MEMO

DATE: March 14, 2020
TO: Ryan Hammonds, Filbey Lab, Center for Brain Health
FROM: Evan Kersey, Filbey Lab, Center for Brain Health
SUBJECT: Freezer Alarm

Introduction

There have been multiple issues related to the sample freezer recently where there has been a failure to notice or log when the temperature fluctuates outside safe ranges. A solution is a freezer alarm allowing immediate notification if the temperature fluctuates outside a certain safe range (T>-75C). Building one from scratch will allow us to certify the probe will meet our extreme temperature requirements while also minimizing cost.

Requirements

I. Mitigate physical harm to the freezer
    A. Mitigate any additional risk to samples in the freezer
    B. Consult HVAC expert prior to any risky intervention
II. Reliable
    A. Handle power supply voltage fluctuation due to the compressor on the freezer kicking on
    B. Provide notification if power is disrupted on the refrigerator circuit
    C. All parts must be certified to work in a given temperature range
III. Log temperature over time
    A. Down time due to upgrades should be limited to 30 minutes per day
IV. Alert lab personnel immediately if temperature falls outside of safe range
    A. Notify personnel offsite
    B. Notify personnel on site

Proposed Solution

1. Insert a cryoprobe through the gasket into the freezer compartment.
    a. This satisfies requirement I as it is a noninvasive solution. The diameter of the cable should be minimized.
    b. This step must be successful in order to move forward with any other step.
    c. Procedure.
        i. Mount probe in freezer using glue or tape.
        ii. Apply gentle heat to a 1in portion of the gasket to soften the rubber where the cable must pass through. This will help the gasket form a better seal.
        iii. Close the freezer door and check for any leaks with the temp gun.

    d. If the procedure is successful, order other required parts.
2. Connect cryoprobe to an analog to digital converter chip.
    a. The signal that comes through the wire from the probe is a very weak signal, too weak to be read by standard computer ports.
    b. There are a wide range of price points here with different functionalities. If the selected component fails it is easily replaceable.
3. Connect converter to a control board.
    a. There may be additional cables needed based on the exact model selected but they should be relatively inexpensive.
4. Write software logging temperature over time on a local thumb drive.
    a. Proof of concept.
    b. Allows verification that the components work with an acceptable degree of accuracy via the digital display on the freezer.
5. Interface the control board remotely.
    a. Interfacing with a remote sensor could be difficult due to cometNet restrictions. Work with IT to allow direct access to the local server.(bhcent01)
    b. Software on the server can pull data from the sensor and do something with it. Ideas include the following:
        i. Chatbot on slack channel giving temperature updates every 30 minutes for peace of mind.
            1. Chatbot allows clients to query information about the sensor.
            2. I have a chatbot software written in Java (not the lab standard) and am able to convert it to pull information from a sensor instead of a RESTful API.

Parts List

Cryoprobe/Thermocouple*	$43.95 (-100C, 1200C) Type K [4]
Thermocouple -> male adapter	$6.95[4]
Analog to Digital converter (compatible with thermocouple type	$14.95 [5][6]
Control Board, arduino uno rev3	$22.00[7]
Surge protector	11.99[10]
glue/tape rated for -80C	
Temperature measurer tool (HVAC tech will have one if maintenance is done)	
Raspberry pi 4**	$35[9]
Additional misc parts (breadboard cables, sd card, device casing)	<$30
total	$152.85

*buy this first, if the cable is too thick to fit through the gasket then another approach is needed
**this may be necessary to link to link to bhcent01 server more easily and also gives local ssh access
***prices do not include shipping or tax
****prices collected on 03/14/2020

Alternative solutions

While alternative solutions do exist [8] most are unsuitable for our needs due to the probe and analog to digital converter not not being rated to work in -80C conditions while also costing significantly more. This could be bypassed by buying an additional probe that is certified to work in these conditions however this would require doing a large amount of work on an undocumented comercial product. Costs associated with the existing alarms are around $250 for hardware and $250 for software a total of $500 not including installation.[8] I was unable to find an option that met the -80C requirement out of the box.

References

[1]https://opensource.com/article/17/12/how-build-custom-iot-hardware-arduino
Outlines procedure for creating an IOT sensor
[2]https://www.mccdaq.com/TechTips/Measuring-Thermocouples-with-Raspberry-Pi.aspx
Outlines requirement for hardware converting analog to digital board
The board for the RPI costs too much so going with an arduino and a cheap chip.
The arduino will need a breadboard
https://www.youtube.com/watch?v=0KJ8H_SUWp0
Video depicts arduino project with temp probe sensor
[4]http://thesensorconnection.com/thermocouples/all-thermocouples/weld-pad-surface-temperature-thermocouple-probe
thermocouple price
[5]https://www.adafruit.com/product/269
Digitizer price
[6]https://cdn-shop.adafruit.com/datasheets/MAX31855.pdf
Digitizer technical information
[7]https://store.arduino.cc/usa/arduino-uno-rev3
Arduino price
[8]https://www.controlbyweb.com/applications/freezer-monitoring.html
Alternative freezer alarm
[9]https://www.raspberrypi.org/products/raspberry-pi-4-model-b/
Rpi price, may become necessary to connect arduino to the bhcent server and add local functionality
[10]https://www.amazon.com/AmazonBasics-6-Outlet-Protector-2-Pack-2-Foot/dp/B014EKQ5AA?ref_=s9_apbd_otopr_hd_bw_b3C6a&pf_rd_r=E28ZA7MMR4GV74XJNHBH&pf_rd_p=c07a3cb9-6785-5a70-99d4-77ad257ef2c5&pf_rd_s=merchandised-search-10&pf_rd_t=BROWSE&pf_rd_i=761520