.
REQ-3.1.4.4-L.F	The liquid pumping system should be able to last 2 years or pumped 40000 times.

Table 3.1.4 - Quality Requirements

3.1.5 Sanitizer Requirements

Requirement ID	Requirement Description
REQ-3.1.5.1-H.A	Sanitizer must effectively kill viruses and germs
REQ-3.1.5.2-H.A	Sanitizer must not cause serious human injury under short exposure
REQ-3.1.5.3-H.A	Sanitizer must be affordable
REQ-3.1.5.4-H.A	Sanitizer must be available in regular retail market
REQ-3.1.5.5-H.A	Sanitizer must meet industrial standards
REQ-3.1.5.6-L.B	Sanitizer should be able to reused under certain constraints
REQ-3.1.5.7-L.B	Sanitizer should be easy to store in a container
REQ-3.1.5.8-H.A	Sanitizer must not change baskets' color
REQ-3.1.5.9-H.A	Sanitizer must not degrade baskets' material
REQ-3.1.5.10-H.A	Sanitizer should be able to spray as mist

Table 3.1.5 - Sanitizer Requirements

3.2 Electrical Requirements

The electrical requirements will be divided into four parts, general, circuit, power supply and outlet receptacle. The general part will consider the requirements for the overall electrical flow of the device. The circuit part will be talking about the voltage and current required to set up the

device. The power supply category will specify the requirements that need to be followed to power the device and finally the outlet section will be on how to properly ground the 3-prong receptacle. Each of these parts require consideration with regards to safety standards and regulations.

3.2.1 General

The following table illustrates the general requirements for the basket cleaner electronics component

Requirement ID	Requirement Description
REQ-3.2.1.1-H.A	System circuitry must have protection for all specialized hardware(lights, microcontroller)
REQ-3.2.1.2-H.A	The system should not be damaged because of a power outage.
REQ-3.2.1.3-H.B	The system must use motors for tilt and rotation
REQ-3.2.1.4-H.A	The system must not have any electrical wires exposed to the operator.

Table 3.2.1 General Electrical Requirements

3.2.2 Circuit

Requirement ID	Requirement Description
REQ-3.2.2.1-H.F	The system should use short circuit protection in case of unexpected excessive voltage frequency and current.

Table 3.2.2 Circuit Requirements

3.2.3 Power Supply

The cleaning machine needs to be powered by a power supply in order for the components to work. Such power supply needs to meet the requirements outline in the below table:

Requirement ID	Requirement Description
REQ-3.2.3.1-H.F	Machine circuit should be a dedicated 120/125-volt, 15-amp circuit (this is standard for a typical dishwasher).
REQ-3.2.3.2-H.F	Appropriate buck converter should be used to bring down the voltage to 3V ~ 12V.

REQ-3.2.3.3-H.F	The power supply circuit must supply a maximum of 5V @ 2A to the microcontroller that the system uses to make lights blink.
REQ-3.2.3.4-H.F	AC-DC converter must be used.

Table 3.2.3 Power Supply Requirements

3.2.4 Outlet receptacle

Requirement ID	Requirement Description
REQ-3.2.4.1-H.A	The system must be powered using a wall plug.
REQ-3.2.4.2-H.F	The system should be using Type B wall plug -> using a NEMA 6 electrical plug
REQ-3.2.4.3-H.B	The System must use electrical cables that can safely handle the power consumption needed for all the modules.
REQ-3.2.4.4-H.F	Wiring must be 2 wire with ground and rated for 75°C (176°F)

Table 3.2.4 Outlet Receptacle Requirements

3.3 Software Requirements

The goal of the *B-Clean* system is to separate a basket from a collection of stacked baskets and feed it into a sanitizing facility as an input. Then, the system will begin the sanitizing process and stack it up once it has completed. Furthermore, to enhance the user experience with the *B-Clean* system, the *B-Clean* system will incorporate a simple GUI on a LCD screen for displaying the health of the system, the sanitizing progress, and the amount of alcohol sanitizer liquid left.

3.3.1 Embedded System Requirements

Requirement ID	Requirement Description
REQ-3.3.1.1-L.F	The software must be able to identify the presence of baskets to start the sanitization process.
REQ-3.3.1.2-H.B	The software must be able to identify different types of basket to adapt the system to deal with the corresponding basket size.
REQ-3.3.1.3-L.F	The software should identify anything that is not a basket and stop the system immediately.

REQ-3.3.1.4-H.A	The software must be able to control the mechanical system that will move the basket from the basket preparation stage, to the sanitization stage and finally to the basket roundup stage.
REQ-3.3.1.5-H.A	The software must be able to control the mechanical system that will execute the sanitization and cleaning process.
REQ-3.3.1.6-H.A	The software should be able to identify the amount of sanitizer available in the system.
REQ-3.3.1.7-L.F	The software should be able to identify a malfunctioning module.
REQ-3.3.1.8-L.F	The software should keep track of frequently used modules for servicing dates.
REQ-3.3.1.9-H.B	The software must be able to detect when all the baskets are done cleaning.
REQ-3.3.1.10-L.F	The software should be able to identify garbage within the basket.

Table 3.3.1 Embedded System Requirements

3.3.2 Operator Interface Requirements

Requirement ID	Requirement Description
REQ-3.3.2.1-H.B	The system must have a display to view notifications and monitor the health of the system.
REQ-3.3.2.2-H.A	The software must notify the operator after the completion of the sanitizing process.
REQ-3.3.2.3-L.F	The software must halt and notify the operator if the following occurs in the system: broken components, input is not a basket, data read in by the system is way off due to the parts not calibrated properly, etc.
REQ-3.3.2.4-H.B	The software must display the amount of alcohol left in the system and notify the operator whenever the sanitizer is running low.
REQ-3.3.2.5-H.B	The software must have an operator interface and a maintenance interface.
REQ-3.3.2.6-L.F	The operator interface shall show the sanitizer liquid level, total number of baskets cleaned, and notifications related to the system (potential errors in the modules)

| REQ-3.3.2.7-L.F | The maintenance interface shall show the sanitizer liquid level, baskets cleaned, last service of the mechanical modules, and malfunctioning modules |

Table 3.3.2 Operator Interface Requirements

3.4 Sustainability Requirements

Sustainable systems are systems that improve and preserve the quality environment (land, air, water and living systems) for a more sustainable world [1]. Our Company has been inspired by the "Cradle to Cradle " design concept in which we will seek to abide by its principles of not only minimizing negative influences but also leaving positive ecological footprints [2]. Our system B-tech strives to conform with this design in order to minimize harmful effects on the environment as well as on the health and well-being of its inhabitants. In order to achieve this, we will implement designs that will be economically sustainable and reduce waste . These design aspects are presented in the table below:

Requirement ID	Requirement Description
REQ-3.4.1.1-H.B	The system should be made of recyclable and eco-friendly materials
REQ-3.4.1.2-H.A	The system should be made of durable materials
REQ-3.4.1.3-H.A	The system should be made of materials that do not degrade when in contact with common sanitization liquid
REQ-3.4.1.4-L.B	The system shall be eco-effective by finding new uses to some components
REQ-3.4.1.5-H.F	The sanitizer shall be reusable
REQ-3.4.1.6-H.F	The sanitizer should be environmental friendly
REQ-3.4.1.7-H.F	The sanitizer must be human-friendly

Table 3.4.1 Sustainability Requirements

3.5 Safety Requirements

One of *B-Clean* fundamental features is safety. Our system should be designed with the safety of the user and others around him in mind. All aspects of safety should be carefully taken into consideration and fully implemented to ensure that our product offers a service that is safe. Potential hazards originating from our system and that can lead to an accident or incident have been identified and summarized in the table below :

Requirement ID	Requirement Description
REQ-3.5.1.1-H.A	The system should be made of non toxic materials to avoid negative impact on the user's health
REQ-3.5.1.2-H.F	The system should not have sharp edges in order to reduce unexpected injuries
REQ-3.5.1.3-H.F	The system must have a protective frame to prevent the system from spilling
REQ-3.5.1.4-H.F	The sanitizer must be non toxic and license under Health Canada to avoid unhealthy impact
REQ-3.5.1.5-H.A	The sanitizer must not be a source of potential hazard (fire hazard, electrical hazard,etc..)
REQ-3.5.1.6-H.B	The system should have a cooling system to avoid overheating
REQ-3.5.1.7-H.F	The system should have parts that display warning signs associated with their use (electrical hazard, electrical shock risk,etc..)
REQ-3.5.1.8-H.A	All electrical component in the system must be grounded
REQ-3.5.1.9-H.A	All electrical component in the system must be insulated to reduce electrical leakage
REQ-3.5.1.10-H.A	The system must be able to turn itself off when it detects danger (overheating, fire, etc ..)
REQ-3.5.1.11-H.A	The system should not represent an electrical hazard in the event of naturally occurring events (storms, lightening,etc..)

Table 3.5.1 Safety Requirements

4 Engineering Standards

To sell *B-Clean* in Canada, there are certain Canadian standards that need to be fulfilled. B-Clean will also meet some international standards to make it easier to sell internationally in the future. These standards are broken down into software, mechanical, electrical and some other general standards.

4.1 Software Standards

We intend to design the *B-Clean* with the ISO/IEEE 24748 and 29148 to ensure our software will be reliable, robust and maintainable as per customer requirements. We also intend to design the software with careful attention to the human interface to ensure the system is easy and logical to use by following ISO 9241-11. Table 4.1.1 has a brief description for each of the standards mentioned above.

Standards	Description
ISO/IEC/IEEE - 24748-3-2020	Systems and software engineering--Life cycle management--Part 3: Guidelines for the application of ISO/IEC/IEEE 12207 (software life cycle processes) [8]
ISO/IEC/IEEE - 29148-2018	Systems and software engineering -- Life cycle processes -- Requirements engineering [7]
ISO 9241-11:2018	Ergonomics of human-system interaction - Part 11: Usability: Definitions and concepts [9]

Table 4.1.1 - Software standards

4.2 Mechanical Standards

Table 4.2.1 indicates the mechanical standard that applies to *B-Clean*:

Standards	Description
ISO/TS 128-71:2010	General principles of presentation - Simplified representation for mechanical engineering drawings [10]

Table 4.2.1 - Mechanical standards

4.3 Electrical Standards

Table 4.3.1 indicates the electrical standards that applies to *B-Clean*:

Standards	Description
CAN/CSA-C22.2 NO. 61508-1:17	Functional safety of electrical/electronic/programmable electronic safety related systems - part I: General requirements [6]
CAN/CSA-C22.1NO. 0-10	General requirements - Canadian Electrical code, part II [6]
CSA C22.2 NO. 0.23- 15	General requirements for battery-powered appliances [11]
CAN/CSA-C22.2 No. 60529:05 (R2010)	Degrees of protection provided by enclosures (IP Code) [12]

Table 4.3.1 - Electrical standards

4.4 Other Standards

All the other standards that does not fall under the above categories are listed below:

Standards	Description
IEEE 1221-1993	IEEE Guide for Fire Hazard Assessment of Electrical Insulating Mate- rials in Electrical Power Systems [5]
IEEE 848-2015	IEEE Standard Procedure for the Determination of the Ampacity Der- ating Factor for Fire-Protected Cable Systems [4]
ISO 14040:2006	Environmental management - Life cycle assessment -Principles and framework [3]

Table 4.4.1 - Other standards

5 Conclusion

The Covid-19 pandemic has changed the world, what were once extra tasks that could be easily ignored are now required to keep people safe. Basket sanitization was never a priority to grocery stores and their customers. But now, the world has realised it is not only necessary to keep the current pandemic from spreading, it is necessary to take steps to hinder future pandemics too. From our interviews, we found that as people are concerned about what they touch, a new market has formed which is dedicated to having a safe experience when people leave their home.

SaniTech is pursuing this market by bringing *B-Clean* to local grocery stores that would like to return their employees to helping customers and leave the menial work of sanitizing baskets to technology. *B-Clean* will be able to carefully sanitize the baskets while ensuring efficiency and safety for all.

SaniTech intends to use this document as the foundation of *B-Clean*. The requirements will be referenced throughout the project, specifically for the next stage, our design specification. The mechanical requirements ensure the product is logical to use and can sanitize the baskets carefully and efficiently. The software and electrical requirements help to ensure the system is easy to use and maintainable. The safety and sustainability requirements help to ensure *B-Clean* is safe for both the operators and the environment.

SaniTech believes that *B-Clean* will be a major force in the current market and will be able to help many Canadians as a result.

6 Appendix

6.1 Proof of Concept

For the proof-of-concept of the *B-Clean* system, the following core functionalities of the system will be proven and demonstrated:

➢ Prototype of the circuits that can adapt to the input electrical power from wall plug.
➢ Separating a basket from a stack of baskets.
➢ Basket recognition and pick up mechanism for the basket once the system identifies a basket is presented.
➢ Capabilities of adapting to different basket sizes.
➢ A simple demonstration of the LCD screen that displays the level of alcohol available in the system.
➢ Demonstrating the process of sanitizing a basket.
➢ Stack up the basket once the sanitize process has completed.

6.2 Acceptance Test Plan-Alpha

Test #	Detailed Descriptions	Pass/Fail (P/F)	Comments
Test 1: Circuitry	The circuits in the system are able to operate with input DC voltage of 3V-12V.		
Test 2: Identifying the basket	The *B-Clean* system is able to identify the presence of the basket(s) and signal the system to start the sanitizing procedure.		
Test 3: Separation of a Basket	The *B-Clean* system is able to separate one basket from a stack of baskets.		
Test 4: Distinguishing various basket sizes	The *B-Clean* system is able to differentiate various basket sizes and adapt to it accordingly.		
Test 5: Sanitizing a Basket	The *B-Clean* system is able to sanitize the basket thoroughly, covering all the surface areas of the basket.		
Test 6: Stacking	After the system has completed sanitizing a		

up the basket	basket, the system is able to stack the sanitized basket on top of a stack of sanitized baskets.		
Test 7: LCD Display	The *B-Clean* system is able to display in real-time of the amount of alcohol sanitizer available in the system.		

Table 6.2.1 Acceptance Test Plan for Alpha Phase

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