Integrated Digital Scale and Data Logger with Alarm to Monitor LN2 Refrigerators

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Product Design Specifications (PDS)

Function: The device shall monitor and record the weight of the LN2 tank, and integrate with Networked Robotics current monitoring system "Tempurity" to log data and send alerts about LN2 levels and leak rate.

Problem Statement: The most common method used by fertility clinics to monitor their liquid nitrogen refrigerators is to measure the level of liquid nitrogen using a simple measuring stick every few days. This method is imprecise, labor intensive, results in the loss of liquid nitrogen and most importantly, is unable to detect a sudden catastrophic failure. Because there is a direct relationship between the weight and the level of liquid nitrogen within a refrigerator (volume), an improved method to monitor liquid nitrogen refrigerators would be to measure the change in weight over time. Our team is tasked with designing and assembling the parts and equipment required to continually monitor and record the weight of a liquid nitrogen refrigerator (Worthington - Model VHC 35) used to store human sperm, eggs and embryos.

Client Requirements:

- The device shall be able to continuously measure and record the weight of a LN2 tank
- The device shall be able to determine the volume of LN2 based on the measured weight
- The device shall be able to calculate the rate of change of LN2 in the tank
- The device shall be able to identify alert thresholds for LN2 volume and rate of change
- The device shall be able to communicate data to the current "Tempurity" monitoring system
- The device shall be able to send alerts about LN2 levels
- The device shall be implemented on the roller base of the LN2 tank
- The device shall not compromise the integrity/stability of the LN2 tanks nor hinder the functionality of the LN2 tanks
- The device shall give an indication of the health/efficiency of the LN2 tank
- The device shall include a physical display showing the current weight of the tank

Design Requirements:

1. Physical and Operational Characteristics

a. Performance Requirements:

- The device shall be able to continuously monitor the weight of LN2 tanks over an extended period of time.
- The device shall be subjected to weights of up to about 45.5 kg.
- The device shall be placed on a roller base and be able to withstand simple translational movement.

b. Safety:

- The device shall not compromise the integrity/stability of the LN2 tanks.
- The device shall not impede the general maintenance of the LN2 tanks, which includes cleaning, lifting, and filling of the tank.

c. Accuracy and Reliability:

- The device shall be implemented so that the loads are evenly distributed about the roller base; the device shall accurately record the weight of the liquid nitrogen in the tank within ±0.1%.
- The device shall have a safety factor of at least 5, due to the fact that the tank may be tilted, in which case the weight of the entire tank is transferred to only one leg of the five-legged roller base.
- The device shall be able to reliably monitor the weight of the LN2 tank through continuous use.
- The device shall record and communicate weight data to the current monitoring system every 10s.
- The device shall require minimum easy recalibration after prolonged use ≥2 years.

d. Life in Service:

- The device shall remain functional for at least 5 years.
- The device shall retain its structure and function over continuous use.
- The device shall retain accuracy for a period of at least 6 months before calibration is necessary.

e. Shelf Life:

- The device shall be created with materials that will allow the device to be usable for a large timeframe (> 5 years).

f. Operating Environment:

- The device shall operate in a cold room in temperatures ~20°C.
- The device shall be able to withstand and accurately read compressive loads no more than 45.5 kg.

g. Ergonomics:

- The device shall fit on the 19'' roller base used for VHC 35 LN2 tanks.
- The device shall be reusable and portable for daily use.

h. Size:

- The roller base fits tanks 19'' or less in diameter. The device shall work with roller bases of at least this size and possibly be flexible enough to work with other sizes.

i. Power Source:

- The device will be a mobile unit, and thus will require a battery operated power source rather than fixed-source power cords.
- Because the device will be "ON" indefinitely, power cords may be used during extended periods of immobilization in order to limit battery consumption.

j. Weight:

- The device shall have a capacity appropriate to that of a full LN2 tank, which weighs approximately 45.5 kg [1].
- The weight of the device itself shall be less than 25 pounds for easy movement and use.

k. Materials:

- The device shall be made with materials that are resistant to shock and corrosion from chemicals such as steel load sensors (either plated or stainless) so as to optimize precision and accuracy throughout its lifetime.

l. Aesthetics, Appearance, and Finish:

- The device shall encompass a digital display to allow the user to easily see readouts.
- The device should fit seamlessly with the roller base.
- The device should be easily recognizable to allow for easy location of the device during maintenance and calibration.

2. Product Characteristics

a. Quantity:

- At least one working model should be fabricated and assembled.

b. Target Product Cost:

- The current funding is approximately $2500.
- Target cost of development, material acquisition, and fabrication should be approximately a factor of 2x less than the allotted budget, in order to eliminate the need for further funding.

3. Miscellaneous

a. User-Related Concerns:

- Because the tanks are occasionally lifted up, there is chance that a tank may be accidentally dropped back onto the base. Therefore, the device should be able to withstand the impact resulting from such drops.
- The device should be easily accessible for the user to conduct maintenance and calibration, in order to reduce potential complications or injuries.

b. Competition:

- Current refinements in digital electronics is, in effect, making level sensors the popular market option for monitoring liquid nitrogen levels [2]. Operation is largely capacitance-based using cryogenic liquid as the dielectric.

4. References

[1] LABRepCo, “VHC35 Series Liquid Nitrogen Freezer with (6) 11" Canisters,” VHC35 datasheet, [Accessed: Sept. 20, 2018].

[2] ABB FormulaE, “A dozen ways to measure fluid level,” [Online]. Available: https://new.abb.com/products/measurement-products/level/a-dozen-ways-to-measure-fluid-level. [Accessed: Sept. 20, 2018].