HUMIDITY CONTROL IN A BASEMENT ART VAULT

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ABSTRACT

The storage of art requires a controlled environment because extreme temperatures, high humidity and variation in humidity can damage artwork and other materials. Staff at the Jordan Schnitzer Museum of Art have noticed that one of their basement storage vaults feels very humid and that the humidity levels in the space seem to fluctuate throughout the day. They have been unable to determine what is causing the high humidity or how to better control the humidity in the storage vault. The focus of our research was on measuring temperature and humidity levels throughout the space in order to determine if the baseline readings taken at the thermostat are accurately reflecting conditions within the vault. Measurements were taken at six locations around the room at one hour increments over a one week period in February of 2011. The data collected indicated that there were significant differences in humidity around the room and that variations in humidity throughout any 24hr period were greater than the accepted standards for environmental control and the storage of art.

1. INTRODUCTION

The users of the textile and small decorations vault in the original part of the Jordan Schnitzer Museum of Art (JSMA) noticed daily variations in the humidity and temperature of the vault. Humidity and temperature fluctuation can cause significant damage to art work.

There are temperature and humidity readings currently being taken from a variety of places using data loggers. The users of the space speculate that there seems to be a more noticeable difference in the relative humidity of the space during the winter months when it tends to be wetter outside. As the weather changes in the summer the space tends to equalize. People working within the space have complained of stuffiness and used the words “muggy,” “wet,” and “swampy” to describe the entrance area of the vault. They even tend to take breaks because they overheat in the space. Water has been seeping into the space along the exterior wall in one area. There has been some oxidation in certain areas along the base of the iron handrails. There is also a sewage line that runs underneath the space in an elevated hallway connecting the front and back of the storage vault.

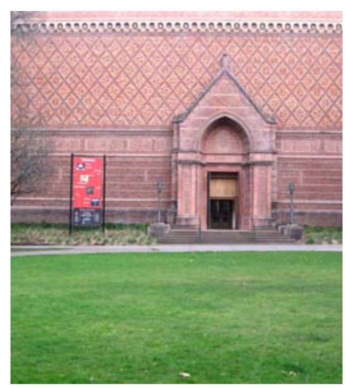



Fig. 1 & 2: Exterior facade of the Jordan Schnitzer Museum

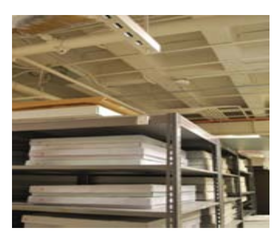



Fig. 3 & 4: Examples of readings already being taken throughout the space (existing thermometer and HOBO)

Fig. 5: ZONE 1 - front storage room, facing main vault entry on north wall

Fig. 6: ZONE 2 - compressed hallway

Fig. 7: ZONE 3 - back storage room

Fig. 8 & 9: The west exterior CMU wall.

The space seems unpredictable in temperature and humidity. A desired temperature for the space is 68°, but the staff is hesitant to change the temperature because of the possibility of condensation. According to staff at the Jordan Schnitzer Museum of Art, the RH fluctuates from 55°– 62°. However, ECS technicians on campus have taken RH readings that range from 45° – 55° on a given day.
Although we were unable to locate specific technical standards for temperature and humidity from the American Association of Museums, we did find standards for specific museums. The Smithsonian Institution museums try to maintain their collections at 45% RH +/- 8% RH and 70° F +/- 4° F (*source: Smithsonian Institution website, http://www.si.edu/mci/english/learn_more/taking_care/geotex.html*). Additionally, the Indianapolis Museum of Art recently set new standards with incremental seasonal adjustments. The range for humidity will be 50% RH +/- 8% (with a variation percentage of +/- 6% in a 24 hour period) and for temperature will be 70°F +/- 4° (with a variation percentage of +/- 2° in a 24 hour period) (*source: ArtDaily website, http://www.artdaily.com/index.asp?int_sec=2&int_new=38716*). Based on our research, it is safe to say that standards for temperature and humidity may vary according to the climate and location of the museum, the needs of objects that they house, and available facility resources. However, the range within which the temperature and humidity must stay is crucial. Too much fluctuation may cause damage to objects.

Donald Neet, an Environmental Control Systems (ECS) Technician with the University of Oregon, has been monitoring the situation within this space. There is inherent difficulty in controlling humidity in any space, but it is particularly difficult in a basement which is susceptible to moisture from the outside conditions. In the JSMA, the exterior walls are not insulated and the original portion of the building is not adequately sealed with a tight exterior envelope for a highly controlled space required by a museum. There is a boiler room across the hallway to the north of the main entry to the space. Additional mechanical rooms flank this area to the east. The current monitoring of this space is determined by a reading taken at the return duct on the wall that is adjacent to a mechanical room.

There are many variables that could be effecting humidity in the space. The goal of this study is to continue to narrow the search for a definitive answer to the perceived mugginess in the space and provide some analysis for best utilization of the HVAC system currently in use in the space.

This work was completed as part of a course assignment for Environmental Control Systems I in the winter of 2011.

The experiment took place on the University of Oregon campus, at the JSMA. The collection vault in the basement of the original structure is approximately 1,000 sq ft of open area. The weather was mostly rainy during the one-week collection time, but a constant relative humidity was maintained.

2. HYPOTHESIS

There is a 10% variation in humidity levels around the room. The averages of humidity readings taken over a one week period at various locations around the room will range from 5% lower than the humidity level at the thermostat to 5% higher than the humidity level at the thermostat.

3. METHODOLOGY & EQUIPMENT

.1 Determine what tools would be appropriate to collect data for humidity levels.

There are several tools in UO Baker Lighting Lab that will measure humidity– HOBOs, Kestrel, Vaisala. The Kestrel or Vaisala would have been effective as well; however, they would require multiple visits to take measurements at different times, and there could be a slight discrepancy in the placement of the tool each time, which would lead to less accurate data. Thus, we used HOBOs so that we could place them on different walls and program them to automatically take readings over the course of a week.

.2 Determine how many HOBOs and where to place them.

We determined that we would place six HOBOs throughout the vault. This was based on a few facts:

a) The basement vault of the vault consists of two rooms with a narrow hallway that connects them. These rooms are not sealed off to the connecting hallway, and the vault is thus considered one space; however, it is important to note that the existing thermostat (which controls both temp and humidity) and HVAC return unit are both located in the connecting hallway. Therefore, the thermostat readings may be accurate for the hallway but not the rooms. Because of this, we decided to treat the vault as three separate zones – the front room, the hallway, and the back room. Each of these three zones will receive two HOBOs.

b) There is one exterior wall that all three zones share. This is a CMU wall that runs along the west side of the building. Since we believe that the CMU wall is not functioning as a moisture barrier and that humidity will be higher closer to this wall, we will place one HOBO on this wall in each of the three zones. The remaining HOBOs will be placed on

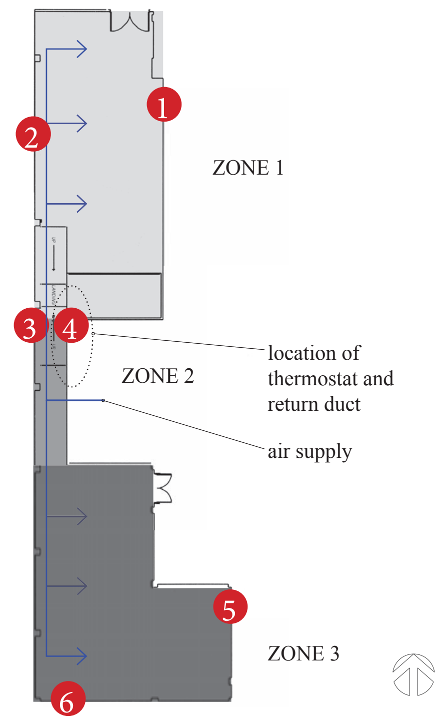


Fig. 10: Plan of placement of Hobo’s in art vault.

interior walls directly opposite the CMU wall.
Each HOBO will be at a consistent height of 60”, with the exception of HOBO 4. HOBO 4 will serve as the baseline HOBO and will be placed right next to the thermostat (close to 72” high). The height of the HOBOs is a rough average of the height of stored items.

.3 Determine how often data will be collected and for how long.

Due to the time constraints for this project, the HOBOs will be programmed to collect data every hour for a period of one week. Ideally, readings would be taken every season to determine whether there is a correlation to rainfall. However, one week will be sufficient to determine whether or not there is a difference from one side of the room to the other, and from one zone to the other. During the week of data collection, daily weather conditions will be recorded.

The data collection began at 5:00 PM on Friday, February 18th and ended at 5:00 PM on Friday, February 25th.
For data analysis, each day begins at 5:00PM and ends at 5:00PM the following day. So, for example, Day 1 is from Feb 18th 5:00PM to Feb 19th 5:00PM.

4. RESULTS AND ANALYSIS

Data collected throughout the week by the six HOBOs

TABLE 1: TEMPERATURE AND HUMIDITY DATA COLLECTION

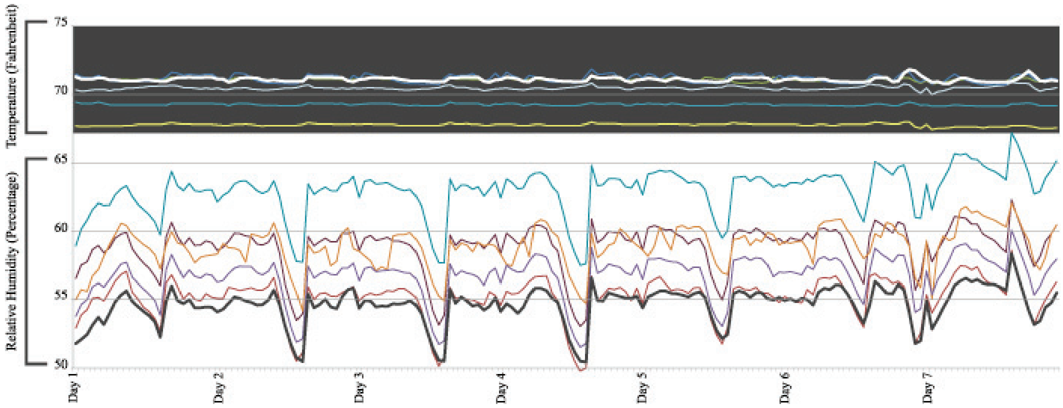
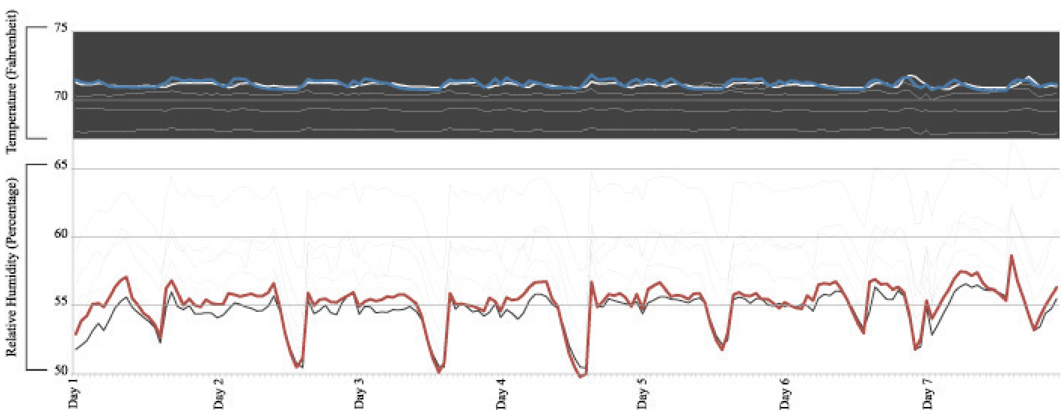


TABLE 2: HOBO 1 (COMPARED TO BASELINE HOBO 4)



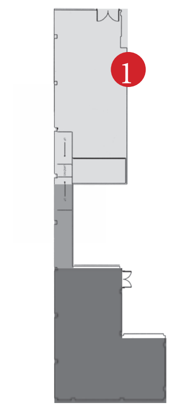
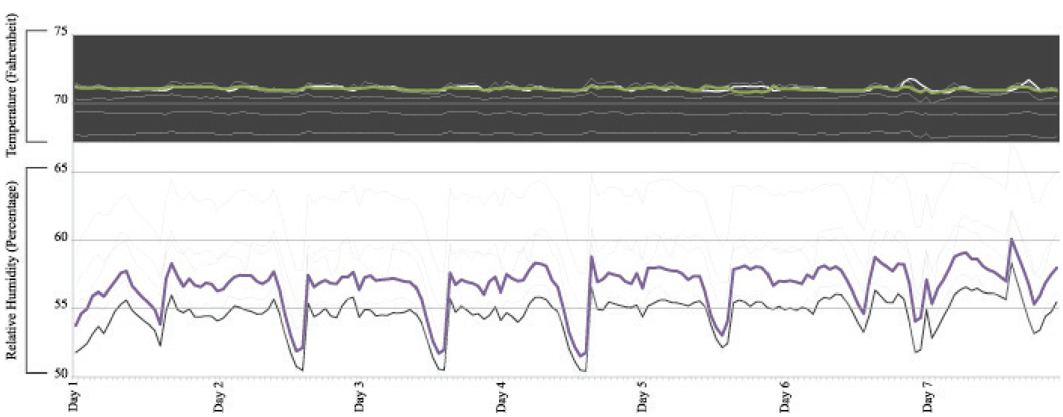


TABLE 3: HOBO 2 (COMPARED TO BASELINE HOBO 4)



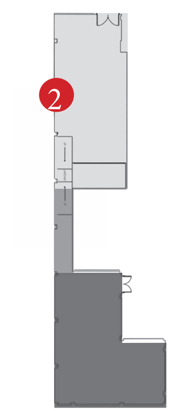


TABLE 4: HOBO 3 (COMPARED TO BASELINE HOBO 4)

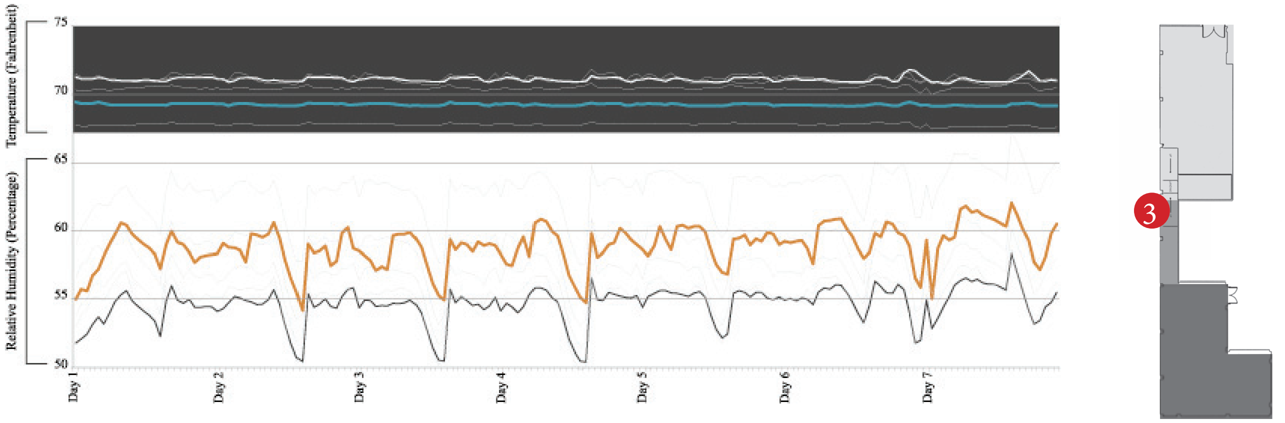


TABLE 5: HOBO 5 (COMPARED TO BASELINE HOBO 4)

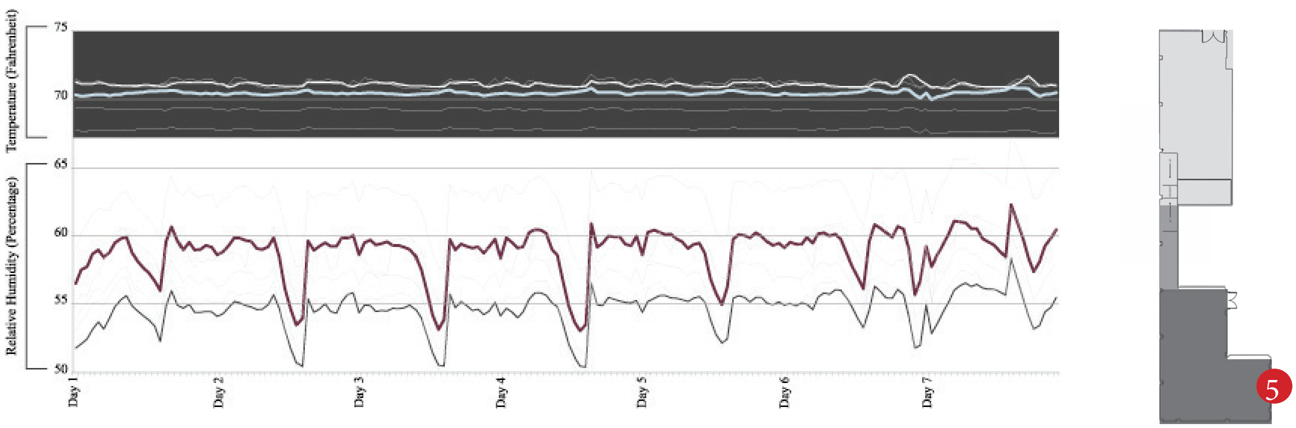


TABLE 6: HOBO 6 (COMPARED TO BASELINE HOBO 4)

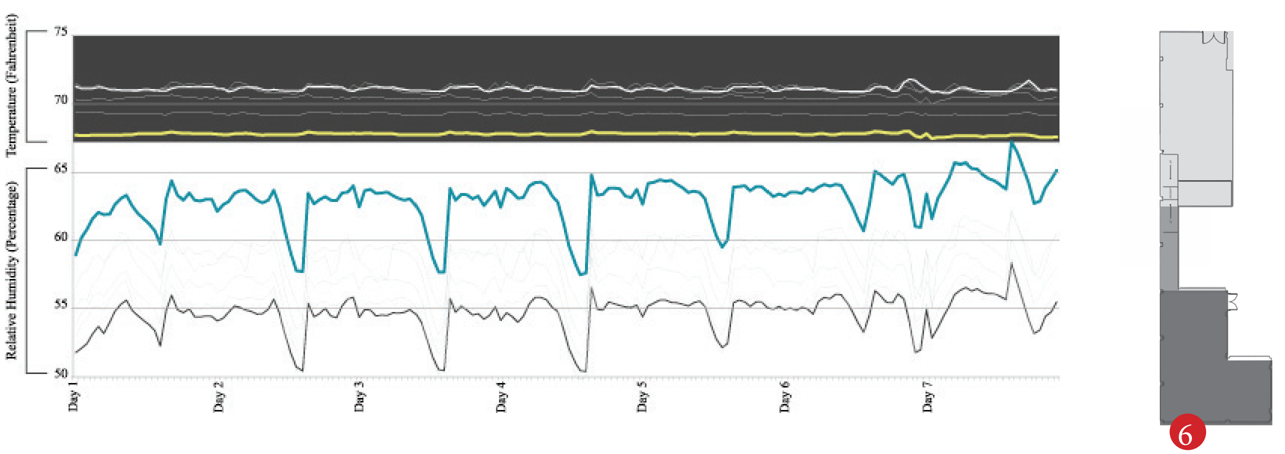


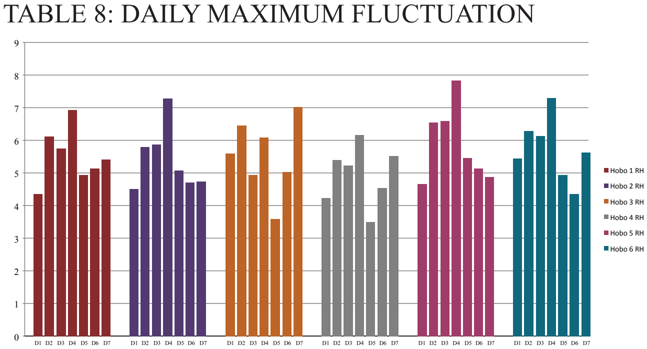
TABLE 7: DAILY RH HIGHS AND LOWS

		Hobo 1		Hobo 2		Hobo 3		Hobo 4 (baseline)		Hobo 5		Hobo 6	
Day 1	low	**52.70**	8:00	**53.77**	17:00	**55.01**	17:00	**51.78**	17:00	**55.99**	8:00	**58.93**	17:00
	high	**57.07**	2:00	**58.29**	10:00	**60.60**	1:00	**56.00**	10:00	**60.66**	10:00	**64.38**	10:00
Day 2	low	**50.48**	7:00	**51.88**	7:00	**54.16**	8:00	**50.43**	8:00	**53.47**	7:00	**57.72**	8:00
	high	**56.59**	3:00	**57.69**	3:00	**60.63**	3:00	**55.83**	17:00	**60.03**	17:00	**64.02**	17:00
Day 3	low	**50.16**	7:00	**51.72**	7:00	**54.93**	8:00	**50.49**	8:00	**53.15**	7:00	**57.69**	7:00
	high	**55.91**	9:00	**57.61**	9:00	**59.88**	2:00	**55.73**	9:00	**59.75**	17:00	**63.82**	9:00
Day 4	low	**49.79**	7:00	**51.50**	7:00	**54.75**	8:00	**50.40**	8:00	**53.04**	7:00	**57.50**	7:00
	high	**56.73**	1:00	**58.79**	9:00	**60.84**	0:00	**56.58**	9:00	**60.88**	9:00	**64.81**	9:00
Day 5	low	**51.74**	7:00	**53.05**	7:00	**56.83**	8:00	**52.16**	7:00	**54.96**	7:00	**59.49**	7:00
	high	**56.68**	20:00	**58.13**	11:00	**60.42**	0:00	**55.65**	21:00	**60.43**	19:00	**64.44**	20:00
Day 6	low	**51.76**	16:00	**54.06**	16:00	**55.85**	17:00	**51.78**	16:00	**55.69**	16:00	**60.70**	7:00
	high	**56.90**	9:00	**58.78**	9:00	**60.89**	3:00	**56.32**	9:00	**60.81**	9:00	**65.07**	9:00
Day 7	low	**53.20**	12:00	**55.34**	12:00	**55.04**	18:00	**52.84**	18:00	**57.39**	12:00	**61.58**	18:00
	high	**58.63**	8:00	**60.09**	8:00	**62.06**	8:00	**58.36**	8:00	**62.28**	8:00	**67.22**	8:00

indicated that temperatures within the room ranged from 67.46° Farenheit to 71.88° Farenheit. Humidity ranged from 49.79% to 67.22% . Although the highest temperature we recorded was within the generally accepted guidelines, it was 3° Farenheit warmer than the staff's desired temperature of 68° Farenheit. The maximum RH level we recorded was almost 12% higher than the highest accepted RH levels at the Smithsonian Institution.

Humidity measurements taken at a single location within a twenty four hour period fluctuated by as little as 3.4% to as much as 7.8%. This daily fluctuation is almost 2% higher than the Indianapolis Museum of Art's standards which allow for a 6% variation in RH levels within a 24 hour period.

TABLE 8: DAILY MAXIMUM FLUCTUATION



The daily average temperature measured by each HOBO ranged from 0.03° Farenheit cooler to 3.43° Farenheit cooler than the baseline temperature measured at HOBO 4. The daily average humidity measured by each HOBO ranged from 0.52% more humid to 8.36% more humid than the baseline humidity measured at HOBO 4. Although the variations in RH levels within the vault were not quite as extreme as the 10 % variation we hypothesized, the measured variation of 7.8% from baseline supports our hypothesis that RH levels at different locations within the vault would vary from the baseline RH measurements taken

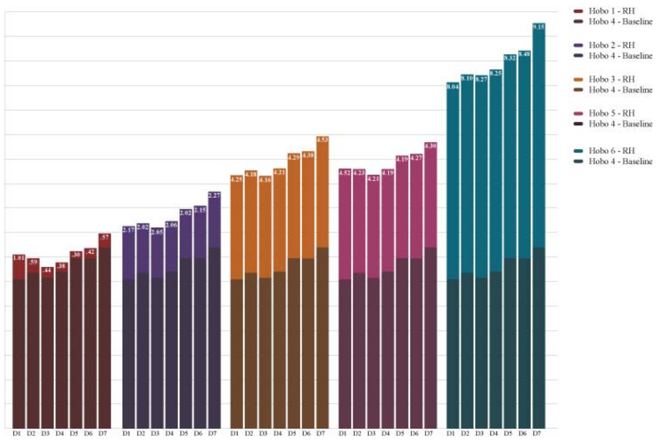
TABLE 9: DAILY AVERAGE RH

	Hobo 1 RH	Hobo 2 RH	Hobo 3 RH	Hobo 4 RH	Hobo 5 RH	Hobo 6 RH
Day 1	55.10	56.26	58.34	54.09	58.61	62.13
Day 2	54.95	56.38	58.54	54.36	58.59	62.46
Day 3	54.59	56.20	58.31	54.15	58.36	62.42
Day 4	54.78	56.46	58.61	54.40	58.59	62.65
Day 5	55.24	56.96	59.23	54.95	59.14	63.27
Day 6	55.37	57.09	59.32	54.94	59.21	63.43
Day 7	55.96	57.67	59.93	55.39	59.69	64.54

TABLE 10: DAILY AVERAGE TEMPERATURE

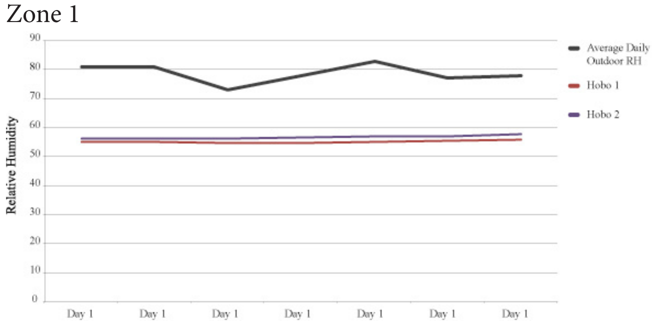
	Hobo 1 Temp	Hobo 2 Temp	Hobo 3 Temp	Hobo 4 Temp	Hobo 5 Temp	Hobo 6 Temp
Day 1	71.24	71.15	69.31	71.13	70.46	67.78
Day 2	71.16	71.10	69.27	71.12	70.45	67.80
Day 3	71.15	71.07	69.27	71.11	70.45	67.80
Day 4	71.25	71.09	69.26	71.10	70.48	67.81
Day 5	71.22	71.07	69.25	71.09	70.48	67.82
Day 6	71.14	71.04	69.23	71.14	70.48	67.81
Day 7	71.05	71.01	69.19	71.05	70.52	67.62

TABLE 11: AVERAGE DAILY RH DIFFERENCE FROM BASELINE

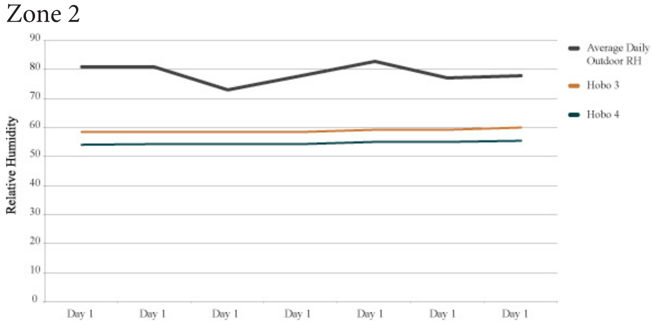


TABLES 12-14: INTERIOR/EXTERIOR RH COMPARISON PER ZONE

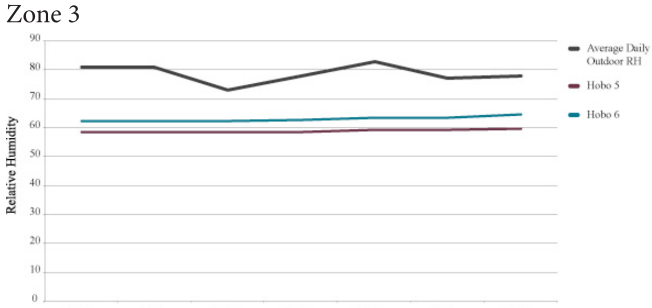
Zone 1



Zone 2



Zone 3



at HOBO 4. While we predicted that RH levels would be higher than baseline at some locations and lower at others, the measured RH levels were always higher than baseline. The three HOBOS placed on exterior walls measured humidity levels that were on average 3.33% closer to exterior humidity levels than the three HOBOS placed on interior walls. The three HOBOS placed on exterior walls measured temperature levels that were on average 1.51° Fahrenheit closer to the exterior temperature than those placed on interior walls. These differences in temperature and humidity indicate that the lack of insulation and an adequate vapor barrier on the exterior masonry wall is affecting conditions within the vault.

5. CONCLUSIONS

The data we recorded throughout the week indicated that fluctuations within any given 24 hour period and throughout the space as a whole are less than ideal for storing art. The data also indicates that one of the factors influencing conditions within the vault is the non-insulated, exterior masonry wall on the west edge of the space. This suggests that a possible solution to difficulties maintaining consistent and appropriate RH and temperature levels within the vault could be mitigated with changes to the exterior wall such as the addition of insulation and a vapor barrier.

We noticed that the most extreme temperatures and RH levels were recorded at HOBO 6 which was placed behind high density storage. Because of the additional variable of the micro-climate created by the high density storage, the data collected at HOBO 6 is inconsistent with the other data collected and is a less accurate measure of general conditions within the vault.

The fact that all of the humidity levels we observed were lower than the baseline RH levels measured at HOBO 4 indicates that the placement of the thermostat directly beneath the return duct is not ideal. Placing the thermostat farther away from any ducts would reflect more accurate measurements and therefore greater control of the environment.

Because humidity levels throughout the space were up to 8% higher than those measured at baseline and recommended humidity levels for the storage of art, the RH could be set 8 -10% lower than the actual desired RH level.

DESIGN LESSONS LEARNED

Potential solutions to the problem of varying humidity in the storage vault offer opportunities for further study: relocating the thermostat to reflect a more accurate room temperature, adding a moisture/vapor barrier to exterior walls, or lowering the thermostat settings to account for the range in humidity throughout the room. The last option would likely be the easiest to pursue.

This case study highlights the importance of providing insulation and appropriate moisture barriers in order to prevent unwanted infiltration of moisture into a space. Our results also indicate that thermostats should be placed in locations that most accurately reflect the general conditions within the space.

7. ACKNOWLEDGMENTS

Thank you to the staff at the JSMA, specifically, Adriane Tafoya. Thank you to ECS Technician Donald Neet.

8. REFERENCES

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