THE PENNSYLVANIA STATE UNIVERSITY

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DEPARTMENT OF MECHANICAL AND NUCLEAR ENGINEERING

REFRIGERATOR EFFICIENCY ANALYSIS FOR APPLICATION IN PSU RESIDENCE HALLS

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ABSTRACT

Current trends in many fields of engineering are leading to new developments in energy efficiency and new more efficient technology. Modern technology often offers users several various settings that compromise between energy efficiency and various performance characteristics of the device much like a laptop computer's various settings which alternate performance settings to either optimize performance of the computer or maintain a minimal level of energy consumption. One such piece of modern technology, which is often taken for granted because it has not seemingly changed in many years, is the refrigerator. Users can choose from various temperature settings based on personal preference. Yet these settings affect the operating efficiency of the device. The major issues facing the improvement of refrigerator use and design is the lack of interest in the effect that each individual temperature setting has on the efficiency of the refrigerator overall and the wide range of applications that a refrigerator can be used for. The Absocold model refrigerator that is currently used in all Pennsylvania State University residence hall rooms was chosen to accurately recreate conditions in the dorms and analyze the energy consumption trends to propose improvements in that specific refrigerator design and use. The analysis of the refrigerator design was achieved by conducting several tests which monitored energy consumption and internal temperature of the refrigerator to determine baseline readings and test possible improvements to the design and usage of the refrigerator in the PSU dorms. The tests that were conducted included a baseline test where the refrigerator was run at "standard" conditions to generate a reference point for comparison to other tests, a ventilation test to determine the effect of ventilated air on the performance of the refrigerator, a test designed to determine the effect of improperly sealed or unclosed doors on the performance of the refrigerator, an insulation test to determine the effect of improved insulation on the

performance of the refrigerator, and a test to determine the difference between a "full" and an "empty" refrigerator. These tests helped to generate prototype improvements to the system as well as suggestions for the relocation of the refrigerator in the dorm rooms to avoid overheating the local environment. These improvements to the design and operation of the refrigerator include adding more insulation to the outside of the refrigerator, ensuring that the refrigerator is not stored, used, and operated next to the heaters in the residence hall rooms, and using higher refrigerator temperature settings for normal operation. These design and operation changes will result in a reduction in energy consumption and consequently savings on the cost of electricity in the residence halls.

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Chapter 1

Introduction

Recently there has been a great deal of interest in reducing energy costs and conserving energy in every aspect of society. When looking at the major sources of energy consumption in the Pennsylvania State University dormitories, it is apparent that the refrigerators supplied by the university use more energy than any other appliance or electronic device in the dorms. Currently, the refrigerators in the residence halls are used to store a number of different food products including, but not limited to, bottled water and other beverages, ready to eat and left over food, frozen food, condiments, and other food stuffs [1]. Clearly, it is an important part of residence hall life, for the students that do use their provided refrigerators. It is important that the university attempt to ensure that the refrigerators are not using more energy than necessary to accomplish the jobs that students commonly use them for. Therefore, if the university wishes to follow current trends towards conserving energy and cutting energy costs, which are well documented in several doctoral thesis dissertations, reports and other publications at Penn State and other universities [2], [3], the refrigerators in the dormitories could be analyzed to determine optimal temperature settings under various conditions to reduce energy consumption.

Testing the various temperature settings could help determine optimal refrigerator settings so that food can be stored at the proper temperature while using the least amount of energy. The research presented in this thesis outlines the testing performed on the refrigerator to determine optimal temperature settings, the effect of improved insulation on the refrigerator's performance, the effect that an improperly sealed or an unclosed door can have on performance, and the effect of ventilation on refrigerator performance. This testing could potentially save the university a substantial amount in energy costs by reducing the amount of energy required to operate the refrigerators in the dorms. This chapter will provide background information on the refrigeration cycle as well as an overview of efficiency and energy consumption.

Background Information and Objectives

A basic refrigeration cycle consists of a four stage cycle in which a low pressure liquid refrigerant is used to extract heat from inside the refrigerator causing the refrigerant to vaporize. This vapor is then compressed to a higher pressure and passed through a condenser which exhausts the heat to the environment and causes the refrigerant to condense. The refrigerant then passes through an expansion valve to return it to a lower pressure before the cycle repeats. The refrigerant cycle is often referred to as the reverse Carnot cycle because it follows the same basic process as a typical Carnot heat engine. The important difference between a refrigeration cycle and a Carnot heat engine cycle is that power must be added to the system to compress the refrigerant in the refrigeration cycle and remove heat from the system unlike a Carnot heat engine which forces the heated fluid in the cycle past a turbine to generate power. A basic refrigeration cycle is shown below in Figure 1-1 [4].

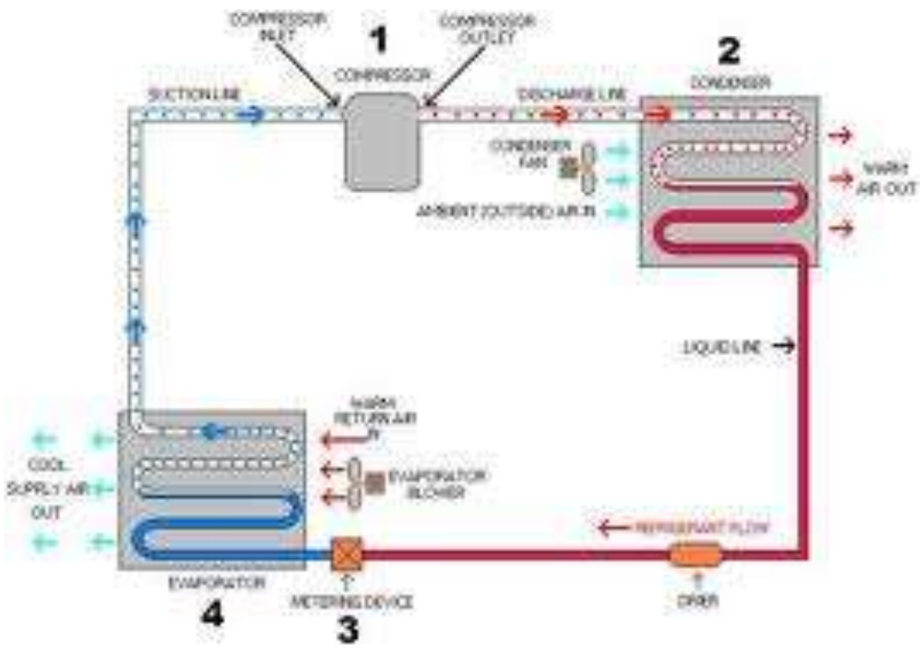

Figure 1-1: Basic refrigeration cycle

The main focus of this report centers on changes in the efficiency of the refrigerator. Therefore, an understanding of the definition of the efficiency of a refrigeration cycle must be explored so that recommendations to improve refrigerator performance can be made and implemented. The formal definition of the efficiency of a refrigeration cycle is dependent on the refrigerant that is used but is commonly defined as the heat removed from the inside of the refrigerator, or the amount of cooling, divided by work done on the system. The efficiency of a refrigeration cycle is commonly known as the coefficient of performance or COP. However, because the temperature and amount of cooling of the refrigerator was considered to be relatively constant, improved efficiency in this report directly means reduced energy input in terms of kilowatt hours used by the refrigerator to keep the interior compartment at the required temperature. This is an important consideration because typically the efficiency of any system is a ratio of the useful energy output divided by the energy input to the system. However, as already mentioned, increased efficiency in this analysis will have units of energy in order to simplify the analysis [5].

The efficiency of the refrigeration cycle can be greatly affected by the temperature that the interior of the refrigerator, the evaporator in the cycle in Figure 1-1, is set to. This is because more energy is required to maintain a lower temperature in the refrigeration chamber. The temperature of the environment that is used as a heat sink is also important to the efficiency of the system. This is because the zeroth law of thermodynamics shows that in order for heat to transfer naturally from one area to another, the receiving area's temperature, the environment, must be lower than the temperature of the heat source, the refrigerator condenser. If the temperature of the environment is too high, the condenser will need to use a large amount of energy to continue exhausting heat to the environment. The effect of temperature on the efficiency of a basic refrigeration cycle is best represented by the Carnot refrigeration cycle. The Carnot refrigeration cycle efficiency is dependent only on the temperature of the environment and the temperature of the refrigeration chamber [5]. Therefore, the temperature of the surrounding environment and the temperature of the refrigeration chamber were an important part of designing the tests for this study and will be further discussed when the tests are outlined.

Finally, a basic understanding of energy consumption must be established. When measuring electricity, energy consumption is measured in terms of kilowatt hours (kWh). This creates a way to measure energy consumption over a period of time so that utility companies can bill consumers for their energy consumption. The refrigerator that was tested in this analysis is rated by the manufacturer to consume an estimated 290 kWh per year with an estimated yearly operating cost of $31. This number will be evaluated for accuracy and to determine what the manufacturer deemed to be “normal operating conditions.” Furthermore, it is easy to see how quickly energy savings can compound when looking at the University Park campus as a whole. This is because there are around 6100 dorm style rooms on the University Park campus, which means that there are approximately that many refrigerators similar to the one tested in this report in operation at all times [6]. This means that these refrigerators use approximately 1.769 GWh of energy per year at a cost of around $189,100 per year based on the manufacturer’s estimations. Therefore, a reduction of ten percent in energy usage, which analysis shows is possible, would result in an average savings of around $18000 per year. Overall, energy consumption is an important consideration in this analysis, which must be carefully evaluated to ensure accuracy and validity when and if the recommendations of this report are put into practice. It is also established by many authors that improving the efficiency of small appliances and other devices can greatly reduce the overall financial cost of energy for a building in both industrial and commercial settings [7].

Conclusions

Overall, an understanding of the refrigeration cycle was a pivotal part of determining the various tests that would be performed during this analysis. Understanding the impact that the environment can have on the cycle including what happens if heat cannot be properly exhausted from the condenser, heat loss due to poor insulation, and several other factors helped establish several possible scenarios that could be evaluated. Many studies and textbooks describing basic thermodynamic principles demonstrate the impact that all of the above conditions can have on the efficiency of the refrigeration cycle and consequently these studies were pivotal in guiding the creation of the tests for this study [8]. Overall, reducing the energy use of the refrigerator was the main focus of the analysis and this concept forms the basis for all the recommendations in this analysis.

Chapter 2

Methods and Materials

The research and testing for this thesis was conducted in several various phases. In order to describe the methods and materials used during the testing process, this material has been divided into three sections including the basic testing procedure that was followed for each test, an overview of each test that was conducted and the environmental and system level modifications that were tested, and the preparation of the additional insulation prototype design that was developed after initial testing to improve the overall energy efficiency of the Absocold refrigerator.

Basic Testing Procedure

Each test was conducted over a twelve hour period during which the total energy consumption of the refrigerator and the internal temperature of the refrigerator were monitored using a kilowatt meter and a temperature sensor respectively. Each test was performed on all five numbered temperature settings to determine a range of operating parameters for the refrigerator. Before each test run, the refrigerator was allowed to run at the desired temperature setting for one hour before testing started to ensure that the internal temperature had reached average values for that setting. This was done to obtain comparable energy consumptions for each setting which could be extrapolated over a longer time period for comparison to existing data provided by the manufacturer. The temperature of the room and the location of the refrigerator were kept constant for every test to ensure consistency and avoid biasing the results. The kilowatt meter, temperature sensors, and the refrigerator that were used in the testing are displayed below in Figures 2-1, 2-2, and 2-3 respectively. The refrigerator used in this analysis is a model ARD298CB Absocold refrigerator, the Watts up? PRO kilowatt meter is a model SM-EE-WU-PRO Watts up? PRO kilowatt meter and the temperature sensor is a model UA-002-64 HOBOWare temperature and light sensor pendant.

Figure 2-1: Watts up? PRO kilowatt meter used to collect energy consumption data

Figure 2-2: HOBOware temperature sensor and thermometers used to collect temperature data

Figure 2-3: Absocold refrigerator used in testing

Individual Test Outline

A series of five tests were developed to determine optimal thermostat settings for typical application in the dormitories, evaluate the impact that the physical location of the refrigerator in the dormitories can have on performance, and determine the practicality of an improved layer of insulation being added onto the existing refrigerator in terms of improved performance. The tests will be outlined below to explain the goal of each test and outline the changes to the basic testing procedure that were applied for each test.

The first test, the “Control Test,” was developed to establish a baseline for comparison to other tests and determine the change in energy consumption between each temperature setting. No changes were made to the standard testing procedure, and all five temperature settings were tested in order to establish a comparison between temperature settings and between later tests. The data collected from this test was used to determine changes in efficiency based on the changes seen in energy consumption when compared to this test. Several testing procedures were analyzed in order to develop an acceptable testing procedure for this project to prevent biasing the results and to maintain the accuracy of the results. These sources demonstrated that each test should be run over a period of at least twelve hours so that a large amount of data could be collected for each test to ensure accuracy [9], [10]. By looking at these other experiments, it also became clear that the refrigerator should be allowed to run and reach an “average” temperature when the temperature setting is changed for each new test. The temperature data that was collected suggests that the refrigerator only needs about an hour to reach a new steady temperature after it is initially turned back on and has been running for several hours. This would prevent the energy data collected from containing erroneous information reflecting the time period when the refrigerator must run continuously to reach a much lower temperature.

The second test, the “Insulation Test,” focused on determining the effect of improved insulation on the performance of the refrigerator. The refrigerator was first tightly wrapped in an extra layer of foam which was then covered with a bed quilt. The heat exchanging system on the back of the refrigerator was left uncovered so that heat could still be properly exhausted from the system. This test was developed to generate an estimation of the efficiency improvements by adding more insulation to the refrigerator. This test merely demonstrates that improved insulation does improve efficiency. This efficiency improvement estimation was used to determine the practicality, in terms of potential gains when compared to material costs, of creating a more functional "insulation prototype" which could be manufactured and sold or assembled by the university or the individual owner as needed. Again, the data collected for this test is only meant to be a preliminary estimation of the performance of improved insulation. Although, an insulation prototype was created as a result of this test, this prototype should be tested before it is implemented. Due to budget constraints, the prototype was never tested to determine more specific reductions in the refrigerator's energy consumption. The results of this initial test led to the generation of an "insulation prototype" which will be detailed later in this report. Overall, improved insulation is a well-documented way to improve the efficiency of any refrigeration cycle by reducing the amount of heat put into the system by the environment, which is why this test was developed and implemented even in this preliminary stage [11]. The refrigerator setup for the Insulation Test is shown below in Figure 2-4 as a visual aid.

Figure 2-4: Insulation Test setup

The next test that was implemented will be referred to as the “Environmental/Circulation Test.” This test was developed to determine the effect of improved air circulation coupled with a slightly cooler environment on overall refrigerator performance and efficiency. The test consisted of running the refrigerator at each temperature setting while a ceiling fan was running in the room. The refrigerator was also moved about six inches farther away from the wall than all other tests. The main focus of this test was to demonstrate the importance of placement of the refrigerator on its overall energy consumption [12]. As already discussed, the temperature of the surrounding environment reflects the amount of energy that the compressor and the condenser must consume in order for the refrigerator to reach its specified temperature.

The forth test consisted of loading both the main refrigerator compartment and the freezer compartment with canned drinks and bottled water. This test will be referred to as the “Loaded Usage Test” in later discussion and was developed to determine the impact that fully filling or loading the refrigerator has on the refrigerator’s energy consumption. The purpose of this test was to create a more accurate estimation of the actual energy usage of the refrigerator in practice and not just the optimal levels of energy consumption that can be reached if the refrigerator is left to run. This test was also used to demonstrate the simple but often overlooked concept that all electronic devices use energy at all times regardless of whether they are actually in use by the “user” or not.

The final test that was performed was designed to demonstrate the impact that opening and closing the refrigerator door can have on energy consumption. This test was again developed to demonstrate more realistic energy consumption levels when the refrigerator is actually in use. Furthermore, this test can be used to estimate the impact that an improperly sealed door can have on the energy consumption of the refrigerator. This test, known as the “Open Usage Test,” was performed by periodically opening and closing the door of the refrigerator for thirty seconds once every three hours. This test was carefully monitored so that the results would be as consistent as possible, and, unlike the other tests which could be run without much supervision, this test was only performed during set intervals when it could be monitored for a full twelve hour period.

Preparation of Insulation Prototype

After initial testing, the data demonstrated that improved insulation greatly improved overall performance of the refrigerator. Therefore, a more practical insulation sleeve which will be known as the "Insulation Prototype" was developed with several specifications in mind. These specifications were developed so that the prototype could be easily constructed at a low cost while still providing an adequate reduction in the energy consumption of the refrigerator. If these goals were met, the prototype could be applied to the refrigerators in the dorms and potentially save the university money on electricity bills over the long term. The effect of improved insulation can often have an extensive impact on the overall efficiency of the refrigeration cycle, which is why improved insulation may be a viable way to reduce the energy costs of the refrigerators used in the dorms [13]. The main specifications include an inexpensive insulation material that would not make the refrigerator overly bulky, a system that remains aesthetically pleasing, and possibly the most important a noticeable improvement in the refrigerator's performance. After some consideration of various materials, Super Tuff-R R-3.3 insulation was chosen for its overall cost of $12.45 per 4' x 8' sheet and thickness of one half inch [14]. The insulation was cut into two 2' 8" high by 1' 3" wide rectangles which would be adhered to the sides of the refrigerator using heavy duty duct tape. A smaller 10" high by 1' 6" wide rectangle was then cut to cover the freezer door and a 1' 8" high by 1' 6" wide rectangle was cut to cover the main compartment door. This setup would allow each door to be opened independently, but is not as aesthetically pleasing. A slight variation could also easily be applied making the front panel one piece which would attach both doors together so that they would no longer open independently. This would serve the same function, but would be more aesthetically pleasing although it may perform differently. The insulation can be adhered to the side of the refrigerator using a heavy duty all-purpose liquid construction adhesive that costs $53.35 for a twenty four pack of ten ounce containers [15]. The insulation could then be spray painted or covered with fabric to make the unit more aesthetically pleasing. It is important to note that this prototype was built and briefly tested to verify that it demonstrated the desired performance improvements. However, it is still in the development phase and should be tested more thoroughly before it is widely implemented. The insulation prototype is displayed below in Figure 2-5.

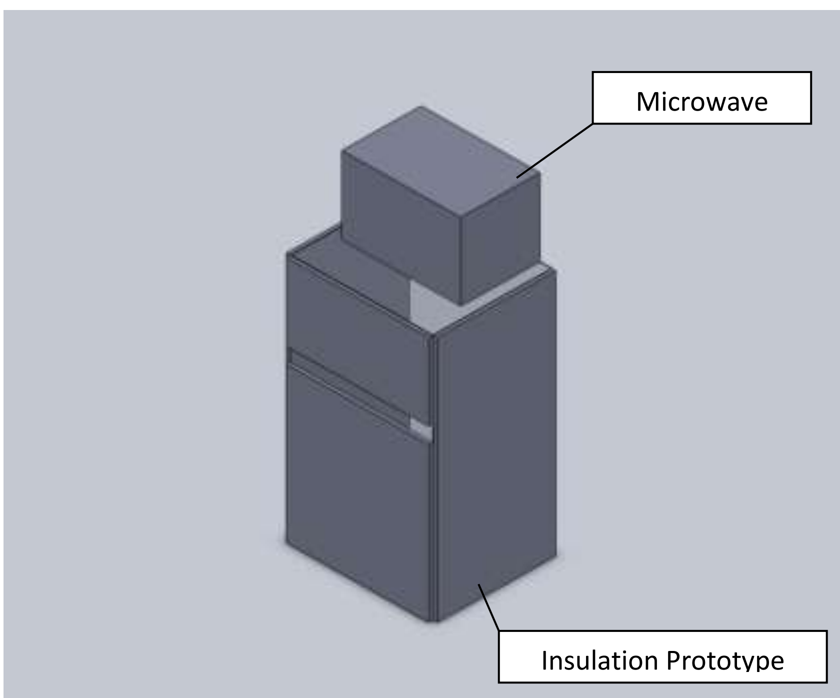

Figure 2-5: 3-D image of Insulation Prototype

Chapter 3

Results

The data and results supporting my final conclusions are outlined below. This data is preliminary, and should be further supported by independent testing. However, the final results of these tests could be used to improve the overall performance of the refrigerators currently in use in the dorms by an average of around ten percent per unit. All graphs of the data are displayed starting with the lowest temperature setting and then continue up through the higher temperature settings. The temperature data reflected in the data charts is an average temperature at each temperature setting. The graphs are in terms of energy consumption in watt hours versus temperature setting in degrees Fahrenheit. An average temperature at each setting was found to create a number for comparison between each setting and between each test. It is important to note that the refrigerator temperature fluctuates above and below this established average temperature during normal operation. An average temperature was used to simplify comparison between settings.

Recorded Testing Data

The first data set reflects the data collected from the Control Test and was used as a baseline for comparison. The data collected from each test run was extrapolated and then compared to the established manufacturer's energy consumption information in order to verify or disprove their estimate. The data is displayed below in Figure 3-1.

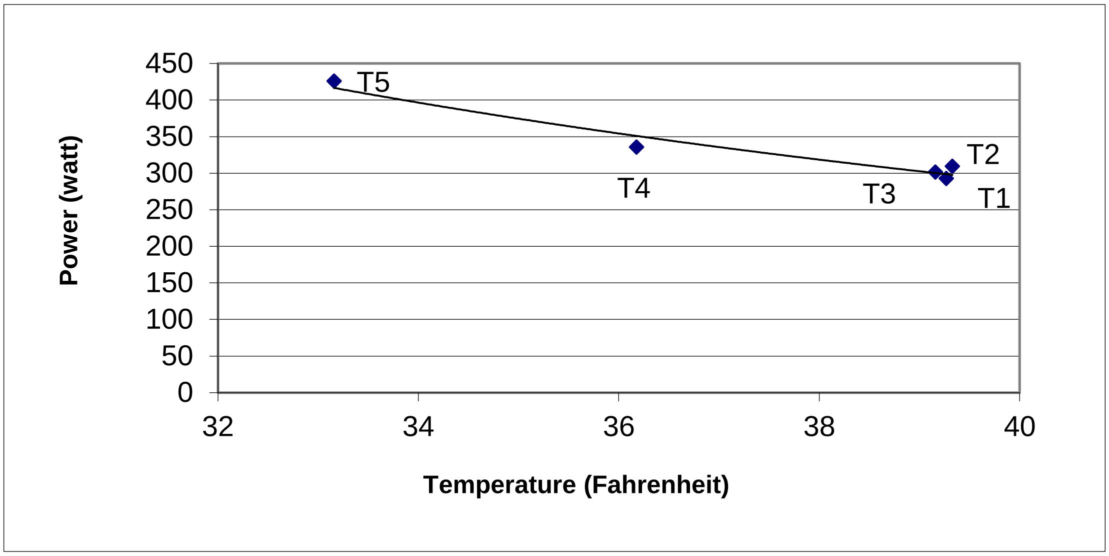

Figure 3-1: Control Test Data

The next data set demonstrates the impact that improved insulation can have on the energy consumption of the refrigerator. The Insulation Test data displayed below in Figure 3-2 was compared to the Control Test data to establish relative reductions or increases in energy consumption and determine the practicality of designing an Insulation Prototype sleeve to improve refrigerator performance.

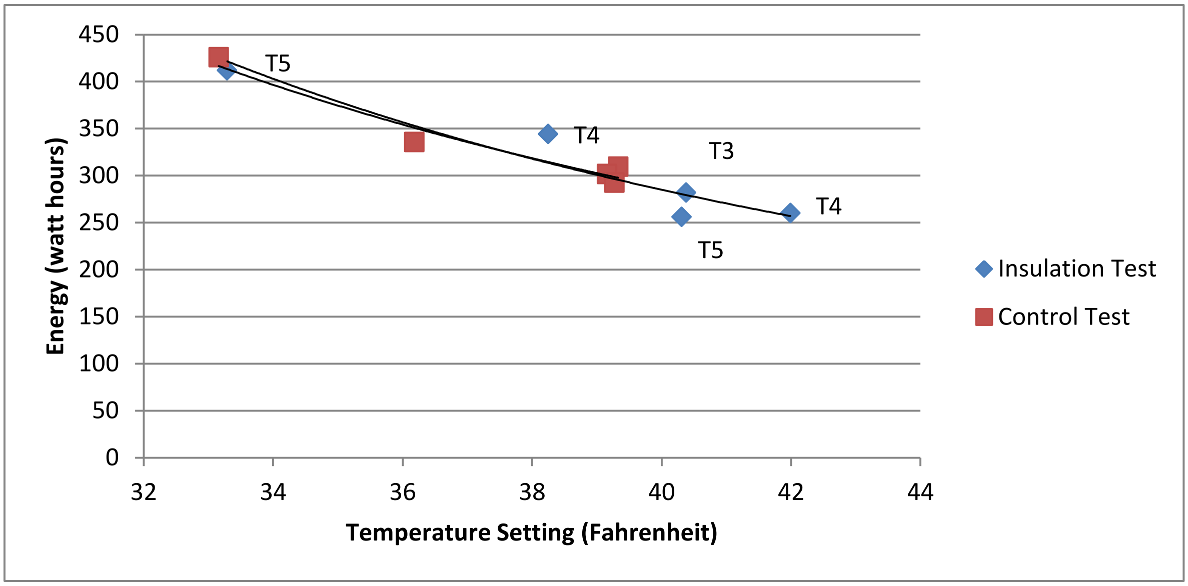

Figure 3-2: Insulation Test Data

The Environment/Circulation Test reflects the impact that a cooler exterior environment or improved air circulation can have on the refrigerator's energy consumption. This data can also reflect the negative impact a warmer surrounding environment can have on refrigerator performance. The data for this test is displayed below in Figure 3-3.

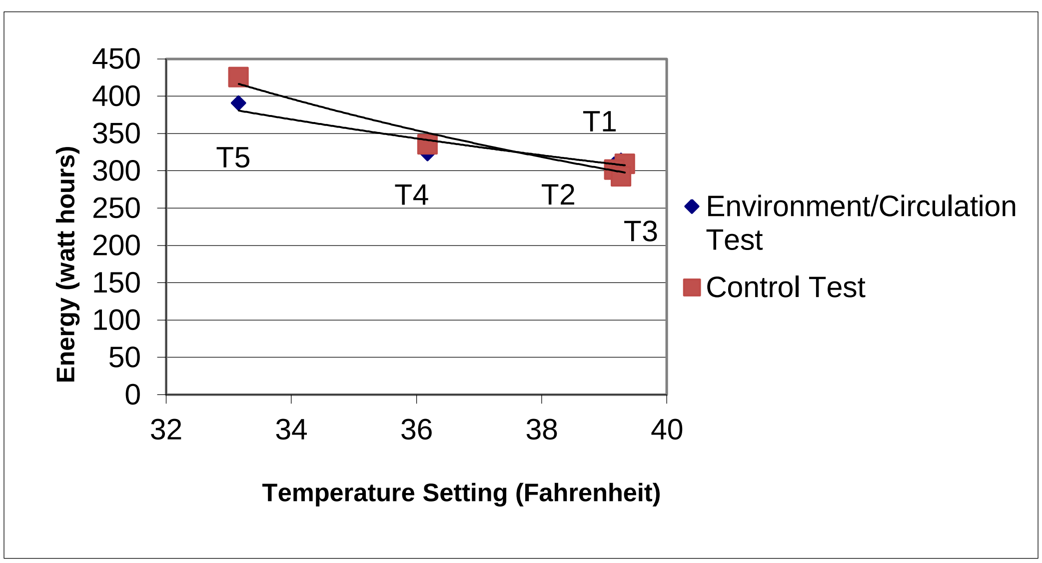

Figure 3-3: Environment / Circulation Test Data

The Loaded Usage Test data represents the effect of filling or loading the refrigerator to establish a more realistic comparison to actual usage. This data is an important comparison tool to determine whether the data provided by the refrigerator company accurately reflects actual energy consumption. The data for the Loaded Usage Test is displayed below in Figure 3-4.

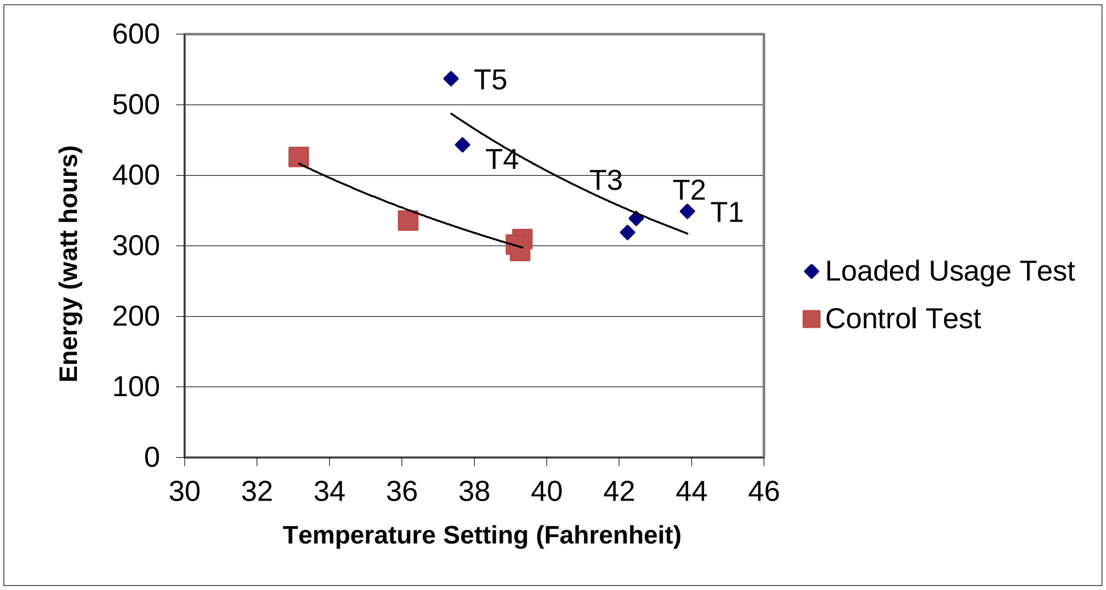

Figure 3-4: Loaded Usage Test Data

The final data set, The Opening Usage Test, represents the effect that opening the refrigerator door has on energy consumption. It can also be used to estimate the effect that an improperly sealed section can have on the refrigerator's energy consumption. The data is displayed below in Figure 3-5.

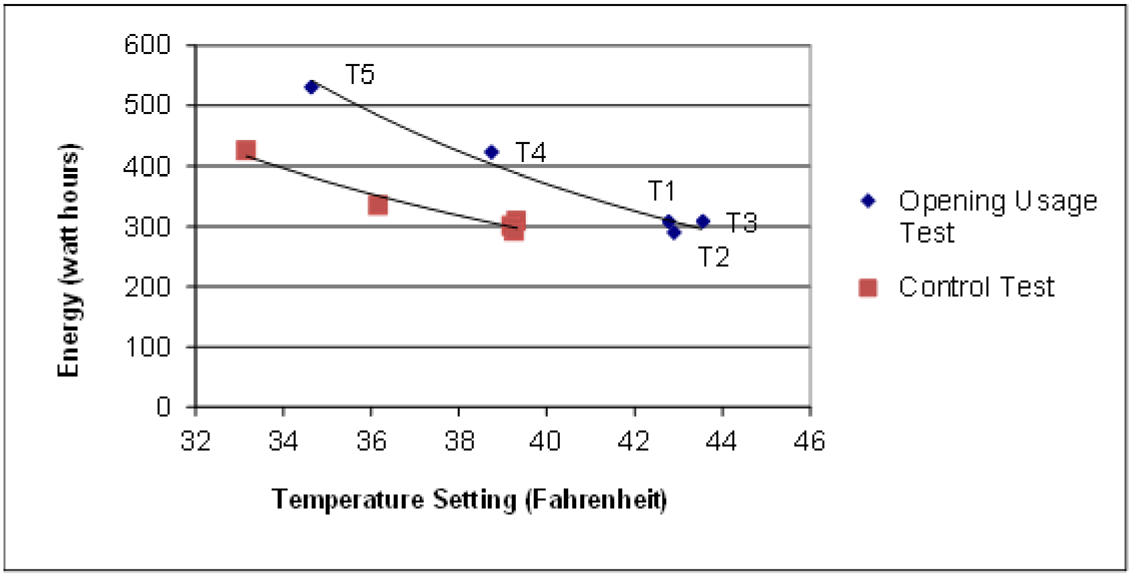

Figure 3-5: Opening Usage Test Data

Chapter 4

Discussion and Conclusions

This section will outline the final results of the tests and outline recommendations for the usage of the refrigerator in the dorms. If implemented, these recommendations have the potential to save the Pennsylvania State University money on electricity bills for the dormitories and reducing the energy consumption of one of the most energy intensive appliances that are currently used by most students in the dorms. Reducing the energy consumption of the dorms will also demonstrate Penn State’s willingness to move towards a more sustainable energy future.

Discussion

The Control Test data demonstrates that the lowest temperature setting, labeled setting #1, which produces an average temperature of around 33.16 °F inside the refrigerator, consumes 425.8 watts hours over a twelve hour period. The highest temperature setting, labeled setting # 5, allow the refrigerator to reach an average temperature setting of 39.27 °F while consuming 292.5 watts hours over a twelve hour period. This demonstrates that the refrigerator can be operated at the highest temperature settings in order to reduce energy consumption while maintaining the temperature necessary for food storage. It is important to note that the temperature remains relatively constant between the middle temperature setting and the highest temperature setting, while the energy consumption at these respective settings decreases slightly for the higher temperature settings. Therefore, if the refrigerator is operated at this setting every day for one year, it would consume approximately 213 kWh, and therefore falls within the manufacturer's estimations of 290 kWh for a year of normal operation.

The Insulation Test demonstrates that improved insulation can reduce the energy consumption of the refrigerator. The data shows that improved insulation can have a maximum of a thirteen percent reduction in power at the higher temperature settings. The average energy reduction from testing is around seven percent. This suggests that improved insulation may be a viable option, and supports the creation of an insulation prototype. However, the increases in internal refrigerator temperature should be further analyzed to determine whether other factors were affecting efficiency or whether a better overall internal temperature average can be determined. Overall, because the refrigerator environment was never completely controlled due to experimental constraints, the data most likely has some inherent error which may explain the internal temperature changes between tests.

The Environment/Circulation Test demonstrates that a cooler surrounding environment and/or improved air circulation can reduce the energy consumption of the refrigerator. As the data suggests, the lower temperature settings are more affected by the exterior environment that the refrigerator is placed in. With proper air circulation, the lower temperature settings can experience around an eight percent reduction in energy consumption. However, the higher temperature settings actually experience an increase in energy consumption. The data suggests that the environment may have an impact on the energy consumption, but more testing needs to be done to verify the data from these tests. Another important implication of this test is that an increase in the temperature of the environment may have a detrimental effect on the energy consumption of the system. This implication can be inferred from the data and is supported by thermodynamic theory because, as already discussed, a high environment temperature makes it difficult for the condenser to exhaust heat during the refrigeration cycle. Therefore, the refrigerator should not be operated near the heater in the residence halls to reach maximum performance levels.

The Loaded Usage Test demonstrates that the energy consumption of the refrigerator changes based on whether the refrigerator is full or empty. The tests suggest that a refrigerator loaded with soda cans and bottles of water can use up to thirty two percent more energy than an empty or unloaded refrigerator. This data is important because it demonstrates that a refrigerator that is being used for its intended purpose will consume more energy suggesting that the actual cost of running the refrigerator will be higher than expected by the manufacturer. This data should be further verified to ensure accuracy, but will not have any major effect on the recommendations of this report. However, the data actually demonstrates that the middle operating setting will still fall within the manufacturer’s estimations and will consume roughly 247 kWh per year.

Furthermore, the Opening Usage Test demonstrates the importance of properly closing and sealing the refrigerator and ensuring that there are no broken or leaking seals. Generally, opening the refrigerator to simulate normal usage patterns suggests that all temperature settings will likely experience an increase in energy consumption which may be as high as twenty six percent. Estimation from this data shows that the middle energy consumption will be around 225 kWh and still falls within the manufacturer's estimation. This test combined with the Loaded Usage Test may represent a more accurate description of the energy consumption of the refrigerators in the dorms. All of the data is displayed below in Figure 4-1 to demonstrate the gains and losses that the test data represents. This allows for a clear visualization and comparison between tests. Furthermore, it should be noted that several tests reflect that the refrigerator does not reach low enough temperatures for proper food storage when set at or above the middle temperature setting, thermostat setting 3, as can be seen in the above graph. This could be due to the fact that these tests were conducted during the summer in a warmer environment which could have effected testing despite efforts to control room temperature.

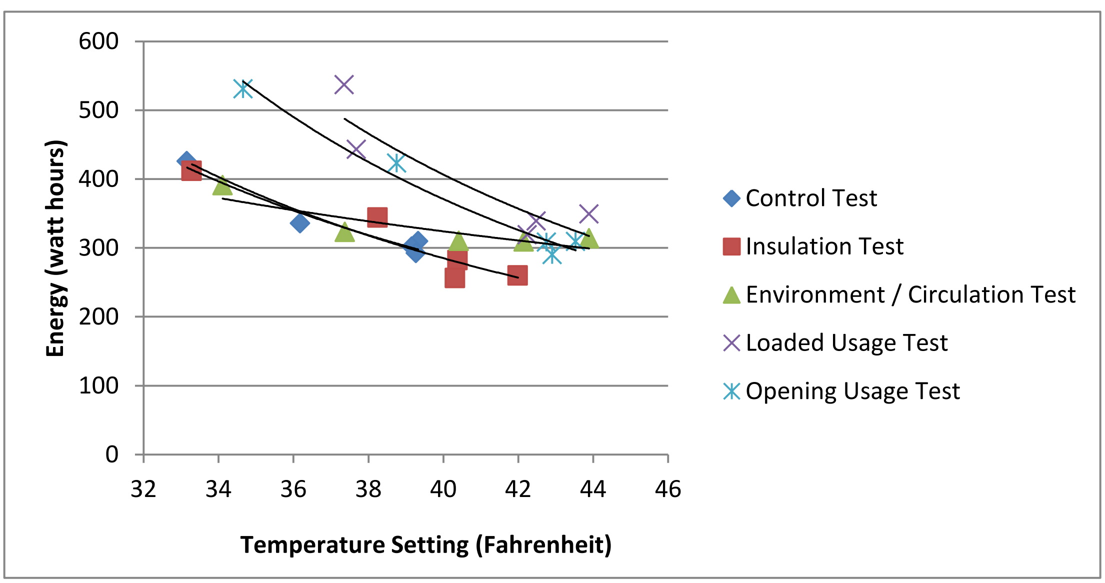

Figure 4-1: Combined Test Data

Summary

After testing, the data points to several basic conclusions about the operation of the refrigerator in the dorm rooms. The first basic conclusion is that the refrigerator will likely use more energy during actual usage than the manufacturer actually claims it will use. This is because the manufacturer's reported numbers indicate that their energy consumption ratings are based on an empty refrigerator, whereas testing shows that a refrigerator with food or drinks inside it will use more energy during normal operation. This is an important consideration because this will affect the amount of money spent on electricity in the dorms. The "Opening Usage Test" further demonstrates that it is important to properly close and seal the refrigerator so that the energy consumption of the refrigerator is minimized during normal usage. This test demonstrates the increase in energy consumption that is possible if the seals on the refrigerator are faulty or if the refrigerator is not properly closed. Overall, testing shows that the refrigerator should be operated at the middle temperature setting, thermostat setting # 3, to minimize energy consumption and ensure that the temperature in the refrigerator remains at a low enough temperature for food storage. The data also suggests that the lowest temperature settings, thermostat settings at and above #4, should not be used because they turn the entire refrigerator into a freezer, which greatly increases the energy consumption of the system. The "Environment/Circulation Test" further suggests that the surrounding environment temperature affects the energy consumption. Therefore, it is recommended that the refrigerator is not set in front of the heater in the dorms so that the refrigerator can properly exhaust heat to the environment. The refrigerator should be placed in a well-ventilated area if possible to further reduce the energy consumption of the refrigerator. The "Insulation Test" suggests that improved insulation on the refrigerator doors and walls can reduce the energy consumption of the system. If the prototype that was developed during this study is implemented, the university will save money on electricity costs due to the reduction in the refrigerator energy consumption. The cost of the prototype should be recovered in these electricity savings in about two years depending on the price of electricity. It is again important to note that some of the tests demonstrate that the thermostat settings at and above the middle setting, setting #3, may not bring the refrigerator to temperatures low enough for food storage. Further testing should be done to create a more accurate average temperature for each setting. Finally, the data in this study suggests that the university could potentially save even more by removing refrigerators from the dorms if students agree that they do not want and/or need them due to the availability of food in the dorm cafeterias and other food suppliers around campus.

Conclusions

Overall, the data collected from testing suggests that there are several ways to reduce the energy consumption of the refrigerator in the dorms and save the university money over the long term. These savings could be substantial and could average around $18000 per year if energy consumption can be reduced by ten percent or more. The changes to the usage and basic design of the refrigerator suggested in this report could help reduce the energy consumption of the refrigerator and ultimately save the university money on electricity bills. Making an effort to reduce energy consumption can also demonstrate the Pennsylvania State University's willingness to become more energy responsible which will improve the university's reputation around the country. The data collected during this study can provide a foundation for further study in other areas around the university, and demonstrate that even small reductions in energy consumption in a single appliance or other system can have a compounding effect throughout the university if applied to multiple areas or appliances.

Appendix

Table A-1: Temperature data complied for Control Test						
#	Time, GMT-04:00	Temp, °F		#	Time, GMT-04:00	Temp, °F
1	7/6/2010 16:30	40.321		21	7/6/2010 19:50	37.679
2	7/6/2010 16:40	39.76		22	7/6/2010 20:00	40.509
3	7/6/2010 16:50	41.81		23	7/6/2010 20:10	40.134
4	7/6/2010 17:00	38.25		24	7/6/2010 20:20	37.107
5	7/6/2010 17:10	38.061		25	7/6/2010 20:30	39.76
6	7/6/2010 17:20	40.881		26	7/6/2010 20:40	41.439
7	7/6/2010 17:30	39.573		27	7/6/2010 20:50	36.914
8	7/6/2010 17:40	37.297		28	7/6/2010 21:00	39.196
9	7/6/2010 17:50	40.321		29	7/6/2010 21:10	41.81
10	7/6/2010 18:00	40.881		30	7/6/2010 21:20	37.488
11	7/6/2010 18:10	36.914		31	7/6/2010 21:30	38.25
12	7/6/2010 18:20	39.76		32	7/6/2010 21:40	40.881
13	7/6/2010 18:30	41.439		33	7/6/2010 21:50	39.76
14	7/6/2010 18:40	36.723		34	7/6/2010 22:00	37.107
15	7/6/2010 18:50	39.007		35	7/6/2010 22:10	39.947
16	7/6/2010 19:00	41.625		36	7/6/2010 22:20	41.254
17	7/6/2010 19:10	37.107		37	7/6/2010 22:30	36.531
18	7/6/2010 19:20	38.25		38	7/6/2010 22:40	39.007
19	7/6/2010 19:30	41.254		39	7/6/2010 22:50	41.439
20	7/6/2010 19:40	38.25		40	7/6/2010 23:00	37.297
41	7/6/2010 23:10	38.25		61	7/7/2010 2:30	40.881
42	7/6/2010 23:20	40.881		62	7/7/2010 2:40	39.76
43	7/6/2010 23:30	38.629		63	7/7/2010 2:50	37.297
44	7/6/2010 23:40	37.488		64	7/7/2010 3:00	40.321
45	7/6/2010 23:50	40.321		65	7/7/2010 3:10	41.067
46	7/7/2010 0:00	40.321		66	7/7/2010 3:20	36.914
47	7/7/2010 0:10	37.107		67	7/7/2010 3:30	39.573
48	7/7/2010 0:20	39.947		68	7/7/2010 3:40	41.625
49	7/7/2010 0:30	41.254		69	7/7/2010 3:50	36.723
50	7/7/2010 0:40	36.914		70	7/7/2010 4:00	39.007
51	7/7/2010 0:50	39.573		71	7/7/2010 4:10	41.625
52	7/7/2010 1:00	41.625		72	7/7/2010 4:20	37.488
53	7/7/2010 1:10	36.914		73	7/7/2010 4:30	38.25
54	7/7/2010 1:20	39.196		74	7/7/2010 4:40	41.067
55	7/7/2010 1:30	41.81		75	7/7/2010 4:50	38.818
56	7/7/2010 1:40	37.488		76	7/7/2010 5:00	37.679
57	7/7/2010 1:50	38.629		77	7/7/2010 5:10	40.509
58	7/7/2010 2:00	41.439		78	7/7/2010 5:20	40.509
59	7/7/2010 2:10	38.44		79	7/7/2010 5:30	36.914
60	7/7/2010 2:20	37.87		80	7/7/2010 5:40	39.76

Temperature Setting 2						
#	Time, GMT-04:00	Temp, °F		#	Time, GMT-04:00	Temp, °F
1	7/7/2010 19:30	38.818		21	7/7/2010 22:50	41.439
2	7/7/2010 19:40	41.067		22	7/7/2010 23:00	36.531
3	7/7/2010 19:50	40.881		23	7/7/2010 23:10	38.44
4	7/7/2010 20:00	36.723		24	7/7/2010 23:20	41.067
5	7/7/2010 20:10	39.196		25	7/7/2010 23:30	39.76
6	7/7/2010 20:20	41.81		26	7/7/2010 23:40	36.914
7	7/7/2010 20:30	38.25		27	7/7/2010 23:50	39.384
8	7/7/2010 20:40	37.488		28	7/8/2010 0:00	41.81
9	7/7/2010 20:50	40.321		29	7/8/2010 0:10	37.297
10	7/7/2010 21:00	41.625		30	7/8/2010 0:20	37.488
11	7/7/2010 21:10	36.723		31	7/8/2010 0:30	40.321
12	7/7/2010 21:20	38.44		32	7/8/2010 0:40	41.254
13	7/7/2010 21:30	41.254		33	7/8/2010 0:50	36.531
14	7/7/2010 21:40	39.76		34	7/8/2010 1:00	38.629
15	7/7/2010 21:50	36.914		35	7/8/2010 1:10	41.439
16	7/7/2010 22:00	39.573		36	7/8/2010 1:20	38.629
17	7/7/2010 22:10	41.81		37	7/8/2010 1:30	37.107
18	7/7/2010 22:20	37.488		38	7/8/2010 1:40	39.947
19	7/7/2010 22:30	37.488		39	7/8/2010 1:50	41.625
20	7/7/2010 22:40	40.321		40	7/8/2010 2:00	36.531
41	7/8/2010 2:10	38.25		61	7/8/2010 5:30	37.87
42	7/8/2010 2:20	41.254		62	7/8/2010 5:40	37.297
43	7/8/2010 2:30	39.384		63	7/8/2010 5:50	40.321
44	7/8/2010 2:40	36.914		64	7/8/2010 6:00	41.254
45	7/8/2010 2:50	39.76		65	7/8/2010 6:10	36.531
46	7/8/2010 3:00	41.81		66	7/8/2010 6:20	38.629
47	7/8/2010 3:10	36.914		67	7/8/2010 6:30	41.439
48	7/8/2010 3:20	38.061		68	7/8/2010 6:40	39.007
49	7/8/2010 3:30	40.881		69	7/8/2010 6:50	36.914
50	7/8/2010 3:40	40.134		70	7/8/2010 7:00	39.76
51	7/8/2010 3:50	36.723		71	7/8/2010 7:10	41.81
52	7/8/2010 4:00	39.384		72	7/8/2010 7:20	36.914
53	7/8/2010 4:10	41.81		73	7/8/2010 7:30	38.061
54	7/8/2010 4:20	37.107		74	7/8/2010 7:40	40.881
55	7/8/2010 4:30	37.679		75	7/8/2010 7:50	40.321
56	7/8/2010 4:40	40.509		76	7/8/2010 8:00	36.723
57	7/8/2010 4:50	40.881		77	7/8/2010 8:10	39.196
58	7/8/2010 5:00	36.531		78	7/8/2010 8:20	41.81
59	7/8/2010 5:10	39.007		79	7/8/2010 8:30	38.061
60	7/8/2010 5:20	41.625		80	7/8/2010 8:40	37.488

Temperature Setting 3						
#	Time, GMT-04:00	Temp, °F				
1	7/8/2010 20:00	38.44		21	7/8/2010 23:20	37.297
2	7/8/2010 20:10	40.321		22	7/8/2010 23:30	37.488
3	7/8/2010 20:20	42.179		23	7/8/2010 23:40	39.947
4	7/8/2010 20:30	38.629		24	7/8/2010 23:50	41.994
5	7/8/2010 20:40	37.107		25	7/9/2010 0:00	38.44
6	7/8/2010 20:50	39.573		26	7/9/2010 0:10	36.914
7	7/8/2010 21:00	41.994		27	7/9/2010 0:20	39.384
8	7/8/2010 21:10	39.573		28	7/9/2010 0:30	41.81
9	7/8/2010 21:20	36.723		29	7/9/2010 0:40	39.573
10	7/8/2010 21:30	39.007		30	7/9/2010 0:50	36.723
11	7/8/2010 21:40	41.439		31	7/9/2010 1:00	39.007
12	7/8/2010 21:50	40.509		32	7/9/2010 1:10	41.439
13	7/8/2010 22:00	36.531		33	7/9/2010 1:20	40.321
14	7/8/2010 22:10	38.44		34	7/9/2010 1:30	36.531
15	7/8/2010 22:20	40.881		35	7/9/2010 1:40	38.44
16	7/8/2010 22:30	41.439		36	7/9/2010 1:50	40.881
17	7/8/2010 22:40	36.723		37	7/9/2010 2:00	41.439
18	7/8/2010 22:50	38.061		38	7/9/2010 2:10	36.723
19	7/8/2010 23:00	40.509		39	7/9/2010 2:20	37.87
20	7/8/2010 23:10	41.994		40	7/9/2010 2:30	40.321
41	7/9/2010 2:40	41.994		61	7/9/2010 6:00	40.321
42	7/9/2010 2:50	37.679		62	7/9/2010 6:10	42.179
43	7/9/2010 3:00	37.488		63	7/9/2010 6:20	37.87
44	7/9/2010 3:10	39.947		64	7/9/2010 6:30	37.488
45	7/9/2010 3:20	41.994		65	7/9/2010 6:40	39.76
46	7/9/2010 3:30	38.818		66	7/9/2010 6:50	41.994
47	7/9/2010 3:40	36.914		67	7/9/2010 7:00	38.629
48	7/9/2010 3:50	39.196		68	7/9/2010 7:10	37.107
49	7/9/2010 4:00	41.625		69	7/9/2010 7:20	39.384
50	7/9/2010 4:10	39.947		70	7/9/2010 7:30	41.81
51	7/9/2010 4:20	36.723		71	7/9/2010 7:40	39.573
52	7/9/2010 4:30	38.629		72	7/9/2010 7:50	36.914
53	7/9/2010 4:40	41.067		73	7/9/2010 8:00	39.007
54	7/9/2010 4:50	41.067		74	7/9/2010 8:10	41.439
55	7/9/2010 5:00	36.723		75	7/9/2010 8:20	40.509
56	7/9/2010 5:10	38.25		76	7/9/2010 8:30	36.723
57	7/9/2010 5:20	40.696		77	7/9/2010 8:40	38.629
58	7/9/2010 5:30	41.81		78	7/9/2010 8:50	40.881
59	7/9/2010 5:40	37.107		79	7/9/2010 9:00	41.439
60	7/9/2010 5:50	37.87		80	7/9/2010 9:10	36.914

Temperature Setting 4						
#	Time, GMT-04:00	Temp, °F		#	Time, GMT-04:00	Temp, °F
1	7/9/2010 21:00	46.908		21	7/10/2010 0:20	31.818
2	7/9/2010 21:10	36.338		22	7/10/2010 0:30	31.818
3	7/9/2010 21:20	30.81		23	7/10/2010 0:40	35.175
4	7/9/2010 21:30	32.815		24	7/10/2010 0:50	38.25
5	7/9/2010 21:40	36.338		25	7/10/2010 1:00	40.696
6	7/9/2010 21:50	39.196		26	7/10/2010 1:10	38.818
7	7/9/2010 22:00	41.067		27	7/10/2010 1:20	32.418
8	7/9/2010 22:10	35.951		28	7/10/2010 1:30	31.617
9	7/9/2010 22:20	30.403		29	7/10/2010 1:40	34.981
10	7/9/2010 22:30	32.018		30	7/10/2010 1:50	38.061
11	7/9/2010 22:40	35.564		31	7/10/2010 2:00	40.509
12	7/9/2010 22:50	38.629		32	7/10/2010 2:10	39.384
13	7/9/2010 23:00	41.067		33	7/10/2010 2:20	32.815
14	7/9/2010 23:10	37.679		34	7/10/2010 2:30	31.415
15	7/9/2010 23:20	31.213		35	7/10/2010 2:40	34.59
16	7/9/2010 23:30	31.617		36	7/10/2010 2:50	37.679
17	7/9/2010 23:40	35.175		37	7/10/2010 3:00	40.321
18	7/9/2010 23:50	38.25		38	7/10/2010 3:10	39.947
19	7/10/2010 0:00	40.881		39	7/10/2010 3:20	33.607
20	7/10/2010 0:10	38.44		40	7/10/2010 3:30	31.213
41	7/10/2010 3:40	34.198		61	7/10/2010 7:00	38.44
42	7/10/2010 3:50	37.297		62	7/10/2010 7:10	40.881
43	7/10/2010 4:00	39.947		63	7/10/2010 7:20	38.629
44	7/10/2010 4:10	40.696		64	7/10/2010 7:30	32.018
45	7/10/2010 4:20	34.394		65	7/10/2010 7:40	31.617
46	7/10/2010 4:30	31.012		66	7/10/2010 7:50	34.786
47	7/10/2010 4:40	33.607		67	7/10/2010 8:00	37.87
48	7/10/2010 4:50	36.914		68	7/10/2010 8:10	40.134
49	7/10/2010 5:00	39.384		69	7/10/2010 8:20	40.134
50	7/10/2010 5:10	41.067		70	7/10/2010 8:30	33.805
51	7/10/2010 5:20	36.338		71	7/10/2010 8:40	31.213
52	7/10/2010 5:30	31.012		72	7/10/2010 8:50	34.198
53	7/10/2010 5:40	33.013		73	7/10/2010 9:00	37.297
54	7/10/2010 5:50	36.338		74	7/10/2010 9:10	39.76
55	7/10/2010 6:00	39.007		75	7/10/2010 9:20	40.881
56	7/10/2010 6:10	41.067		76	7/10/2010 9:30	35.175
57	7/10/2010 6:20	37.297		77	7/10/2010 9:40	31.012
58	7/10/2010 6:30	31.213		78	7/10/2010 9:50	33.411
59	7/10/2010 6:40	32.418		79	7/10/2010 10:00	36.723
60	7/10/2010 6:50	35.758		80	7/10/2010 10:10	39.196

Temperature Setting 5						
#	Time, GMT-04:00	Temp, °F		#	Time, GMT-04:00	Temp, °F
1	7/10/2010 22:00	22.996		21	7/11/2010 1:20	28.139
2	7/10/2010 22:10	26.245		22	7/11/2010 1:30	24.31
3	7/10/2010 22:20	30.403		23	7/11/2010 1:40	24.744
4	7/10/2010 22:30	34.198		24	7/11/2010 1:50	28.555
5	7/10/2010 22:40	37.107		25	7/11/2010 2:00	32.617
6	7/10/2010 22:50	39.384		26	7/11/2010 2:10	35.758
7	7/10/2010 23:00	41.067		27	7/11/2010 2:20	38.25
8	7/10/2010 23:10	37.679		28	7/11/2010 2:30	40.509
9	7/10/2010 23:20	32.418		29	7/11/2010 2:40	40.134
10	7/10/2010 23:30	28.139		30	7/11/2010 2:50	35.175
11	7/10/2010 23:40	24.528		31	7/11/2010 3:00	30.2
12	7/10/2010 23:50	22.554		32	7/11/2010 3:10	26.033
13	7/11/2010 0:00	25.39		33	7/11/2010 3:20	24.528
14	7/11/2010 0:10	29.586		34	7/11/2010 3:30	27.721
15	7/11/2010 0:20	33.607		35	7/11/2010 3:40	31.617
16	7/11/2010 0:30	36.531		36	7/11/2010 3:50	34.981
17	7/11/2010 0:40	39.007		37	7/11/2010 4:00	37.679
18	7/11/2010 0:50	41.067		38	7/11/2010 4:10	39.947
19	7/11/2010 1:00	37.87		39	7/11/2010 4:20	40.881
20	7/11/2010 1:10	32.815		40	7/11/2010 4:30	36.531
41	7/11/2010 4:40	31.415		61	7/11/2010 8:00	30.607
42	7/11/2010 4:50	26.881		62	7/11/2010 8:10	26.245
43	7/11/2010 5:00	24.96		63	7/11/2010 8:20	26.033
44	7/11/2010 5:10	27.93		64	7/11/2010 8:30	29.381
45	7/11/2010 5:20	31.617		65	7/11/2010 8:40	33.013
46	7/11/2010 5:30	34.981		66	7/11/2010 8:50	36.145
47	7/11/2010 5:40	37.679		67	7/11/2010 9:00	38.629
48	7/11/2010 5:50	39.76		68	7/11/2010 9:10	40.696
49	7/11/2010 6:00	41.067		69	7/11/2010 9:20	39.573
50	7/11/2010 6:10	36.914		70	7/11/2010 9:30	34.59
51	7/11/2010 6:20	31.617		71	7/11/2010 9:40	29.586
52	7/11/2010 6:30	27.091		72	7/11/2010 9:50	25.819
53	7/11/2010 6:40	26.033		73	7/11/2010 10:00	26.67
54	7/11/2010 6:50	29.176		74	7/11/2010 10:10	30.2
55	7/11/2010 7:00	32.815		75	7/11/2010 10:20	33.805
56	7/11/2010 7:10	35.951		76	7/11/2010 10:30	36.723
57	7/11/2010 7:20	38.44		77	7/11/2010 10:40	39.007
58	7/11/2010 7:30	40.321		78	7/11/2010 10:50	41.067
59	7/11/2010 7:40	40.696		79	7/11/2010 11:00	39.007
60	7/11/2010 7:50	35.758		80	7/11/2010 11:10	33.805

Table A-2: Temperature data complied data for Insulation Test

#	Time, GMT-04:00	Temp, °F		#	Time, GMT-04:00	Temp, °F
1	7/20/2010 21:30	70.995		21	7/21/2010 0:50	37.87
2	7/20/2010 21:40	48.695		22	7/21/2010 1:00	39.384
3	7/20/2010 21:50	41.81		23	7/21/2010 1:10	41.254
4	7/20/2010 22:00	41.994		24	7/21/2010 1:20	40.696
5	7/20/2010 22:10	42.548		25	7/21/2010 1:30	38.061
6	7/20/2010 22:20	38.44		26	7/21/2010 1:40	39.76
7	7/20/2010 22:30	39.76		27	7/21/2010 1:50	41.625
8	7/20/2010 22:40	41.81		28	7/21/2010 2:00	39.573
9	7/20/2010 22:50	40.696		29	7/21/2010 2:10	38.25
10	7/20/2010 23:00	38.25		30	7/21/2010 2:20	40.134
11	7/20/2010 23:10	40.134		31	7/21/2010 2:30	41.994
12	7/20/2010 23:20	41.994		32	7/21/2010 2:40	38.818
13	7/20/2010 23:30	39.007		33	7/21/2010 2:50	38.44
14	7/20/2010 23:40	38.629		34	7/21/2010 3:00	40.321
15	7/20/2010 23:50	40.509		35	7/21/2010 3:10	41.994
16	7/21/2010 0:00	41.994		36	7/21/2010 3:20	38.25
17	7/21/2010 0:10	38.25		37	7/21/2010 3:30	38.629
18	7/21/2010 0:20	39.007		38	7/21/2010 3:40	40.509
19	7/21/2010 0:30	40.881		39	7/21/2010 3:50	41.994
20	7/21/2010 0:40	41.625		40	7/21/2010 4:00	38.061
41	7/21/2010 4:10	39.007		61	7/21/2010 7:30	39.384
42	7/21/2010 4:20	40.881		62	7/21/2010 7:40	41.067
43	7/21/2010 4:30	41.625		63	7/21/2010 7:50	41.254
44	7/21/2010 4:40	37.679		64	7/21/2010 8:00	37.679
45	7/21/2010 4:50	39.007		65	7/21/2010 8:10	39.196
46	7/21/2010 5:00	41.067		66	7/21/2010 8:20	41.067
47	7/21/2010 5:10	41.439		67	7/21/2010 8:30	41.439
48	7/21/2010 5:20	37.87		68	7/21/2010 8:40	37.679
49	7/21/2010 5:30	39.196		69	7/21/2010 8:50	39.196
50	7/21/2010 5:40	41.067		70	7/21/2010 9:00	40.881
51	7/21/2010 5:50	41.254		71	7/21/2010 9:10	41.625
52	7/21/2010 6:00	37.679		72	7/21/2010 9:20	37.87
53	7/21/2010 6:10	39.384		73	7/21/2010 9:30	39.007
54	7/21/2010 6:20	41.254		74	7/21/2010 9:40	40.881
55	7/21/2010 6:30	41.067				
56	7/21/2010 6:40	37.679				
57	7/21/2010 6:50	39.196				
58	7/21/2010 7:00	41.067				
59	7/21/2010 7:10	41.067				
60	7/21/2010 7:20	37.679				

Temperature Setting 2						
#	Time, GMT-04:00	Temp, °F				
1	7/21/2010 10:00	50.819		21	7/21/2010 13:20	42.363
2	7/21/2010 10:10	42.179		22	7/21/2010 13:30	43.831
3	7/21/2010 10:20	42.363		23	7/21/2010 13:40	41.81
4	7/21/2010 10:30	43.466		24	7/21/2010 13:50	40.134
5	7/21/2010 10:40	44.195		25	7/21/2010 14:00	41.81
6	7/21/2010 10:50	40.134		26	7/21/2010 14:10	43.282
7	7/21/2010 11:00	40.881		27	7/21/2010 14:20	43.466
8	7/21/2010 11:10	42.548		28	7/21/2010 14:30	39.947
9	7/21/2010 11:20	44.195		29	7/21/2010 14:40	41.067
10	7/21/2010 11:30	41.439		30	7/21/2010 14:50	42.732
11	7/21/2010 11:40	40.134		31	7/21/2010 15:00	44.013
12	7/21/2010 11:50	41.81		32	7/21/2010 15:10	40.509
13	7/21/2010 12:00	43.466		33	7/21/2010 15:20	40.509
14	7/21/2010 12:10	43.099		34	7/21/2010 15:30	42.179
15	7/21/2010 12:20	39.76		35	7/21/2010 15:40	43.648
16	7/21/2010 12:30	41.254		36	7/21/2010 15:50	42.363
17	7/21/2010 12:40	42.915		37	7/21/2010 16:00	39.947
18	7/21/2010 12:50	44.013		38	7/21/2010 16:10	41.625
19	7/21/2010 13:00	40.134		39	7/21/2010 16:20	43.282
20	7/21/2010 13:10	40.696		40	7/21/2010 16:30	43.831
41	7/21/2010 16:40	39.947		61	7/21/2010 20:00	43.282
42	7/21/2010 16:50	40.881		62	7/21/2010 20:10	44.013
43	7/21/2010 17:00	42.732		63	7/21/2010 20:20	40.134
44	7/21/2010 17:10	44.195		64	7/21/2010 20:30	41.067
45	7/21/2010 17:20	41.254		65	7/21/2010 20:40	42.732
46	7/21/2010 17:30	40.321		66	7/21/2010 20:50	44.195
47	7/21/2010 17:40	42.179		67	7/21/2010 21:00	41.625
48	7/21/2010 17:50	43.648		68	7/21/2010 21:10	40.321
49	7/21/2010 18:00	43.282		69	7/21/2010 21:20	41.994
50	7/21/2010 18:10	39.947		70	7/21/2010 21:30	43.466
51	7/21/2010 18:20	41.439		71	7/21/2010 21:40	43.648
52	7/21/2010 18:30	43.099		72	7/21/2010 21:50	39.947
53	7/21/2010 18:40	44.195		73	7/21/2010 22:00	41.254
54	7/21/2010 18:50	40.509				
55	7/21/2010 19:00	40.696				
56	7/21/2010 19:10	42.363				
57	7/21/2010 19:20	44.013				
58	7/21/2010 19:30	42.548				
59	7/21/2010 19:40	39.947				
60	7/21/2010 19:50	41.81				

Temperature Setting 3						
#	Time, GMT-04:00	Temp, °F				
1	7/21/2010 22:30	38.818		21	7/22/2010 1:50	38.25
2	7/21/2010 22:40	39.76		22	7/22/2010 2:00	40.321
3	7/21/2010 22:50	41.439		23	7/22/2010 2:10	42.179
4	7/21/2010 23:00	43.099		24	7/22/2010 2:20	42.363
5	7/21/2010 23:10	40.509		25	7/22/2010 2:30	38.061
6	7/21/2010 23:20	37.87		26	7/22/2010 2:40	38.629
7	7/21/2010 23:30	39.573		27	7/22/2010 2:50	40.696
8	7/21/2010 23:40	41.439		28	7/22/2010 3:00	42.363
9	7/21/2010 23:50	42.915		29	7/22/2010 3:10	41.81
10	7/22/2010 0:00	39.76		30	7/22/2010 3:20	37.679
11	7/22/2010 0:10	38.061		31	7/22/2010 3:30	38.629
12	7/22/2010 0:20	39.76		32	7/22/2010 3:40	40.696
13	7/22/2010 0:30	41.625		33	7/22/2010 3:50	42.548
14	7/22/2010 0:40	43.099		34	7/22/2010 4:00	41.625
15	7/22/2010 0:50	39.007		35	7/22/2010 4:10	37.87
16	7/22/2010 1:00	38.25		36	7/22/2010 4:20	39.007
17	7/22/2010 1:10	40.134		37	7/22/2010 4:30	41.067
18	7/22/2010 1:20	41.994		38	7/22/2010 4:40	42.732
19	7/22/2010 1:30	42.732		39	7/22/2010 4:50	41.067
20	7/22/2010 1:40	38.44		40	7/22/2010 5:00	37.679
41	7/22/2010 5:10	39.196		61	7/22/2010 8:30	39.384
42	7/22/2010 5:20	41.067		62	7/22/2010 8:40	41.254
43	7/22/2010 5:30	42.732		63	7/22/2010 8:50	42.915
44	7/22/2010 5:40	40.881		64	7/22/2010 9:00	40.881
45	7/22/2010 5:50	37.679		65	7/22/2010 9:10	37.488
46	7/22/2010 6:00	39.196		66	7/22/2010 9:20	39.196
47	7/22/2010 6:10	41.067		67	7/22/2010 9:30	41.067
48	7/22/2010 6:20	42.915		68	7/22/2010 9:40	42.732
49	7/22/2010 6:30	40.509		69	7/22/2010 9:50	41.439
50	7/22/2010 6:40	37.87		70	7/22/2010 10:00	37.679
51	7/22/2010 6:50	39.384		71	7/22/2010 10:10	39.007
52	7/22/2010 7:00	41.254		72	7/22/2010 10:20	40.881
53	7/22/2010 7:10	42.915		73	7/22/2010 10:30	42.548
54	7/22/2010 7:20	40.509				
55	7/22/2010 7:30	37.87				
56	7/22/2010 7:40	39.384				
57	7/22/2010 7:50	41.254				
58	7/22/2010 8:00	42.915				
59	7/22/2010 8:10	40.509				
60	7/22/2010 8:20	37.679				

Temperature Setting 4						
#	Time, GMT-04:00	Temp, °F				
1	7/22/2010 10:45	50.466		21	7/22/2010 14:05	36.914
2	7/22/2010 10:55	39.007		22	7/22/2010 14:15	33.411
3	7/22/2010 11:05	35.37		23	7/22/2010 14:25	35.564
4	7/22/2010 11:15	37.107		24	7/22/2010 14:35	38.25
5	7/22/2010 11:25	39.384		25	7/22/2010 14:45	40.321
6	7/22/2010 11:35	41.067		26	7/22/2010 14:55	42.179
7	7/22/2010 11:45	42.363		27	7/22/2010 15:05	39.573
8	7/22/2010 11:55	38.44		28	7/22/2010 15:15	34.198
9	7/22/2010 12:05	34.198		29	7/22/2010 15:25	34.198
10	7/22/2010 12:15	35.758		30	7/22/2010 15:35	36.914
11	7/22/2010 12:25	38.25		31	7/22/2010 15:45	39.384
12	7/22/2010 12:35	40.321		32	7/22/2010 15:55	41.254
13	7/22/2010 12:45	41.994		33	7/22/2010 16:05	41.994
14	7/22/2010 12:55	40.134		34	7/22/2010 16:15	37.107
15	7/22/2010 13:05	34.59		35	7/22/2010 16:25	33.213
16	7/22/2010 13:15	34.59		36	7/22/2010 16:35	35.37
17	7/22/2010 13:25	37.107		37	7/22/2010 16:45	38.061
18	7/22/2010 13:35	39.384		38	7/22/2010 16:55	40.321
19	7/22/2010 13:45	41.254		39	7/22/2010 17:05	42.363
20	7/22/2010 13:55	41.994		40	7/22/2010 17:15	39.76
41	7/22/2010 17:25	34.59		61	7/22/2010 20:45	33.213
42	7/22/2010 17:35	33.607		62	7/22/2010 20:55	34.59
43	7/22/2010 17:45	36.338		63	7/22/2010 21:05	37.488
44	7/22/2010 17:55	39.196		64	7/22/2010 21:15	40.134
45	7/22/2010 18:05	41.254		65	7/22/2010 21:25	42.179
46	7/22/2010 18:15	42.179		66	7/22/2010 21:35	40.509
47	7/22/2010 18:25	37.488		67	7/22/2010 21:45	35.175
48	7/22/2010 18:35	33.013		68	7/22/2010 21:55	33.411
49	7/22/2010 18:45	34.59		69	7/22/2010 22:05	36.338
50	7/22/2010 18:55	37.488		70	7/22/2010 22:15	39.007
51	7/22/2010 19:05	40.134		71	7/22/2010 22:25	41.254
52	7/22/2010 19:15	42.179		72	7/22/2010 22:35	42.363
53	7/22/2010 19:25	40.321		73	7/22/2010 22:45	37.488
54	7/22/2010 19:35	35.37				
55	7/22/2010 19:45	33.607				
56	7/22/2010 19:55	36.145				
57	7/22/2010 20:05	39.007				
58	7/22/2010 20:15	41.254				
59	7/22/2010 20:25	42.548				
60	7/22/2010 20:35	37.87				

Temperature Setting 5						
#	Time, GMT-04:00	Temp, °F				
1	7/22/2010 23:00	40.509		21	7/23/2010 2:20	40.134
2	7/22/2010 23:10	32.418		22	7/23/2010 2:30	34.198
3	7/22/2010 23:20	27.513		23	7/23/2010 2:40	29.176
4	7/22/2010 23:30	24.31		24	7/23/2010 2:50	25.39
5	7/22/2010 23:40	26.67		25	7/23/2010 3:00	26.033
6	7/22/2010 23:50	30.607		26	7/23/2010 3:10	29.791
7	7/23/2010 0:00	34.394		27	7/23/2010 3:20	33.805
8	7/23/2010 0:10	37.297		28	7/23/2010 3:30	37.107
9	7/23/2010 0:20	39.573		29	7/23/2010 3:40	39.573
10	7/23/2010 0:30	41.625		30	7/23/2010 3:50	41.81
11	7/23/2010 0:40	39.947		31	7/23/2010 4:00	39.573
12	7/23/2010 0:50	34.394		32	7/23/2010 4:10	33.805
13	7/23/2010 1:00	29.381		33	7/23/2010 4:20	28.969
14	7/23/2010 1:10	25.39		34	7/23/2010 4:30	25.39
15	7/23/2010 1:20	25.819		35	7/23/2010 4:40	24.31
16	7/23/2010 1:30	29.586		36	7/23/2010 4:50	27.721
17	7/23/2010 1:40	33.607		37	7/23/2010 5:00	31.818
18	7/23/2010 1:50	36.914		38	7/23/2010 5:10	35.37
19	7/23/2010 2:00	39.384		39	7/23/2010 5:20	38.25
20	7/23/2010 2:10	41.625		40	7/23/2010 5:30	40.321
41	7/23/2010 5:40	41.625		61	7/23/2010 9:00	41.067
42	7/23/2010 5:50	36.914		62	7/23/2010 9:10	40.509
43	7/23/2010 6:00	31.617		63	7/23/2010 9:20	35.175
44	7/23/2010 6:10	27.302		64	7/23/2010 9:30	29.997
45	7/23/2010 6:20	24.093		65	7/23/2010 9:40	26.033
46	7/23/2010 6:30	25.819		66	7/23/2010 9:50	24.744
47	7/23/2010 6:40	29.791		67	7/23/2010 10:00	28.139
48	7/23/2010 6:50	33.805		68	7/23/2010 10:10	32.218
49	7/23/2010 7:00	36.914		69	7/23/2010 10:20	35.758
50	7/23/2010 7:10	39.384		70	7/23/2010 10:30	38.44
51	7/23/2010 7:20	41.439		71	7/23/2010 10:40	40.696
52	7/23/2010 7:30	39.76		72	7/23/2010 10:50	41.254
53	7/23/2010 7:40	34.198				
54	7/23/2010 7:50	29.176				
55	7/23/2010 8:00	25.39				
56	7/23/2010 8:10	25.39				
57	7/23/2010 8:20	29.176				
58	7/23/2010 8:30	33.213				
59	7/23/2010 8:40	36.531				
60	7/23/2010 8:50	39.007				

Table A-3: Temperature data compiled for Environmental / Circulation Test						
#	Time, GMT-04:00	Temp, °F				
1	7/24/2010 9:15	54.322		21	7/24/2010 12:35	42.732
2	7/24/2010 9:25	45.648		22	7/24/2010 12:45	42.548
3	7/24/2010 9:35	43.648		23	7/24/2010 12:55	44.379
4	7/24/2010 9:45	45.104		24	7/24/2010 13:05	45.286
5	7/24/2010 9:55	46.008		25	7/24/2010 13:15	42.179
6	7/24/2010 10:05	42.548		26	7/24/2010 13:25	43.099
7	7/24/2010 10:15	43.099		27	7/24/2010 13:35	44.742
8	7/24/2010 10:25	44.922		28	7/24/2010 13:45	44.56
9	7/24/2010 10:35	45.286		29	7/24/2010 13:55	41.625
10	7/24/2010 10:45	42.179		30	7/24/2010 14:05	43.099
11	7/24/2010 10:55	43.466		31	7/24/2010 14:15	44.922
12	7/24/2010 11:05	45.286		32	7/24/2010 14:25	43.831
13	7/24/2010 11:15	44.379		33	7/24/2010 14:35	41.625
14	7/24/2010 11:25	41.994		34	7/24/2010 14:45	43.282
15	7/24/2010 11:35	43.831		35	7/24/2010 14:55	45.104
16	7/24/2010 11:45	45.648		36	7/24/2010 15:05	42.915
17	7/24/2010 11:55	43.466		37	7/24/2010 15:15	41.994
18	7/24/2010 12:05	42.179		38	7/24/2010 15:25	43.831
19	7/24/2010 12:15	44.013		39	7/24/2010 15:35	45.104
20	7/24/2010 12:25	45.466		40	7/24/2010 15:45	41.994
41	7/24/2010 15:55	42.363		61	7/24/2010 19:15	44.742
42	7/24/2010 16:05	44.013		62	7/24/2010 19:25	41.81
43	7/24/2010 16:15	44.742		63	7/24/2010 19:35	41.994
44	7/24/2010 16:25	41.625		64	7/24/2010 19:45	43.648
45	7/24/2010 16:35	42.732		65	7/24/2010 19:55	44.742
46	7/24/2010 16:45	44.56		66	7/24/2010 20:05	41.439
47	7/24/2010 16:55	43.648		67	7/24/2010 20:15	42.363
48	7/24/2010 17:05	41.625		68	7/24/2010 20:25	44.013
49	7/24/2010 17:15	43.282		69	7/24/2010 20:35	43.831
50	7/24/2010 17:25	44.922		70	7/24/2010 20:45	41.067
51	7/24/2010 17:35	42.179		71	7/24/2010 20:55	42.732
52	7/24/2010 17:45	42.179		72	7/24/2010 21:05	44.56
53	7/24/2010 17:55	44.013		73	7/24/2010 21:15	42.732
54	7/24/2010 18:05	44.56				
55	7/24/2010 18:15	41.439				
56	7/24/2010 18:25	42.732				
57	7/24/2010 18:35	44.56				
58	7/24/2010 18:45	43.282				
59	7/24/2010 18:55	41.439				
60	7/24/2010 19:05	43.282				

Temperature Setting 2						
#	Time, GMT-04:00	Temp, °F				
1	7/24/2010 21:30	49.228		21	7/25/2010 0:50	42.363
2	7/24/2010 21:40	46.369		22	7/25/2010 1:00	44.195
3	7/24/2010 21:50	40.696		23	7/25/2010 1:10	41.254
4	7/24/2010 22:00	41.439		24	7/25/2010 1:20	40.509
5	7/24/2010 22:10	43.282		25	7/25/2010 1:30	42.548
6	7/24/2010 22:20	44.013		26	7/25/2010 1:40	44.195
7	7/24/2010 22:30	39.947		27	7/25/2010 1:50	41.439
8	7/24/2010 22:40	41.254		28	7/25/2010 2:00	40.321
9	7/24/2010 22:50	43.282		29	7/25/2010 2:10	42.363
10	7/24/2010 23:00	44.379		30	7/25/2010 2:20	44.195
11	7/24/2010 23:10	40.321		31	7/25/2010 2:30	41.625
12	7/24/2010 23:20	41.067		32	7/25/2010 2:40	39.947
13	7/24/2010 23:30	42.915		33	7/25/2010 2:50	41.994
14	7/24/2010 23:40	44.195		34	7/25/2010 3:00	43.831
15	7/24/2010 23:50	41.067		35	7/25/2010 3:10	42.732
16	7/25/2010 0:00	40.509		36	7/25/2010 3:20	39.573
17	7/25/2010 0:10	42.363		37	7/25/2010 3:30	41.625
18	7/25/2010 0:20	44.195		38	7/25/2010 3:40	43.466
19	7/25/2010 0:30	41.439		39	7/25/2010 3:50	43.282
20	7/25/2010 0:40	40.509		40	7/25/2010 4:00	39.573
41	7/25/2010 4:10	41.439		61	7/25/2010 7:30	39.384
42	7/25/2010 4:20	43.282		62	7/25/2010 7:40	41.439
43	7/25/2010 4:30	43.282		63	7/25/2010 7:50	43.282
44	7/25/2010 4:40	39.384		64	7/25/2010 8:00	43.099
45	7/25/2010 4:50	41.067		65	7/25/2010 8:10	39.196
46	7/25/2010 5:00	43.099		66	7/25/2010 8:20	40.881
47	7/25/2010 5:10	43.831		67	7/25/2010 8:30	42.732
48	7/25/2010 5:20	39.384		68	7/25/2010 8:40	43.466
49	7/25/2010 5:30	40.881		69	7/25/2010 8:50	39.196
50	7/25/2010 5:40	42.732		70	7/25/2010 9:00	40.321
51	7/25/2010 5:50	44.013		71	7/25/2010 9:10	42.363
52	7/25/2010 6:00	39.947		72	7/25/2010 9:20	43.831
53	7/25/2010 6:10	40.321		73	7/25/2010 9:30	40.134
54	7/25/2010 6:20	42.363				
55	7/25/2010 6:30	44.013				
56	7/25/2010 6:40	41.067				
57	7/25/2010 6:50	39.573				
58	7/25/2010 7:00	41.625				
59	7/25/2010 7:10	43.466				
60	7/25/2010 7:20	42.363				

Temperature Setting 3						
#	Time, GMT-04:00	Temp, °F				
1	7/25/2010 9:45	48.695		21	7/25/2010 13:05	43.648
2	7/25/2010 9:55	46.728		22	7/25/2010 13:15	39.947
3	7/25/2010 10:05	42.915		23	7/25/2010 13:25	40.881
4	7/25/2010 10:15	40.509		24	7/25/2010 13:35	42.915
5	7/25/2010 10:25	42.363		25	7/25/2010 13:45	44.56
6	7/25/2010 10:35	44.013		26	7/25/2010 13:55	41.81
7	7/25/2010 10:45	44.742		27	7/25/2010 14:05	39.76
8	7/25/2010 10:55	40.696		28	7/25/2010 14:15	41.81
9	7/25/2010 11:05	40.509		29	7/25/2010 14:25	43.648
10	7/25/2010 11:15	42.732		30	7/25/2010 14:35	44.195
11	7/25/2010 11:25	44.379		31	7/25/2010 14:45	40.321
12	7/25/2010 11:35	43.282		32	7/25/2010 14:55	40.509
13	7/25/2010 11:45	39.76		33	7/25/2010 15:05	42.548
14	7/25/2010 11:55	41.067		34	7/25/2010 15:15	44.195
15	7/25/2010 12:05	43.282		35	7/25/2010 15:25	43.099
16	7/25/2010 12:15	44.742		36	7/25/2010 15:35	39.76
17	7/25/2010 12:25	41.625		37	7/25/2010 15:45	41.254
18	7/25/2010 12:35	40.134		38	7/25/2010 15:55	43.099
19	7/25/2010 12:45	42.179		39	7/25/2010 16:05	44.56
20	7/25/2010 12:55	43.831		40	7/25/2010 16:15	41.81
41	7/25/2010 16:25	39.76		61	7/25/2010 19:45	41.625
42	7/25/2010 16:35	41.625		62	7/25/2010 19:55	43.282
43	7/25/2010 16:45	43.466		63	7/25/2010 20:05	44.56
44	7/25/2010 16:55	44.379		64	7/25/2010 20:15	41.994
45	7/25/2010 17:05	40.509		65	7/25/2010 20:25	39.573
46	7/25/2010 17:15	40.134		66	7/25/2010 20:35	41.625
47	7/25/2010 17:25	42.363		67	7/25/2010 20:45	43.282
48	7/25/2010 17:35	44.013		68	7/25/2010 20:55	44.56
49	7/25/2010 17:45	43.648		69	7/25/2010 21:05	42.179
50	7/25/2010 17:55	39.76		70	7/25/2010 21:15	40.321
51	7/25/2010 18:05	40.696		71	7/25/2010 21:25	42.179
52	7/25/2010 18:15	42.548		72	7/25/2010 21:35	43.648
53	7/25/2010 18:25	44.195		73	7/25/2010 21:45	44.379
54	7/25/2010 18:35	43.099				
55	7/25/2010 18:45	39.76				
56	7/25/2010 18:55	41.254				
57	7/25/2010 19:05	43.099				
58	7/25/2010 19:15	44.56				
59	7/25/2010 19:25	42.363				
60	7/25/2010 19:35	39.947				

Temperature Setting 4						
#	Time, GMT-04:00	Temp, °F				
1	7/25/2010 22:00	52.576		21	7/26/2010 1:20	33.411
2	7/25/2010 22:10	41.625		22	7/26/2010 1:30	31.012
3	7/25/2010 22:20	36.531		23	7/26/2010 1:40	31.012
4	7/25/2010 22:30	33.805		24	7/26/2010 1:50	34.981
5	7/25/2010 22:40	32.218		25	7/26/2010 2:00	38.44
6	7/25/2010 22:50	31.617		26	7/26/2010 2:10	40.509
7	7/25/2010 23:00	34.786		27	7/26/2010 2:20	41.994
8	7/25/2010 23:10	38.44		28	7/26/2010 2:30	41.625
9	7/25/2010 23:20	40.696		29	7/26/2010 2:40	37.107
10	7/25/2010 23:30	42.179		30	7/26/2010 2:50	33.607
11	7/25/2010 23:40	42.732		31	7/26/2010 3:00	31.012
12	7/25/2010 23:50	38.629		32	7/26/2010 3:10	31.213
13	7/26/2010 0:00	34.394		33	7/26/2010 3:20	35.175
14	7/26/2010 0:10	33.013		34	7/26/2010 3:30	38.25
15	7/26/2010 0:20	36.145		35	7/26/2010 3:40	40.321
16	7/26/2010 0:30	39.007		36	7/26/2010 3:50	41.625
17	7/26/2010 0:40	41.067		37	7/26/2010 4:00	41.994
18	7/26/2010 0:50	42.363		38	7/26/2010 4:10	37.87
19	7/26/2010 1:00	41.625		39	7/26/2010 4:20	34.002
20	7/26/2010 1:10	36.914		40	7/26/2010 4:30	31.415
41	7/26/2010 4:40	32.418		61	7/26/2010 8:00	40.134
42	7/26/2010 4:50	35.951		62	7/26/2010 8:10	41.439
43	7/26/2010 5:00	38.818		63	7/26/2010 8:20	41.439
44	7/26/2010 5:10	40.509		64	7/26/2010 8:30	37.297
45	7/26/2010 5:20	41.81		65	7/26/2010 8:40	33.607
46	7/26/2010 5:30	41.254		66	7/26/2010 8:50	31.818
47	7/26/2010 5:40	36.723		67	7/26/2010 9:00	34.59
48	7/26/2010 5:50	33.013		68	7/26/2010 9:10	37.679
49	7/26/2010 6:00	31.012		69	7/26/2010 9:20	39.76
50	7/26/2010 6:10	33.805		70	7/26/2010 9:30	41.067
51	7/26/2010 6:20	37.107		71	7/26/2010 9:40	41.994
52	7/26/2010 6:30	39.384		72	7/26/2010 9:50	39.384
53	7/26/2010 6:40	40.881		73	7/26/2010 10:00	34.786
54	7/26/2010 6:50	41.994				
55	7/26/2010 7:00	39.196				
56	7/26/2010 7:10	34.981				
57	7/26/2010 7:20	31.818				
58	7/26/2010 7:30	32.018				
59	7/26/2010 7:40	35.564				
60	7/26/2010 7:50	38.44				

Temperature Setting 5						
#	Time, GMT-04:00	Temp, °F				
1	7/30/2010 0:21	27.091		21	7/30/2010 3:41	36.531
2	7/30/2010 0:31	30.607		22	7/30/2010 3:51	39.196
3	7/30/2010 0:41	34.198		23	7/30/2010 4:01	41.625
4	7/30/2010 0:51	37.297		24	7/30/2010 4:11	39.573
5	7/30/2010 1:01	39.573		25	7/30/2010 4:21	33.805
6	7/30/2010 1:11	41.439		26	7/30/2010 4:31	28.762
7	7/30/2010 1:21	37.87		27	7/30/2010 4:41	26.881
8	7/30/2010 1:31	32.617		28	7/30/2010 4:51	29.997
9	7/30/2010 1:41	27.93		29	7/30/2010 5:01	34.002
10	7/30/2010 1:51	28.139		30	7/30/2010 5:11	37.297
11	7/30/2010 2:01	31.617		31	7/30/2010 5:21	39.76
12	7/30/2010 2:11	35.37		32	7/30/2010 5:31	41.625
13	7/30/2010 2:21	38.25		33	7/30/2010 5:41	38.818
14	7/30/2010 2:31	40.696		34	7/30/2010 5:51	33.013
15	7/30/2010 2:41	41.067		35	7/30/2010 6:01	28.139
16	7/30/2010 2:51	35.758		36	7/30/2010 6:11	28.555
17	7/30/2010 3:01	30.607		37	7/30/2010 6:21	32.218
18	7/30/2010 3:11	26.881		38	7/30/2010 6:31	35.758
19	7/30/2010 3:21	29.381		39	7/30/2010 6:41	38.629
20	7/30/2010 3:31	33.213		40	7/30/2010 6:51	40.881
41	7/30/2010 7:01	41.439		61	7/30/2010 10:21	27.513
42	7/30/2010 7:11	36.145		62	7/30/2010 10:31	29.381
43	7/30/2010 7:21	30.607		63	7/30/2010 10:41	33.013
44	7/30/2010 7:31	27.513		64	7/30/2010 10:51	36.338
45	7/30/2010 7:41	29.997		65	7/30/2010 11:01	39.007
46	7/30/2010 7:51	33.607		66	7/30/2010 11:11	41.254
47	7/30/2010 8:01	36.914		67	7/30/2010 11:21	41.439
48	7/30/2010 8:11	39.384		68	7/30/2010 11:31	35.758
49	7/30/2010 8:21	41.81				
50	7/30/2010 8:31	39.947				
51	7/30/2010 8:41	34.198				
52	7/30/2010 8:51	28.762				
53	7/30/2010 9:01	28.762				
54	7/30/2010 9:11	32.018				
55	7/30/2010 9:21	35.564				
56	7/30/2010 9:31	38.44				
57	7/30/2010 9:41	40.696				
58	7/30/2010 9:51	42.179				
59	7/30/2010 10:01	37.297				
60	7/30/2010 10:11	31.617				

Table A-4: Temperature data complied for Loaded Usage Test						
#	Time, GMT-04:00	Temp, °F				
1	7/27/2010 10:15	46.369		21	7/27/2010 13:35	41.994
2	7/27/2010 10:25	40.509		22	7/27/2010 13:45	44.013
3	7/27/2010 10:35	41.254		23	7/27/2010 13:55	44.379
4	7/27/2010 10:45	42.732		24	7/27/2010 14:05	40.134
5	7/27/2010 10:55	43.648		25	7/27/2010 14:15	41.625
6	7/27/2010 11:05	39.007		26	7/27/2010 14:25	43.466
7	7/27/2010 11:15	40.134		27	7/27/2010 14:35	44.922
8	7/27/2010 11:25	41.994		28	7/27/2010 14:45	40.696
9	7/27/2010 11:35	44.013		29	7/27/2010 14:55	41.254
10	7/27/2010 11:45	42.363		30	7/27/2010 15:05	43.099
11	7/27/2010 11:55	39.384		31	7/27/2010 15:15	44.922
12	7/27/2010 12:05	41.439		32	7/27/2010 15:25	41.625
13	7/27/2010 12:15	43.282		33	7/27/2010 15:35	41.067
14	7/27/2010 12:25	44.56		34	7/27/2010 15:45	43.099
15	7/27/2010 12:35	40.134		35	7/27/2010 15:55	45.104
16	7/27/2010 12:45	40.881		36	7/27/2010 16:05	42.363
17	7/27/2010 12:55	42.732		37	7/27/2010 16:15	40.881
18	7/27/2010 13:05	44.56		38	7/27/2010 16:25	43.099
19	7/27/2010 13:15	42.363		39	7/27/2010 16:35	45.104
20	7/27/2010 13:25	40.134		40	7/27/2010 16:45	42.915
41	7/27/2010 16:55	41.067		61	7/27/2010 20:15	40.881
42	7/27/2010 17:05	43.099		62	7/27/2010 20:25	41.625
43	7/27/2010 17:15	45.104		63	7/27/2010 20:35	43.648
44	7/27/2010 17:25	43.648		64	7/27/2010 20:45	45.286
45	7/27/2010 17:35	41.254		65	7/27/2010 20:55	41.81
46	7/27/2010 17:45	43.282		66	7/27/2010 21:05	41.439
47	7/27/2010 17:55	45.286		67	7/27/2010 21:15	43.466
48	7/27/2010 18:05	44.379		68	7/27/2010 21:25	45.286
49	7/27/2010 18:15	41.254		69	7/27/2010 21:35	42.732
50	7/27/2010 18:25	43.282		70	7/27/2010 21:45	40.881
51	7/27/2010 18:35	45.286		71	7/27/2010 21:55	42.915
52	7/27/2010 18:45	44.742		72	7/27/2010 22:05	44.742
53	7/27/2010 18:55	41.254		73	7/27/2010 22:15	44.195
54	7/27/2010 19:05	43.099				
55	7/27/2010 19:15	44.922				
56	7/27/2010 19:25	45.286				
57	7/27/2010 19:35	40.696				
58	7/27/2010 19:45	42.363				
59	7/27/2010 19:55	44.195				
60	7/27/2010 20:05	45.466				

Temperature Setting 2						
#	Time, GMT-04:00	Temp, °F				
1	7/27/2010 22:30	52.576		21	7/28/2010 1:50	40.881
2	7/27/2010 22:40	47.982		22	7/28/2010 2:00	41.254
3	7/27/2010 22:50	46.369		23	7/28/2010 2:10	43.466
4	7/27/2010 23:00	40.881		24	7/28/2010 2:20	45.104
5	7/27/2010 23:10	41.81		25	7/28/2010 2:30	41.254
6	7/27/2010 23:20	43.648		26	7/28/2010 2:40	41.067
7	7/27/2010 23:30	45.104		27	7/28/2010 2:50	43.282
8	7/27/2010 23:40	41.439		28	7/28/2010 3:00	45.104
9	7/27/2010 23:50	40.134		29	7/28/2010 3:10	41.439
10	7/28/2010 0:00	42.363		30	7/28/2010 3:20	40.696
11	7/28/2010 0:10	44.379		31	7/28/2010 3:30	42.915
12	7/28/2010 0:20	43.831		32	7/28/2010 3:40	44.922
13	7/28/2010 0:30	39.947		33	7/28/2010 3:50	41.994
14	7/28/2010 0:40	41.81		34	7/28/2010 4:00	40.509
15	7/28/2010 0:50	43.831		35	7/28/2010 4:10	42.732
16	7/28/2010 1:00	44.742		36	7/28/2010 4:20	44.742
17	7/28/2010 1:10	40.134		37	7/28/2010 4:30	42.915
18	7/28/2010 1:20	41.254		38	7/28/2010 4:40	40.321
19	7/28/2010 1:30	43.466		39	7/28/2010 4:50	42.363
20	7/28/2010 1:40	45.104		40	7/28/2010 5:00	44.379
41	7/28/2010 5:10	43.466		61	7/28/2010 8:30	43.648
42	7/28/2010 5:20	39.947		62	7/28/2010 8:40	44.922
43	7/28/2010 5:30	41.81		63	7/28/2010 8:50	40.509
44	7/28/2010 5:40	43.831		64	7/28/2010 9:00	41.067
45	7/28/2010 5:50	44.56		65	7/28/2010 9:10	43.099
46	7/28/2010 6:00	39.947		66	7/28/2010 9:20	44.922
47	7/28/2010 6:10	41.254		67	7/28/2010 9:30	41.439
48	7/28/2010 6:20	43.466		68	7/28/2010 9:40	40.321
49	7/28/2010 6:30	44.742		69	7/28/2010 9:50	42.363
50	7/28/2010 6:40	40.509		70	7/28/2010 10:00	44.379
51	7/28/2010 6:50	40.696		71	7/28/2010 10:10	43.099
52	7/28/2010 7:00	42.915		72	7/28/2010 10:20	39.76
53	7/28/2010 7:10	44.742		73	7/28/2010 10:30	41.81
54	7/28/2010 7:20	41.994				
55	7/28/2010 7:30	40.134				
56	7/28/2010 7:40	42.363				
57	7/28/2010 7:50	44.195				
58	7/28/2010 8:00	43.648				
59	7/28/2010 8:10	39.947				
60	7/28/2010 8:20	41.625				

Temperature Setting 3						
#	Time, GMT-04:00	Temp, °F				
1	7/28/2010 10:45	51.699		21	7/28/2010 14:05	42.548
2	7/28/2010 10:55	43.466		22	7/28/2010 14:15	44.56
3	7/28/2010 11:05	43.466		23	7/28/2010 14:25	46.008
4	7/28/2010 11:15	44.922		24	7/28/2010 14:35	41.81
5	7/28/2010 11:25	46.188		25	7/28/2010 14:45	41.81
6	7/28/2010 11:35	42.732		26	7/28/2010 14:55	44.013
7	7/28/2010 11:45	41.625		27	7/28/2010 15:05	46.008
8	7/28/2010 11:55	43.466		28	7/28/2010 15:15	43.466
9	7/28/2010 12:05	45.286		29	7/28/2010 15:25	41.439
10	7/28/2010 12:15	45.104		30	7/28/2010 15:35	43.648
11	7/28/2010 12:25	40.696		31	7/28/2010 15:45	45.648
12	7/28/2010 12:35	42.363		32	7/28/2010 15:55	45.286
13	7/28/2010 12:45	44.379		33	7/28/2010 16:05	41.254
14	7/28/2010 12:55	45.828		34	7/28/2010 16:15	43.099
15	7/28/2010 13:05	42.179		35	7/28/2010 16:25	45.286
16	7/28/2010 13:15	41.439		36	7/28/2010 16:35	46.188
17	7/28/2010 13:25	43.648		37	7/28/2010 16:45	41.81
18	7/28/2010 13:35	45.466		38	7/28/2010 16:55	42.363
19	7/28/2010 13:45	44.922		39	7/28/2010 17:05	44.195
20	7/28/2010 13:55	40.881		40	7/28/2010 17:15	46.008
41	7/28/2010 17:25	43.466		61	7/28/2010 20:45	40.881
42	7/28/2010 17:35	41.254		62	7/28/2010 20:55	42.732
43	7/28/2010 17:45	43.099		63	7/28/2010 21:05	44.379
44	7/28/2010 17:55	44.922		64	7/28/2010 21:15	44.922
45	7/28/2010 18:05	45.648		65	7/28/2010 21:25	40.509
46	7/28/2010 18:15	41.254		66	7/28/2010 21:35	41.067
47	7/28/2010 18:25	41.81		67	7/28/2010 21:45	42.915
48	7/28/2010 18:35	43.466		68	7/28/2010 21:55	44.56
49	7/28/2010 18:45	45.286		69	7/28/2010 22:05	44.195
50	7/28/2010 18:55	44.195		70	7/28/2010 22:15	40.134
51	7/28/2010 19:05	40.509		71	7/28/2010 22:25	41.439
52	7/28/2010 19:15	41.994		72	7/28/2010 22:35	43.282
53	7/28/2010 19:25	43.648		73	7/28/2010 22:45	44.922
54	7/28/2010 19:35	45.286				
55	7/28/2010 19:45	42.548				
56	7/28/2010 19:55	40.509				
57	7/28/2010 20:05	42.179				
58	7/28/2010 20:15	43.831				
59	7/28/2010 20:25	45.104				
60	7/28/2010 20:35	41.254				

Temperature Setting 4						
#	Time, GMT-04:00	Temp, °F				
1	7/29/2010 0:21	27.091		21	7/29/2010 3:41	36.531
2	7/29/2010 0:31	30.607		22	7/29/2010 3:51	39.196
3	7/29/2010 0:41	34.198		23	7/29/2010 4:01	41.625
4	7/29/2010 0:51	37.297		24	7/29/2010 4:11	39.573
5	7/29/2010 1:01	39.573		25	7/29/2010 4:21	33.805
6	7/29/2010 1:11	41.439		26	7/29/2010 4:31	28.762
7	7/29/2010 1:21	37.87		27	7/29/2010 4:41	26.881
8	7/29/2010 1:31	32.617		28	7/29/2010 4:51	29.997
9	7/29/2010 1:41	27.93		29	7/29/2010 5:01	34.002
10	7/29/2010 1:51	28.139		30	7/29/2010 5:11	37.297
11	7/29/2010 2:01	31.617		31	7/29/2010 5:21	39.76
12	7/29/2010 2:11	35.37		32	7/29/2010 5:31	41.625
13	7/29/2010 2:21	38.25		33	7/29/2010 5:41	38.818
14	7/29/2010 2:31	40.696		34	7/29/2010 5:51	33.013
15	7/29/2010 2:41	41.067		35	7/29/2010 6:01	28.139
16	7/29/2010 2:51	35.758		36	7/29/2010 6:11	28.555
17	7/29/2010 3:01	30.607		37	7/29/2010 6:21	32.218
18	7/29/2010 3:11	26.881		38	7/29/2010 6:31	35.758
19	7/29/2010 3:21	29.381		39	7/29/2010 6:41	38.629
20	7/29/2010 3:31	33.213		40	7/29/2010 6:51	40.881
41	7/29/2010 7:01	41.439		61	7/29/2010 10:21	27.513
42	7/29/2010 7:11	36.145		62	7/29/2010 10:31	29.381
43	7/29/2010 7:21	30.607		63	7/29/2010 10:41	33.013
44	7/29/2010 7:31	27.513		64	7/29/2010 10:51	36.338
45	7/29/2010 7:41	29.997		65	7/29/2010 11:01	39.007
46	7/29/2010 7:51	33.607		66	7/29/2010 11:11	41.254
47	7/29/2010 8:01	36.914		67	7/29/2010 11:21	41.439
48	7/29/2010 8:11	39.384		68	7/29/2010 11:31	35.758
49	7/29/2010 8:21	41.81				
50	7/29/2010 8:31	39.947				
51	7/29/2010 8:41	34.198				
52	7/29/2010 8:51	28.762				
53	7/29/2010 9:01	28.762				
54	7/29/2010 9:11	32.018				
55	7/29/2010 9:21	35.564				
56	7/29/2010 9:31	38.44				
57	7/29/2010 9:41	40.696				
58	7/29/2010 9:51	42.179				
59	7/29/2010 10:01	37.297				
60	7/29/2010 10:11	31.617				

Temperature Setting 5						
#	Time, GMT-04:00	Temp, °F				
1	7/30/2010 0:21	27.091		21	7/30/2010 3:41	36.531
2	7/30/2010 0:31	30.607		22	7/30/2010 3:51	39.196
3	7/30/2010 0:41	34.198		23	7/30/2010 4:01	41.625
4	7/30/2010 0:51	37.297		24	7/30/2010 4:11	39.573
5	7/30/2010 1:01	39.573		25	7/30/2010 4:21	33.805
6	7/30/2010 1:11	41.439		26	7/30/2010 4:31	28.762
7	7/30/2010 1:21	37.87		27	7/30/2010 4:41	26.881
8	7/30/2010 1:31	32.617		28	7/30/2010 4:51	29.997
9	7/30/2010 1:41	27.93		29	7/30/2010 5:01	34.002
10	7/30/2010 1:51	28.139		30	7/30/2010 5:11	37.297
11	7/30/2010 2:01	31.617		31	7/30/2010 5:21	39.76
12	7/30/2010 2:11	35.37		32	7/30/2010 5:31	41.625
13	7/30/2010 2:21	38.25		33	7/30/2010 5:41	38.818
14	7/30/2010 2:31	40.696		34	7/30/2010 5:51	33.013
15	7/30/2010 2:41	41.067		35	7/30/2010 6:01	28.139
16	7/30/2010 2:51	35.758		36	7/30/2010 6:11	28.555
17	7/30/2010 3:01	30.607		37	7/30/2010 6:21	32.218
18	7/30/2010 3:11	26.881		38	7/30/2010 6:31	35.758
19	7/30/2010 3:21	29.381		39	7/30/2010 6:41	38.629
20	7/30/2010 3:31	33.213		40	7/30/2010 6:51	40.881
41	7/30/2010 7:01	41.439		61	7/30/2010 10:21	27.513
42	7/30/2010 7:11	36.145		62	7/30/2010 10:31	29.381
43	7/30/2010 7:21	30.607		63	7/30/2010 10:41	33.013
44	7/30/2010 7:31	27.513		64	7/30/2010 10:51	36.338
45	7/30/2010 7:41	29.997		65	7/30/2010 11:01	39.007
46	7/30/2010 7:51	33.607		66	7/30/2010 11:11	41.254
47	7/30/2010 8:01	36.914		67	7/30/2010 11:21	41.439
48	7/30/2010 8:11	39.384		68	7/30/2010 11:31	35.758
49	7/30/2010 8:21	41.81				
50	7/30/2010 8:31	39.947				
51	7/30/2010 8:41	34.198				
52	7/30/2010 8:51	28.762				
53	7/30/2010 9:01	28.762				
54	7/30/2010 9:11	32.018				
55	7/30/2010 9:21	35.564				
56	7/30/2010 9:31	38.44				
57	7/30/2010 9:41	40.696				
58	7/30/2010 9:51	42.179				
59	7/30/2010 10:01	37.297				
60	7/30/2010 10:11	31.617				

Table A-5: Temperature data complied for Opening Usage Test						
#	Time, GMT-04:00	Temp, °F				
1	8/3/2010 10:15	46.369		21	8/3/2010 13:35	41.994
2	8/3/2010 10:25	40.509		22	8/3/2010 13:45	44.013
3	8/3/2010 10:35	41.254		23	8/3/2010 13:55	44.379
4	8/3/2010 10:45	42.732		24	8/3/2010 14:05	40.134
5	8/3/2010 10:55	43.648		25	8/3/2010 14:15	41.625
6	8/3/2010 11:05	39.007		26	8/3/2010 14:25	43.466
7	8/3/2010 11:15	40.134		27	8/3/2010 14:35	44.922
8	8/3/2010 11:25	41.994		28	8/3/2010 14:45	40.696
9	8/3/2010 11:35	44.013		29	8/3/2010 14:55	41.254
10	8/3/2010 11:45	42.363		30	8/3/2010 15:05	43.099
11	8/3/2010 11:55	39.384		31	8/3/2010 15:15	44.922
12	8/3/2010 12:05	41.439		32	8/3/2010 15:25	41.625
13	8/3/2010 12:15	43.282		33	8/3/2010 15:35	41.067
14	8/3/2010 12:25	44.56		34	8/3/2010 15:45	43.099
15	8/3/2010 12:35	40.134		35	8/3/2010 15:55	45.104
16	8/3/2010 12:45	40.881		36	8/3/2010 16:05	42.363
17	8/3/2010 12:55	42.732		37	8/3/2010 16:15	40.881
18	8/3/2010 13:05	44.56		38	8/3/2010 16:25	43.099
19	8/3/2010 13:15	42.363		39	8/3/2010 16:35	45.104
20	8/3/2010 13:25	40.134		40	8/3/2010 16:45	42.915
41	8/3/2010 16:55	41.067		61	8/3/2010 20:15	40.881
42	8/3/2010 17:05	43.099		62	8/3/2010 20:25	41.625
43	8/3/2010 17:15	45.104		63	8/3/2010 20:35	43.648
44	8/3/2010 17:25	43.648		64	8/3/2010 20:45	45.286
45	8/3/2010 17:35	41.254		65	8/3/2010 20:55	41.81
46	8/3/2010 17:45	43.282		66	8/3/2010 21:05	41.439
47	8/3/2010 17:55	45.286		67	8/3/2010 21:15	43.466
48	8/3/2010 18:05	44.379		68	8/3/2010 21:25	45.286
49	8/3/2010 18:15	41.254		69	8/3/2010 21:35	42.732
50	8/3/2010 18:25	43.282		70	8/3/2010 21:45	40.881
51	8/3/2010 18:35	45.286		71	8/3/2010 21:55	42.915
52	8/3/2010 18:45	44.742		72	8/3/2010 22:05	44.742
53	8/3/2010 18:55	41.254		73	8/3/2010 22:15	44.195
54	8/3/2010 19:05	43.099				
55	8/3/2010 19:15	44.922				
56	8/3/2010 19:25	45.286				
57	8/3/2010 19:35	40.696				
58	8/3/2010 19:45	42.363				
59	8/3/2010 19:55	44.195				
60	8/3/2010 20:05	45.466				

Temperature Setting 2						
#	Time, GMT-04:00	Temp, °F				
1	8/4/2010 22:30	52.576		21	8/5/2010 1:50	40.881
2	8/4/2010 22:40	47.982		22	8/5/2010 2:00	41.254
3	8/4/2010 22:50	46.369		23	8/5/2010 2:10	43.466
4	8/4/2010 23:00	40.881		24	8/5/2010 2:20	45.104
5	8/4/2010 23:10	41.81		25	8/5/2010 2:30	41.254
6	8/4/2010 23:20	43.648		26	8/5/2010 2:40	41.067
7	8/4/2010 23:30	45.104		27	8/5/2010 2:50	43.282
8	8/4/2010 23:40	41.439		28	8/5/2010 3:00	45.104
9	8/4/2010 23:50	40.134		29	8/5/2010 3:10	41.439
10	8/5/2010 0:00	42.363		30	8/5/2010 3:20	40.696
11	8/5/2010 0:10	44.379		31	8/5/2010 3:30	42.915
12	8/5/2010 0:20	43.831		32	8/5/2010 3:40	44.922
13	8/5/2010 0:30	39.947		33	8/5/2010 3:50	41.994
14	8/5/2010 0:40	41.81		34	8/5/2010 4:00	40.509
15	8/5/2010 0:50	43.831		35	8/5/2010 4:10	42.732
16	8/5/2010 1:00	44.742		36	8/5/2010 4:20	44.742
17	8/5/2010 1:10	40.134		37	8/5/2010 4:30	42.915
18	8/5/2010 1:20	41.254		38	8/5/2010 4:40	40.321
19	8/5/2010 1:30	43.466		39	8/5/2010 4:50	42.363
20	8/5/2010 1:40	45.104		40	8/5/2010 5:00	44.379
41	8/5/2010 5:10	43.466		61	8/5/2010 8:30	43.648
42	8/5/2010 5:20	39.947		62	8/5/2010 8:40	44.922
43	8/5/2010 5:30	41.81		63	8/5/2010 8:50	40.509
44	8/5/2010 5:40	43.831		64	8/5/2010 9:00	41.067
45	8/5/2010 5:50	44.56		65	8/5/2010 9:10	43.099
46	8/5/2010 6:00	39.947		66	8/5/2010 9:20	44.922
47	8/5/2010 6:10	41.254		67	8/5/2010 9:30	41.439
48	8/5/2010 6:20	43.466		68	8/5/2010 9:40	40.321
49	8/5/2010 6:30	44.742		69	8/5/2010 9:50	42.363
50	8/5/2010 6:40	40.509		70	8/5/2010 10:00	44.379
51	8/5/2010 6:50	40.696		71	8/5/2010 10:10	43.099
52	8/5/2010 7:00	42.915		72	8/5/2010 10:20	39.76
53	8/5/2010 7:10	44.742		73	8/5/2010 10:30	41.81
54	8/5/2010 7:20	41.994				
55	8/5/2010 7:30	40.134				
56	8/5/2010 7:40	42.363				
57	8/5/2010 7:50	44.195				
58	8/5/2010 8:00	43.648				
59	8/5/2010 8:10	39.947				
60	8/5/2010 8:20	41.625				

Temperature Setting 3						
#	Time, GMT-04:00	Temp, °F				
1	8/6/2010 10:45	51.699		21	8/6/2010 14:05	42.548
2	8/6/2010 10:55	43.466		22	8/6/2010 14:15	44.56
3	8/6/2010 11:05	43.466		23	8/6/2010 14:25	46.008
4	8/6/2010 11:15	44.922		24	8/6/2010 14:35	41.81
5	8/6/2010 11:25	46.188		25	8/6/2010 14:45	41.81
6	8/6/2010 11:35	42.732		26	8/6/2010 14:55	44.013
7	8/6/2010 11:45	41.625		27	8/6/2010 15:05	46.008
8	8/6/2010 11:55	43.466		28	8/6/2010 15:15	43.466
9	8/6/2010 12:05	45.286		29	8/6/2010 15:25	41.439
10	8/6/2010 12:15	45.104		30	8/6/2010 15:35	43.648
11	8/6/2010 12:25	40.696		31	8/6/2010 15:45	45.648
12	8/6/2010 12:35	42.363		32	8/6/2010 15:55	45.286
13	8/6/2010 12:45	44.379		33	8/6/2010 16:05	41.254
14	8/6/2010 12:55	45.828		34	8/6/2010 16:15	43.099
15	8/6/2010 13:05	42.179		35	8/6/2010 16:25	45.286
16	8/6/2010 13:15	41.439		36	8/6/2010 16:35	46.188
17	8/6/2010 13:25	43.648		37	8/6/2010 16:45	41.81
18	8/6/2010 13:35	45.466		38	8/6/2010 16:55	42.363
19	8/6/2010 13:45	44.922		39	8/6/2010 17:05	44.195
20	8/6/2010 13:55	40.881		40	8/6/2010 17:15	46.008
41	8/6/2010 17:25	43.466		61	8/6/2010 20:45	40.881
42	8/6/2010 17:35	41.254		62	8/6/2010 20:55	42.732
43	8/6/2010 17:45	43.099		63	8/6/2010 21:05	44.379
44	8/6/2010 17:55	44.922		64	8/6/2010 21:15	44.922
45	8/6/2010 18:05	45.648		65	8/6/2010 21:25	40.509
46	8/6/2010 18:15	41.254		66	8/6/2010 21:35	41.067
47	8/6/2010 18:25	41.81		67	8/6/2010 21:45	42.915
48	8/6/2010 18:35	43.466		68	8/6/2010 21:55	44.56
49	8/6/2010 18:45	45.286		69	8/6/2010 22:05	44.195
50	8/6/2010 18:55	44.195		70	8/6/2010 22:15	40.134
51	8/6/2010 19:05	40.509		71	8/6/2010 22:25	41.439
52	8/6/2010 19:15	41.994		72	8/6/2010 22:35	43.282
53	8/6/2010 19:25	43.648		73	8/6/2010 22:45	44.922
54	8/6/2010 19:35	45.286				
55	8/6/2010 19:45	42.548				
56	8/6/2010 19:55	40.509				
57	8/6/2010 20:05	42.179				
58	8/6/2010 20:15	43.831				
59	8/6/2010 20:25	45.104				
60	8/6/2010 20:35	41.254				

Temperature Setting 4						
#	Time, GMT-04:00	Temp, °F				
1	8/7/2010 0:21	27.091		21	8/7/2010 3:41	36.531
2	8/7/2010 0:31	30.607		22	8/7/2010 3:51	39.196
3	8/7/2010 0:41	34.198		23	8/7/2010 4:01	41.625
4	8/7/2010 0:51	37.297		24	8/7/2010 4:11	39.573
5	8/7/2010 1:01	39.573		25	8/7/2010 4:21	33.805
6	8/7/2010 1:11	41.439		26	8/7/2010 4:31	28.762
7	8/7/2010 1:21	37.87		27	8/7/2010 4:41	26.881
8	8/7/2010 1:31	32.617		28	8/7/2010 4:51	29.997
9	8/7/2010 1:41	27.93		29	8/7/2010 5:01	34.002
10	8/7/2010 1:51	28.139		30	8/7/2010 5:11	37.297
11	8/7/2010 2:01	31.617		31	8/7/2010 5:21	39.76
12	8/7/2010 2:11	35.37		32	8/7/2010 5:31	41.625
13	8/7/2010 2:21	38.25		33	8/7/2010 5:41	38.818
14	8/7/2010 2:31	40.696		34	8/7/2010 5:51	33.013
15	8/7/2010 2:41	41.067		35	8/7/2010 6:01	28.139
16	8/7/2010 2:51	35.758		36	8/7/2010 6:11	28.555
17	8/7/2010 3:01	30.607		37	8/7/2010 6:21	32.218
18	8/7/2010 3:11	26.881		38	8/7/2010 6:31	35.758
19	8/7/2010 3:21	29.381		39	8/7/2010 6:41	38.629
20	8/7/2010 3:31	33.213		40	8/7/2010 6:51	40.881
41	8/7/2010 7:01	41.439		61	8/7/2010 10:21	27.513
42	8/7/2010 7:11	36.145		62	8/7/2010 10:31	29.381
43	8/7/2010 7:21	30.607		63	8/7/2010 10:41	33.013
44	8/7/2010 7:31	27.513		64	8/7/2010 10:51	36.338
45	8/7/2010 7:41	29.997		65	8/7/2010 11:01	39.007
46	8/7/2010 7:51	33.607		66	8/7/2010 11:11	41.254
47	8/7/2010 8:01	36.914		67	8/7/2010 11:21	41.439
48	8/7/2010 8:11	39.384		68	8/7/2010 11:31	35.758
49	8/7/2010 8:21	41.81				
50	8/7/2010 8:31	39.947				
51	8/7/2010 8:41	34.198				
52	8/7/2010 8:51	28.762				
53	8/7/2010 9:01	28.762				
54	8/7/2010 9:11	32.018				
55	8/7/2010 9:21	35.564				
56	8/7/2010 9:31	38.44				
57	8/7/2010 9:41	40.696				
58	8/7/2010 9:51	42.179				
59	8/7/2010 10:01	37.297				
60	8/7/2010 10:11	31.617				

Temperature Setting 5						
#	Time, GMT-04:00	Temp, °F				
1	8/2/2010 9:30	72.372		21	8/2/2010 12:50	35.951
2	8/2/2010 9:40	63.626		22	8/2/2010 13:00	38.818
3	8/2/2010 9:50	52.75		23	8/2/2010 13:10	37.679
4	8/2/2010 10:00	44.195		24	8/2/2010 13:20	32.815
5	8/2/2010 10:10	37.87		25	8/2/2010 13:30	28.139
6	8/2/2010 10:20	32.815		26	8/2/2010 13:40	24.528
7	8/2/2010 10:30	28.762		27	8/2/2010 13:50	24.093
8	8/2/2010 10:40	25.39		28	8/2/2010 14:00	28.348
9	8/2/2010 10:50	23.216		29	8/2/2010 14:10	32.617
10	8/2/2010 11:00	26.458		30	8/2/2010 14:20	36.145
11	8/2/2010 11:10	31.012		31	8/2/2010 14:30	39.007
12	8/2/2010 11:20	34.786		32	8/2/2010 14:40	41.625
13	8/2/2010 11:30	38.061		33	8/2/2010 14:50	39.196
14	8/2/2010 11:40	40.509		34	8/2/2010 15:00	33.213
15	8/2/2010 11:50	39.573		35	8/2/2010 15:10	28.348
16	8/2/2010 12:00	33.607		36	8/2/2010 15:20	24.744
17	8/2/2010 12:10	28.555		37	8/2/2010 15:30	26.67
18	8/2/2010 12:20	24.744		38	8/2/2010 15:40	34.198
19	8/2/2010 12:30	24.528		39	8/2/2010 15:50	37.488
20	8/2/2010 12:40	32.018		40	8/2/2010 16:00	39.76
41	8/2/2010 16:10	38.25		62	8/2/2010 19:40	24.31
42	8/2/2010 16:20	32.617		63	8/2/2010 19:50	25.819
43	8/2/2010 16:30	27.721		64	8/2/2010 20:00	29.997
44	8/2/2010 16:40	24.96		65	8/2/2010 20:10	34.002
45	8/2/2010 16:50	28.139		66	8/2/2010 20:20	37.107
46	8/2/2010 17:00	32.218		67	8/2/2010 20:30	39.573
47	8/2/2010 17:10	35.758		68	8/2/2010 20:40	41.81
48	8/2/2010 17:20	38.629		69	8/2/2010 20:50	41.067
49	8/2/2010 17:30	40.696		70	8/2/2010 21:00	35.37
50	8/2/2010 17:40	42.179		71	8/2/2010 21:10	29.997
51	8/2/2010 17:50	37.297		72	8/2/2010 21:20	26.033
52	8/2/2010 18:00	31.213		73	8/2/2010 21:30	23.437
53	8/2/2010 18:10	26.67				
54	8/2/2010 18:20	24.96				
55	8/2/2010 18:30	28.762				
56	8/2/2010 18:40	35.175				
57	8/2/2010 18:50	38.061				
58	8/2/2010 19:00	40.509				
59	8/2/2010 19:10	38.44				
60	8/2/2010 19:20	32.815				

Table A-6: Comparison Data used to make Figures 3-1 to 3-5

Control Test			-		Insulation Test
Temp (°F)	Energy (kWh)		Temp (°F)	Energy (kWh)	Efficiency Change
33.16	425.8		33.29	412	0.03240958
36.18	335.5		38.25	344	-0.0253353
39.33	309.5		40.38	282	0.08885299
39.16	301.5		41.99	260	0.13764511
39.27	292.5		40.31	256	0.12478632
Usage Tests (Loaded & Opening Tests)					
Temp (°F)	Energy (kWh)	Efficiency Change	Temp (°F)	Energy (kWh)	Efficiency Change
37.36	537	-0.261155472	34.66	531	-0.2470643
37.68	443	-0.320417288	38.76	423	-0.2608048
42.48	339	-0.095315024	43.53	309	0.00161551
42.24	319	-0.058043118	42.91	290	0.03814262
43.89	349	-0.193162393	42.76	308	-0.0529915
Environment / Circulation Test					
Temp (°F)	Energy (kWh)	Efficiency Change			
34.11	391	0.081728511			
37.38	323	0.037257824			
40.42	310	-0.001615509			
42.15	309	-0.024875622			
43.89	314	-0.073504274			

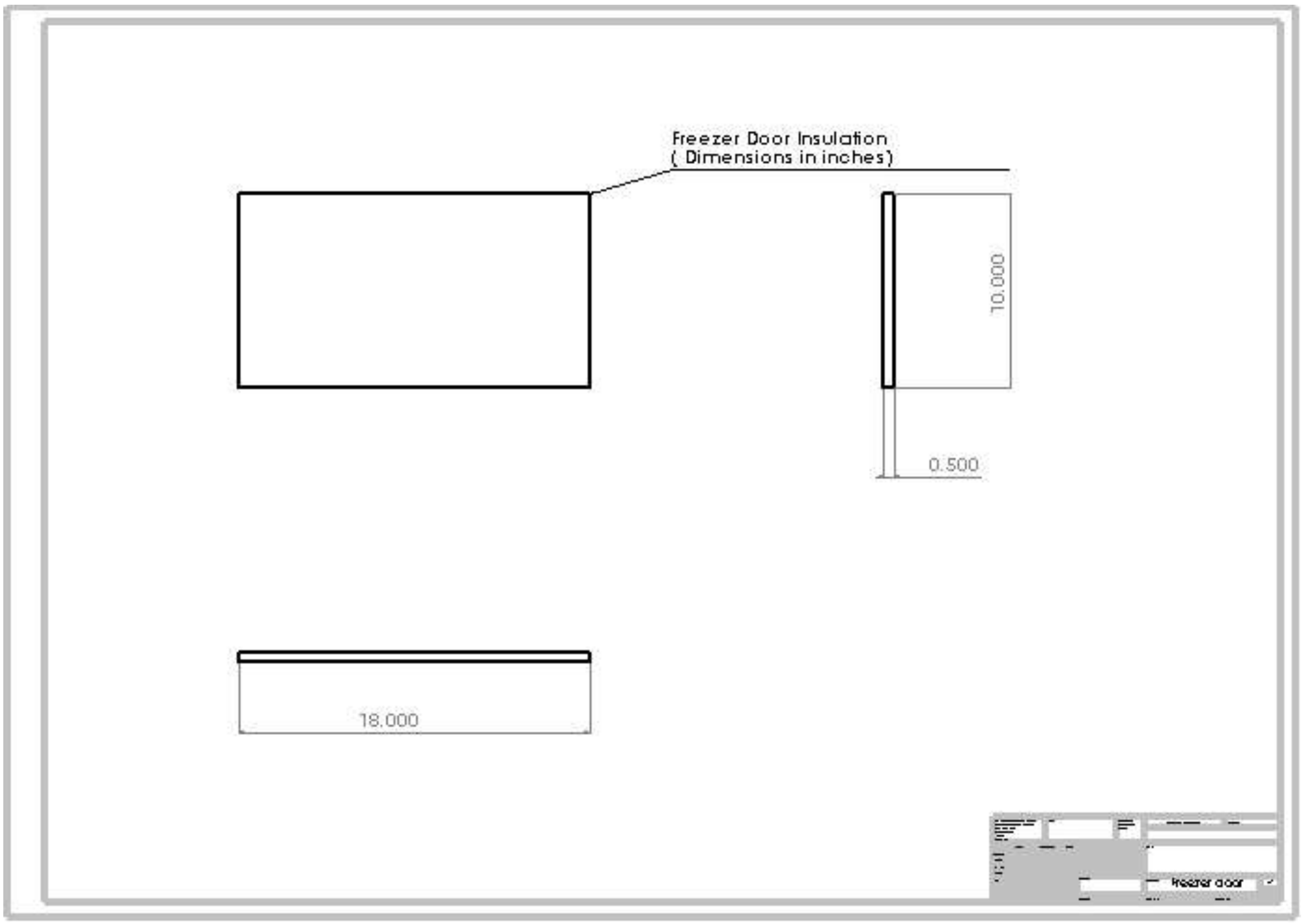

Figure A-1: Insulation Prototype freezer door schematics

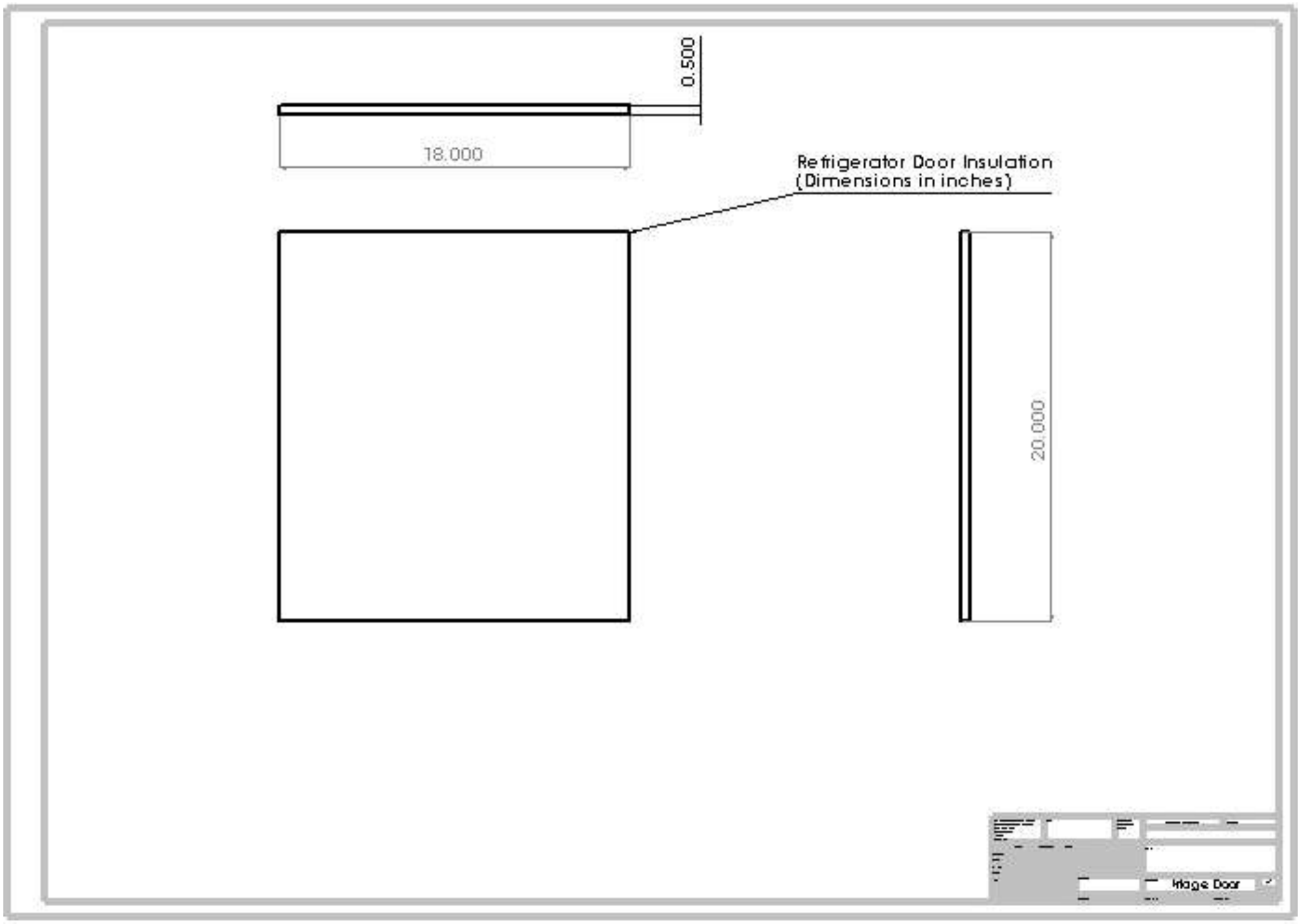

Figure A-2: Insulation Prototype fridge door schematics

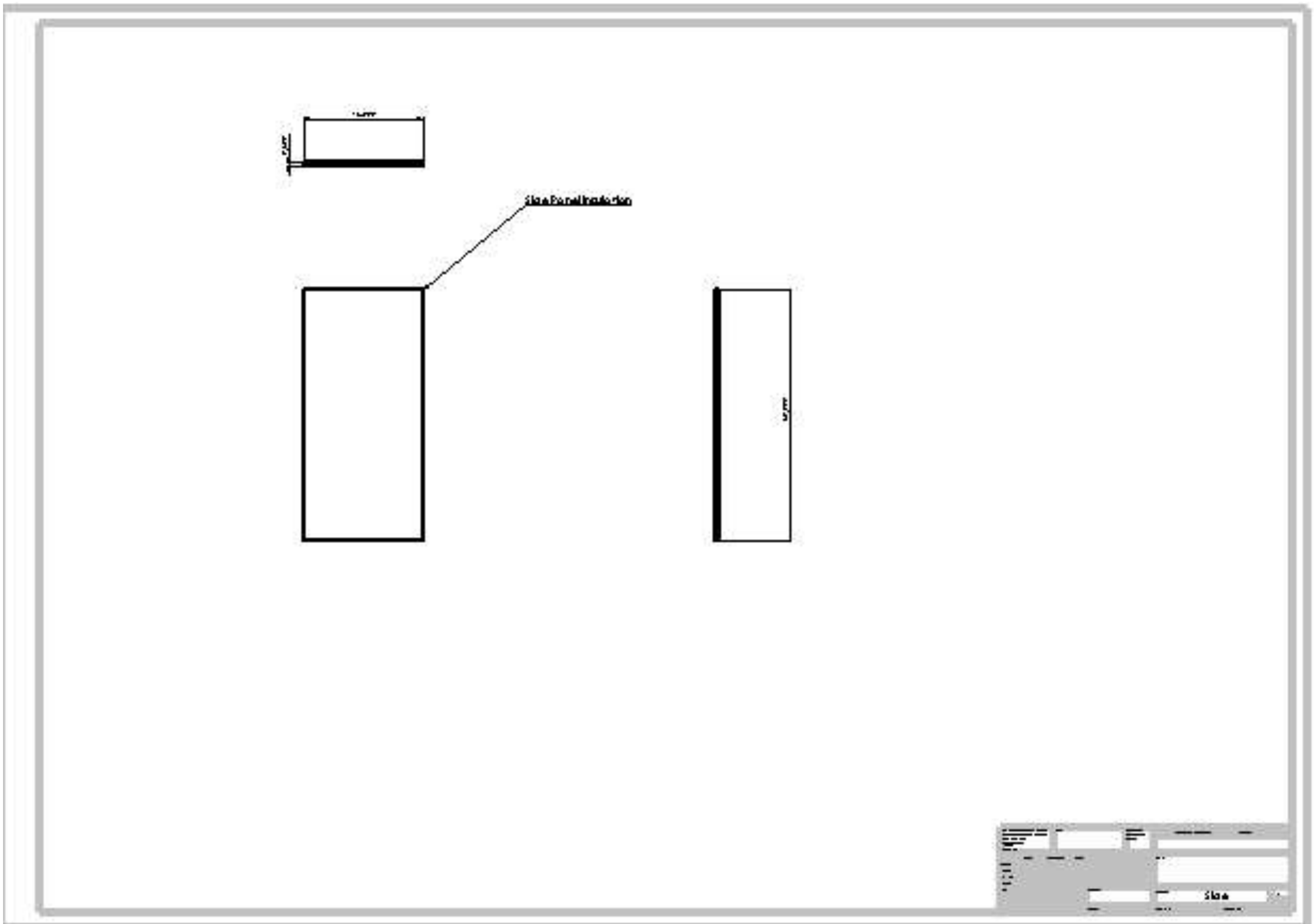

Figure A-3: Insulation Prototype side schematics

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Professional Experience

PENNTap Energy Assessment Team Intern

- Helped conduct energy usage investigations for local businesses
- Helped compose energy assessment reports

Research Experience (Focus in Alternative Energy)

Photovoltaic System Research

Dr. Wieslaw Grebski

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- Developed experiments to allow students to test and observe basic theories supporting photovoltaics

Geothermal Power Generation and Heating

Dr. Ljubisa Radovic

- Researched geothermal power and heat generation
- Composed findings detailing current systems and applications in detailed report

Research Interests

I have broad interests in alternative energy systems and their application in various industries to reduce current dependence on fossil fuels. Specifically, I am interested in redesigning current technology to improve efficiency and reduce power consumption. I have also conducted somewhat extensive research relating to current and developing alternative energy systems including photovoltaic or solar cells, wind turbines, and geothermal power generation and heating and cooling.