**Preliminary Testing Plan**

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**Introduction**

Given the emphasis on electrical safety and reliability in devices used in laboratory settings, following the relevant standards is of utmost importance. In this context, such a device (in this case, an alarm and locking device) should meet standards for electrical safety, functionality, and reliability. To ensure that these standards are met, the following section goes over verification processes to ensure that all components and systems function properly along with validation testing to ensure the system works as intended in meeting user needs.

**Scope**

Components to Test:

* Adafruit METRO M0: Turns on, accepts code, and runs code (Hello World program)
* Red and Green LED: Both LEDs turn on with appropriate voltage to their respective pin
* Pin Pad: Accepts and measures passcode
* Potentiometer: Resistance changes as expected corresponding with rotation
* Speaker: Makes sound (Intended audio, decibels)
* Closer: Internal Spring doesn’t deform, closes effectively,
* Resistor: Use a multimeter and give appropriate values, 5% tolerance
* Battery Holder: Transmits power through 2.1 mm jack, battery stays in position even when jostling
* Servo: Moves according to specified code
* Limit switch: Can switch between binary open or closed states
* Battery: measure the voltage, maH, and life across all 4 batteries, in stated ranges, record results, no leaks etc

**Standards to Meet**

Limit to ANSI, ISO (international non-electrical), and IEC (international electrical)

* ANSI/BHMA A156.4-2019: This standard pertains to door closers, outlining specifications and requirements for their design, testing, and performance. It ensures the reliability and safety of door closer mechanisms in various applications. Evaluations conducted under this standard include those of door control, durability, appearance, and pivots.
* IEC 60601-1-8 Ed. 2.2 b:2020: This standard relates to medical electrical equipment, specifically focusing on the alarms and alarm systems used in medical devices. It provides guidelines for the design, testing, and implementation of alarm systems to ensure their effectiveness and reliability in alerting healthcare professionals to potential issues.
* Occupational Safety and Health Standard 1910.95 - Occupational Noise Exposure: This standard pertains to the maximum noise level that workers can be exposed to for varying lengths of working hours.
* IEC 63356-2 Ed. 1.0 b:2022: This standard focuses on LED light sources. It outlines requirements and testing procedures to ensure these components' reliability, safety, and performance in electrical systems.

**Verification Testing**

The goal of Verification tests is to confirm all materials in use are not malfunctioned or dead on arrival. This is to ensure that no other factors can affect future tests. This phase includes an assessment of the battery, microcontroller, and closer. Afterward, we will test components as a subsystem and finally test the entire system overall.

**Battery**

*Purpose:* To ensure that the circuitry and program are effective when active, we must confirm the batteries are properly working. Testing will involve measuring voltage and battery life.

*Test Protocol:*

1. Turn on the multimeter
2. Turn the dial to the voltage setting 15V
3. Touch the red probe to the positive terminal and the black probe to the negative terminal
4. Note the voltage shown
5. Perform an average and standard dev.
6. After getting voltage, test for maH using the multimeter over 1 minute, then divide by 1000 to get aH
7. After getting maH, test how much energy the microprocessor draws using the multimeter over 1 minute (both idle and when activating the servo)
8. The battery life is now: V\*aH(battery) / wH(microprocessor) to get the hours that the battery will last
9. The acceptable range is 6-12 months
10. Obtain data from other sources and base our results on results from data

**Microcontroller Component Testing**

*Purpose:* By testing each component of the Arduino, we will effectively find any defect that might exist before Validation testing.

*Standards To Meet:* IEC 60601-1-8 Ed. 2.2 b:2020 | Occupational Safety and Health Standard 1910.95 | IEC 63356-2 Ed. 1.0 b:2022

*Test Component Protocols:*

Adafruit METRO M0:

1. Turn on the AdafruitMETRO
2. Install Arduino IDE into METRO
3. “Hello World”
   1. See if it outputs the code
   2. Code in for a simple LED system, with a resistor
      1. Test for AdafruitMETRO, if code works with circuitry, then Adafruit works
      2. Possibly test for multiple pins

Red and Green LED:

1. Add a resistor in series with each cathode
2. Plug into the microcontroller and output 2.1V into the red LED pin
3. See if the red LED lights up
4. Turn off the 2.1 V output
5. Output 2.4 volts into the green LED pin
6. See if the green LED lights up
7. Turn off the 2.4V output

Pin Pad:

1. Activate and program in a certain passcode for the pin pad
2. Type in the passcode
3. If the correct passcode is entered, the lock status will change to “unlocked”

Speaker:

1. Use the METRO to program an alarm sound of frequency 1 Hz and 100% volume level
2. Measure the sound level from 2 feet away
   1. If the sound level is higher than 85 dB, adjust until it is 85 dB or lower
   2. If the sound level is inaudible or softer than the conversational level, the speaker has failed

Resistor:

1. Turn on the multimeter
2. Turn the dial to the resistance setting 20kΩ
3. Touch the red probe to one of the metal wires on the resistor and the black probe to the other wire
4. Note the resistance shown

Servo

1. Program in code with specific angle degrees
2. Note the initial position of the servo, then Note the new position of the servo with the programming, if the difference between the new position and initial position is set similarly to the programmed code, then the servo works.

Limit Switch

1. Turn on the multimeter
2. Turn the dial to the lowest resistance setting
3. Touch the test leads to the terminals of the limit switch
4. Press down the lever arm of the limit switch
5. Note the resistance from the multimeter
6. Release the lever arm
7. Note the resistance
8. Resistance should be low when the lever is pushed down, and high when released

LCD Screen

1. Connect screen to METRO
2. Code METRO to output a 32-character long word to screen
3. See if all cells on the screen can display a character

**Closer:**

*Purpose:* As the main component of the device, testing the closer will be important so that the status of the door can change with the closer component present.

*Standard To Meet:* ANSI/BHMA A156.4-2019

*Test Protocol:*

1. Test the range of motion of the closer arms
   1. The segment of the arm directly connected to the rack and pinion should have a range of motion of approximately 360 degrees
   2. The other segment of the arm should have a range of motion of approximately 180 degrees
2. Install the device onto the intended controlled laboratory environment
3. Test the Air Pressure Release Valve
   1. Open and close the door of the laboratory environment and observe the security and smoothness of closing. The door should close smoothly without slamming

**Attachment System (epoxy)**

*Purpose:* An epoxy attachment system is how the lock system is attached to the refrigerator. This test is required to ensure the system can be applied properly on the CLE.

*Test Protocol:*

1. An L-shaped aluminum plate with a hole drilled through the exposed arm will be epoxied onto a stainless steel test device
2. Attach a luggage scale to the aluminum plate
3. Pull the luggage scale until the plate comes off
4. Note the scale reading of the maximum force required to pull the plate off

**Microprocessor Subsystems:**

*Purpose:* These tests are final testing before the whole system is tested together. This test will be used to confirm circuit and programming aspects work effectively together before taking into account the physical aspect of the device

*Standards To Meet:* IEC 60601-1-8 Ed. 2.2 b:2020

*Test Protocol:*

1. Alarm
   1. Connect the speaker and LED to the Adafruit Metro in accordance with the circuit schematic
   2. Program the speakers and LED to alarm when the limit switch detects an open door and to turn off when it detects a closed door
      1. Press down on the limit switch and print the current door status to the display
      2. Ensure that the current door status displayed is “closed”
      3. Release the limit switch and print the current door status to the display
      4. Ensure that the current door status displayed is “open”
2. PINpad/Lock system
   1. Connect PIN pad and screen to METRO
   2. Program the lock to activate and deactivate off a default code (1111) then test if it does so
      1. Connect the PIN pad and servo to the Adafruit Metro
      2. Set the door lock status to be “locked”
      3. Print the current door lock status to the display
      4. Input the default code into the PIN pad
      5. Print the current door status to the display, which should now be “unlocked”. The Servo arm should rotate upwards and not block the closer arm
      6. Input the default code into the PIN pad
      7. Print the current door status to the display, which should now be “locked”. The Servo arm should rotate downwards and block the closer arm

**The Whole System Must Be Tested**

*Purpose:* As the final test, this test will be done to ensure the entire system all together is effectively working as it properly should.

*Test Protocol:*

1. The system locks the door when necessary, closes the door in most cases, and sounds an alarm when specified
2. Test system similar to an intended day in the lab
   1. Unlock the system with the pin pan to unlock the servo
   2. Open the door and close it and test if the system detects the door is closed
   3. Test leaving the door open for 3 minutes and test when the speaker and LED go off
      1. Note: the system is supposed to alarm at 2 mins. Testing for 3 minutes will help discover unwanted or unnoticed factors.
   4. Repeat the previous two tests a couple of times
   5. Close the door, final test, if the alarm detects the door, is closed
   6. Lock the system using the pin pad

**Validation Testing**

Validation tests will involve both small and large-scale assessments to confirm functionality, durability, and usability. The small-scale testing will focus on general testing, while large-scale testing will help with finalized specifications and detailing.

Small Scale Testing

| **Test** | **Metric** | **Test Protocol** |
| --- | --- | --- |
| Cost | Dollar | Sum final costs of components and materials |
| Battery Life | Hours | Use a multimeter to measure voltage before usage and then again after 1 hour. Repeat 3 times. Use the average difference in voltage per hour to calculate the theoretical battery life |
| Weight | Pounds | Weigh the final assembly with a digital scale |
| Passive Operation | Door Status | Place the final assembly on a device such as a mini refrigerator and open the door. The door status should read as open.  Let go of the door and let the device close it automatically. The door status should read as closed |

Large Scale Testing

| **Test** | **Metric** | **Test Protocol** |
| --- | --- | --- |
| Average Cost | Dollar | Sum final costs of components and materials along with manufacturing, then divide per unit |
| Average Battery Life | Hours | Use [small scale test] on a randomly selected 10% of batteries and perform a T test to make sure that all batteries fall within the acceptable value to test for average battery life |
| Average Weight | Pounds | Weigh 1 in 10 random units and average their weights to make sure that it is close to the small scale weight value |
| Passive Operation | Ease of Use | Installation of multiple units should be swift and passcodes should be easily set up. Then, set one alarm to go off and make sure that the source of the sound is easily discerned |