LN2 Digital Scale Alarm Monitoring System

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Client:

Dr. Jeffrey Jones

Advisor:

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Overview

- Problem Statement
- Background
- Competing Designs
- Product Design Specifications
- Designs and Design Matrix
- Market Analysis
- Implications
- Future Work
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Problem Statement

- Client: Dr. Jeffrey Jones
- Design a system to monitor and record the weight of LN2 tanks
    - Integrate with current monitoring system to log data and send alerts about LN2 levels and leak rate
- Budget: $2500

Figure 1: Small capacity LN2 storage tank used by our client Dr. Jeffrey Jones at the Generations Fertility Care clinic.

Background - LN2 Storage Tank Failure

- March 4th - 2018 - two separate fertility centers report malfunctioning equipment [1]
  - University Hospital Cleveland Medical Center
    - Loss of more than 4,000 human eggs/embryos
    - Trouble w/automatic refill
    - Temperature alarm system turned off
  - Pacific Coast Fertility
    - LN2 levels too low

Figure 2: Large capacity LN2 storage tanks at the University Hospitals Cleveland Medical Center.

Background - LN2 Methods of Measurement

- Thermophysical properties:
  - Temperature
  - Liquid Levels
- Forms of LN2 sensing:
  - Point level-sensing
  - Continuous level-sensing
- Competing measuring techniques:
  - Dipstick
  - Capacitance liquid gauge
  - Ultrasound sensor
  - Temperature sensor

Competing Designs - Dipstick Method

- Advantages:
  - Simple
  - Widely used
- Disadvantages
  - Imprecise
  - Labor intensive
  - Loss of LN2
  - Unable to detect sudden failure
    - Not continuous

Figure 3: Simple measuring sticks are a quick and easy way to check LN2 levels.

Competing Designs - Capacitive Sensors

- Advantages:
  - High sensitivity
  - Adjustable to the geometry of application
  - Low in cost
- Disadvantages:
  - Temperature sensitivity
  - Accuracy requires complex sensor arrangement
  - Not intrinsically safe

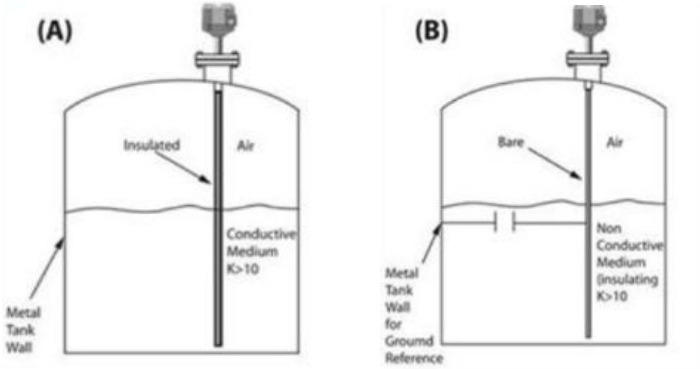

Figure 4: Capacitive level sensors measure the change in capacitance between two plates and can be used for fluids with high dielectric constants (A) or low dielectric constants (B) [3].

Competing Designs - Ultrasonic Sensors

- Advantages:
  - Easy installation and maintenance
  - High degree of accuracy
- Disadvantages:
  - Must be integrated with the lid
  - Susceptible to interference
  - Very limited options for low temperature application

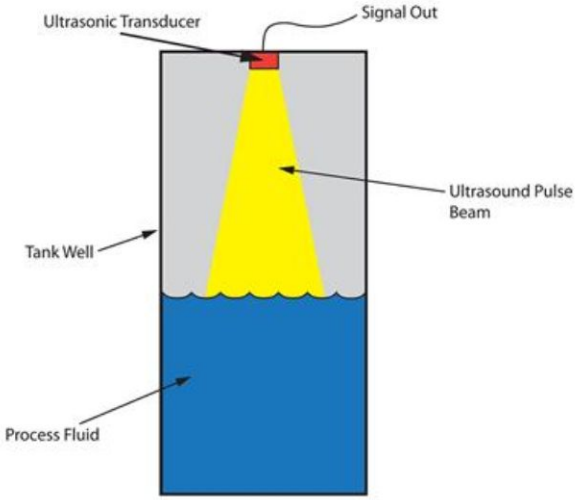

Figure 5: Ultrasonic sensors possess advantages such as simple structure and easy installation/maintenance, but are susceptible to interferences [3].

Competing Designs - Temperature Sensors

- Advantages:
  - Support wide temperature range
  - High output, fast in operation
  - Correlates to viability of specimens
- Disadvantages:
  - Vertical position of the sensor
  - Unable to detect if LN2 levels are too low [4]

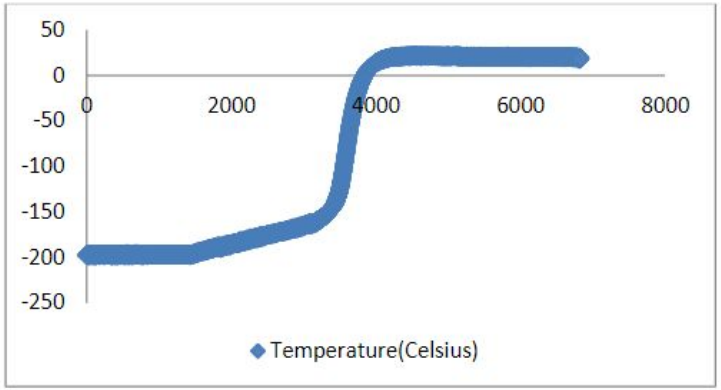

Figure 6: The temperature of a 20L dewar as LN2 evaporates.

Product Design Specifications

- Client Requirements
  - Design and manufacture a scale that integrates w/the roller base
  - Continuous weight measurement and data logging
  - Interface with current monitoring system to communicate data and send alerts
- Physical/Operational Characteristics
  - Digital display
  - Tare functionality
  - Calibration functionality

Matrix 1 - Methodology

Criterion (Weight)	Weight		Capacitance		Ultrasonic Transducer	
Market Potential (35)	5/5	35	4/5	28	3/5	21
Longevity (30)	3/5	18	4/5	24	5/5	30
Easy of installation (20)	5/5	20	2/5	10	3/5	15
Cost (15)	3/5	9	5/5	15	3/5	9
Total (100)	**82**		**77**		**75**	

Matrix 2 - Implementation

Criterion (Weight)	Custom scale fitting existing roller base 		Platform scale w/ connecting ramp 		Conversion of existing base into a scale 	
Data Aquisition Frequency (30)	5/5	30	2/5	12	5/5	30
Longevity (25)	3/5	15	5/5	25	3/5	15
Ease of Use/Automation (15)	5/5	15	3/5	9	3/5	9
Model Compatibility (10)	1/5	2	5/5	10	1/5	2
Ease of Fabrication (10)	3/5	6	5/5	10	2/5	4
Size (5)	5/5	5	3/5	3	4/5	4
Cost (5)	3/5	3	4/5	4	2/5	2
Total (100)	**76**		**73**		**66**	

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Matrix 3 - Preliminary Design Solution

Criterion (Weight)	Option 1 - 3rd party scale w/ existing base		Option 2 - Custom scale w/ existing base		Option 3 - Custom scale/base	
Reliability of Performance (35)	5/5	35	4/5	28	4/5	28
Model Compatibility (30)	2/5	12	4/5	24	5/5	30
Ease of Fabrication (20)	4/5	16	4/5	16	3/5	12
Cost (15)	3/5	9	5/5	15	2/5	6
Total (100)	**72**		**83**		**76**	

Market Analysis

- Marketing approach to the product design
- We are designing for the specific problem presented by the client!
  - However, this approach will influence our design
- Customer analysis
- Understand current market and consumer need
- Survey to record responses
  - Big Takeaway: Continuous monitoring and automated alarm system

Discussion

- Weight provides a more reliable method of monitoring LN2 levels
  - Gives an indication on the health of the tank
  - Continuous data measurement and data logging
- Possible applications to other types of storage units
  - Marketing approach
- Concerns:
  - Load cells will deform over time
    - Accuracy
    - Calibration
  - Third-party collaboration

Future Work

- Heavy focus on software design
- Interface with current monitoring system
  - Record data
  - Use weight to calculate:
    - Volume/level of LN2
    - Rate of evaporation
  - Send alerts
- Collaboration with Networked Robotics
- Product development & marketing

Figure 7: Networked Robotics Interface to Adam Equipment® Scale.

Acknowledgements and References

Thank you to:

- Client - Dr. Jeffrey Jones
- Advisor - Sarah Sandock
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References:

[1] Krieger, Lisa M. “Lawsuit Filed over Lost Eggs at San Francisco Fertility Clinic.” *The Mercury News*, The Mercury News, 14 Mar. 2018, www.mercurynews.com/2018/03/13/lawsuit-filed-over-lost-eggs-at-san-francisco-fertility-clinic/.

[2] CT Cryogenics Inc. “How to Measure Liquid Nitrogen Levels.” *LiquidNitrogenTank.com*, iquidnitrogentank.com/How_to_Measure_Liquid_Nitrogen_Level.php.

[3] H. Hopper, “A Dozen Ways to Measure Fluid Level and How They Work,” Sensors Magazine, 01-Dec-2004. [Online]. Available: https://www.sensorsmag.com/components/a-dozen-ways-to-measure-fluid-level-and-how-they-work. [Accessed: 05-Oct-2018].

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