February 07, 2019

Dr. Craig Scratchley

School of Engineering Science

Simon Fraser University

Burnaby, BC, V5A 1S6

Re: ENSC 405W/440 Requirements Specification for a Cat Health Monitor

Dear Dr. Scratchley,

The attached document is the specification of the requirements for the successful implementation of our product, a Cat Health Monitor, developed by our company 9 Lives. Our product's goal is to provide cat owners and their veterinarians with important information regarding the health of a cat by using different sensors to collect data about a cat when it is in the litter box and trending the data over time. This information would allow veterinarians to provide a quicker diagnosis for sick cats and help owners to know when their cat is sick, even though he/she may not show any obvious signs.

This requirement specification documents all the requirements for our product throughout the various stages of the design process, including Proof-of-Concept (C), Prototype (P), and Final Product (F). The document will also serve as a reference throughout the design process which may be revised throughout the development stage.

9 Lives is composed of six aspiring engineering students: Hakeem Wewala, Harinder Khakh, Brandon Shen, Gabe Teeger, Timothy Yu and Gary Atwal. Thank you for taking the time to review our requirements specification. If you have any questions, please contact our Chief Communications Officer, Gary Atwal, by email (gatwal@sfu.ca) or by phone (604-908-1456).

Sincerely,

Hakeem Wewala

Chief Information Officer

9 Lives

Enclosed: Requirements Specification for a Cat Health Monitor

Requirements Specification – Cat Health Monitor

Project Team: Gary Atwal
Harinderpal Khakh
Brandon Shen
Gabe Teeger
Hakeem Wewala
Timothy Yu

Contact Person: Gary Atwal
gatwal@sfu.ca
604-908-1456

Submitted To: Dr. Craig Scratchley (ENSC 405W)
Dr. Andrew Rawicz (ENSC 440)
School of Engineering Science
Simon Fraser University

Abstract

The Cat Health Monitor is a surface that can be placed underneath a cat litter box and provides the user with the capability to monitor their cat's health remotely through data that is collected and analyzed via sensors placed within the surface. The duration and frequency of the cat's use of the litter box, the weight of the cat and the pH of the cat's waste is measured and trended over time. The information is provided in a user-friendly manner to the owner and/or veterinarian. In this document, the requirement and functional specifications are defined for the Proof-of-Concept, Prototype and Final version of the Cat Health Monitor product created by 9 Lives. Engineering standards, environmental impact and safety concerns are also considered.

Revision Record

Revision #	Description	Revised By	Date
1.0	Initial Release	Gary Atwal, Harinderpal Khakh, Brandon Shen, Gabe Teeger, Hakeem Wewala and Timothy Yu	February 07, 2019

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Glossary

Term	Definition
ADC	Analog to Digital Converter
BOM	Bill of Materials
C	Proof-of-Concept
F	Final Product
HI	Health Index
P	Prototype
PCB	Printed Circuit Board
Req.	Requirement
ROH	
UI	User Interface

1.0 Introduction

Diagnosing illnesses in animals is a core part of Veterinary Sciences. Unlike animals, humans can convey symptoms precisely to doctors. Pet owners will usually only seek care for their pets once their symptoms are clearly presented through their appearance and behavior. Unfortunately, pets are often brought to veterinarians after their illnesses has progressed further than necessary, making it harder to treat them and at a greater cost to the owner and to the animal's health.

Pre-emptively avoiding certain serious health problems in animals would be greatly beneficial to owners, veterinarians, and pets. Many aspects of any animal's health, particularly their digestive health, can be measured by their bathroom habits. Our goal is to design a device that will provide consistent and reliable information to the owner about a cat's health by capturing the cat's duration and frequency of use of the litter box, the cat's weight and pH of the cat's waste over time. This data can be examined for any early indicators of illness and pre-emptively warn users. For example, frequent attempts at urination may be linked to kidney stones or blockage and if there is blood in the urine it may be linked to a more life-threatening condition, feline interstitial cystitis [1]. However, the device would be able measure how frequent the cat uses the litter box and potentially sense that there is blood in the urine using a pH sensor.

Although this technology would be beneficial to all animals, our product is specifically designed for pet cats. Because cats are independent and do not require much supervision, their symptoms of illness may go unnoticed. Many owners are left with an unexpected death to their cats that may have been preventable through simple monitoring of the cat's health. According to a study by Olsen and Allen [2] on 1000 cats over 10 years, 79 cats died suddenly and unexpectedly [2].

The Cat Health Monitor is a surface with built-in sensors that can be placed underneath an owner's current litter box as opposed to the product being a whole new litter box, resulting in a more economical and user-friendly product. We aim to provide accurate real time alternatives to obtaining important parameters regarding a cat's behaviour. This will allow the owners of cats and veterinarians to monitor a cat's health in a quick easy way so they can provide better care for the cats and save money on otherwise expensive medical bills.

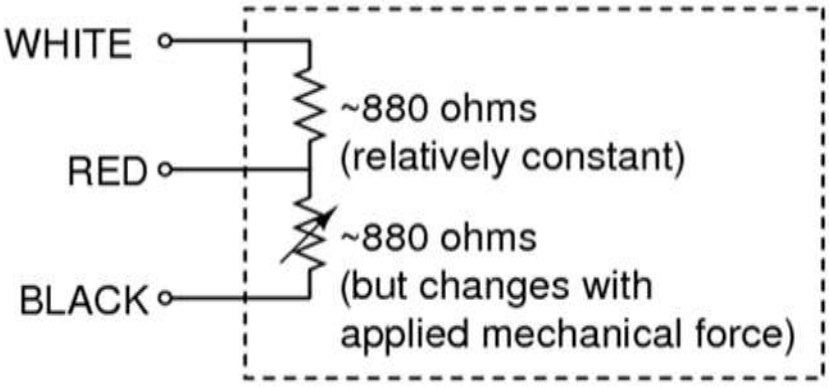
This document outlines the requirement specifications for the Cat Health Monitor throughout the three stages of the design process: Proof-of-Concept (C), Prototype (P) and Final Product (F). An Acceptance Test Plan is provided. Engineering standards, environmental impact and safety concerns are also considered. The requirements are broken down into six categories:

1. High Level Requirements
2. Overall Performance Requirements
3. General Physical Requirements
4. General Hardware Requirements
5. General Software Requirements
6. User Interface Functionality Requirements

1.1 Background

The cat health monitor focuses on three main aspects, the weight of the cat, duration in the litter box, and the frequency of usage. To achieve this, a load sensor will be an important component. It will allow us to measure weight and detect whether the cat has entered or left the litter box. The load sensors abilities come from the strain gauge inside it. The circuit components inside a load sensor that is in the cat health monitor is shown in Figure 1.

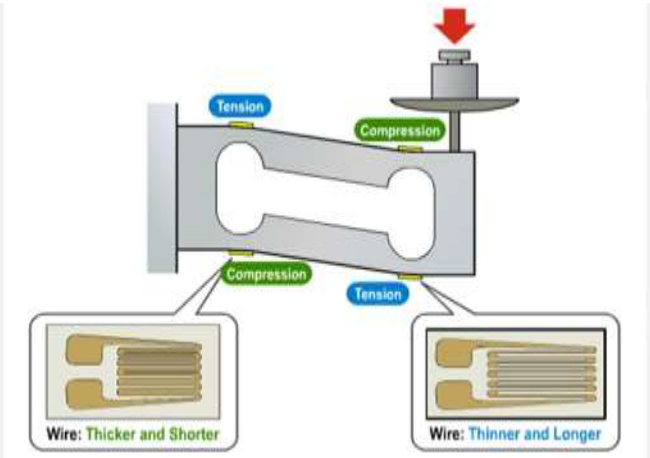
Figure 1: The Load Sensor



The inside of a 50 kg square load sensor [3].

The variable resistor in Figure 1 is a strain gauge. The strain gauge resistance value changes based on the force exerted on it because of the thin conductive wire inside that changes shape. Tension is when the strain gauge and the wire inside is stretched and the resistance goes up. Compression is when the wire inside is pressed closer together and the resistance goes down [4]. This process is demonstrated in the following

Figure 2: The Strain-Gauge



An illustration of a strain gauge in compression and tension [4]

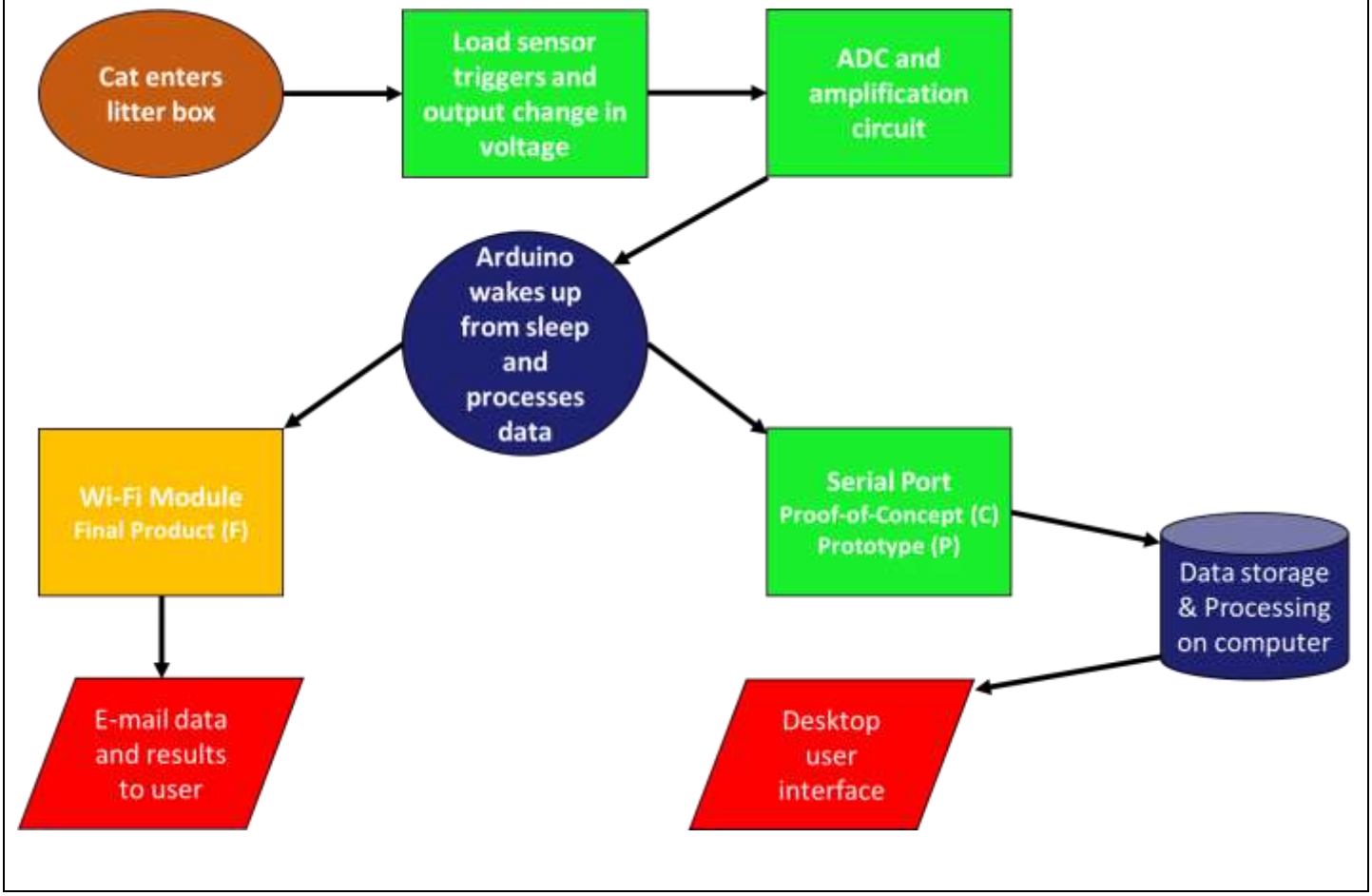
So, with a voltage divider created from a resistor and strain gauge, the change in output voltage can be measured and calculated as weight. The change in output voltage can also be a signal to when the cat has entered and exited the litter box, facilitating calculations of duration and frequency.

Sometimes the force exerted on the strain gauge can be very minute like a light object on the load sensors, so the change in output voltage is very small even after amplification. An Arduino does not have an ADC with high enough resolution to detect the small steps of voltages. Thus, the HX711 24 bits ADC and integrated amplifier is used. The amplifier allows the detection of much smaller steps in output voltages from the load sensors and has a built in 128 gain amplifier [5].

2.0 System Overview

Figure 3 shows a high-level system overview diagram of the Cat Health Monitor. When the cat enters the litter box, it triggers the load sensors and the system begins to collect data. In the Proof-of-Concept (C) and Prototype (P) version of the product, the data will be communicated from the Arduino to the computer through a serial port. Whereas in the Final Product (F), the data will be communicated wirelessly to the user.

Figure 3: System Overview



High-level system overview of the Cat Health Monitor.

3.0 Requirements

3.1 High-Level Requirements

The Cat Health Monitor aims to provide owners with pre-emptive warning of behaviours that indicate illness in addition to providing veterinarians with longevity to accurate data to assist in their diagnosis. Our project will tackle this problem with a smart litter box that activates and acquires measurements upon the detection of a cat. Indicators of illness and important parameters will need to be identified through research and discussions with professional veterinarians in the field. The product will be required to identify and indicate problems and document data for veterinarians. Table 1 contains the general high level requirements that will be broken done further in the following sections.

Table 1: High Level Requirements

Req 3.1.1 – P	Reliably measure, record and analyze parameters from cats to identify and notify users of potential problems
Req 3.1.2 – P	Provide longevity to data allowing users to submit to professionals for further analysis
Req 3.1.3 – P	Be a weight measuring and processing add-on device to existing cat litter boxes
Req 3.1.4 – F	Be an urinary pH testing along with weight measuring add-on device to existing cat litter boxes
Req 3.1.5 – F	Identify and create profiles for different cats; providing users with basic analysis of health and trends

3.2 Overall Performance Requirements

Table 2 specifies the overall performance requirements for the Cat Health Monitor.

Table 2: Overall Performance Requirements

Req 3.2.1 – C	Activate upon the detection of a cat and distinguish between false positives
Req 3.2.2 – C	Accurately measure and store weight data of the cat
Req 3.2.3 – C	Provide analytics on weight data obtained
Req 3.2.4 – P	Measure and store data using sensors to record pH in urine and provide alerts if something is not normal
Req 3.2.5 – P	Provide analytics on urinary parameters along with weight
Req 3.2.6 – P	Detect and alert the user of problems from trends of parameters through the expertise of veterinarians.
Req 3.2.7 – P	Based on previous data, distinguish between different cats
Req 3.2.8 – F	Be durable, sturdy and non-slip.
Req 3.2.9 – F	Be easy to clean.
Req 3.2.10 – F	Have wireless capabilities/either connect to a phone application or personal computer.
Req 3.2.11 – F	Provide printable files with graphical representation of selected parameters

3.3 Physical Requirements

Cat Health Monitor needs to be easily compatible with most cat litter boxes. The product shouldn't require any relocation of litter boxes, if they are within range of an electrical outlet. Table 3 outlines the physical requirements to ensure that the Cat Health Monitor can be integrated into a home with ease.

Table 3: General Physical Requirements

Req 3.3.1 – C	The surface can be made from wood or plastic
Req 3.3.2 – P	The surface material must be able to prevent the litter box from slipping due to excessive force.
Req 3.3.3 – F	The surface area of the surface should not be much greater than the surface area of a generic litter box
Req 3.3.4 – F	The size of the PCB should not exceed the size of the surface.
Req 3.3.5 – F	The circuitry should be protected by the surface without interfering with the sensors
Req 3.3.6 – F	The surface should be able to withstand the combined weight of a cat and its litter box
Req 3.3.7 – F	The surface should not change the height of the litter box by too much when placed underneath
Req 3.3.8 – F	Circuitry should not be exposed anywhere
Req 3.3.9 – F	The surface should be sealed such that nothing leaks into it and damages the sensors or circuitry
Req 3.3.10 – F	Company logo must be visible on the product

3.4 Hardware Requirements

The Cat Health Monitor will require the integration of different systems to capture, parse and record weight sensor measurements. This system will ultimately be put on a fully-fabricated printed circuit board (PCB), requiring the design of a schematic and its corresponding layout. Table 4 specifies the physical pieces and the documents required for the hardware design process.

Table 4: General Hardware Requirements

Req 3.4.1 – C	Employ a hardware system that can deliver interrupts to underlying software
Req 3.4.2 – C	Capture information from weight sensors when necessary
Req 3.4.3 – C	An amplifier is needed to capture small changes in output from weight sensors
Req 3.4.4 – C	An ADC is needed to capture analog measurements taken from the weight sensors and to convert them into digital signals
Req 3.4.5 – C	The ADC should have a high resolution, preferably 24-bits
Req 3.4.6 – C	An Arduino to capture and manage the data from the weight sensors
Req 3.4.7 – C	A schematic of the overall layout of the circuit
Req 3.4.8 – C	Have a computer to connect to via serial port
Req 3.4.8 – P	Weight must be measured precisely with an accuracy of approximately 1 gram
Req 3.4.9 – P	Use LEDs to convey information about the status of the device to the user
Req 3.4.10 – P	Perform analysis to find trends and potential health indicators
Req 3.4.11 – P	A bill of material (BOM) containing all of the components needed, their prices and reference to their datasheet
Req 3.4.12 – P	A PCB layout with footprints corresponding to each component
Req 3.4.13 – P	A prototype circuit constructed on a breadboard with through-hole components

Req 3.4.14 – P	Gerber files generated from the PCB layout that are to be submitted to a third-party company for fabrication
Req 3.4.15 – P	5V input is needed for the weight sensors and Arduino
Req 3.4.16 – F	Addition of pH sensor and necessary hardware
Req 3.4.17 – F	Power adapter for the PCB so it can be plugged into an outlet

3.5 Software Requirements

The Cat Health Monitor will require an embedded system to integrate with the weight-sensing circuitry. Analytics on the data shall also be performed on the same device for compactness and efficiency. The collected data will be converted into useful charts to allow the user to easily keep track of their cat companion's litter habits. The software requirements are defined in Table 5 and the user interface requirements are defined in

Table 5: General Software Requirements

Req 3.5.1 – C	Employ an interrupt-driven system to wake from a low-power state to measure weight
Req 3.5.2 – C	Convert readings from scale to weight values
Req 3.5.3 – C	Communicate data to a connected computer using a physical port
Req 3.5.4 – C	Measure weight trends over time
Req 3.5.5 – C	Extract additional data from weight sensor such as amount of time spent in litter box and the frequency of the visits
Req 3.5.6 – P	Perform analysis to find trends and potential health indicators
Req 3.5.7 – P	Handle data collection and analysis for multiple cats
Req 3.5.8 – P	Issue alerts for urgent situations (too few visits, too many visits, excessive visit duration, drastic changes in weight, etc.)
Req 3.5.9 – F	Record urine pH level
Req 3.5.10 – F	Communicate data to user wirelessly
Req 3.5.11 – F	Provide printable document with analytics data

3.6 User Interface Functionality Requirements

A key component of the Cat Health Monitor system will be a clear and concise representation of collected data and performed analytics to the user. This will be initially displayed using a wired connection to a computer and eventually communicated wirelessly for the final product. The user interface requirements are defined in Table 6.

Table 6: User Interface (UI) Functional Requirements

Req 3.6.1 – C	Basic representation of data using 'dummy data' to represent the look aimed for regarding the UI window and printable document
Req 3.6.2 – P	Perform the task specified in Req. 3.6.1 but with measured data.
Req 3.6.3 – P	Health Index (HI) shall be calculated from measured parameters and displayed.
Req 3.6.4 – P	User shall be able to create a profile with general information and profiles shall be adjustable such that multiple cats can be monitored by one device.
Req 3.6.5 – F	User shall be able to access and print analytics.
Req 3.6.6 – F	There shall be a trigger to reset non-responsive device.
Req 3.6.7 – F	Summary cat status window shall display brief graphical representation of the general health of the cat.
Req 3.6.8 – F	Optional detailed cat status window shall display detailed analysis of the health of the cat and potential down trending parameters.
Req 3.6.9 – F	There shall be a calendar showing the HI for each day to provide accessible temporal data.

4.0 Engineering Standards and Responsibilities

9 Lives and its cat health monitor will conform to proper Canadian and international standards to create a maintainable, marketable, and safe product. 9 Lives will follow the standards outlined by the CSA and ISO. In addition, 9 Lives will reference the FDA guidelines on Animal Medical Devices for important animal safety and responsibilities.

Cat Health Monitor Standards and Responsibilities Requirements

1. The AC power adapter and electrical connections to the cat health monitor will comply with the CSA Safety Standards for Electrical Installations CSA 22.1-18 [6]
2. The electronic components and system will follow the safety guidelines for consumers and users under ISO 10377:2013 [7]
3. The cat health monitor will have an environmentally sensitive product life cycle as outlined in ISO 14040:2006 [8]
4. The cat health monitor's safety and responsibility for animals will reference FDA regulations on Animal Medical Devices [9]

5.0 Sustainability and Safety

5.1 Sustainability

At 9 Lives, what happens to our product at the end of its life is always on our mind during development. We follow a cradle to cradle and environmentally friendly approach when choosing our materials and components. This means our product is recyclable and reusable at the end of its life cycle and it will not pollute and preserve the environment for future generations. Here is an outline of our product's major components and materials and the reason for its sustainability:

Casing – The plastic casing protects both the circuitry and the user. We choose to use recyclable plastic like polyethylene or ABS that can be processed most facilities and reused in other products [10].

PCB, solder, load sensors, microcontroller – The circuit components and PCB are all RoHS compliant, meaning they do not contain hazardous materials [11]. Each region has its own electronics recycling process and facility, for example Return-It for BC, Canada can break down our product's PCB and IC components for recycling and reuse [12].

Wirings – The wirings can be disassembled/cut off easily and reused in other electronics and they are made from copper, so they can also easily be recycled.

Adhesive – We do need adhesive to tape the load sensors and PCB to the casing, but we try to use biodegradable and recyclable options when available.

5.2 Safety

The product will be near a living animal, so there is extra consideration in making the product design and materials not physically harmful or toxic to living thing. There is also precaution taken for the unpredictability and agility of cats, so the product does not break easily and hurt the cat.

The list below contains the safety requirements our product must conform.

1. All electronics and wires will be protected and hidden so they cannot be tampered
2. The product's protective casing will be waterproof and prevents the electrical components to be in contact with liquid
3. The casing will be slip-proof when its dry or wet
4. The casing will not have sharp edges and rough surfaces to reduce risk of cuts and scratches
5. The product will be securely situated in the litter box even under force and movement
6. The product will withstand weight of up to 50 kg and warm temperature conditions
7. The product will not contain any toxic or dangerous material

6.0 Conclusion

The Cat Health Monitor is an add-on to existing litter boxes marketed towards all the 7.9 million cat owners and 3,224 veterinary clinics in Canada alone. Our product will be an easy to use device that allows users to acquire data about their cat's health. It will be able to extract basic urinary parameters specifically for veterinarians due to the required expertise. We aim to provide accurate real time alternatives to obtaining important parameters regarding a cat's behaviour

7.0 References

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[12] “The Electronics Recycling Process,” Encorp Return-It. [Online]. Available: https://www.return-it.ca/electronics/recycling/productrecycling/. [Accessed Feb. 2, 2019].

8.0 Appendix

8.1 Proof-of-Concept (C) Acceptance Test Plan

Proof of Concept Acceptance Test		
		Date:
Software		
Test	***Result***	***Comments***
Arduino wakes up from sleep mode	☐Pass ☐Fail	
Data transmits to computer from Arduino through serial port connection	☐Pass ☐Fail	
Weight of the 3kg test object is calculated correctly and displayed on the Desktop UI	☐Pass ☐Fail	
Correct duration is recorded when test weight is removed from the surface	☐Pass ☐Fail	
Change in weight is registered under 1 second	☐Pass ☐Fail	
Hardware		
Load sensors can detect weight minimum weight of 2kg	☐Pass ☐Fail	
Cat health monitor surface and load sensors can withstand and measure a maximum weight of 6kg	☐Pass ☐Fail	
The HX711 outputs a digital signal	☐Pass ☐Fail	
The HX711 output is at a voltage level readable by the Arduino	☐Pass ☐Fail	
Tester Name:	**Tester Signature:**	