Evaluating Performance of Re-Circulating Total Heat System

Case Study Report

Prepared by:

Shawn Manisto

Thomas Boeckermann

Harold Jack Stevens III

Contributors:

RUPP Air Management Systems

American Signature Furniture

Metz Company

Prepared for:

Robert L. Luddy, President

Rupp Air Management Systems

Abstract

Rupp Air space heating equipment was installed at a warehouse in York Pennsylvania. To test the effectiveness of these units in providing heat to the building a study was conducted. Over the course of a year thermocouples in conjunction with data logging devices recorded the temperatures at different points in the warehouse. In viewing this data it is apparent that the Rupp Air space-heating units effectively mitigated stratification year-round and provided effective space heating. Zone variances in space temperature were found to be minimal regardless of seasonality.

Introduction

The purpose of this report is to investigate the efficacy of space heating units installed on an American Signature Furniture warehouse in York, Pennsylvania. This warehouse covers 624,800 square feet, with forty-two dock doors and forty-three foot ceilings. A full architectural layout of the American Signature facility can be found in Appendix A. Note the concentration of dock doors along the northern wall of the facility, as well as the de-stratification fans along the same wall. The main goals of the space heating equipment were to efficiently maintain comfortable space temperatures and reduce stratification within the building, all while meeting ASHRAE 62.1 requirements.

Heating Equipment

Five Rupp Air direct-fired heaters were installed on the roof of this facility. Three units provided 1,885,464 BTU at 29,000 CFM while the remaining two provided 2,860,560 BTU at 29,000 CFM for a total of 11,377,512 BTU. Direct-fired units are advantageous for large buildings such as this one as direct fired heaters operate at the highest combustion efficiency, 92%, ensuring lower energy costs compared to other heating methods. In order to achieve this efficiency, all direct fired units discharge the complete set of combustion products directly into the space. The degree to which combustion products may build up in a space is regulated by ANSI standard Z83.4 for cycling units and Z83.18 for re-circulating units. The Rupp Air units have been tested and proven to operate well within the standards outlined by these regulations, providing a heating method that is clean, safe, and efficient.

Another important feature of the Rupp Air heating equipment is the re-circulation capabilities. Re-circulation saves fuel by replacing a percentage of the incoming outside air with hot air recaptured from ceiling level inside the building. The amount of air to re-circulate is controlled by the static pressure of the building. Rupp Air typically holds most buildings at a slight positive pressure. This eliminates infiltration and drafts through the building. When the building becomes pressurized the re-circulating units use their maximum re-circulation capacity; when the building is under-pressurized (as may happen when dock doors are opened) the heating units go into 100% outside air mode to bring more air into the space.

Data Collection

Data was gathered for this report using Lascar EL-USB-2 data loggers. J-Type thermocouples were installed at various locations throughout the facility, detailed in Appendix B. Each thermocouple took temperature readings on a half hour basis during the course of the study, which took place over the course of one calendar year.

Unfortunately data loggers W5-W9 were unable to be recovered from the job site at the conclusion of the study. This is not expected to impact data viability as the remaining data loggers were distributed along the length of the wall containing the dock doors. The recovered data loggers can reasonably be expected to represent the area of greatest fluctuation; the interior of the building should not experience as great of a thermal loading.

Stratification

Stratification of air within a building is a major source of heating inefficiencies. Air density varies inversely with temperature, creating a layer of hot air bounded by the facility's roof. This layer of hot air in contact with the ceiling leads to a greater amount of heat transfer between the roof of the building and outside air. Greater heat transfer leads to higher energy costs, as heating equipment must offset this amplified thermal loading.

Rupp Air Management combats stratification through the implementation of re-circulating units. As mentioned earlier, these units re-circulate the air within the building, creating a uniform temperature from floor to ceiling. The large fans installed along the dock doors of the American Signature facility further enhance re-circulation.

In order to monitor stratification in the American Signatures facility, two data logging devices were installed in the same location. The first data logger (W6, Appendix B) was installed at floor level while the second (W8, Appendix B) was installed at ceiling height. Figure 1, below, displays the stratification present during the coldest day within the duration of the study. As can be seen in the figure the floor and ceiling temperatures remain extremely consistent, even as the outside temperature fluctuates over a ten-degree range.

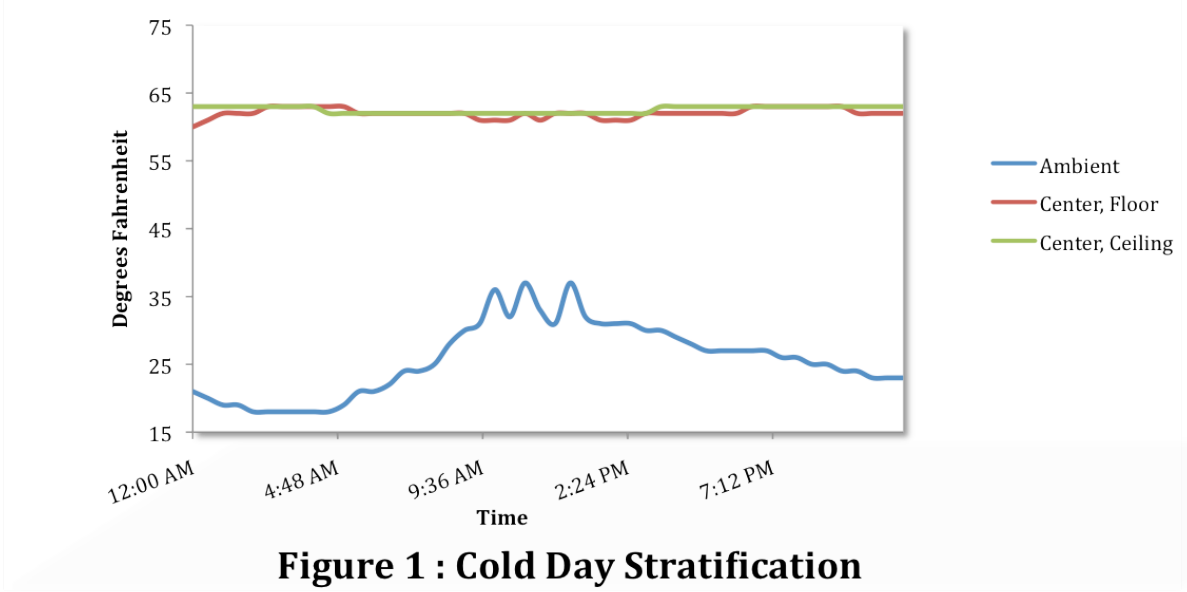


Figure 1 : Cold Day Stratification

While air stratification is primarily a concern during the heating season, make up air units may also be run in the summer months to provide environmental cooling during the early morning. Other summertime applications of make up air include providing constant ventilation and frequently turning over the air in the space. In light of these warm weather applications it is also worth investigating the extent of stratification of air in the summer months. Figure 2 displays the stratification within the facility during the hottest day recorded.

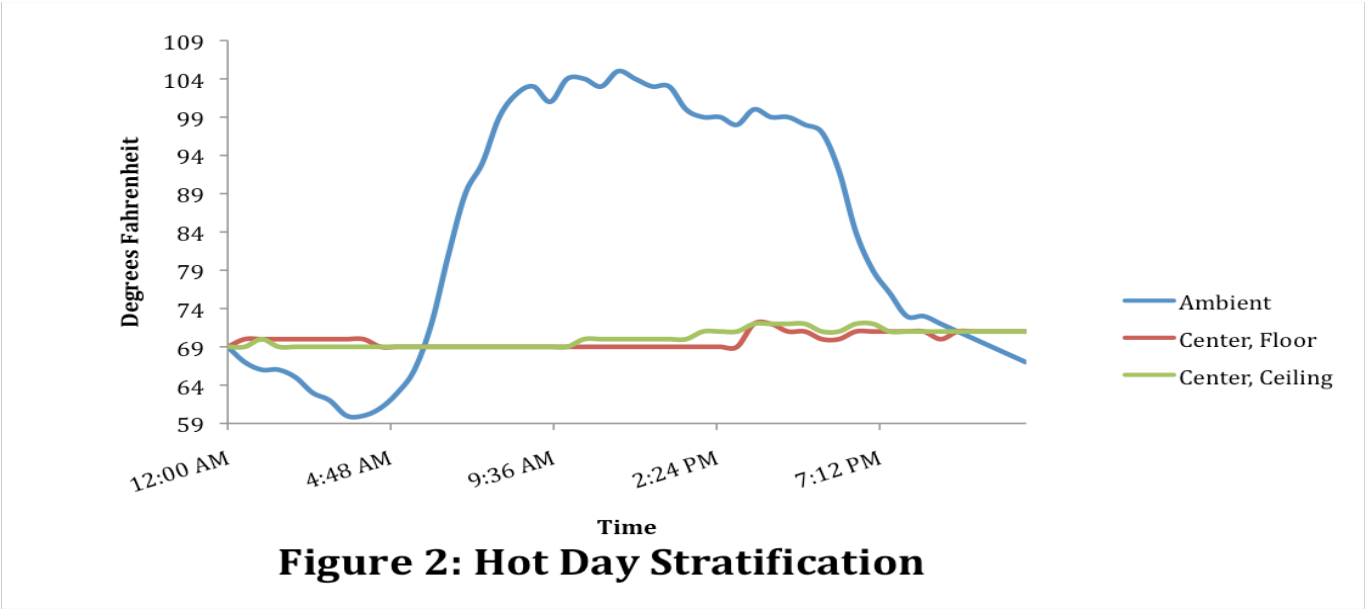


Figure 2: Hot Day Stratification

As seen in the figure, the data recorded at the ceiling and the floor of the building indicates stratification is minimal. Of note is the large temperature differential between the ambient temperature and the interior temperatures. While the temperatures do increase in the afternoon, the ceiling and floor temperatures remain very close to one another, evidence that stratification is minimized even during heavy thermal loading.

Temperature Variation

In addition to heating the air within a space to a desired temperature it is also important that this temperature be maintained throughout the building. A facility that is evenly heated will provide much more in the way of worker comfort and productivity than a facility that has cold and hot zones. To ensure uniform heating throughout the building the space heating units were strategically positioned to maximize air distribution. In addition, the re-circulation capabilities of the units allow for continuous air movement within the building. Air movement directly corresponds to lower variance in average temperature. Figure 3 shows the monthly average temperatures for multiple data acquisition locations.

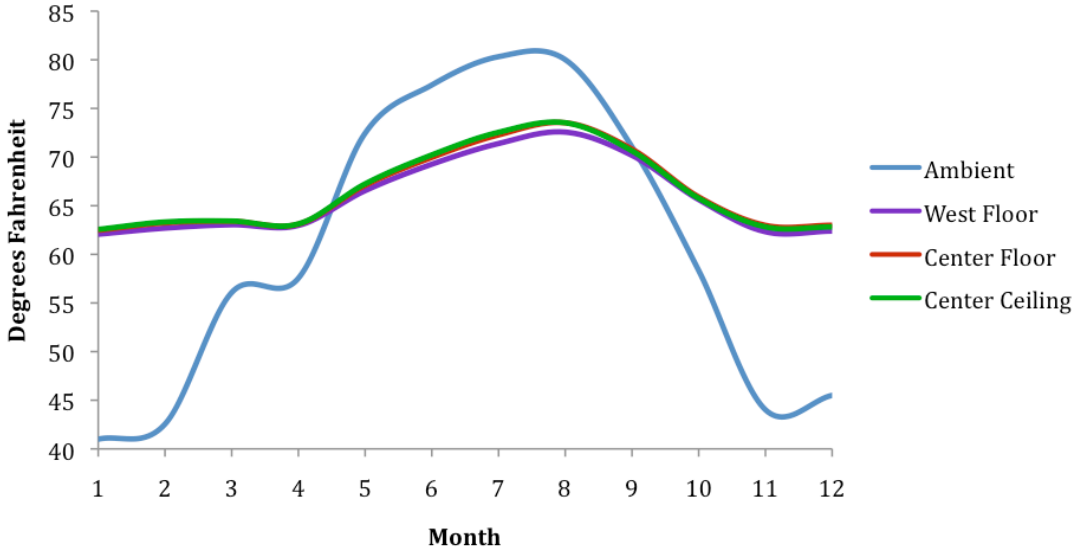


Figure 3: Multiple Locations-Monthly Averages

As can be seen in the figure the monthly indoor temperatures remain very consistent during the heating season. Some discrepancy can be seen in the summer, but this should be expected as during this time the units solely provided ventilation and environmental cooling. Another measure of air distribution can be found by looking at the same data, but over the course of a day. This approach is more likely to show fluctuations

that could be smoothed out by a mean statistic. Figure 4 displays the recorded temperatures over the coldest day of the year. In this figure it can clearly be seen that despite the fluctuations of the ambient outdoor temperatures the interior space has a near uniform temperature throughout the day.

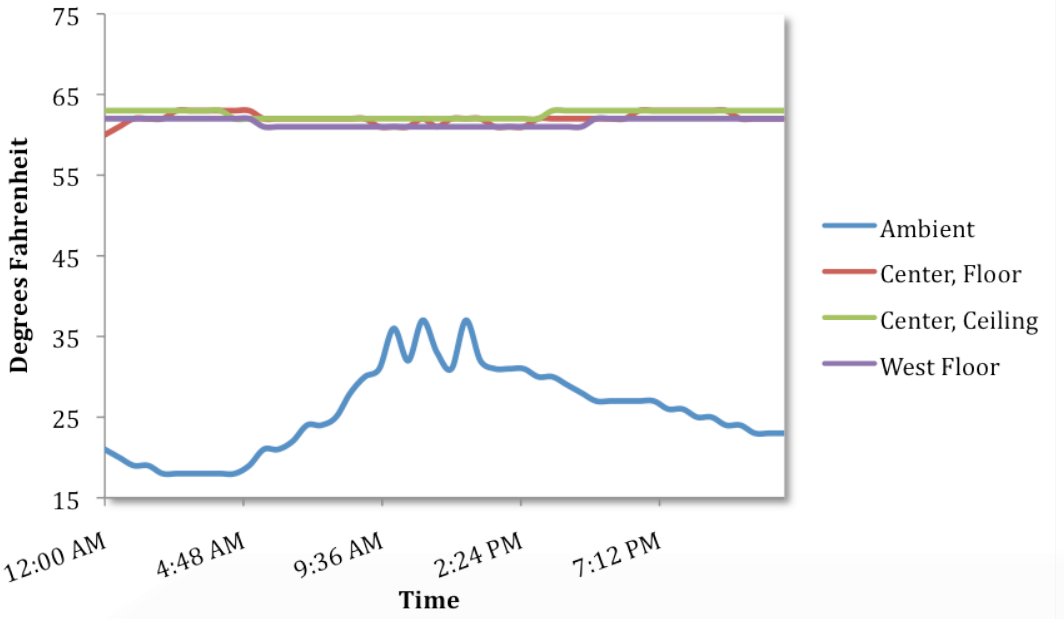


Figure 4: Cold Day Hourly

As mentioned earlier, the make up air units provided for the American Signatures facility do not have any innate cooling capabilities. The units are, however, capable of providing ventilation during the day. Another option available is to turn the units on in the morning or night to draw in cooler air (thereby providing environmental cooling). Regardless of which method is used, it can be expected that the facility will experience temperature distributions that exceed those encountered in the heating season. Figure 5, below, shows these fluctuations on an hourly basis during a typical summer day over the period of data collection. Of note in the figure is the temperature swing in the afternoon. This occurred as would be expected due to the thermal mass of the facility. This swing is mitigated by ventilation provided by the make up air units, as seen in the consistency in the morning and nighttime temperatures.

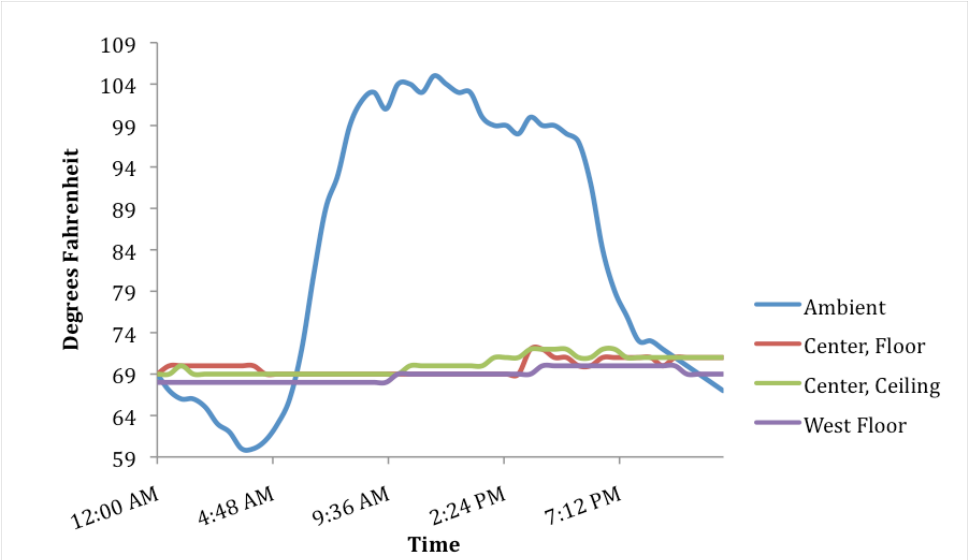
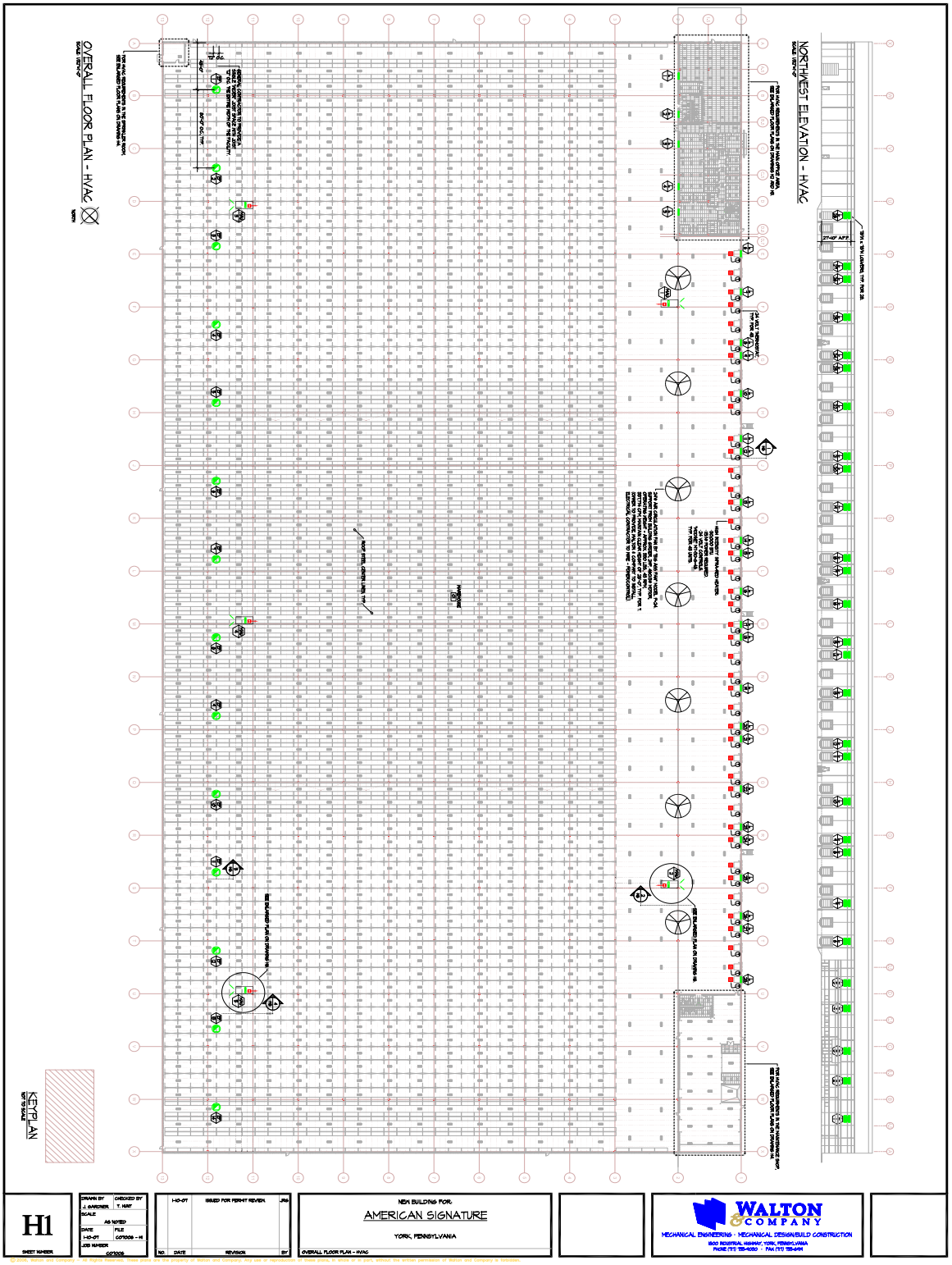


Figure 5: Hot Day Hourly

Conclusion

The Rupp Air equipment nearly eliminated stratification in the American Signature facility. The Rupp equipment also maintained a homogenous temperature throughout the building. These two observations held true regardless of seasonality over a one-year time span. In addition, the Rupp Air space-heating units maximized efficiency by incorporating technology such as re-circulation, pressure control, and direct-fired combustion. These techniques combine to pass annual savings onto the owners, while conforming to all relevant ASHRAE and ANSI standards.

Appendix A : Facility Plan



Appendix B: Data Acquisition Locations