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HOT IN HERE: OFFICE OCCUPANT THERMAL COMFORT IN LAWRENCE HALL

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ABSTRACT

This case study investigated office occupant thermal comfort in Lawrence Hall. More specifically, it focused on the winter heating season thermal comfort in these office spaces. In a building that is composed of approximately seven major additions and/or renovations spanning nearly a century, the variety of heating and ventilation systems varies greatly. The combination of qualitative and quantitative data from both humans and metering devices combined begins to show a comprehensive view of thermal comfort in Lawrence Hall offices. Through occupant surveys and data collecting, the thermal comfort levels of office spaces in Lawrence Hall were analyzed and compared via ASHRAE Standard 55-2004. Furthermore, other considerations such as heating system types, the presence of operable windows and thermostat controls were analyzed to find out more about thermal comfort in Lawrence Hall office spaces. While the results of this study are just the beginning of understanding thermal comfort issues in office spaces, they begin to show surprising relationships between office occupants and their office spaces.

INTRODUCTION

Lawrence Hall on the University of Oregon campus is the result of different major additions to several campus buildings in 1901, 1914, 1923, 1940/41, 1957, 1971, and 1991. The relatively large span of time between additions includes a diverse array of heating, cooling, and ventilation strategies. This case study surveyed office occupants in Lawrence Hall about their thermal comfort levels during the heating season(winter). The study was limited to office spaces since they are for the most part smaller, single occupancy, thermally controlled spaces with doors. Occupants are also more likely to control thermal levels in these spaces as well as have a clear idea of these spaces' thermal qualities.

The main bulk of data collecting occured in occupant interviews. During these interviews, data about the office, such as dry-bulb temperature, relative humidity, heating systems, and presence of windows and thermostat controls were collected. This data was then organized and plotted on the ASHRAE Psychrometric Chart for analysis. This psychrometric chart includes the bounding box that includes the ASHRAE 55-2010 standards for thermal comfort in blue.

From this analysis we disproved our hypothesis that only 60% of office spaces in Lawrence Hall are thermally comfortable in relation to relative humidity and temperature as described by their occupants during the heating season. In fact, 75% of office spaces are described as thermally comfortable by their occupants in the winter heating season. Furthermore, we gained additional information on the relationship between thermal comfort and the presence and use of thermostat controls, operable windows, and the characteristics of different heating systems. Surprising results were also found when considering how occupants maintain thermal comfort in their offices in regard to clothing and personal space heaters.

HYPOTHESIS

The intent of this case study was to begin to quantify the thermal comfort levels of office occupants. Other than brief anecdotal commentary, the thermal comfort levels of

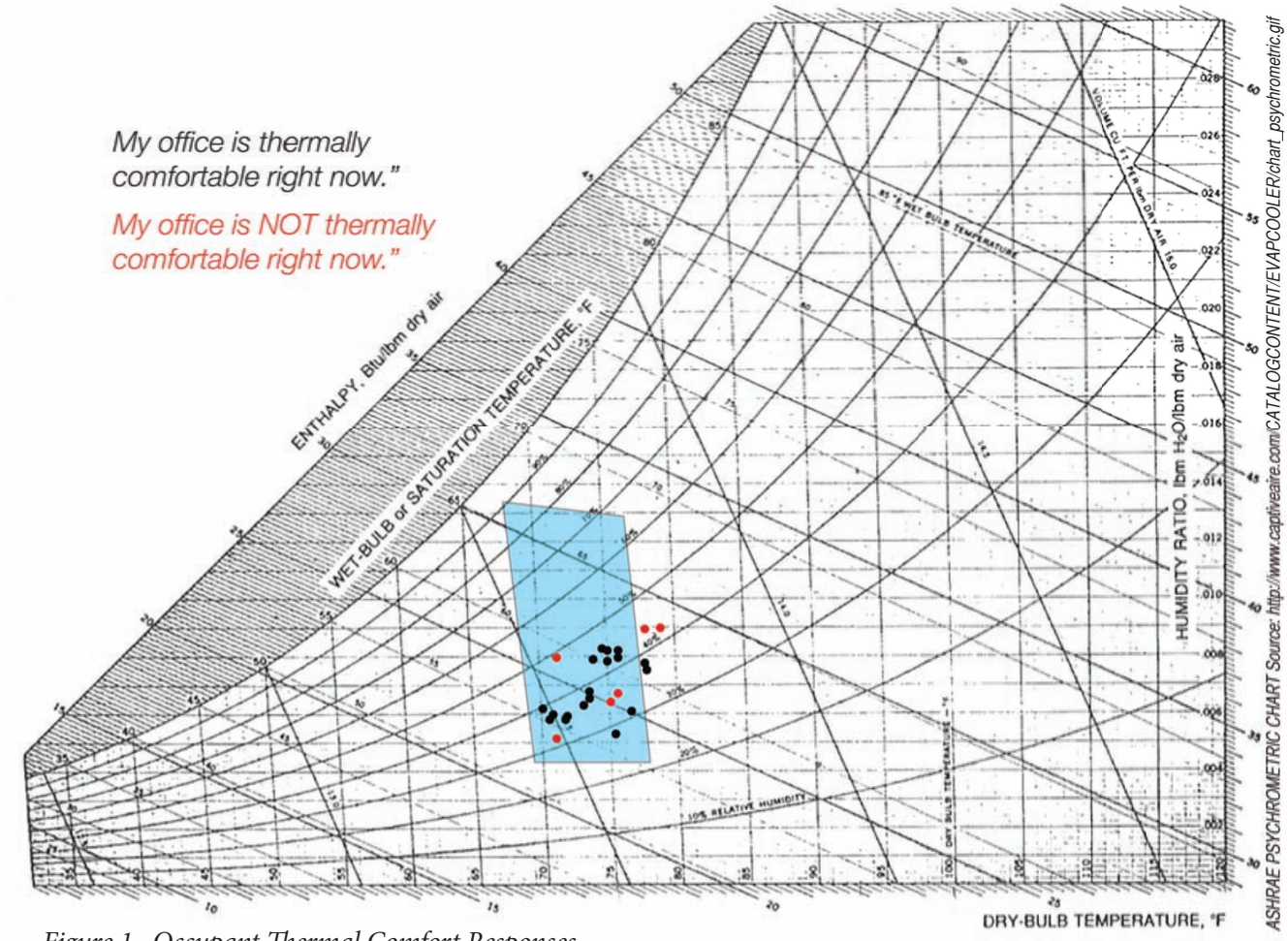

Figure 1. Occupant Thermal Comfort Responses

Lawrence Hall office spaces have never been investigated thoroughly. In addition, the unique character of Lawrence Hall provides an opportunity to survey different heating systems and to compare their performance in terms of occupant comfort when possible. These realities produced several questions that began to inform our hypothesis. How many people are thermally comfortable in the winter? Do thermostat controls, heating system types, or operable windows affect this, and to what extent? Are there other elements other than above-mentioned that affect occupant comfort opinions? Our final hypothesis is as follows:

We propose that 60% of office spaces in Lawrence Hall are thermally comfortable in relation to relative humidity and temperature as described by their occupants during the winter heating season.

METHODOLOGY & EQUIPMENT

The basis of data collection for this case study were office occupant surveys (see attached survey example). The first half of this survey consisted of a series of six questions asking occupants about their office spaces. The authors asked them about their general thermal comfort, what they do when their office is too hot, or too cold, and ask them if they have thermostat controls, and if so, do they use them? Additionally, the authors recorded the average number of hours per week occupants spend in their office. Permission to use this information for the case study was also obtained in writing at the time of these interviews.

In addition to this occupant-based data, dry-bulb temperature and relative humidity point readings were recorded during these interviews. Due to the large amount of data to be collected as well as the issue of repetitively gaining access to these offices, only single-point data was collected in these offices. While this is a limitation of the surveys, the data that was collected begins to show a clear pattern. It is proposed that additional data collecting over time would only reinforce these already-present trends.

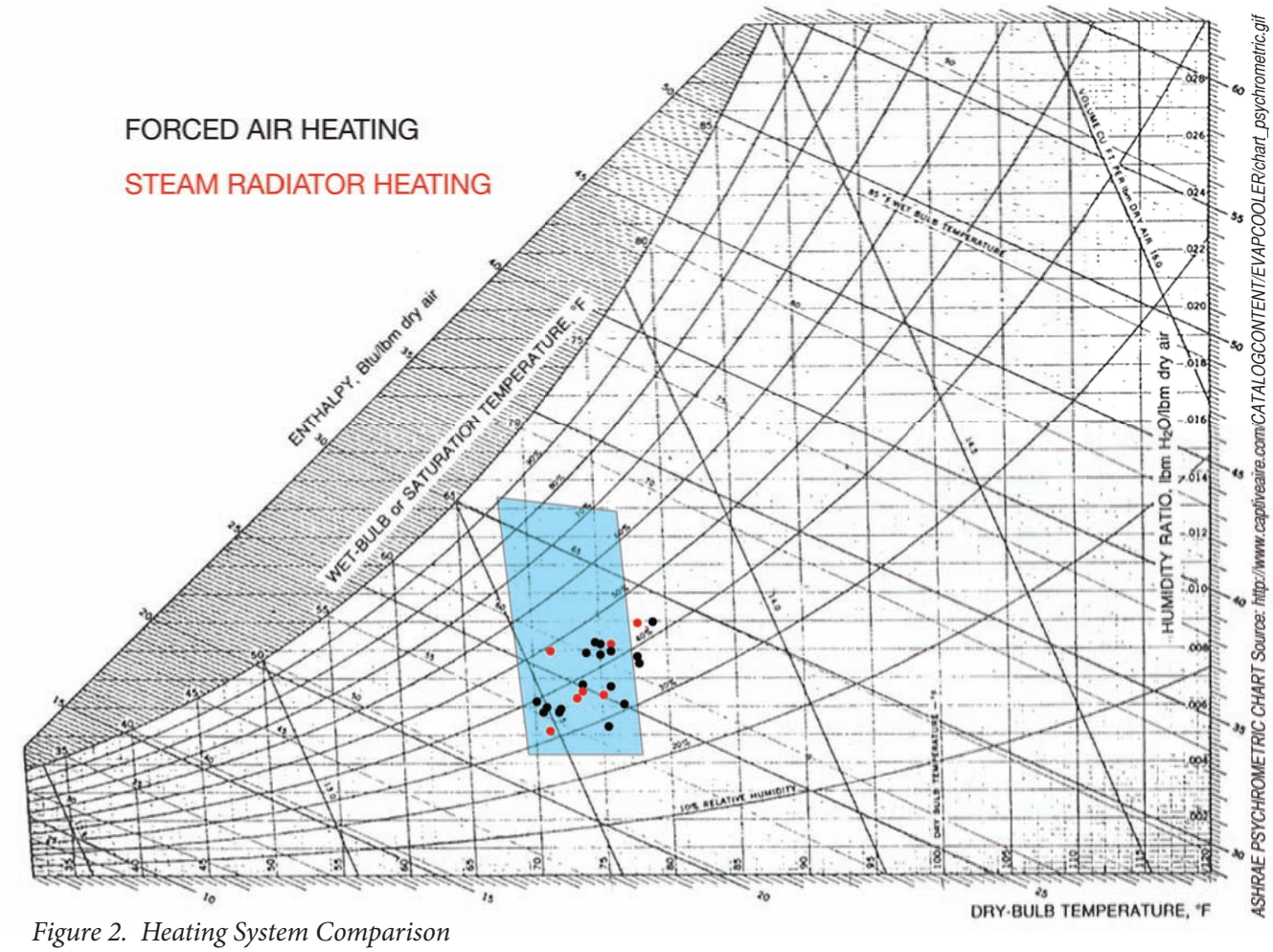

Figure 2. Heating System Comparison

Additional information such as the apparent heating systems used in these offices was also recorded. To further supplement this information the authors recorded if there were any windows (and their orientation), if they are operable, and note any special conditions, such as occupant-owned heating or cooling devices, or any unusual amount of incandescent lighting, computers, or other heat-producing devices.

The surveys were completed during between February 14th and 25th, 2011. These surveys were conducted randomly throughout the building on weekdays (Monday through Friday) between the hours of 10:00 a.m. and 5:00 p.m. The number of surveys was determined by the number of office occupants that are willing to take the survey, approximately 40% of the office spaces in Lawrence Hall.

The surveys were conducted orally, in order to obtain thorough responses, but also to keep a consistent control on the input of responses in the survey. The dry bulb temperature and relative humidity were taken with a Kestrel Weather Meter. While the identification of heating systems was made via visual inspection, this information was confirmed by the reviewal of building plans made available by the UO Campus Operations office.

The data collected from interviews was entered into spreadsheets and assigned a random number in order to protect the privacy of office occupants surveyed. The data of dry-bulb temperature and relative humidity were then plotted on the ASHRAE Psychrometric Chart to gain an understanding of the ranges of actual conditions within Lawrence Hall office spaces during the winter heating season. Further iterations of this graph were used to compare the other factors, such as number of hours the office was used per week, operable windows, operable thermostat controls, and occupant comfort data.

EQUIPMENT USED:

- Kestrel Weather Meters
- Lawrence Hall mechancial system floor plans
- Office occupant surveys
- ASHRAE Psychrometric Chart
- ASHRAE Standard 55-2010

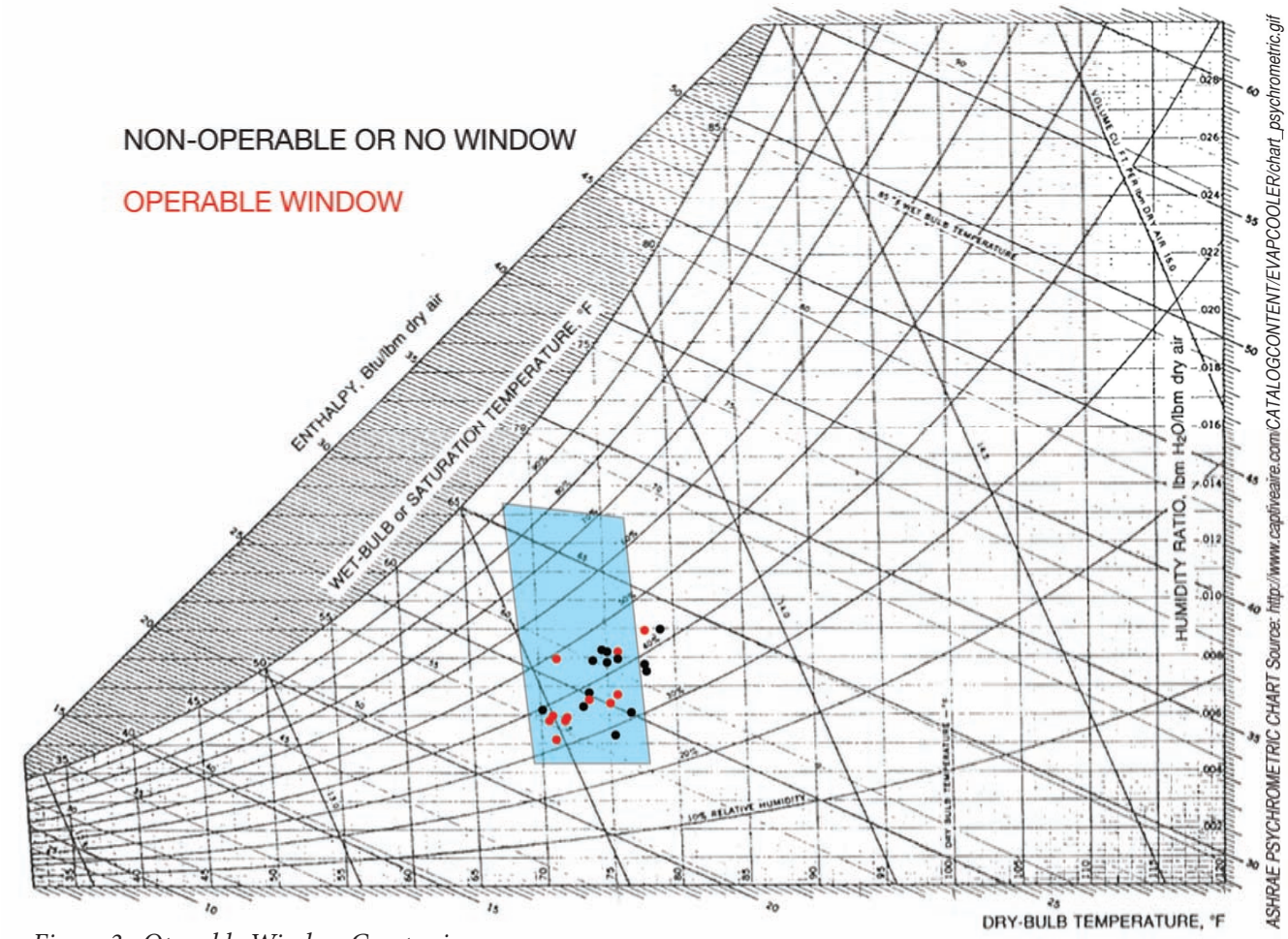

Figure 3. Operable Window Comparison

DATA AND ANALYSIS

After surveying office occupants, the responses were plotted on three different psychrometric charts. The first of these (see Fig. 1) compares human occupant comfort levels with a simple "yes" or "no" categorization of the responses. This chart shows that the ASHRAE Standard 55-2010 does not match the occupant responses in determining what is and what is not comfortable. Taking into account that Standard 55-2004 only requires 80% of occupants to be comfortable within this box begins to show a demand for more data points to be collected. It is unclear with only 24 surveys as to the accuracy of the sampling.

The second iteration of the psychrometric chart compared the data with the heating system used to heat each office (see Fig. 2). There were two categories in this chart. The first being forced air systems delivered via ductwork, most often in the ceiling. The second group consisted of steam-heated fin radiators. The forced air system was responsible for heating the largest amount of offices (71% of the total number), and had a large range of temperatures and relative humidities. However, the steam radiator system had a similar range of values. However, when combined with the first chart comparing human occupant comfort, only 43% of occupants in steam radiator-heated offices were thermally comfortable. This is less than half of the 93% of occupants that felt thermally comfortable in forced air-heated offices. This is at first seemingly significant. However, closer inspection revealed that 100% of the occupants who had personal space heaters were in forced air-heated spaces. This brings a new question to light: Is there a reason why occupants are only using personal space heaters in forced-air offices?

The third iteration of the psychrometric chart compares offices in regard to the presence of windows (see Fig. 3). This chart seperates all offices into two categories. The first being offices with non-operable or no windows at all. These were condensed into one category since there was virtually no way for an occupant to maintain his/her thermal comfort levels with an non-operable window.

The second category consisted of offices with operable windows. This chart shows that there is little to no difference in the ranges of the two categories. This was a surprise, as the authors thought there may be a difference between these two categories before the survey.

In addition to these charts, the additional data collected produced a few other noteworthy conclusions. First, only 17% of the offices surveyed had working thermostats. However, when these offices were compared with the offices that were deemed thermally comfortable by their occupants, there was little or no correlation. In regard to occupant strategies for maintaining their thermal comfort levels, 42% of occupants added or removed layers of clothing to remain comfortable. An equal 42% of occupants used personal space heaters. And of those occupants who added or removed layers of clothing, 70% of them found their office thermally comfortable. That is slightly lower than the 90% of occupants who used personal space heaters to maintain thermal comfort levels.

CONCLUSIONS

In the process of the survey and the analysis of the resulting data, there were several surprising conclusions. The first being the high percentage of people (75%) that were satisfied with their office thermal levels in the winter heating season. The 75% exceeded the initial hypothesis that only 60% of Lawrence Hall office occupants were comfortable in their offices during the winter heating system.
Perhaps the most interesting conclusions are from the secondary data collected. To begin, forced air-heated offices are much more thermally comfortable than steam radiator-heated offices. However, all of the personal space heaters found in the survey were in forced air systems. So perhaps the forced air systems are not in fact more comfortable for occupants. Furthermore, the same percentage of occupants rely on adding or removing layers of clothing as do those who use personal space heaters. And each of these two groups experience roughly the same level of success in maintaining thermally comfortable offices. Finally, the lack of thermostat controls does not seem to inhibit the ability of systems to produce thermally comfortable offices.

While the original question has been solved, the secondary data conclusions create several new questions to be explored. Future research on these factors would further clarify the complex relationships between different elements that contribute to office occupant thermal comfort in Lawrence Hall.

DESIGN LESSONS LEARNED

This case study provided several enlightening conclusions that inform future design of office spaces. This proves to be timely due to the relatively soon relocation of the School of Architecture and Allied Arts. This move will require the design of a new AAA school and offices, as well as the renovation of existing office spaces in Lawrence Hall to be used for the sciences departments.

The first design lesson learned is that individual offices need not have individual thermostats. In this case study it was shown that the presence of thermostat controls was perhaps one of the least relevant factors contributing to occupant thermal comfort.

Secondly, there are significant differences in forced air and steam radiator heating systems and their ability to provide human occupant thermal comfort. While more research would be need to be done in order to determine what makes one more successful than the other, it shows the reality that different systems have secondary impacts on users, and those should be considered in the design process.

Finally, a large percentage of occupants will find ways to maintain thermal comfort levels in their offices. This may be through adding or removing layers of clothing, opening or closing a door, or using personal space heaters. We as designers cannot limit which options they choose. However, we can make energy-reducing options more enticing to occupants in the design process. For example, this may mean including operable windows, or adjustable vent registers as an alternative to relying on high energy-use devices like personal space heaters.

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