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DOE/CS/34145-1

EXPERIMENTAL INVESTIGATION OF THE TROMBE WALL

Final Report for Period October 1977—March 1979

MASTER

By
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May 15, 1979

Work Performed Under Contract No. EG-77-G-04-4145

Energy Engineering Group, Inc.
Golden, Colorado

U.S. Department of Energy

Solar Energy

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FINAL REPORT FOR PERIOD OCTOBER, 1977 TO MARCH, 1979

MAY 15, 1979

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DOE GRANT NO. EG-77-G-04-4145

This research has been supported by the Solar Heating and Cooling Research and Development Branch, Office of Conservation and Solar Applications, U.S. Department of Energy.

ACKNOWLEDGEMENT

The authors wish to express their appreciation to Dr. Frank Kreith at the Solar Energy Research Institute (formerly at the University of Colorado) for his ideas relating to the research performed in the project reported here. The genesis of this research was due to Dr. Kreith while at the University of Colorado, and was based on his discussions with French solar researchers during a visit to the Centre National de la Recherche Scientifique (CNRS) solar research facilities in Odeillo, France in 1976, under an invitation from the French government. Without Dr. Kreith's early suggestions and comments on passive solar research needs, this research would not have been performed.

Also, the authors wish to express their appreciation to Dr. Tom Borgers of the Humboldt State University Department of Chemistry. Dr. Borgers while on leave at the Lawrence Berkeley Labs was most generous in sharing the results of his and his colleagues' analytical investigations into the free convective flow processes of passive solar energy systems. Discussions between Dr. Borgers and the authors established a cooperative basis for sharing experimental and analytical results relating to the Trombe wall passive solar energy system.

ABSTRACT

A variable geometry test facility was constructed and an experimental program conducted to investigate the performance characteristics of the Trombe wall, passive solar heating system. The principal objective met in the research project was the determination of representative values of wall gap thermocirculation parameters for various wall geometries. Velocity and temperature profiles in the wall gap were obtained for 2, 4 and 6-inch gap widths. Maximum values for the Grashof number under measured flow conditions ranged approximately from 6×10^5 for the 2-inch gap to 1.5×10^7 for the 6-inch gap, indicating laminar flow and possibly the initiation of transitional flow regimes at the higher Grashof numbers. Turbulent flow behavior was not exhibited within the relatively broad range of test conditions studied in this research, conditions typical of one-story Trombe walls employing practical geometries.

A second objective accomplished in this research was the characterization of the Trombe wall thermal efficiency for a variety of operating conditions and wall geometries. Using data collected under essentially clear-sky conditions, collector efficiency curves similar to those commonly used to describe the performance of flat-plate solar collectors were developed for the Trombe wall. The efficiency plots were determined for 2, 4 and 6-inch gap widths using linear regression fits. These regression fits were sufficiently good to validate the applicability of this approach in describing Trombe wall performance.

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SECTION 1

INTRODUCTION

1.1 SURVEY OF RELATED RESEARCH

A substantial quantity of experimental and analytical results have been produced to date relating to the Trombe wall, or Trombe-Michel wall, passive solar energy system. These results have been due in large part to groups of researchers at the Centre National de la Recherche Scientifique (CNRS) in Odeillo, France, and at the Los Alamos Scientific Lab (LASL) in Los Alamos, New Mexico. In recent years, other researchers have addressed research areas associated with the Trombe wall.

Experimental data exists (1-7)* regarding the thermal performance of specific buildings and test facilities heated with Trombe wall systems. This type of information is of limited value to the designer or technical analyst, however, since it tends to be building and climate specific in nature. In addition, it is further limited as a design tool by being in a relatively unusable, raw data form.

Detailed experimental data defining the thermocirculation mechanism in the Trombe wall air gap is virtually nonexistent. Estimates of free convection thermal energy delivery have been made (2) using bulk velocity and temperature measurements in the wall inlet and outlet ducts, but with coarse estimates of accuracy placed at $\pm 25\%$.

Limited information is available in the literature regarding analytical models of Trombe wall performance. A number of thermal simulation (thermal network model) computer programs have been written (4-6, 8-11) for the analysis

* Numbers in parentheses refer to references listed at the end of the report.

of passively heated buildings. However, the descriptions of the thermal network models in the literature are generally lacking in sufficient detail to allow verification and reproduction of the methodology. This is particularly true with regards to the thermocirculation models.

A limited number of comparisons have been made to date between experimental data on overall building performance parameters and analytical thermal simulation predictions (4-7,12,13). However, it is not clear that these comparisons are made between test data and *independently* derived analytical results. It appears that some of the analytical models for the Trombe wall contain parameters that can be adjusted so that correlation can be obtained with the test data. These parameters then serve as crude correlation coefficients, but are strictly applicable only to the wall geometry in question.

Analytical development work related specifically to the thermocirculation phenomena in the Trombe wall air gap is being performed by a research group at the Lawrence Berkeley Lab (LBL) (14,25). The analytical approach being used is a fundamental mathematical formulation of the wall gap fluid mechanics and heat transfer processes. A numerical solution to the governing differential equations is made using finite difference techniques. This is a distinctly different approach than the thermal network type of models being developed elsewhere, where the fluid flow processes are not considered in detail or are modeled simply as a single volume. To date, the method has been developed sufficiently to model laminar flow regimes, although verification with experimental data is still needed. Transition and turbulent flow regimes pose a more difficult analytical problem and have not been solved to date. Preliminary comparisons of the analytical predictions of Akbari and Borgers (25) with limited data from this project are discussed in Section 3.

1.2 PROJECT RESEARCH

The research reported here is considered to be a first step in obtaining detailed and comprehensive experimental data on the thermocirculation behavior and overall collector efficiency of the Trombe wall. This type of information is essential to the development of accurate and comprehensive design procedures and analytical methods applicable to a variety of Trombe wall configurations.

The most critical need appeared to be thermocirculation data for vented Trombe wall geometries during periods of solar illumination. Therefore, the scope of this project was limited to this situation. Other geometric configurations and operational modes such as unvented geometries, the use of backdraft control on the wall ducts, the use of insulating panels or curtains, and operation of the wall during periods of no insolation were not considered in this research.

Extending the data base for the Trombe wall in areas where definitive information was lacking was considered the primary purpose of this experimental project. Specifically, research efforts were concentrated on investigating the free convection thermocirculation processes in the Trombe wall air gap. A second, significant effort was directed towards defining the overall Trombe wall thermal performance and the convective and conductive thermal energy transfer components of this performance. A certain amount of building performance data was collected, but this was not considered to be an important research need due to the extensive amount of data of this type collected elsewhere.

Hence, the experimental research presented here concentrated on obtaining velocity and temperature profiles in the wall gap and Trombe wall collector efficiencies for a variety of wall geometries. For this purpose, a specially designed test facility was constructed as part of the project. This facility allowed for variable wall gap widths and inlet/outlet duct geometries.

Preliminary data obtained in an early test series was reported elsewhere (15). The gap velocity and temperature profile data reported there was subsequently improved in great measure with a modification of both the velocity and temperature probes.

SECTION 2

DESCRIPTION OF EXPERIMENTAL FACILITY

2.1 TEST BUILDING

The Trombe wall test facility built under this grant is located in Idaho Springs, Colorado, on Clear Creek County School District property. In agreement with the school district, the test building will be turned over to the district upon completion of all research programs. The building will then be used as a science education facility by the high school and the student body.

The outside dimensions of the passive solar test facilities are approximately 14 feet long by 12 feet deep by 10 feet high. The interior room height is 97 inches. A sketch of the building exterior is presented in Figure 2.1, and a floor plan view is shown in Figure 2.2.

Architectural simplicity was emphasized in the building envelope design to provide a "clean" geometry for analytical modeling purposes. The tight construction was enhanced by allowing no windows and by incorporating an entrance vestibule.

The test building is basically a wood-frame structure on a concrete foundation. The wall structure consists of 2 x 8 plates, off-set 2 x 4 studs on 24-inch centers, 1/2-inch plywood exterior sheathing, and 1/2-inch gypsum interior wallboard. The floor is constructed of 2 x 10 joists on 12-inch centers with 3/4-inch plywood flooring and a linoleum covering. The roof is constructed of 2 x 12 joists on 16-inch centers, a 3-ply built-up roof, and a 1/2-inch gypsum wallboard. All walls, the roof, and the floor are insulated with cellulose which was blown in under pressure and is fairly tightly packed. The interior vestibule walls are standard 2 x 4 construction with gypsum wallboard and are uninsulated. The two doors used in the outer entryway and in the vestibule entryway are 3/4-inch hollow-core doors.

Front Elevation

Side Elevation

FIGURE 2.1 ELEVATION VIEWS OF EXPERIMENTAL TEST FACILITY

FIGURE 2:2 FLOOR PLAN OF TEST FACILITY

The Trombe wall consists of an 11 9/16-inch thick, solid concrete block wall with a movable, double-glazed, Kalwall cover unit. The movable feature of the cover panel design allows the air gap dimension to be varied from about 1 inch to approximately 8 inches. When the cover unit was secured in the desired position, a vinyl, bead-type insulation strip was stapled tight against the outer surface of the cover unit to prevent air infiltration. The general location of the Trombe wall and the relationship between the masonry and fiberglass cover panel are shown in Figure 2.2.

The masonry wall is 10 feet long, 86 inches high, and 11 9/16 inches thick. A 4-inch high gap between the top of the wall and the ceiling served as the outlet duct. The inlet duct was also 4 inches high and, because of a unique design, extended the full 10 foot length of the wall. The concrete blocks were 7 5/8 inches high, 11 9/16 inches thick, and 15 9/16 inches long. A sketch of the masonry wall is presented in Figure 2.3.

The movable glazing cover unit is 8 feet high and 10 feet long. Double-glazed, Kalwall Sun-Lite Premium II panels with a 1 1/2-inch internal air gap and an aluminum frame were used in the cover panel assembly. Two 4 foot by 8 foot panels and one 2 foot by 8 foot panel were fastened together in a lightweight, movable, aluminum frame.

The Kalwall material has an overall solar transmittance of 88% at a 0° incidence angle, and 73% at a 60° angle. The spectral transmissivity characteristics of Kalwall Sun-Lite Premium II are reported to be quite similar to those of glass.

The contents of the building have very little thermal storage capacity. The contents consisted of two lightweight director chairs, a wooden table, an extra concrete block, miscellaneous hardware and supply items, and a data logger.

FIGURE 2.3 SKETCH OF MASONRY WALL

2.2 INSTRUMENTATION

Instrumentation in the test facility consisted of the following items:

- 30 thermocouples implanted in the concrete wall at 10 locations,
- thermocouples on the inside surface of the Kalwall cover unit at 8 locations,
- 2 thermocouples measuring bulk air temperature in the inlet and outlet ducts,
- 4 thermocouples measuring inside room air temperature, crawl space air, and ambient air temperatures,
- 12 thermocouples measuring inside and outside surface temperatures on the building envelope,
- a combined velocity and temperature probe for measuring air velocity and temperature profiles in the wall air gap, and
- 2 pyranometers, with one mounted in the horizontal plane on the roof and one mounted in the vertical plane on the south wall of the building.

In this section, the instrumentation locations and the accuracy characteristics of the instruments are discussed briefly. The instrumentation location details are presented in Appendix A.

2.2.1 THERMOCOUPLES

All thermocouples used in this project were constructed of copper-constantan wire which was calibrated to special limits-of-error standards, that is, $\pm 3/4^{\circ}\text{F}$. The thermocouple wire was purchased from the Omega Engineering Company. Most of the thermocouples were made of 20 gage wire (0.032-inch diameter) which was covered with a double-jacketed, Teflon insulator. The exception was the thermocouple used to measure the air temperature in the flow channel. It was a magnesium oxide insulated, stainless steel sheathed thermocouple constructed of 34 gage wire (0.006-inch diameter).

The response time of the thermocouples used in the masonry wall, on the Kalwall surface, in the building envelope, in the room air, and in the outside air was

slow. However, since the temperature changes in these locations occurred slowly, the long time constant was not a problem. The time constant of the thermocouple used to monitor the air temperature in the gap is more critical and will be discussed later in this section.

Thermocouples - Masonry Wall

Nine concrete blocks were instrumented with thermocouples at various locations. Three of the blocks were "fully" instrumented and six were "partially" instrumented. The thermocouple locations in these nine blocks are described below.

The three fully instrumented blocks each had five thermocouple junctions located at staggered positions 0, 1, 3, 6, and 11 9/16 inches from the front (south) surface, and 2 inches from the top of the block. On the front and rear surfaces, grooves were chipped in the block and the thermocouple junctions were positioned flush with the surfaces. The thermocouple wires were placed in the grooves, and the grooves were then filled with cement. At interior points, 2-inch deep holes (1/8-inch diameter at the bottom) were drilled perpendicularly to the top surface. The thermocouples were positioned with the junctions at the bottom of these holes, and the holes were filled with cement. The thermocouple junction locations in the blocks are known to within $\pm 1/16$ inches. The thermocouple locations for the fully instrumented blocks are shown in Figure A.1 in Appendix A.

Thermocouple locations for the three different types of partially instrumented blocks are shown in Figures A.2-A.4. In those blocks, the thermocouples were installed in a similar manner as for the fully instrumented blocks, but fewer thermocouples were used in each block.

The instrumented blocks were located in the masonry wall at six elevations along the vertical centerplane and at two elevations on the east and west quarter-planes. A sketch of the masonry wall showing the relative location of the various

types of instrumented blocks is shown in Figure 2.4. The shade lines indicated on the figure are not strictly valid for the Kalwall cover because of its diffusive characteristics.

The actual positions of the thermocouple junctions in the masonry wall are summarized in Table A.1. The thermocouple locations are given relative to the floor of the test building, the front (south) surface of the masonry wall, and the east end of the masonry wall. The identification code used in Table A.1 is also discussed in Appendix A.

Thermocouples - Kalwall

Eight thermocouples were attached to the inner Kalwall surface, that is, the surface closest to the masonry wall. The thermocouple junctions were placed adjacent to the Kalwall surface and were then glued in place. These thermocouples were positioned approximately opposite the eight surface thermocouples on the masonry wall along the wall centerplane, and at approximately the east quarter-plane. The junction locations are summarized in Table A.2. The locations are given relative to the east end of the masonry wall and the floor of the test room.

Thermocouples - Building Envelope

Twelve thermocouples were located in the building envelope. Nine were located on interior and exterior wall surfaces as indicated in Figure A.5. These thermocouples were positioned at an elevation of 48 inches above the floor. The junctions were mounted flush with the interior and exterior surfaces, and the lead wires were buried in the walls to provide smooth wall surfaces. In addition, thermocouples were located on the floor, ceiling, and roof.

Thermocouples - Air

One thermocouple was located in the inlet opening and one in the outlet duct. These thermocouples were positioned at approximately the center of these ducts.

INSTRUMENTATION KEY:

△ Velocity/Temperature Probe Port

○ Thermocouple Locations (0",1",3",6",12") (Type 1 Block)

○ Thermocouple Locations (0",3",12") (Type 3 Block)

□ Thermocouple Locations (0",3") (Type 2 Block)

▽ Thermocouple Locations (0",12") (Type 4 Block)

Theoretical Shade Lines
on Masonry at Noon

FIGURE 2.4 CONCRETE BLOCK WALL VIEWED FROM BUILDING INTERIOR (LOOKING SOUTH)

The air temperature in the room interior was obtained at two locations. Thermocouples were installed approximately two feet from the north wall; one about one foot above the floor and the other about one foot below the ceiling.

One thermocouple was installed external to the building. It extended about 2 inches from the north wall. This thermocouple provided an ambient air temperature measurement. Another thermocouple was located in the crawl space beneath the floor.

Because of the low air velocities anticipated in the air flow channel, a fine-wire thermocouple (0.006-inch diameter) was chosen for the air gap temperature measurements. Even with such a fine-wire thermocouple, the amount of time required for the thermocouple to respond fully to a step change in temperature, at the velocities encountered in these experiments, ranged from about 5 seconds to 10's of seconds.

The air gap thermocouple was fastened to the velocity probe, which, in turn, was attached to a traverse mechanism. This setup allowed the thermocouple and the velocity probe to be moved simultaneously across the air gap between the masonry wall and the Kalwall cover along a horizontal axis. As a result, the air velocity and temperature measurements could be taken at the same positions in the flow channel. The manner in which the air gap thermocouple was attached to the velocity probe is shown schematically in Figure 2.5. Attachment of the traverse mechanism to the masonry wall is described in Section 2.2.2.

Epoxy cement was used to glue the thermocouple sheath to the velocity probe shield. The mid-point of the thermocouple junction was located in the same fore-aft position as the mid-point of the velocity sensor, that is, both mid-points are the same distance from the masonry surface. To minimize the impact on the flow field, the thermocouple junction was positioned slightly higher and to one side of the velocity sensor element. The two sensors were approximately 0.1 inch apart.

Front View

Top View

2-11

FIGURE 2.5 SCHEMATIC OF VELOCITY PROBE AND AIR GAP THERMOCOUPLE

The error in the measured air temperature can exceed the stated calibration limit of $\pm 3/4^{\circ}\text{F}$. This can occur if the thermocouple wires are exposed to large temperature gradients. A discussion of this conduction error phenomenon is presented in Section 3.2.2.

2.2.2 VELOCITY TRANSDUCER

The velocity profiles in the air gap were obtained with a Thermo-Systems, Inc. Model 1610 velocity transducer. The velocity sensor element is 0.016 inches in diameter and 0.10 inches long. The velocity is determined by calibration of the cooling effect of a moving air stream over the electrically heated sensor element. The probe was specially calibrated for low velocity flow conditions.

The standard version of the Model 1610 velocity probe supplied by the manufacturer is temperature compensated. The temperature compensation design was not appropriate for the flow conditions encountered in these experiments, however. Reasons why the design was not appropriate are discussed in the subsection "Maximum Velocity Magnitudes" in Section 3.2.1.

The temperature compensation winding was disconnected after preliminary testing was completed. The velocity transducer was then recalibrated at three different ambient air temperature levels. This set of calibration curves, along with the local air temperature obtained by the air gap thermocouple, allowed the velocity to be determined.

The accuracy of the velocity transducer is less than 5.3% for velocities exceeding about 0.3 ft/sec. The error becomes larger at lower velocities. It is stated to be $\pm 12\%$ at 0.1 ft/sec. At velocity magnitudes of 0.1 ft/sec and lower, free convection effects may become important with the error becoming proportionately larger with decreasing velocities.

According to the manufacturer, the time constant for the velocity transducer is approximately 0.1 seconds for a step change in velocity from 10 ft/sec to 100 ft/sec. For low flow velocities such as encountered in these experiments, the time constant is estimated to be on the order of 0.5 to 1.0 seconds. Of course, the total response time will be longer than this.

A traverse mechanism was used to position the velocity probe in the air gap. The base of the traverse mechanism was attached to the inside surface (room interior side) of the masonry wall. Threaded studs were positioned in the masonry wall during construction to allow the traverse mechanism to be positioned and aligned quickly. Nuts were threaded onto the studs to secure the base in place. The use of pre-positioned studs and threaded mountings allowed the velocity probe to be changed from one location on the wall to another in a few minutes. A sketch of the traverse mechanism and the way it is attached to the masonry wall is shown in Figure 2.6.

The velocity transducer was attached to the traverse mechanism with a collet. The probe extended horizontally through a port in the masonry wall in the air gap between the glazing and the masonry. A vernier scale on the traverse mechanism allowed the velocity sensor to be positioned to within 0.01 inches.

Velocity probe ports were located at seven positions in the masonry wall; five positions along the vertical centerplane, and two off-center locations. The seven velocity probe port locations are shown schematically in Figure 2.4 and are described in detail in Table A.3.

2.2.3 PYRANOMETERS

An Eppley Model 8-48 pyranometer was used to measure the insolation rate. The instrument could be mounted either horizontally on the roof or vertically

Top Section View

FIGURE 2.6 VELOCITY TRAVERSE MECHANISM AND VELOCITY PROBE ATTACHMENT

on the front surface of the test facility. In most of the tests it was mounted vertically near the top of the Kalwall cover panel and on the west side of the south wall. In this position, the pyranometer extended beyond the roofline and, consequently, was not shaded by the roof.

In some tests a second pyranometer (owned by Energy Engineering Group), a Hollis Laboratory Model MR-5, was located horizontally on the roof.

2.3 DATA ACQUISITION

Digitized data was recorded using a Monitor Labs Model 9300 data logger. The data logger could monitor up to 40 channels of information. The logger had the following features: signal averaging, dual scan rates, front panel programmable features, built-in thermocouple reference junction, units conversion (scaling) option, LED digital display monitoring, and printed paper output.

Data could be averaged over any practical time period using the signal averaging option. Unfortunately, only one averaging period could be used at a time. For instance, it was not possible to average data on one channel over a specific time interval and simultaneously average data on another channel over a different time interval. The manner in which the averaging feature was used during the tests is discussed more fully in Section 2.4.

2.4 TEST PROCEDURE

2.4.1 GAP VELOCITY AND TEMPERATURE PROFILE DATA

Gap profile data was typically taken over the period of an entire test day with the probe traverse mechanism mounted at one elevation on the masonry wall. An exception to this was multiple elevation data taken during one test day with the gap width set at six inches. This is discussed further in Section 3.2.1.

Simultaneous readings could not be taken with the velocity transducer and the thermocouple probe. Energizing the velocity transducer sensing element produced noticeable heating of the thermocouple junction. Therefore, the procedure in obtaining profiles was the following: (1) the probe was initially located such that the ends of the sensing element protecting arms were set against the Kalwall inside surface, with the velocity transducer energized, (2) two to five averaged readings were taken with the velocity transducer, (3) the velocity transducer power supply was turned off (de-energized), (4) two to five averaged readings were taken with the thermocouple probe, with the probe still at the same position as in step (2), (5) the velocity transducer was energized and the probe was moved to the next gap position, and (6) steps (2) and (5) were repeated as many times as required by the number of gap positions monitored.

Because of thermal bowing of the Kalwall cover unit with time during the course of a test period, the gap width would continuously change by small amounts. The cover unit would bow in towards the masonry wall during heat-up periods early in the day. As temperatures on the wall decreased later in the day, the cover unit would gradually return to its original position. This change in gap width was measured and recorded before each set of profile data was taken.

The "averaging" feature of the data logging equipment was programmed to sample three instantaneous values of velocity (or temperature) every ten seconds and to print the average values at the end of the ten-second period. Accurate profile data required two to six of these averaged values to be printed for each of the two probes at each gap position. This resulted in a total data taking time of 10 to 25 minutes to obtain a complete gap profile of both velocity and temperature. Relatively large gap widths, variable insolation rates caused by intermittent cloud cover, start-up wall gap conditions early in the morning, and rapidly decreasing insolation rates late in the afternoon all contributed to flow conditions that made steady profiles difficult, if not impossible, to obtain. The result of these kinds of conditions was a dramatic increase in the time required to obtain profile data.

2.4.2 INSULATION AND THERMOCOUPLE DATA

The data logging system used would allow two sets of monitored channels to be independently scanned at different rates, but the time-averaging function could be used with only one set of channels. The priority requirement was for the velocity and temperature probe output to be averaged. Therefore, data on these two channels was averaged and data on the remaining channels was not.

Since averaging the 38 channels of pyranometer and thermocouple data by hand would have posed a formidable data reduction problem, this data was taken as instantaneous values at intervals of 15 minutes. These values were automatically printed out on paper tape. The 15-minute time interval was considered to be close to the minimum allowable for accurate data analysis results (this is discussed in detail in Section 4).

SECTION 3

EXPERIMENTAL RESULTS

The major objective of the project was the determination of collector performance data for the Trombe wall solar collector. Toward meeting this goal, a set of experiments was established to determine both the thermocirculation behavior in the air gap and the amount of thermal energy storage in the masonry wall. Since the determination of the thermal energy storage quantity is relatively straightforward, the majority of the test program was devoted to obtaining detailed velocity and temperature data in the air gap. A series of experiments was performed in which the air gap width was varied, and the velocity and temperature probes were positioned at different elevations in the air gap.

In addition to the collector performance tests, several other types of experiments were performed during the project. Prior to the collector performance tests, several preliminary tests were run to determine the spatial and temporal characteristics of the temperature field in the concrete portion of the Trombe wall. Also, during a period when the velocity transducer was being rebuilt and recalibrated, an experiment was run to obtain overall building performance data for the test facility as an entity.

The preliminary masonry wall temperature distribution tests and the building performance test will be discussed only briefly. Since the major experimental objective was to investigate the thermocirculation behavior of the air in the gap, the majority of the discussion will be oriented to the presentation and interpretation of the detailed velocity and temperature profile data.

3.1 MASONRY WALL TEMPERATURE VARIATIONS

Several tests were run early in the test program to investigate the amount of temperature variations that could be expected throughout the masonry wall. Such information is necessary when the energy storage heat transfer process is analyzed.

Three-dimensional temperature distributions were obtained at different times during the day to determine both spatial and temporal variations. Examples of these results are shown in Figures 3.1-3.3 for clear-sky conditions existing on October 14, 1978.

Surface temperatures on the exterior centerline of the concrete wall are shown in Figure 3.1 for a 24-hour period. The temperature at the 13-inch elevation is relatively low because the lower part of the wall is cooled by the air entering from the test room. The 87-inch elevation is shaded by the roof overhang and, consequently, the temperature at that elevation is also low. Although the temperature level at the 46-inch elevation would be expected to be quite high, it is relatively low because of shading by a structural cross-member of the glazing panel frame.

Temperature distributions through the thickness of the masonry wall for the 79-inch elevation locations on the wall centerplane and at the approximate quarterplanes on the wall are shown in Figure 3.2. There is a significant difference in surface temperature from east to west, especially when the wall is heating up prior to mid-afternoon. Though not shown here because the data is less complete, this east-west effect is even more pronounced at the 30-inch elevation. The surface temperature contours shown in Figure 3.3 show the surface temperature variations more clearly.

FIGURE 3.1 CONCRETE WALL SURFACE TEMPERATURES
ON THE EXTERIOR CENTERLINE

October 14, 1978
2" Nominal Gap Width
Inlet/Outlet Vents 100% Open

Time = 1100 (MST)
October 14, 1978
2" Nominal Gap Width
Inlet/Outlet Vents 100% Open

FIGURE 3.3 MEASURED TEMPERATURE FIELD ON EXTERIOR SURFACE OF CONCRETE WALL

From Figures 3.1 through 3.3 it can be seen that the variation in temperature on the masonry wall outside surface can vary approximately 30°F to 40°F vertically and horizontally across the wall. The variations decrease through the thickness of the wall with the horizontal variation essentially vanishing at the inside surface. Some vertical variation in temperature at the inside surface still occurs due to stratification of the inside room air.

Several factors cause the temperature variations described above. A prominent factor is the shading caused by the building itself. Shading on the east portion of the wall caused by the window frame is significant early in the day. And, there is a geometric trapping of thermal energy in the west end of the window unit during the morning hours because of solar energy impinging directly on that end of the window frame. This thermal trapping effect is reversed in the afternoon hours causing east wall surface temperatures to rise noticeably above the west wall values. Another factor influencing the temperature distribution in the masonry is the convective flow process in the gap. Horizontal temperature distributions in the air at the lower levels become less pronounced at the higher elevations because of diffusive flow mechanisms. These flow field temperature distributions affect the masonry surface temperatures through the natural convection heat transfer process.

Based on the information obtained in these initial studies, the flow and heat transfer processes occurring in both the air and masonry wall along the centerplane can be considered to be two-dimensional in nature. Consequently, data collected along the vertical centerplane can be used to investigate the behavior of a very long Trombe wall system which is uniformly illuminated. The data collected along the centerplane in this project is used in this manner.

It is also apparent that three-dimensional flow and heat transfer processes exist over portions of any real Trombe wall system. Although the shading in this test facility is abnormally great because of the unusually large setback of the masonry wall (required to accommodate the movable glazing panel), all Trombe wall collector designs will result in three-dimensional flow and heat transfer processes to some degree. Also, Trombe wall systems in which the inlet and outlet ducts do not extend along the entire length of the wall will experience even more pronounced three-dimensional effects. Any practical design of Trombe wall systems should consider the three-dimensional nature of the heat transfer processes in both the air gap and the masonry wall.

3.2 WALL PERFORMANCE TESTS

During the wall performance tests, velocity and temperature data were obtained in the air gap. Simultaneously, temperature information was obtained in the masonry wall. During a given test, velocity and temperature profile data was obtained at a given elevation while temperature data was obtained at a number of different elevations along the vertical centerplane of the wall, both in the masonry and on the inside surface of the Kalwall. The results of these experiments are discussed in this section.

3.2.1 AIR VELOCITY PROFILES

Generally, the results of these experiments show that the natural convection flow processes occurring in the air gap are fairly complex. The velocity profile shapes are a function of the gap width, the ambient air temperature, the insolation rate, the masonry surface temperature, and the elevation above the Trombe wall inlet duct. The average velocity is largest in the narrow gap and smallest in the wide gap as would be expected. Significant entrance effects were observed at the lower elevation in the wide gap. The data shows flow patterns developing during the day and in the vertical dimension of the channel. The natural convective flow processes are generally laminar in nature, although the flow in the wider gaps may be approaching a transitional nature.

Profile Shapes

Velocity profiles are shown in Figures 3.4-3.9 for representative tests run in the 2, 4, and 6-inch wide channels at both the 24 and 73-inch elevations. Five profiles are presented for each test. Profiles are generally presented for times early and late in the test and at the time when the maximum velocities occurred.

During the month of February, 1979 when most of the data was collected, the sun illuminated the Trombe wall at approximately 830^{*} in the morning. The velocity

* Astronomical times are used throughout this report. For instance, 830 means 8:30 A.M. and 1300 means 1:00 P.M. civil time.

FIGURE 3.4 VELOCITY PROFILE IN 2-INCH GAP
AT 24-INCH ELEVATION

TEST NO. GAP01-2-100

January 24, 1979

Nominal Gap = 2 inches

Elevation = 24 inches

Intermittent Cumulus & Cirrus

FIGURE 3.5 VELOCITY PROFILE IN 2-INCH GAP
AT 73-INCH ELEVATION

TEST NO. GAP03-2-100

February 5, 1979

Nominal Gap = 2 inches

Elevation = 73 inches

Clear to Light Cirrus

FIGURE 3.6 VELOCITY PROFILE IN 4-INCH GAP
AT 24-INCH ELEVATION

TEST NO. GAP06-4-100

February 15, 1979

Nominal Gap = 4 inches

Elevation = 24 inches

Very Light Haze

FIGURE 3.7 VELOCITY PROFILE IN 4-INCH GAP
AT 73-INCH ELEVATION

TEST NO. GAP05-4-100

February 14, 1979

Nominal Gap = 4 inches

Elevation = 73 inches

Light Haze to Intermittent Cirrus

FIGURE 3.8 VELOCITY PROFILE IN 6-INCH GAP
AT 24-INCH ELEVATION

TEST NO. GAP08-6-100

February 19, 1979

Nominal Gap = 6 inches

Elevation = 24 inches

Cirrus to Clear

FIGURE 3.9 VELOCITY PROFILE IN 6-INCH GAP
AT 73-INCH ELEVATION

TEST NO. GAP10-6-100

February 24, 1979

Nominal Gap = 6 inches

Elevation = 73 inches

Intermittent Cirrus & Cumulus

profiles were reasonably well established within about one hour and then the magnitude of the velocity values increased until early afternoon. The maximum velocity values occurred at approximately 1300 hours under clear-sky conditions, the exact time being a function of parameters such as collector surface temperature, ambient air temperature, and initial temperature levels in the masonry wall. The maximum velocity values generally occurred about one hour before the maximum air gap temperatures were attained. The magnitude of the velocities remained relatively constant over roughly a four hour period from 1100 to 1500 hours. In all cases, the velocity values had decreased significantly by 1600 hours. After the sun no longer illuminated the test building (approximately 1630 hours), the velocity values were extremely small, and it was impossible to obtain accurate values with the instrumentation available.

There are distinctly different flow patterns in the narrow and wide channels. In the 2-inch gap (aspect ratio = wall height to gap width ratio ≈ 43), the velocity profile is generally convex in shape. The velocity profile is not symmetric, but is skewed, with the higher velocity occurring near the hotter masonry surface. At the lower elevation, the profile is relatively flat over the outer one-half of the channel, and is sharply peaked near the masonry surface. At the higher elevations, the profile is more fully developed, but is still skewed toward the masonry wall.

In the 6-inch wide channel (aspect ratio ≈ 14), the flow pattern is definitely characteristic of a double boundary layer flow. In this geometry, a velocity profile is developing adjacent to each heated surface. The profile is still relatively flat at the 24-inch elevation, but convex humps already exist near each surface. At this elevation, the velocity is larger near the Kalwall surface because of a turning flow entrance effect (a discussion of this phenomenon appears later in this section). At the higher elevations, the convex peaks near the boundaries are larger as the velocity profile develops further.

The 4-inch wide channel appears to be a transitional geometry with the velocity profiles exhibiting characteristics of both the narrower and the wider gap flow patterns. Early in the day, before about 1100 hours, the flow pattern in the 4-inch channel is similar to that in the 2-inch gap. Then, as the boundary temperatures increase considerably after mid-morning, the flow pattern changes to the double boundary layer pattern existing in the 6-inch gap. The peaks in the velocity profile near the surfaces are not as pronounced as they are in the 6-inch gap, however, and the core region is also narrower.

The velocity data clearly indicates a transition to more fully developed profiles as the elevation increases. This can be seen by comparing velocity profile shapes for the 24-inch elevation with those for the 73-inch elevation at a particular gap width. For instance, Figures 3.6 and 3.7 show this phenomenon for the 4-inch gap width.

A separate series of tests was run in the 6-inch gap to investigate the flow development process more fully. The results are shown in Figure 3.10. Two profiles were obtained at the 73-inch elevation, one early in the afternoon and one in mid-afternoon. Several other profiles were obtained between these times at the 24, 40, and 56-inch elevations. The data indicates a continuous shift in profile shape from the low elevation to the high one. In this case, the velocity is maximum near the Kalwall cover plate at the low elevation because of the entrance effect. Then the flow pattern develops into a more pronounced double boundary layer shape with the largest velocity peak occurring near the hotter masonry surface.

It does not appear that the velocity profile ever develops fully in the 6-inch gap. This is indicated by the change in velocity profile shape between the 56 and 73-inch elevations. This is not surprising because the height to gap width ratio, that is, the aspect ratio, is only 12 at the upper elevation.

FIGURE 3.10 VELOCITY PROFILE IN 6-INCH GAP
AT SEVERAL ELEVATIONS

TEST NOS. GAP11-6-100, GAP12-6-100
GAP13-6-100, GAP14-6-100

February 28, 1979

Nominal Gap = 6 inches

Light Cirrus & Inter. Cumulus

Most flow processes require longer distances to develop fully. It is possible that velocity profiles may have been fully developed at the upper elevation in the 2-inch gap, but time did not permit a series of experiments to investigate the flow development pattern in the narrower gaps.

The velocity profiles remain relatively constant in shape and magnitude until approximately 1500 hours under clear-sky conditions. Then as the insolation rate begins to decrease noticeably, the masonry surface temperature drops. The Kalwall surface temperature decreases more rapidly than the masonry surface temperature because of decreased radiant heat transfer from the masonry wall and because of increased energy losses to the outside air. The result is a degradation in velocity profiles, particularly after 1600 hours. In the 2-inch gap, the profile becomes quite flat, similar in shape to a forced convection, turbulent velocity profile in a tube. In the 4 and 6-inch channels the profiles change shape and appear more typical of a natural convection velocity profile adjacent to a single, vertical, heated wall. Since the masonry wall is still quite warm, the velocity profile maintains a sharp peak near the masonry wall. The magnitude is significantly lower than it had been earlier in the day, however. The velocity peak near the Kalwall has disappeared, and the flow rate in the outer half of the channel is very low, approximately zero in some cases. This behavior can be seen in Figures 3.6, 3.7, and 3.9.

Since it was difficult to obtain clear-sky conditions throughout an entire day, a number of the tests were run under intermittent cloud cover conditions. During such periods, the masonry surface temperatures dropped as would be expected, and the velocities decreased accordingly. An example of this behavior can be seen in Figure 3.8 at 1040 hours when the velocity values were lower than those at the earlier time.

Intermittent cloud cover conditions resulted in fairly unsteady flow conditions. Data collected during periods of intermittent cloud cover frequently had

to be discarded because of this unsteady behavior. It appears that reliable collector performance data for Trombe walls should be collected under clear-sky conditions and, therefore, steady flow conditions. While it seems reasonable to assume that this clear-sky data can also be used for design purposes under intermittent cloud cover conditions (assuming appropriate average insolation rates are used), this assumption has not been verified.

An initial investigation indicates that most of the flow regimes encountered during this project were laminar in nature. However, it is difficult to draw final conclusions regarding all the flow regimes because a critical Grashof number for the transition from laminar to turbulent flow in vertical, heated, open channel flows has not been well established.

Some analytical and experimental results regarding natural convection processes along vertical plates and in open channels and enclosures are available in the literature. The critical Grashof number for the simplest case, a single, vertical, heated plate, appears to be about 10^9 (16,17). In vertical, heated enclosures, laminar flow exists below Grashof numbers of 10^6 and turbulent flow probably exists for Grashof numbers greater than 10^7 (18,19,20). Unfortunately, there is not much information available regarding the critical Grashof number in a vertical, heated, open channel. It seems reasonable to assume, however, that the critical Grashof number lies somewhere between 10^7 and 10^9 , the critical values for the bounding cases of the single plate and the enclosure flow cases.

In the 2-inch gap tests the maximum Grashof number was on the order of 6×10^5 . According to the best available information, the flow field is laminar for these conditions. It is possible that in the 6-inch channel the flow may be transitional in nature because the maximum Grashof numbers attained in those tests were about 1.5×10^7 .

The developing flow and fully developed flow processes in a vertical, heated, open channel have been studied analytically by a number of authors. Many of these studies do not appear to be applicable to the Trombe wall system considered in this project, however, because the range of parameters considered in the studies were atypical of those encountered during these tests. For instance, studies by Engel and Mueller (21), Currie and Newman (22), and Aung, Fletcher, and Sernas (23) considered very low Rayleigh number flow situations and, therefore, the results of those studies are not applicable to this research. A sagging flow velocity profile, such as observed in this project in the wider gaps, was not predicted by any of those studies.

Savkar (24) did predict double boundary layer velocity profile shapes for relatively low values of the Rayleigh number and for constant heat flux wall conditions. A very limited set of results was presented. The parameters used in that study were considerably different than those encountered in the present set of experiments, and consequently, the results are not applicable.

The most applicable analytical study to date is that of Akbari and Borgers (25). That study predicted the general trends of the measured velocity profiles, including the double boundary layer behavior. Preliminary comparisons of the experimental data with the analytical results of Akbari and Borgers show qualitative agreement in some cases, but not all. It was difficult to obtain a thorough quantitative check because the velocity profiles shown in that reference were computed for a set of dimensionless parameter values that were different than those obtained in the present experiments. In the few cases where a quantitative comparison was possible, the predicted velocity values were within about 20% of the experimental ones. The fact that the study of Akbari and Borgers predicts the general trends of the velocity profiles, and also appears to estimate reasonably the magnitudes of the velocity, suggest that the pertinent physical phenomena are being considered in the analytical model.

In addition, in a conversation with one of the authors of Reference (25)^{*}, it was learned that the Lawrence Berkeley Laboratory analysis was predicting laminar flow behavior for the test conditions and geometries of this experimental project. This essentially has been confirmed with the data from the tests runs in this project. Even a doubling of flow velocity and an increase in gap width in relation to the test conditions reported here would probably not produce turbulent flow behavior. A transitional flow regime might be encountered, however.

Consistency and Uncertainty

The velocity profiles appear to be reasonably consistent in shape and magnitude, although unsteady velocity transducer readings were experienced at times. Start-up flow conditions occurring early in the day, rapidly changing insolation rates, and loss of wall illumination late in the day all caused velocity transducer readings indicative of pulsating or unsteady flow.

Some questionable velocity data was obtained, particularly when the velocity readings were below about 0.3 ft/sec. For instance, in some cases the velocity values do not increase monotonically and/or smoothly from the Kalwall as would be expected. It is possible that in some of these instances the velocity transducer was being used beyond its capabilities (see Section 2.2.2).

It was more difficult to obtain data in the 6-inch gap than in the narrower channels. In the 6-inch gap tests the velocity values were generally less than 1 ft/sec. At these low velocity values the response times of the velocity transducer is relatively long (on the order of seconds), and it took longer to obtain valid data. Also, at times it appeared that low frequency flow pulsations were occurring, particularly in the center of the channel.

Maximum Velocity Magnitudes

The maximum air velocity attained in any of the tests was 2.0 ft/sec. This value was achieved in the 2-inch wide gap. Generally, the maximum velocity value

* Telephone conversation with Dr. Borgers early in the project period.

observed decreased as the gap width increased. A summary of the maximum values, both point values and averages, obtained for each gap width is presented in Table 3.1.

TABLE 3.1
MAXIMUM VELOCITY VALUES VERSUS GAP WIDTH

Nominal Gap Width	Maximum Point Velocity	Maximum Average Velocity
in	ft/sec	ft/sec
2	2.0	1.4
4	1.5	1.1
6	1.3	0.7

The maximum velocity values in the 2 and 4-inch wide channels were obtained during times when the masonry surface temperatures were 150-160°F. These temperatures occurred under clear-sky conditions and, consequently, the velocity values are probably the maximum attainable in this test facility. However, the velocity values shown for the 6-inch gap may not be the maximum possible because the masonry surface temperatures were lower, about 130°F. The lower temperatures in these tests were due to intermittent cloud cover conditions during portions of the tests, and to lower starting gap inlet temperatures.

Preliminary velocity tests in the 2-inch gap taken in October, 1978, indicated maximum velocity magnitudes of approximately 3.5 ft/sec (15). Those tests were performed with a temperature compensated velocity probe. The 0.25-inch long temperature compensation winding was located between 0.40 and 0.65 inches from the mid-point of the velocity sensing resistor. Since the velocity probe was exposed to large temperature gradients in the air gap and inside the masonry wall, the temperature compensation winding was exposed to a different temperature

than the velocity transducer element. In addition, the temperature compensation winding itself was often exposed to a significant temperature gradient. Consequently the velocity data obtained with the temperature compensated probe was in error.

To eliminate this problem, the probe was returned to the manufacturer and the temperature compensation winding was disconnected. The probe was then calibrated at three different ambient temperature levels.

Entrance Effects

The entrance geometry will influence the flow and heat transfer processes occurring in any channel flow situation. Consequently, it is desirable to have some understanding of this phenomenon for the particular test facility being used. A brief discussion is presented below regarding the entrance effects for the test facility used in this project.

The air enters the Trombe wall horizontally from the room near the floor and then turns upward in the vertical flow channel. A two-dimensional flow process is established near the vertical centerplane of the wall. In the inlet portion of the vertical channel, the velocity is higher near the Kalwall than it is near the masonry because of turning flow inertial acceleration forces. Then, as the air flows upward, these two-dimensional effects are dissipated and a primarily one-dimensional flow pattern is established.

In a narrow channel such as the 2-inch gap, the two-dimensional effects should be dissipated quickly. Figure 3.4 indicates that this had indeed happened. At the 24-inch elevation, which is 17 inches above the top of the inlet duct (≈ 8 length-to-gap width ratios from the inlet), the velocity profile is quite flat in the outer half of the channel indicating that any turning flow effects have been dissipated. The sharp peak near the masonry surface indicates that a

boundary layer has already developed near the wall and has grown over a considerable fraction of the channel width.

In the intermediate 4-inch gap width, the velocity is relatively uniform at the 24-inch elevation (l/d above inlet ≈ 5), although the double boundary layer growth pattern is beginning to develop. This is shown in Figure 3.6. The velocity near the Kalwall is not larger than that near the masonry, however, which indicates that the entrance effects have been smoothed out.

The two-dimensional, turning flow effects are quite apparent in the 6-inch channel at the 24-inch elevation (l/d above inlet ≈ 3). The velocity profiles for this case are shown in Figure 3.8.

Considering the results discussed above, it appears that the inlet effects are dissipated in a distance equal to approximately five times the gap width. For the 2-inch channel, the entrance effects, therefore, exist over about one-tenth of the channel length and should be negligible. In the 6-inch gap, the entrance effects exist over about one-third of the wall height and, consequently, are important.

3.2.2 AIR TEMPERATURE PROFILES

The temperature profiles in the Trombe wall air gap are generally concave as would be anticipated in a natural convection process between two vertical, heated, parallel plates. The profile shapes develop soon after insolation begins. They do not change shape significantly during the day, but the temperature level increases as the wall temperature increases and as the inlet temperature increases.

Profile Shapes

The temperature profiles are concave except when the Kalwall temperature is decreasing due to a loss of insolation or to a rapidly decreasing ambient air

temperature. Temperature profiles are presented in Figures 3.11-3.16 for the same tests that were discussed in Section 3.2.1.

The temperature profiles are relatively flat in the center of the 4 and 6-inch channels. Near the masonry surface, the temperature increases from the value in the core to the level at the masonry surface in a distance of approximately 1 inch. Near the Kalwall, the temperature rise occurs over a distance of about 1/2 inch. This behavior indicates the existence of boundary layers developing along both heated walls.

There appears to be a slightly modified profile shape at the 73-inch elevation in the 6-inch gap. The temperature profiles are slightly convex in the outer half of the channel. This behavior is shown in Figure 3.16. The reason for the behavior is not clear.

The study of Akbari and Borgers (25), which was discussed in Section 3.2.1, also predicted temperature distributions in the flow channel. Whereas the results of that study predict the general trends of the velocity data, they do not predict the temperature distributions as well. The experimental temperature data is consistently underestimated by the analytical predictions, particularly in the central core of the 4 and 6-inch wide channels. However, the comparisons between the test results produced in this research and the temperature prediction analysis of Reference (25) is preliminary. Further collaboration with the authors of the above cited report regarding analytical and experimental comparisons is anticipated.

Maximum Bulk Air Temperatures

The temperature levels in the air gap generally attained maximum values around 1400 hours. This coincided with the time of peak masonry surface temperatures.

FIGURE 3.11 TEMPERATURE PROFILE IN 2-INCH GAP AT 24-INCH ELEVATION

FIGURE 3.12 TEMPERATURE PROFILE IN 2-INCH GAP AT 73-INCH ELEVATION

FIGURE 3.13 TEMPERATURE PROFILE IN 4-INCH GAP AT 24-INCH ELEVATION

FIGURE 3.14 TEMPERATURE PROFILE IN 4-INCH GAP AT 73-INCH ELEVATION

FIGURE 3.15 TEMPERATURE PROFILE IN 6-INCH GAP AT 24-INCH ELEVATION

FIGURE 3.16 TEMPERATURE PROFILE IN 6-INCH GAP AT 73-INCH ELEVATION

The maximum bulk temperature values in the air gap are strongly dependent upon the insolation rate and inlet air temperature, and to a lesser extent, on gap width, masonry wall temperature at the start of the test, and the ambient air temperature. The maximum average, bulk air temperature attained in any test was 126°F in test number GAP5-4-100. The ambient temperature was quite high during this test, over 60°F and, consequently, the inlet air temperature was also high, about 94°F. The maximum bulk air temperature at the 73-inch elevation normally ran about 30°F higher than the inlet air temperature under clear-sky conditions.

Thermocouple Errors

The thermocouple used to monitor the air gap temperature was calibrated to special limits-of-error standards, that is, $\pm 3/4^\circ\text{F}$. The indicated temperature, however, can be in error by more than this amount. This can occur when the thermocouple leads are exposed to a large temperature gradient. The resulting conduction in the leads can cause noticeable instrumentation errors.

Near the masonry wall surface the thermocouple leads are exposed to variable, non-uniform temperature fields in the air and inside the probe port in the masonry wall. When the thermocouple junction is within 1 to 1/4 inch of the masonry surface, the temperature in the thermocouple leads increases progressively back to the masonry surface (where the air and masonry temperatures are generally maximum), and then decreases inside the masonry wall probe port. In this case, the indicated temperature reading will be higher than the true value. The temperature field inside the masonry wall is, of course, variable depending upon the initial conditions, time of day, ambient air temperature, cloud cover patterns, etc. Under these variable conditions, the magnitude of the conduction error would be extremely difficult to estimate. When the thermocouple junction is very close to the masonry surface, the temperature continuously decreases

along the leads from the junction inward towards the room interior. In this case, the indicated temperature reading will be lower than the true value. This effect can be seen in Figures 3.11-3.16.

The conduction error can also explain an apparent anomaly in the data near the Kalwall surface at times when the Kalwall temperature is dropping rapidly and is below the temperature level in the core of the channel. This condition can occur late in the day or even at mid-day during periods of cloud cover. In this situation, the thermocouple is exposed to a large temperature gradient near the Kalwall which results in temperature readings higher than the true values. The measured air gap temperature data indicates a local peak in the profile near the Kalwall surface, although a smooth, monotonically increasing temperature distribution from the Kalwall to the core region would be expected. This anomalous behavior can be explained qualitatively by the previous conduction error discussion. The false peak in the temperature profile can be seen clearly in Figure 3.13 at 1553 hours and is evident in most of the temperature profile figures.

Fortunately, most of the air gap temperature data obtained in these experiments should have been only negligibly affected by conduction errors. The overall impact should be relatively minor where the error did not occur since the regions affected were small. The temperature errors affect the bulk air temperature values only slightly. Also, they impact the average velocity values in a minor way through the calibration curves.

3.2.3 BULK AIR TEMPERATURE INCREASES

During the peak heating periods of the day, the net increase in bulk air temperature from the inlet duct to the outlet duct was on the order of 14-20°F.

The maximum observed temperature difference was about 22°F in a 2-inch gap test. Generally, the air temperature rise in the 2-inch gap was around 20°F. In the 4 and 6-inch channels, the bulk air temperature increases between the ducts typically ranged from about 14°F to 17°F, with no definite trend indicating which gap width would result in the largest temperature change. The overall temperature changes depend on numerous operating parameters, and an insufficient amount of data was obtained to establish systematic design information.

In Section 3.2.2 it was stated that the bulk air temperature at the 73-inch elevation typically exceeded the inlet air temperature by up to 30°F. Yet, in this section the overall temperature change between the inlet and outlet ducts is said to be on the order of 20°F. This apparent inconsistency is explained by the fact that there is energy transferred from the air to the masonry at the top of the wall. The masonry at the top of the wall is shaded by the roof overhang, and is cooler than the masonry below which is illuminated. The result is a decrease in air temperature from the top of the illuminated portion of the wall to the outlet duct.

3.2.4 MASONRY WALL TEMPERATURES

Masonry wall temperature data was obtained at six different elevations during the wall performance tests. At two elevations, temperatures were measured at five positions through the wall. At the other locations, temperatures were measured at fewer positions. The positions of the thermocouple locations used in these tests are given in Section 2.

The temperatures in the masonry were generally monitored at 15-minute intervals. The data was representative of typical thermal conduction data. Since the emphasis in this study is on the thermocirculation behavior in the air gap, the masonry wall temperature distribution data is not discussed except

in Section 4.2 in the context of thermal energy storage in the masonry wall.

Although detailed temperature distributions are not presented, summary tables giving average temperature levels in different regions of the wall are presented in Appendices B, C, and D.

3.3 BUILDING PERFORMANCE DATA

During November and December, 1978, instrumentation problems prevented the collection of wall performance data. The velocity probe was damaged (by wind gusts on the Kalwall cover unit), the data logger malfunctioned, and both pieces of equipment had to be returned to the manufacturers. The data logger manufacturer supplied a replacement data logger at the end of December. This replacement logger was then used to collect a limited amount of overall building performance data.

Building performance data was collected continuously over a period of five days for the vented Trombe wall having a 2-inch gap. No backdraft control was used on the wall inlet/outlet ducts. This data is presented in Appendix E and includes insolation, ambient air temperatures, masonry wall temperatures, Kalwall cover temperatures, and building envelope, inside/outside temperatures. This information can be used to investigate overall performance characteristics of the Trombe wall and test building as an entity, but it cannot be used to determine specific operating characteristics of the Trombe wall alone.

SECTION 4

ANALYTICAL RESULTS

The results of computer analyses based on the experimental data collected in test runs with the Trombe wall test facility are presented in this section. Computer printout summaries of data analysis results for wall gap widths of 2, 4 and 6 inches are given in Appendices B, C and D, respectively, for a total of eight test runs. Table 4.1 provides a key to the test runs included in the appendices. Each appendix summary includes: (1) time variations of the wall gap boundary temperatures, inlet/outlet duct bulk air temperatures, and the ambient conditions of temperature and insolation; (2) time variations of the calculated average temperatures for zones in the masonry wall; (3) conductive thermal energy storage changes in the masonry wall as a function of time; (4) gap thermocirculation parameters as a function of time; and (5) convective thermal energy transfer to the building interior as a function of time. Appendix B.1 also contains several additional pages with descriptive information applicable to all of the test run summaries.

TABLE 4.1 TEST RUNS USED FOR ANALYSIS PURPOSES.

TEST NUMBER	WALL GAP WIDTH (INCHES)	INLET/OUTLET DUCT OPENING SIZES (% OPEN)	PROBE TRAVERSE ELEVATION (IN ABOVE FLOOR)	SKY CONDITIONS
GAP1-2-100	2	100	24	AM: Clear PM: Partly Cloudy
GAP3-2-100	2	100	73	AM: Clear PM: Light Clouding
GAP5-4-100	4	100	73	AM: Clear PM: Light Clouding
GAP6-4-100	4	100	24	AM: Clear PM: Clear
GAP8-6-100	6	100	24	AM: Partly Cloudy PM: Clear
GAP9-6-100	6	100	24	AM: Light Clouding PM: N/A
GAP10-6-100	6	100	73	AM: Light Clouding PM: Mostly Clear
GAP15-6-100	6	100	73	AM: Clear PM: Heavy Cloud Cover

4.1 CONVECTIVE THERMAL ENERGY

One of the two primary modes of heat transfer to the building interior from the Trombe wall is the free convection, thermocirculation process taking place in the wall air gap. Values of the thermal energy delivery to the building interior over a specified interval of time were calculated as

$$Q_{convective} = \dot{Q}_{convective} \Delta t = \dot{m} c_p \Delta T \Delta t ,$$

where,

$Q_{convective}$ = convective thermal energy delivered to the building interior over a Δt period of time and calculated per lineal foot of wall length (Btu/ft),

$\dot{Q}_{convective}$ = convective heat transfer rate per lineal foot of wall length (Btu/hr-ft),

$\dot{m}$ = mass flow rate of the air in the gap calculated per lineal foot of wall length using the experimental value for gap average velocity (lbm/hr-ft),

c_p = specific heat of air, taken as 0.24 Btu/lbm-°F ,

ΔT = difference between the inlet and outlet duct, bulk air temperatures (°F),

Δt = time interval over which results were calculated/tabulated (hr).

A summary of the gap flow profile parameters and the concurrent ambient conditions is given for each test run in Appendices B, C and D. The "velocity profile time" given in the summary is the time occurring at the mid-point of the experimental time interval during which the profile data was taken. Profile measurement time intervals were approximately 10 to 25 minutes depending on gap width and flow conditions. The summaries also include the convective heat transfer rate.

A separate summary sheet is presented in the appendices giving values of thermal energy, $Q_{convective}$, calculated over 15-minute intervals corresponding to the wall thermocouple data. These values are calculated by linearly interpolating in time the convective heat transfer rate terms in the profile summaries. This 15-minute data can be smoothed somewhat by averaging over two 15-minute intervals. The resulting 30-minute interval values are plotted as rate terms in Figure 4.1 against an abscissa variable commonly used in instantaneous efficiency plots for active-type solar collectors. In this figure, T_{inlet} is the bulk air temperature in the wall inlet duct, $T_{ambient}$ is the ambient air temperature at the test site, and $\dot{Q}_{insolation}$ is the insolation rate on a vertical surface at the test site.

It should be noted at this point that for a plot of active-type collector, instantaneous efficiency referred to above, the insolation value is typically taken at mid-day times and is measured at normal incidence to the collector covers. Solar incidence angles, measured from the normal to the Kalwall cover surface, that apply to the data presented in the figures, are on the order of 35 to 40 degrees, maximum. When this kind of data is used for design purposes, the incidence angles at the time of data acquisition, and the incidence angles at the time of year for which the data is being applied, need to be taken into account. This level of data taking and data analysis was reserved for future research.

Figure 4.1 depicts representative values of convective energy transferred to the building interior for all three gap widths studied in the project. The data points forming a vertically oriented cluster to the left of an abscissa value of 0.2 correspond predominantly to morning and mid-day conditions for all tests. The data points trailing off to the right in Figure 4.1 correspond primarily to late afternoon conditions where the insolation rate is monotonically

FIGURE 4.1 REPRESENTATIVE VALUES OF CONVECTIVE THERMAL ENERGY DELIVERY RATE.

decreasing in time to small values. Although very little data was collected during the first one to two hours of solar illumination of the wall (because of unstable flow conditions), such data would also plot to the right in Figure 4.1 because of the small values of insolation rate occurring at that time.

There is no apparent gap width effect on the values of the convective heat transfer rate plotted in Figure 4.1. In fact, there is no apparent trend in data points within the separate test runs for a single gap width.

Convective thermal energy values as a percentage of the total (convective + conductive) thermal energy delivered by the test Trombe wall are presented in Figure 4.2. The comments on Figure 4.1 regarding times of day corresponding to various data points apply also to Figure 4.2. Test conditions late in the day produce points that plot up and to the right; that is, the conductive energy into the masonry wall decreases significantly as insolation rate decreases, while the convective heat transfer rate remains relatively large because of the still elevated masonry surface temperatures. If they existed, data points obtained early in the day would plot down and to the right in Figure 4.2 since the convective heat transfer rate would be at minimal values for near zero-flow conditions. As with Figure 4.1, the data points in Figure 4.2 exhibit no gap width effect that is readily apparent.

A preponderance of the data points in Figure 4.2 fall in the range of 20% to 35%. This is a significant percentage of the Trombe wall energy delivery during periods of time when the insolation rate values are the greatest. The convective portion becomes obviously predominant over the conductive portion of the thermal energy delivered in the last two to three hours of solar illumination. With wall insulation applied after this time, the convective mechanism could provide a continuing energy delivery to the building interior.

FIGURE 4.2. FREE CONVECTIVE THERMAL ENERGY AS A PERCENTAGE OF TOTAL ENERGY COLLECTED.

Although most of the data points fall within the 20% to 35% band in Figure 4.2, these values would likely represent the low end of convective performance for most practical Trombe wall applications of basically similar design. The reason for this is the abnormally large setback of the masonry wall from the outside surface of the test building. As discussed in Section 3.2.3, this results in an abnormal amount of shading on the top of the masonry wall caused by the window frame overhang. Test data indicates that typical drops in gap air temperature occurring in this shaded portion of the gap are on the order of 10 to 15°F. This produces a corresponding, significant decrease in convective performance of the wall. In a practical application, the masonry setback would be considerably less, and, in fact, should be designed such that the top of the wall below the outlet duct remains illuminated under most operating conditions. Care should be taken, then, in using the convective fraction results of Figure 4.2 for design purposes.

The masonry wall setback does affect the convective performance of the test wall, but the impact on the overall performance of the wall is less pronounced. This results from the fact that much of the heat loss from the air in the shaded portion of the gap is to the masonry wall, and this gain to the masonry wall then becomes part of the total energy collected by the Trombe wall system. The net heat loss caused by the shading effect, then, is the sum of the loss to the Kalwall in the shaded portion of the gap and the loss to the top of the window box and outlet duct.

Data accuracy factors that affect the calculated values of convective heat transfer rates are discussed in Section 3. Since the convective heat transfer rate is calculated directly from the profile data of that section, the comments there regarding velocity profile measurement and average gap velocity calculations are appropriate also to this section.

Another factor peculiar to the test facility that affects the modes of heat transfer in the wall is the material used in the thermal storage portion of the wall. Dense aggregate, solid concrete block was not available at the time of building construction; thus, a lightweight aggregate block was used. The density of this material was measured as 80.4 lbm/ft^3 (89.4 lbm/ft^3 considering the mortar matrix as well). This density implies a certain, undetermined porosity for the block. These air voids, in turn, have the effect of decreasing the value of thermal conductivity for the block. The combination of effects from the lightweight aggregate and the porosity produces a value of thermal conductivity for the masonry wall in the test facility lower than would be expected using denser block, poured concrete, etc. This lower value of thermal conductivity would produce higher surface temperatures on the illuminated masonry wall with the attendant increase in convected thermal energy, and a decrease in the thermal energy conducted into the masonry itself.

4.2 CONDUCTIVE THERMAL ENERGY

The conductive heat transfer mode in the Trombe wall is generally the predominant one, but as was discussed in Section 4.1, this is not the case for later in the day when the insolation rate is decreasing to relatively small values. Summary tables of calculated values of conductive thermal energy for each of the test runs used in the data analysis are included in Appendices B, C and D. These values are given per lineal foot of wall length.

The conductive thermal energy gain, $Q_{\text{conductive}}$, was calculated using the readings from thermocouples implanted at four elevations along the vertical centerplane of the concrete block wall: 13, 30, 79 and 87 inches above the floor of the building. At the 30 and 79-inch elevations, five thermocouples were installed at depths of 0, 1, 3, 6 and 11 9/16 inches from the outside surface of the masonry wall. These five thermocouples, then, monitored both inside and outside surface temperatures, and gave adequate definition of the temperature gradient through the wall thickness. Two additional, outside surface thermocouples were used at the 13 and 87-inch elevations.

For thermal energy storage calculations, the concrete wall was divided into three major zones vertically, and each of these into four horizontally oriented subzones. These zones are defined in Figure 4.3. For a given time, average temperatures were calculated for each zone and subzone assuming linear spatial distributions of temperature in the wall between points of measured temperature. If the test procedure was such that data was not obtained at 15-minute intervals, then a biparabolic interpolation procedure was used to estimate temperatures at 15-minute intervals.

The change in stored thermal energy over a 15-minute test interval was calculated essentially as follows: (1) for a given time, the temperature distributions through the wall thickness were calculated at the mid-elevations of zones 1,

FIGURE 4.3 CALCULATION ZONES FOR CONDUCTIVE THERMAL ENERGY STORAGE.

2 and 3 using the measured data at the 13, 30, 79 and 87-inch elevations, per the assumptions of steps (2) to (5); (2) the temperature distributions at elevations 86.3 and 18.6 were assumed to be proportional to the measured distributions at the 79 and 30-inch elevations, respectively, based on the temperature differences between the inside and outside surfaces at the various elevations; that is, the calculated distributions were assumed to be similar in shape to the measured distributions; (3) inside surface temperatures at the 18.6 and 86.3-inch elevations were found by linear extrapolation from the 30 and 79-inch elevation data; (4) outside surface temperatures at the 18.6 and 86.3-inch elevations were found by linear interpolation of the 13, 30, 79 and 87-inch elevation data; (5) the temperature distribution at the 54.5-inch elevation was taken as the average of the measured distributions at the 30 and 79-inch elevations; (6) the average temperatures for each zone were calculated using the temperature distributions found in the previous steps; and (7) the conductive thermal energy gain or loss over a 15-minute interval of time was calculated using the average temperatures of step (6) determined from the data for two, sequential test times.

Zone averaged temperatures in the masonry wall are summarized as a function of time for each test run in Appendices B, C and D. The thermal energy storage changes due to conduction in the masonry wall are also summarized for 15-minute intervals in the appendices, and were calculated from the expression

$$Q_{\text{conductive}} = \rho C_p V \Delta T ,$$

where,

$Q_{\text{conductive}}$ = conductive thermal energy gain/loss in a zone of the masonry wall over a specified time interval, and calculated per lineal foot of wall length (Btu/ft),

ρ = density of the concrete block wall, determined as a composite of lightweight block and dense mortar to be 89.4 lbm/ft³,

C_p = specific heat of the masonry wall, taken to be equal to 0.21 Btu/lbm-°F ,

V = volume of the wall zone per lineal foot of wall length (ft³/ft), and

ΔT = the change in average temperature for the zone wall over the specified time interval (°F) .

The value of conductive thermal energy storage for the entire wall was then calculated as the sum of the individual zone values. A representative sampling of calculations was made to determine the effect of the convective and radiative heat transfer to/from the building interior air and walls. This effect was determined to be not significant enough to include in the data analysis for the scope/purposes of this project.

The conductive energy gain could have been calculated by an alternative means using the heat flux measured in the outer one to three inches of the masonry wall. This approach, however, would have required the accurate determination of the wall thermal conductivity (for the lightweight, concrete block over a range of temperatures). It would also have necessitated knowing the locations of the thermocouples at the 0, 1 and 3-inch depths with considerable accuracy. This complexity was deemed inappropriate for the purposes of this research, although in future work it may allow shorter time intervals to be used in data acquisition.

Accuracy of Results:

Any procedure used for calculating thermal energy storage is directly affected by the inherent accuracy in the readings of the thermocouples used in the calculation procedure. To minimize recorded temperature error in this research, special limits-of-error thermocouple wire was used to fabricate thermocouples. In addition, all thermocouples were fabricated from the same individual spool of thermocouple wire.

More important than the actual magnitudes of the temperature readings, however, is the change in magnitude over a specified time interval and the amount of error in that change. Two components of error are associated with the thermocouple readings; the error caused by the wire itself, and the error associated with the digitizer, reference junction, relay offsets, etc. in the data logger. The first component of error will be negligible over the temperature changes encountered during typical time intervals used in these experiments. The second factor, however, could be relatively large, up to $\pm 0.2^{\circ}\text{F}$, based on experience during the project.

Too short of a time interval produces temperature differences of such small magnitude that the error can easily be as large as $\pm 50\%$. This problem is most apparent in the test data of this project for the thermocouples implanted in the back half of the masonry wall, on the interior side. Temperatures in this part of the wall were changing slowly. The problem can be alleviated by choosing larger intervals for data collection and analysis, but at the cost of a reduced number of data points.

Fortunately, for most reasonable time intervals under which data was recorded, the greatest percentage of thermal energy gained or lost in the masonry wall was in the outer three to six inches of the wall. Temperatures at points in this portion of the wall changed significantly in magnitude over relatively short

periods of test time, and consequently, the amount of error involved in the temperature differences was quite small. A 15-minute time interval was chosen for temperature data recording in the test project and proved to be a satisfactory compromise between accuracy and data reduction time requirements.

4.3 TROMBE WALL COLLECTOR EFFICIENCY

Determination of the thermocirculation processes in the Trombe wall air gap is of paramount importance in the development of comprehensive and accurate analytical models and design methods. The results of the previous sections are intended to be one of the first steps in this process. Although the major intent of this research was to provide detailed thermocirculation data for further analysis efforts, the data collected to date can be presented in a general form that can be used as a design guide. The data is presented here in such a form - that of an instantaneous, collector efficiency curve widely used to describe the thermal performance of active-type, flat plate solar collectors. Use of these performance plots should be tempered with the appropriate qualifications on the test data. These qualifications are presented and discussed in Section 4.4.

Trombe wall collector efficiency is presented in this section as plots of $\dot{Q}_{total}/\dot{Q}_{insolation}$ versus $(T_{inlet} - T_{ambient})/\dot{Q}_{insolation}$. The $\dot{Q}_{total}$ term is the total rate of thermal energy gain in the Trombe wall, calculated as the sum of $\dot{Q}_{convective}$ and $\dot{Q}_{conductive}$ which were determined in Sections 4.1 and 4.2, respectively. The other efficiency plot parameters are defined in Section 4.1.

Linear regression fits (by the method of least squares) are made to the data points based on 15-minute time intervals. These fits are shown in Figures 4.4, 4.5 and 4.6 for wall gap widths of 2, 4 and 6 inches, respectively. Also shown in these figures are the 95% confidence intervals (envelopes) on the three sets of data points. Presented in Table 4.2 are the linear regression fit constants and coefficients of determination for the three straight-line fits.

Given certain limitations on the data, described subsequently, the linear regression fits shown in the figures represent the data points quite well. This is particularly true for the 4-inch gap data. Ambient test conditions existing

FIGURE 4.4 TROMBE WALL COLLECTOR EFFICIENCY FOR 2" GAP WIDTH

FIGURE 4.5 TROMBE WALL COLLECTOR EFFICIENCY FOR 4" GAP WIDTH.

FIGURE 4.6 TROMBE WALL COLLECTOR EFFICIENCY FOR 6" GAP WIDTH.

TABLE 4.2 LINEAR REGRESSION FIT PARAMETERS FOR EFFICIENCY DATA

REGRESSION FIT LINE: $Y = A_0 + A_1 X$ where: $Y = \dot{Q}_{total} / \dot{Q}_{insolation}$ $X = (T_{inlet} - T_{ambient}) / \dot{Q}_{insolation}$			
GAP WIDTH (INCHES)	A_0	A_1	COEFFICIENT OF DETERMINATION r^2
2	0.663	-1.370	0.801
4	0.594	-1.038	0.892
6	0.638	-1.574	0.804

during the 4-inch gap tests were quite consistent and produced the highest quality data of the three gap widths studied.

Figure 4.7 shows the linear regression, collector efficiency lines for all three gap widths. No clear conclusions can be drawn from the figure except that there is no significant, obvious quantitative difference in the three separate efficiency curves. Considering the preliminary nature of these efficiency lines and the limited number of data points available to make the regression fits, no definite conclusions should be drawn. Only a substantial increase in the size of the data samples using a wide range in values for the pertinent efficiency variables will produce highly reliable efficiency curves. The combination of a

FIGURE 4.7 COLLECTOR EFFICIENCY AS A FUNCTION OF GAP WIDTH.

large number of data points along with a wide range of parameter values should result in a much smaller uncertainty band. Also, such efficiency curves will have to be produced for a variety of Trombe wall configurations to be widely applicable.

Efficiency Data Accuracy:

The necessity for taking pyranometer and implanted thermocouple data as instantaneous values over elapsed time intervals of approximately 15 minutes was discussed in Sections 2.4 and 4.2. The use of instantaneous data places limitations on test procedures. Specifically, it necessitates that tests be run under clear-sky conditions.

Pyranometer and surface thermocouple readings respond rapidly to changes in insolation that can arise with even light, intermittent cloud cover. Instantaneous readings taken under intermittent cloud cover conditions could be considerably different than the average values of readings taken over even short, but finite periods of time. The effect over a period of 15 minutes could easily mean that the instantaneous values of insolation at the 0 and 15-minute time points in no way represented the average insolation values occurring over the 15-minute time interval. The consequences of using non-representative insolation values in the efficiency plots may be serious because the insolation rate appears directly in both the ordinate and abscissa variables.

The conductive and convective thermal energy transfer terms discussed in previous sections both require a minimum of approximately 15 minutes for their accurate determination. The recording of the instantaneous data values at 15-minute intervals, while greatly simplifying the data reduction process, necessitated using data collected under essentially clear-sky conditions. Test log records on sky conditions and reviews of insolation rate time-histories were utilized in screening the test data for periods of clear-sky conditions.

Fortuitously, during the 4-inch gap test runs, two continuous days of clear-sky conditions occurred. The impact this had on the efficiency data accuracy is quite obvious in the data fit of Figure 4.5. Not only is the data more tightly spaced about the linear regression line, but whole day data produced a greater range of values of the parameter $(T_{inlet} - T_{ambient}) / \dot{Q}_{insolation}$ than occurred in the test runs using gap widths of 2 and 6 inches. Both factors contribute to the better fit with the 4-inch gap data.

In producing the 2 inch and 6-inch gap results, many days of data had to be inspected to obtain sufficiently long periods of clear-sky conditions. However, even this level of precaution was not sufficient to prevent the greater spread in the 2 and 6-inch gap data points seen in Figures 4.4 and 4.6. This is the direct result of intermittent, light cumulus and cirrus cloud cover which was thought to have an inconsequential effect at the time the tests were conducted.

4.4 QUALIFICATIONS ON ANALYTICAL RESULTS

In light of the information presented in the previous sections of this report, certain qualifications should be made here concerning the use of the Trombe wall performance and efficiency data developed in this research for general design purposes. Some of these qualifications stem from limitations in data acquisition equipment, test procedures or time limitations. Others derive as a result of peculiarities in the design of the test facility itself.

The following are the more pertinent qualifications to be considered before the information presented in this report is applied to other Trombe wall applications:

- (1) The collector efficiency plots should be treated as preliminary in nature because of the limited number of data points used to generate them, and because of the limitations inherent in the use of instantaneous data values.

- (2) The collector efficiency data applies only to the Trombe wall performance, not to overall building efficiency.
- (3) The test wall, as discussed in Section 4.1, underestimates the convective thermal energy transfer rate of a Trombe wall with less masonry wall set-back; i. e., a wall with less shading due to overhanging structure.
- (4) As noted in Section 4.1, the insolation rate used in the performance and efficiency plots was not corrected for test conditions of solar incidence angles; i.e., normal incidence cannot be assumed with this data.
- (5) The performance and efficiency data produced with the test wall is in part a function of certain properties of materials used in the test facility:
 - a) the thermal conductivity of the dried, lightweight, solid concrete block used in the thermal storage wall,
 - b) effective transmittance, absorptance, reflectance of the framed, double-glazed, Kalwall "Sunlite Premium II" cover panel,
 - c) absorptance/emittance of the flat-black, common masonry paint used to coat the outside surface of the masonry wall, and
 - d) heat transfer characteristics of the Kalwall cover unit with 1 1/2-inch spacing between glazings.
- (6) Gap widths of 2, 4 and 6 inches combined with masonry wall height of 86.5 inches gave channel aspect ratios ($1/d$) of 43, 22 and 14, approximately.
- (7) Inlet and outlet ducts used in the tests were relatively large in relation to the flow area. They were approximately 4 inches in height and extended the full length of the masonry wall; considerably larger than those used in most practical applications to date. Ratios of the gap cross-sectional flow area to the duct cross-sectional/flow area were $1/2$, 1 and $3/2$, respectively, for the 2, 4 and 6-inch gaps.

- (8) Because of the wall construction materials/techniques, the amount of entrained moisture in the wall was minimal.
- (9) Building construction methods were employed that produced a building envelope that was very tight thermally. The result was atypically high values of room temperature and inlet duct bulk air temperature for many of the test periods.

SECTION 5

CONCLUSIONS

The research performed under the project grant has produced findings on the Trombe wall passive heating system not previously reported elsewhere. In some instances, it has also provided hard data to support the preliminary findings reported in other research. The major findings of this research project are summarized as follows:

► Gap widths of 2, 4 and 6 inches were investigated in this study. With the masonry wall height being 86.5 inches, these gap widths produced flow channel aspect ratios (l/d) of 43, 22 and 14, respectively. The free convection flow in the wall gap for the test aspect ratios appeared to remain laminar, with a possible initiation of transitional regimes in the 6-inch gap wall configuration. It appears that this conclusion would also be valid for gap widths of eight inches because the estimated Grashof numbers for that gap width would still imply non-turbulent flow. Hence, for conceivable gap widths and one-story Trombe wall applications, laminar flow regimes should be the norm. Turbulent flow regimes should not be encountered unless radically different Trombe wall design parameters (e.g., wall height, gap width, etc.) are employed. The importance of this finding is that laminar flow presents a considerably simpler analytical problem to the designer/analyst than does turbulent flow.

► From preliminary results using the data of this project, it appears that the thermal efficiency of the Trombe wall system can be well represented with the straight-line, instantaneous efficiency plot universally employed for defining the performance of active-type, flat-plate solar collectors. It is anticipated that future research will more completely confirm this.

- ▶ The experimental research in this project has produced a number of gap velocity and temperature profiles under a variety of gap geometries and test conditions. This information provides the necessary basis for detailed heat transfer correlations now lacking for the accurate definition of Trombe wall thermocirculation processes. Future research effort will be made in this area of analytical development.
- ▶ The free convection, thermal energy transfer in the gap constitutes a significant portion of the total energy delivered by the Trombe wall collector during periods when the wall is illuminated. When comparing the convective thermal energy delivered to the building interior to the total thermal energy delivered by all heat transfer modes, the percentage of the total due to the convection mode ranges from 15% to 65% in the results from the project tests. However, most of these values ranged from 20% to 35%. Because of wide variations in wall temperatures and ambient conditions occurring throughout a typical day, the percentage of convective transfer also varies widely. The 20% to 35% range of values should represent the minimum values to be expected for other, practical Trombe wall designs incorporating large inlet and outlet vents. This is due to the atypically large shading that occurs on the upper portions of the test wall, resulting from the large setback of the masonry wall needed to accommodate the movable cover unit. The shading effects a reduction in the convective thermal energy transfer to the building.
- ▶ The convective thermal energy transfer to the building interior and the conductive transfer into the masonry wall decreased dramatically late in the afternoon as a result of rapidly decreasing insolation rates. The

convective transfer rate decrease lagged the conductive transfer rate decrease somewhat during this period. By the time the insolation rate was at or near zero, the free convection heat transfer process has essentially terminated. This is further accentuated if ambient air temperatures are low, since this parameter has a strong influence on the inside surface temperatures of the wall glazing unit. Coincident with vanishing convective energy transfer rates, however, are increasingly negative values of thermal energy storage change in the masonry wall. These observations provide a strong argument for using insulating devices on the outside of the Trombe wall. The specific finding of this research, however, is that the insulating device should probably be installed one to two hours before the insolation rate on the wall is zero. This time, of course, will vary with operating conditions/requirements on the wall (e.g., ambient temperature, cloud cover, space heating demand, etc.).

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APPENDIX A

INSTRUMENTATION DESCRIPTION AND DATA KEYS

INSTRUMENTATION KEY

A shorthand notation is used to identify the type of instrumentation and the location of the thermocouples. A description of the instrumentation key is given below.

Pyranometers:

P1	Eppley Model 8-48 Black and White
P2	Hollis Model MR-5
Ver	Vertical orientation
Hor	Horizontal orientation

Example: P1VER Refers to the Eppley pyranometer oriented in a vertical position

Velocity Probe:

VEL	Thermal Systems Inc. Model 1610 Velocity Transducer
-----	---

Thermocouples:

The thermocouple identification code uses 4 to 6 letters and/or digits. The codes for the thermocouples in the masonry wall, on the Kalwall cover panel, and on the building walls are similar. The first character identifies the general location, e.g.

M	Masonry wall
K	Kalwall cover panel
E	Building envelope
V	Vestibule

The next two digits indicate the vertical position relative to the floor. The next character refers to a direction or position. For instance, on the masonry wall and Kalwall

C	Refers to the centerplane
E	Refers to the east location (approximately the east quarter-plane)
W	Refers to the west location (approximately the west quarter-plane)

and in the building envelope

N	Refers to the north wall
E	Refers to the east wall
W	Refers to the west wall.

The last two digits refer to the position of the thermocouple relative to the outermost surface. For example, on the Kalwall the code "02" refers to the inner Kalwall surface since the overall thickness of the double-glazed cover panel is approximately 2 inches. In the masonry wall "00" refers to the outer surface, i.e., the south-facing surface, and "06" refers to a location 6 inches from the front surface. An example of the key for the masonry wall given below:

M30W03	
M	Masonry wall
30	Vertical distance from the floor in inches
W	On west part of wall (approximately at the west quarter-plane)
03	Distance from the front (outermost) surface in inches.

Another example, that for a building envelope location, is

E48N08	
E	Building envelope
48	Vertical distance from the floor in inches
N	On north wall
08	Distance from outer surface; in this case, the inner surface.

The relationship between the masonry wall and the Kalwall cover panel thermocouple identification codes and the thermocouple locations is presented in detail in Tables A.1 and A.2. A summary of the complete instrumentation key is given in Table A.4.

TABLE A.1 THERMOCOUPLE JUNCTION POSITIONS
IN MASONRY WALL

Thermocouple Identification Code	Vertical Dis- tance From The Floor	Distance From Front Surface	Horizontal Dis- tance From East End of Wall
	in	in	in
M13C00	13 1/8	0	58
M13C12	13 1/8	11 9/16	56
M30C00	30 1/16	0	59 13/16
M30C01	30 1/16	1	57 13/16
M30C03	30 1/16	3	55 13/16
M30C06	30 1/16	6	53 13/16
M30C12	30 1/16	11 9/16	51 13/16
M46C00	46	0	57 7/16
M46C03	46	3	55 7/16
M62C00	62 1/2	0	56 9/16
M62C03	62 1/2	3	54 9/16
M79C00	79	0	58 5/8
M79C01	79	1	56 5/8
M79C03	79	3	54 5/8
M79C06	79	6	52 5/8
M79C12	79	11 9/16	50 5/8
M87C00	87 1/8	0	63 7/16
M87C03	87 1/8	3	61 7/16
M79E00	78 7/8	0	25 15/16
M79E01	78 7/8	1	23 15/16
M79E03	78 7/8	3	21 15/16
M79E06	78 7/8	6	19 15/16
M79E12	78 7/8	11 9/16	17 15/16
M30E00	30 1/16	0	25 1/16
M30E03	30 1/16	3	23 1/16
M30E12	30 1/16	11 9/16	21 1/16
M79W00	78 7/8	0	89 1/4
M79W03	78 7/8	3	87 1/4
M30W00	30	0	90 1/4
M30W03	30	3	88 1/4

TABLE A.2 THERMOCOUPLE JUNCTION POSITIONS
ON KALWALL COVER PANEL

Thermocouple Identification Code	Vertical Distance From Floor	Horizontal Distance From East End of Masonry Wall
	in	in
K13C02	12 7/8	60
K30C02	30 3/8	60
K46C02	46 1/8	57 1/2
K63C02	62 7/8	57
K79C02	79 3/8	59
K87C02	87 5/8	64
K79E02	79 3/8	26
K30E02	30 3/8	25

TABLE A.3 VELOCITY PROBE PORT LOCATIONS

Velocity Probe Port Position	Vertical Distance From Floor	Horizontal Distance From East End of Masonry Wall
	in	in
1	23 7/8	60 1/8
2	40 5/16	60
3	56 13/16	60 1/16
4	73 1/8	60
5	89 3/4	60
6	73 1/16	30 1/16
7	73 1/16	12 1/16

TABLE A.4 INSTRUMENTATION KEY SUMMARY

Identification Code	Description
M13C00	TC, Masonry, A=13, B=58, C= 0
M13C12	TC, Masonry, A=13, B=56, C=12
M30C00	TC, Masonry, A=30, B=60, C= 0
M30C01	TC, Masonry, A=30, B=58, C= 1
M30C03	TC, Masonry, A=30, B=56, C= 3
M30C06	TC, Masonry, A=30, B=54, C= 6
M30C12	TC, Masonry, A=30, B=52, C=12
M46C00	TC, Masonry, A=46, B=57, C= 0
M46C03	TC, Masonry, A=46, B=55, C= 3
M62C00	TC, Masonry, A=62, B=57, C= 0
M62C03	TC, Masonry, A=62, B=55, C= 3
M79C00	TC, Masonry, A=79, B=59, C= 0
M79C01	TC, Masonry, A=79, B=57, C= 1
M79C03	TC, Masonry, A=79, B=55, C= 3
M79C06	TC, Masonry, A=79, B=53, C= 6
M79C12	TC, Masonry, A=79, B=51, C=12
M87C00	TC, Masonry, A=87, B=63, C= 0
M87C03	TC, Masonry, A=87, B=61, C= 3
M79E00	TC, Masonry, A=79, B=26, C= 0
M79E01	TC, Masonry, A=79, B=24, C= 1
M79E03	TC, Masonry, A=79, B=22, C= 3
M79E06	TC, Masonry, A=79, B=20, C= 6
M79E12	TC, Masonry, A=79, B=18, C=12
M30E00	TC, Masonry, A=30, B=25, C= 0
M30E03	TC, Masonry, A=30, B=23, C= 3
M30E12	TC, Masonry, A=30, B=21, C=12
M79W00	TC, Masonry, A=79, B=89, C= 0
M79W03	TC, Masonry, A=79, B=87, C= 3
M30W00	TC, Masonry, A=30, B=90, C= 0
M30W03	TC, Masonry, A=30, B=88, C= 3
K13C02	TC, Kalwall, A=13, B=60, C= 2
K30C02	TC, Kalwall, A=30, B=60, C= 2
K46C02	TC, Kalwall, A=46, B=58, C= 2
K62C02	TC, Kalwall, A=63, B=57, C= 2
K79C02	TC, Kalwall, A=79, B=59, C= 2
K87C02	TC, Kalwall, A=87, B=64, C= 2
K79E02	TC, Kalwall, A=79, B=26, C= 2
K30E02	TC, Kalwall, A=30, B=25, C= 2

Note: Dimensions given in whole numbers
A = Vertical distance from floor
B = Horizontal distance east end of wall
C = Distance from outermost surface

TABLE A.4 INSTRUMENTATION KEY SUMMARY (CONT)

Identification Code	Description
AGAP	TC, Air gap between masonry and Kalwall
AINC	TC, Inlet duct
AOUTC	TC, Outlet duct
ARMHI	TC, Inside air temperature, high elevation
ARMLO	TC, Inside air temperature, low elevation
AAMB	TC, Outside ambient air temperature
ACRLSP	TC, Crawl space air temperature
E48E08	TC, East wall, inside surface
E48E00	TC, East wall, outside surface
E48W08	TC, West wall, inside surface
E48W00	TC, West wall, outside surface
E48N08	TC, North wall, inside surface
E48N00	TC, North wall, outside surface
V48W04	TC, Vestibule, west wall, room interior
V48W00	TC, Vestibule, west wall, vestibule interior
V48N04	TC, Vestibule, north wall, vestibule interior
EROOF	TC, Roof top
ECEIL	TC, Ceiling
EFLOOR	TC, Floor
VEL	Velocity Probe
P1	Pyranometer, Eppley
P2	Pyranometer, Hollis

Scale: 1"=3"

FIGURE A.1 THERMOCOUPLE LOCATIONS FOR FULLY INSTRUMENTED BLOCK (TYPE 1)

FIGURE A.2 THERMOCOUPLE LOCATIONS FOR PARTIALLY INSTRUMENTED BLOCK (TYPE 2)

FIGURE A.3 THERMOCOUPLE LOCATIONS FOR PARTIALLY INSTRUMENTED BLOCK (TYPE 3)

FIGURE A.4 THERMOCOUPLE LOCATIONS FOR PARTIALLY INSTRUMENTED BLOCK (TYPE 4)

FIGURE A.5 THERMOCOUPLE LOCATIONS IN BUILDING ENVELOPE

B-1

APPENDIX B

SUMMARY OF RESULTS FOR 2" GAP WIDTH

B-2

APPENDIX B.1

TEST NO. GAP1-2-100

***** ENERGY ENGINEERING GROUP, INC. *****
***** GOLDEN, COLORADO *****

TROMBE WALL EXPERIMENTAL TEST DATA

THIS TEST DATA WAS TAKEN IN THE PASSIVE SOLAR TEST FACILITY
IN IDAHO SPRINGS, COLORADO. THE TROMBE WALL TEST FACILITY
WAS CONSTRUCTED AND OPERATED UNDER DOE GRANT NO. EG-77-G-04-4145
BY EEG, INC.

.....
.....
EXPERIMENTAL AND ANALYTICAL RESULTS
FOR
CONCRETE BLOCK THERMAL STORAGE WALL

TROMBE WALL TEST FACILITY
IDAHO SPRINGS, COLORADO

RESEARCH PERFORMED FOR U.S. DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
AND CHICAGO OPERATIONS OFFICE

UNDER DOE GRANT NO. EG-77-G-04-4145
SEPTEMBER, 1977 - APRIL, 1979

RESEARCH PERFORMED BY ENERGY ENGINEERING GROUP, INC.
GOLDEN, COLORADO
.....
.....

***** DESCRIPTION OF OUTPUT QUANTITIES *****

EACH TEST WAS RUN AT A FIXED NOMINAL AIR GAP WIDTH AND VELOCITY PROBE ELEVATION. A NUMBER OF AIR GAP VELOCITY AND TEMPERATURE PROFILES, RANGING FROM 1 TO 20, WAS OBTAINED FOR EACH TEST. TEST GENERALLY BEGAN ABOUT MID-MORNING AND RAN UNTIL LATE AFTERNOON, THE ACTUAL TEST PERIOD BEING DEPENDENT UPON THE WEATHER CONDITIONS.

THE AIR GAP VELOCITY AND TEMPERATURE PROFILES WERE OBTAINED OVER PERIODS OF TIME RANGING UP TO 20 MINUTES. A UNIQUE TIME, THE AVERAGE OR MEAN TIME VALUE, IS ASSIGNED TO EACH PROFILE. A PAIR OF VELOCITY AND TEMPERATURE PROFILES IS ASSIGNED A PROFILE NUMBER.

AVERAGE VELOCITY AND TEMPERATURE VALUES ARE COMPUTED FOR EACH VELOCITY AND TEMPERATURE PROFILE.

INLET DUCT AND OUTLET DUCT TEMPERATURES ARE GIVEN AT TIMES CORRESPONDING TO THE AVERAGE VELOCITY PROFILE TIMES.

INSTANTANEOUS SOLAR INSOLATION RATES (VERTICAL ORIENTATION) AND AMBIENT AIR TEMPERATURES ARE ALSO GIVEN AT EACH PROFILE TIME.

THE MASS FLOW RATE IN THE AIR GAP IS DETERMINED AT EACH VELOCITY PROFILE TIME. THE MASS FLOW RATE IS BASED ON THE AVERAGE VELOCITY AND TEMPERATURE VALUES AT THE VELOCITY PROBE ELEVATION. THE MASS FLOW RATE IS GIVEN PER LINEAL FOOT OF MASONRY WALL, THAT IS, FOR A 1 FOOT WIDE STRIP.

THE CONVECTIVE HEAT TRANSFER RATE IN THE AIR GAP IS DETERMINED AT EACH VELOCITY PROFILE TIME. THE HEAT TRANSFER RATE IS BASED ON THE MASS FLOW RATE AND THE TEMPERATURE DIFFERENCE BETWEEN THE OUTLET DUCT AND THE INLET DUCT. THE CONVECTIVE HEAT TRANSFER RATE IS COMPUTED PER LINEAL FOOT OF MASONRY WALL, THAT IS, FOR A 1 FOOT WIDE STRIP FROM THE BOTTOM TO THE TOP OF THE WALL.

THE AMOUNT OF ENERGY CONVECTED OUT OF THE AIR GAP IS PRESENTED FOR EACH 15 MINUTE PERIOD DURING THE TEST. THIS CONVECTIVE ENERGY TRANSFER VALUE IS DETERMINED PER LINEAL FOOT OF MASONRY WALL, THAT IS, FOR A 1 FOOT WIDE STRIP FROM THE BOTTOM TO THE TOP OF THE WALL.

DETAILED TEMPERATURE DISTRIBUTION INFORMATION IS GIVEN FOR EACH PROFILE NUMBER. THE TEMPERATURE IS GIVEN AT EACH GAP POSITION MEASURED FROM THE KALWALL BOUNDARY SURFACE TOWARD THE MASONRY WALL. THE AIR TEMPERATURE AT EACH GAP POSITION IS GIVEN AT THE SAME TIME THAT THE VELOCITY DATA WAS OBTAINED.

THE VOLTAGE OUTPUT SIGNAL FROM THE VELOCITY TRANSDUCER IS PRESENTED FOR EACH GAP POSITION AND PROFILE NUMBER.

THE ACTUAL VELOCITY IS GIVEN AT EACH GAP POSITION. THIS VELOCITY VALUE IS DETERMINED BY USING THE STANDARD VELOCITY CALIBRATION CURVES FOR THE VELOCITY TRANSDUCER AND BY CORRECTING FOR LOCAL PRESSURE AND TEMPERATURE CONDITIONS.

TEST NUMBER...GAP1-2-100

TEST DATE...JAN. 24, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

KEY TO SUMMARY OF WALL EXPERIMENTAL DATA

DATA NAME
.....

.....
DESCRIPTION OF EXPERIMENTAL DATA
.....

P1VER = SOLAR INSOLATION RATE, INCIDENT ON A VERTICAL SURFACE (BTU/HR-FT²)
AAMB = TEST BUILDING SITE, AMBIENT AIR TEMPERATURE (DEGREES-F)
AINC = BULK AIR TEMPERATURE IN THE TROMBE WALL INLET DUCT (DEGREES-F)
AOUTC = BULK AIR TEMPERATURE IN THE TROMBE WALL OUTLET DUCT (DEGREES-F)
M13C00 = MASONRY WALL, OUTSIDE SURFACE TEMPERATURE AT 13 INCHES ABOVE THE TEST CELL FLOOR (DEGREES-F)
M30C00 = MASONRY WALL, OUTSIDE SURFACE TEMPERATURE AT 30 INCHES ABOVE THE TEST CELL FLOOR (DEGREES-F)
M79C00 = MASONRY WALL, OUTSIDE SURFACE TEMPERATURE AT 79 INCHES ABOVE THE TEST CELL FLOOR (DEGREES-F)
M87C00 = MASONRY WALL, OUTSIDE SURFACE TEMPERATURE AT 87 INCHES ABOVE THE TEST CELL FLOOR (DEGREES-F)
K13C02 = KALWALL, INSIDE SURFACE TEMPERATURE AT 13 INCHES ABOVE THE TEST CELL FLOOR (DEGREES-F)
K30C02 = KALWALL, INSIDE SURFACE TEMPERATURE AT 30 INCHES ABOVE THE TEST CELL FLOOR (DEGREES-F)
K79C02 = KALWALL, INSIDE SURFACE TEMPERATURE AT 79 INCHES ABOVE THE TEST CELL FLOOR (DEGREES-F)
K87C02 = KALWALL, INSIDE SURFACE TEMPERATURE AT 87 INCHES ABOVE THE TEST CELL FLOOR (DEGREES-F)

COMMENTS ON THE COMPUTER PRINTOUT

-
- (1) DUE TO INTERMITTENT ANOMOLIES IN THE DATA ACQUISITION SYSTEM, A MODIFIED TEST PROCEDURE WAS SOMETIMES REQUIRED TO OBTAIN PYRANOMETER AND THERMOCOUPLE DATA. THIS NECESSITATED A REDUCTION IN THE NUMBER OF RECORDED DATA CHANNELS. THE MODIFIED TEST PROCEDURE RESULTED IN THE FOLLOWING.....
 - (A) FOUR T-C CHANNELS DEFINING SURFACE TEMPERATURES AT THE 13 AND 87-INCH ELEVATIONS FOR BOTH THE MASONRY AND KALWALL WERE NOT RECORDED. HENCE, THESE VALUES DO NOT APPEAR IN THE TABLE...SUMMARY OF WALL EXPERIMENTAL DATA...
 - (B) THE SURFACE TEMPERATURES IN THE WALL GAP AT THE 13 AND 87-INCH ELEVATIONS USED IN THE DATA ANALYSIS WERE ESTIMATED FROM WALL DATA TAKEN UNDER SIMILAR TEST CONDITIONS.
 - (C) DATA WAS TAKEN AT IRREGULAR TIME INTERVALS, WITH ANALYSIS BASED ON INTERPOLATED TIME VALUES (SEE ITEM(3) BELOW).
 - (2) TEMPERATURE DISTRIBUTIONS THROUGH THE WALL THICKNESS WERE MEASURED AT THE 30 AND 79-INCH ELEVATIONS. DISTRIBUTIONS AT THE 18.6, 54.5 AND 86.3-INCH ELEVATIONS WERE CALCULATED USING LINEAR, SPATIAL INTERPOLATION. THESE DISTRIBUTIONS WERE USED TO CALCULATE AVERAGE TEMPERATURES AND CONDUCTIVE, THERMAL ENERGY STORAGE IN ZONES WITHIN THE WALL.
 - (3) INTERPOLATION/EXTRAPOLATION OF T-C DATA IN SPACE WAS DONE LINEARLY, AND IN TIME WAS DONE USING A BIPARABOLIC METHOD.
 - (4) FOR PURPOSES OF CALCULATING THERMAL ENERGY STORAGE, THE MASONRY WALL WAS DIVIDED INTO 3 PRIMARY, HORIZONTAL ZONES...WITH EACH OF THESE ZONES DIVIDED INTO FOUR SUBZONES VERTICALLY. LINEAR TEMPERATURE VARIATIONS WERE ASSUMED THROUGHOUT EACH ZONE OR SUBZONE. THE MID-PLANE ELEVATIONS OF THE 3 PRIMARY ZONES WERE AT 13.6, 54.5 AND 86.3 INCHES. TEMPERATURE DISTRIBUTIONS AT THESE 3 ELEVATIONS, USED IN CALCULATING THERMAL ENERGY STORAGE CHANGES WITH TIME, WERE DETERMINED FROM MASONRY WALL T-C DATA TAKEN AT ELEVATIONS OF 13, 30, 79 AND 87 INCHES.

TEST NUMBER...GAP1-2-100

TEST DATE...JAN. 24,1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY OF WALL EXPERIMENTAL DATA
 GAP BOUNDARY TEMPERATURES, GAP INLET/OUTLET AIR TEMPERATURES, AND AMBIENT CONDITIONS

TIME OF DAY	VERTICAL PYRANOMETER READING (BTU/HR-FT2)	THERMOCOUPLE READINGS (DEGREES-F)										
	P1VER	AAMB	AINC	AOUTC	M13C00	M30C00	M79C00	M87C00	K13C02	K30C02	K79C02	K87C02
1115	304.0	35.7	64.3	80.4	*****	126.9	128.9	*****	*****	114.1	117.1	*****
1130	302.6	41.0	65.6	82.7	*****	129.5	132.8	*****	*****	116.0	119.4	*****
1145	304.6	42.8	66.7	84.7	*****	132.8	136.9	*****	*****	118.0	121.8	*****
1200	291.5	44.5	67.8	86.8	*****	134.9	140.6	*****	*****	119.8	123.8	*****
1215	272.8	44.0	68.6	88.4	*****	135.4	142.3	*****	*****	118.5	123.2	*****
1230	277.4	43.6	69.6	89.9	*****	137.4	144.8	*****	*****	119.2	124.2	*****
1245	291.6	43.4	70.6	91.3	*****	140.0	147.5	*****	*****	120.8	126.1	*****
1300	289.4	43.5	71.4	92.8	*****	141.7	149.3	*****	*****	122.3	128.0	*****
1315	260.4	43.6	72.2	94.1	*****	142.8	150.4	*****	*****	123.2	129.2	*****
1330	274.7	43.2	73.1	94.8	*****	142.4	150.2	*****	*****	120.9	127.2	*****
1345	261.4	42.6	73.9	95.4	*****	141.0	149.1	*****	*****	117.8	124.4	*****
1400	226.3	42.1	74.4	96.0	*****	139.7	148.5	*****	*****	118.2	124.9	*****
1415	151.3	42.0	74.2	94.9	*****	132.4	141.9	*****	*****	108.7	115.8	*****
1430	73.1	41.8	73.5	92.6	*****	121.9	131.6	*****	*****	94.8	102.0	*****
1445	43.8	41.1	72.7	90.4	*****	112.7	121.3	*****	*****	85.9	92.6	*****
1500	114.6	40.4	72.8	89.8	*****	112.3	119.4	*****	*****	87.9	93.2	*****
1515	203.6	39.7	73.3	90.1	*****	115.4	121.6	*****	*****	94.0	98.2	*****
1530	133.0	38.6	73.1	90.1	*****	113.3	121.0	*****	*****	91.4	98.2	*****
1545	25.1	37.5	72.6	89.7	*****	108.6	118.2	*****	*****	85.0	94.5	*****
1600	13.6	37.3	72.1	88.2	*****	101.8	110.9	*****	*****	77.1	85.5	*****

TEST NUMBER...GAP1-2-100

TEST DATE...JAN. 24, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

ESTIMATED VALUES FOR MASONRY SURFACE TEMPERATURES
.....

TEMPERATURE ESTIMATES
(DEGREES-F)
.....

TIME OF DAY	M13C00	M37C00
1115	115.7	119.7
1130	117.7	121.8
1145	119.8	122.8
1200	120.9	124.9
1215	121.9	125.9
1230	123.3	126.9
1245	124.7	127.8
1300	126.0	128.5
1315	127.0	129.0
1330	127.0	129.2
1345	128.1	129.0
1400	124.0	128.5
1415	118.0	125.1
1430	110.1	119.0
1445	103.5	110.7
1500	103.2	109.2
1515	105.1	111.0
1530	102.3	110.6
1545	97.3	108.3
1600	91.7	102.2

TEST NUMBER...GAP1-2-100

TEST DATE...JAN. 24, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

AVERAGE TEMPERATURES FOR ZONES IN THE MASONRY WALL
 (TEMPERATURES IN UNITS OF DEGREES-F)

TIME	ZONE1	ZONE11	ZONE12	ZONE13	ZONE14	ZONE2	ZONE21	ZONE22	ZONE23	ZONE24	ZONE3	ZONE31	ZONE32	ZONE33	ZONE34
1115	68.4	108.7	82.9	62.7	59.1	68.2	115.2	86.3	61.5	57.0	65.8	108.8	82.3	59.8	55.4
1130	70.4	112.0	86.7	64.9	60.0	70.4	119.3	90.0	63.9	58.0	67.7	111.7	85.8	61.9	56.4
1145	71.9	113.8	89.0	66.6	61.0	72.2	123.2	93.6	65.9	58.8	69.2	114.5	88.7	63.7	57.1
1200	73.5	116.2	91.7	68.5	61.9	74.1	126.4	96.8	68.1	59.7	70.8	116.6	91.4	65.6	58.0
1215	75.2	118.0	94.1	70.5	63.2	75.9	128.4	99.9	70.3	60.9	72.4	118.4	94.2	67.6	58.9
1230	76.6	119.4	96.1	72.3	64.3	77.6	130.9	105.3	72.3	61.9	73.8	120.2	96.4	69.3	59.7
1245	78.0	120.6	97.7	73.9	65.4	79.2	133.4	108.2	74.2	62.8	75.1	122.0	98.2	70.9	60.5
1300	79.3	121.7	99.4	75.6	66.5	80.8	135.4	109.5	76.2	63.9	76.4	123.6	100.1	72.5	61.5
1315	80.7	122.6	101.1	77.3	67.7	82.4	136.9	111.4	78.1	65.1	77.7	124.8	101.9	74.2	62.5
1330	82.2	123.6	103.0	79.1	69.0	83.9	137.5	113.0	80.1	66.3	79.0	125.5	103.6	75.9	63.5
1345	83.7	124.3	104.8	81.0	70.3	85.2	137.4	114.1	81.9	67.5	80.1	125.3	104.9	77.5	64.5
1400	84.7	124.3	105.8	82.3	71.2	86.3	137.2	114.4	83.6	68.7	81.0	124.3	105.4	78.8	65.6
1415	85.7	122.6	107.0	84.0	72.2	86.9	133.0	113.5	85.1	69.7	81.4	120.2	105.1	80.1	66.6
1430	86.2	118.6	107.1	85.6	73.1	86.8	125.8	111.6	86.4	70.7	81.4	114.1	104.0	81.3	67.5
1445	85.6	111.6	104.4	86.3	73.9	86.3	117.5	108.8	87.3	71.7	81.2	107.7	101.5	82.4	68.5
1500	85.6	109.1	102.5	86.8	74.7	86.2	114.9	105.8	87.7	72.6	81.1	105.7	99.4	82.6	69.3
1515	85.9	109.2	101.4	87.0	75.5	86.3	115.2	105.1	87.8	73.4	81.1	105.9	97.7	82.5	69.9
1530	86.3	109.4	101.5	87.2	76.2	86.7	114.8	105.5	88.0	74.1	81.1	104.2	96.9	82.4	70.6
1545	86.6	108.5	101.6	87.4	76.8	87.0	113.1	102.1	88.3	74.9	81.1	101.4	96.1	82.4	71.3
1600	86.0	103.5	99.6	87.6	77.2	86.6	107.5	102.1	88.7	75.5	80.7	96.4	94.0	82.5	72.1

NOTE...ZONE(K) IS THE HORIZONTAL LAYER OF WALL LYING BETWEEN 93.5 AND 79 INCH ELEVATIONS (K=1), OR BETWEEN 79 AND 30 INCH ELEVATIONS (K=2), OR BETWEEN 30 AND 7.25 INCH ELEVATIONS (K=3). ZONE(KJ) IS A SUBZONE OF ZONE K FORMED BY VERTICAL PLANES HYPOTHETICALLY LOCATED AT DEPTHS OF 1, 3 AND 6 INCHES FROM THE FRONT, OUTSIDE WALL SURFACE...THE SUBZONE LIES BETWEEN THE OUTSIDE SURFACE AND A 1-INCH DEPTH (J=1), OR BETWEEN A 1-INCH AND 3-INCH DEPTH (J=2), OR BETWEEN A 3-INCH AND 6-INCH DEPTH (J=3), OR BETWEEN A 6-INCH DEPTH AND THE WALL INSIDE SURFACE (J=4).

TEST NUMBER...GAP1-2-100

TEST DATE...JAN. 24, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY TABLE
 OF
 CONDUCTIVE THERMAL ENERGY STORAGE IN MASONRY WALL

	TIME OF DAY											
	1115	1130	1145	1200	1215	1230	1245	1300	1315	1330	1345	1400
	----	----	----	----	----	----	----	----	----	----	----	----
ETOTAL (BTU/FT)	260.44	222.47	226.67	226.26	238.23	196.06	182.48	168.72	181.74	161.42	125.90	

	TIME OF DAY								
	1400	1415	1430	1445	1500	1515	1530	1545	1600
	----	----	----	----	----	----	----	----	----
ETOTAL (BTU/FT)	64.15	1.60	-53.58	-20.99	28.81	43.85	-20.31	-28.43	

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP1-2-100 NOMINAL GAP = 2 IN ELEVATION = 24 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON JANUARY 24, 1979 024 JULIAN

THE ATMOSPHERIC PRESSURE CORRECTED TO SEA LEVEL WAS 29.65 IN HG

PROFILE NUMBER	1	2	3	4	5	6	7	8	9	10
VELOCITY PROFILE TIME	1126	1154	1223	1255	1324	1351	1411	1433	1456	1551
AVERAGE VELOCITY (FT/SEC)	1.33	1.35	1.34	1.36	1.41	1.34	1.19	.84	.58	.54
AVERAGE AIR TEMPERATURE IN GAP (F)	83.5	85.7	88.2	89.3	91.3	91.7	90.2	86.0	84.4	81.9
AIR TEMPERATURE IN INLET DUCT (F)	65.1	67.2	69.0	71.1	72.6	74.0	74.3	73.3	72.8	72.4
AIR TEMPERATURE IN OUTLET DUCT (F)	81.8	85.7	89.0	92.1	94.4	95.5	95.4	92.2	90.2	88.9
MASS FLOW RATE (LBM/HR-FT)	57.5	58.1	57.6	57.2	59.1	55.8	49.9	35.2	25.0	23.5
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	230.5	258.1	276.7	288.3	309.5	287.9	252.8	159.5	104.3	93.0
SOLAR INSOLATION RATE (BTU/HR-FT**2)	303.2	299.1	275.3	289.7	275.3	252.1	176.8	71.2	87.5	21.9
AMBIENT AIR TEMPERATURE (F)	38.9	43.5	43.9	43.4	43.4	42.5	42.0	41.9	40.6	37.4

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP1-2-100 NOMINAL GAP = 2 IN ELEVATION = 24 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON JANUARY 24, 1979 024 JULIAN

TIME OF DAY	1115	1130	1145	1200	1215	1230	1245	1300	1315	1330
CONVECTIVE ENERGY TRANSFER (BTU/FT)	56.8	60.5	64.2	65.7	69.1	70.5	71.8	74.4	77.1	

TIME OF DAY	1330	1345	1400	1415	1430	1445	1500	1515	1530	1545
CONVECTIVE ENERGY TRANSFER (BTU/FT)	74.7	71.3	64.7	51.0	37.2	28.2	25.5	24.7	23.9	

TIME OF DAY	1545	1600
CONVECTIVE ENERGY TRANSFER (BTU/FT)	23.2	

APPENDIX B.2

TEST NO. GAP3-2-100

TEST NUMBER...GAP3-2-100

TEST DATE...FEB. 05, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY OF WALL EXPERIMENTAL DATA
 GAP BOUNDARY TEMPERATURES, GAP INLET/OUTLET AIR TEMPERATURES, AND AMBIENT CONDITIONS

TIME OF DAY	VERTICAL PYRANOMETER READING (BTU/HR-FT2)	THERMOCOUPLE READINGS (DEGREES-F)										
	P1VER	AAMB	A1NC	AOUTC	M13C00	M30C00	M79C00	M87C00	K13CC2	K30C02	K79C02	K87C02
.....												
915	215.5	28.4	57.5	66.5	*****	84.4	86.2	*****	*****	79.3	80.7	*****
930	228.6	29.3	59.2	68.9	*****	93.6	95.9	*****	*****	86.7	87.8	*****
945	237.1	30.5	60.8	71.4	*****	101.2	103.4	*****	*****	92.1	93.8	*****
1000	247.0	31.7	62.0	73.7	*****	107.8	110.0	*****	*****	96.3	98.0	*****
1015	256.2	32.3	63.5	76.1	*****	113.6	115.9	*****	*****	99.8	102.6	*****
1030	262.4	33.9	64.7	78.3	*****	118.8	120.7	*****	*****	103.2	106.0	*****
1045	270.2	33.0	66.0	80.7	*****	123.7	125.8	*****	*****	107.0	109.7	*****
1100	274.6	33.8	67.0	82.5	*****	127.5	130.0	*****	*****	109.4	112.5	*****
1115	278.6	34.8	68.0	84.6	*****	131.0	134.0	*****	*****	112.0	115.2	*****
1130	282.0	35.0	69.3	86.6	*****	134.3	137.9	*****	*****	114.6	117.9	*****
1145	283.0	34.4	70.5	88.2	*****	136.9	141.1	*****	*****	116.6	119.9	*****
1200	279.8	34.6	71.5	89.5	*****	138.4	143.6	*****	*****	117.4	121.2	*****
1215	276.9	34.9	72.4	90.9	*****	139.9	146.0	*****	*****	118.3	122.5	*****
1230	278.4	34.8	73.2	92.6	*****	142.0	143.7	*****	*****	120.2	124.3	*****
1245	283.6	34.6	74.3	94.0	*****	144.1	151.1	*****	*****	121.7	125.9	*****
1300	262.8	33.9	75.2	94.9	*****	144.1	151.5	*****	*****	120.6	125.3	*****
1315	255.0	33.0	75.7	95.2	*****	142.3	149.8	*****	*****	118.0	123.5	*****
1330	265.9	33.3	76.4	96.1	*****	143.0	150.2	*****	*****	118.8	124.2	*****
1345	244.9	34.2	77.1	97.2	*****	144.7	151.9	*****	*****	120.1	125.7	*****
1400	251.5	34.5	77.8	97.8	*****	144.3	151.9	*****	*****	119.7	125.4	*****
1415	242.9	34.5	78.2	98.2	*****	143.7	151.9	*****	*****	117.9	123.6	*****
1430	239.1	34.5	78.9	98.7	*****	142.8	151.3	*****	*****	117.2	123.1	*****
1445	220.9	34.1	79.3	98.8	*****	140.6	149.3	*****	*****	115.2	121.4	*****
1500	170.0	32.8	79.2	98.3	*****	136.4	145.2	*****	*****	109.6	116.0	*****

TEST NUMBER...GAP3-2-100

TEST DATE...FEB. 05, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

ESTIMATED VALUES FOR MASONRY SURFACE TEMPERATURES

.....

TEMPERATURE ESTIMATES
(DEGREES-F)

.....

TIME OF DAY	M13C00	M87C00
.....		
915	80.5	85.7
930	88.1	95.2
945	96.0	102.0
1000	101.3	107.3
1015	106.0	112.0
1030	109.0	115.0
1045	113.7	116.9
1100	116.1	119.6
1115	118.4	122.5
1130	120.9	124.7
1145	122.9	125.9
1200	124.1	127.1
1215	125.2	128.1
1230	126.9	129.0
1245	128.6	129.2
1300	128.7	130.6
1315	127.9	131.2
1330	128.4	129.8
1345	129.1	130.0
1400	128.9	130.0
1415	127.9	130.0
1430	127.6	129.3
1445	126.2	128.1
1500	122.2	126.5

TEST NUMBER...GAP3-2-100

TEST DATE...FEB. 05, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

AVERAGE TEMPERATURES FOR ZONES IN THE MASONRY WALL
 (TEMPERATURES IN UNITS OF DEGREES-F)

TIME	ZONE1	ZONE11	ZONE12	ZONE13	ZONE14	ZONE2	ZONE21	ZONE22	ZONE23	ZONE24	ZONE3	ZONE31	ZONE32	ZONE33	ZONE34
915	67.6	78.4	67.8	66.0	66.4	65.6	77.3	65.6	63.8	64.4	63.2	74.3	63.5	61.4	62.1
930	69.0	86.6	71.8	66.3	66.2	67.2	85.8	69.7	64.3	64.3	64.8	81.9	67.6	62.0	62.2
945	70.5	92.7	75.5	67.2	66.5	68.8	92.6	75.4	65.3	64.6	66.4	88.8	71.6	62.9	62.4
1000	71.9	97.9	79.0	68.2	66.7	70.4	98.8	78.1	66.4	64.7	67.9	94.4	75.5	64.0	62.4
1015	73.3	102.6	82.4	69.4	66.9	72.0	104.4	82.6	67.6	64.9	69.3	99.4	79.2	65.2	62.6
1030	74.8	106.0	85.4	70.7	67.5	73.6	109.3	86.0	69.0	65.3	70.5	103.0	82.0	66.3	62.8
1045	75.9	108.5	87.8	71.9	67.8	75.3	114.1	90.1	70.6	65.6	72.2	107.7	85.7	67.9	63.3
1100	77.2	111.5	90.5	73.3	68.3	76.8	118.2	94.5	72.2	66.1	73.5	110.8	88.5	69.3	63.6
1115	78.6	114.5	93.2	74.8	69.0	78.5	122.0	97.2	73.9	66.7	74.8	113.7	91.2	70.7	64.1
1130	80.1	117.0	95.6	76.4	69.8	80.2	125.6	100.5	75.7	67.4	76.2	116.6	93.8	72.3	64.7
1145	81.2	118.7	97.6	77.7	70.6	81.7	128.7	104.2	77.3	68.1	77.6	119.0	96.3	73.8	65.4
1200	82.5	120.3	99.6	79.2	71.4	83.2	131.2	107.4	79.0	68.8	78.8	120.9	98.7	75.2	66.0
1215	83.8	121.7	101.3	80.6	72.3	84.7	133.5	108.9	80.8	69.6	79.9	122.7	100.8	76.6	66.6
1230	84.9	122.7	102.6	82.0	73.3	86.2	135.8	110.6	82.5	70.6	81.3	124.6	102.8	78.2	67.4
1245	85.8	123.3	103.6	83.1	74.1	87.6	138.1	113.8	84.1	71.5	82.5	126.5	104.7	79.6	68.2
1300	87.3	125.1	105.9	84.8	75.1	88.9	139.1	114.7	85.7	72.4	83.7	127.4	106.5	81.0	69.1
1315	88.7	126.3	108.0	86.6	76.1	90.0	138.6	115.4	87.4	73.5	84.7	127.1	107.8	82.6	70.0
1330	89.4	125.5	108.3	87.6	77.1	91.1	139.3	117.2	88.9	74.4	85.6	127.7	108.7	83.8	70.7
1345	90.2	125.8	109.0	88.6	78.0	92.3	140.8	118.7	90.3	75.3	86.5	128.6	109.6	84.9	71.5
1400	91.2	126.2	110.0	89.9	79.0	93.4	141.1	119.6	91.7	76.3	87.5	128.7	110.6	86.1	72.4
1415	92.2	126.5	110.9	91.1	80.0	94.4	141.3	120.7	93.0	77.3	88.3	128.5	111.3	87.2	73.3
1430	93.1	126.3	111.5	92.1	80.9	95.3	141.1	121.9	94.2	78.3	89.1	128.4	112.1	88.3	74.2
1445	93.8	125.6	112.1	93.3	81.8	96.0	139.9	122.8	95.4	79.2	89.8	127.5	112.5	89.4	75.1
1500	94.7	124.8	112.9	94.6	82.7	96.5	137.1	121.4	96.5	80.1	90.0	124.6	111.9	90.2	75.8

NOTE...ZONE(K) IS THE HORIZONTAL LAYER OF WALL LYING BETWEEN 93.5 AND 79 INCH ELEVATIONS (K=1), OR BETWEEN 79 AND 30 INCH ELEVATIONS (K=2), OR BETWEEN 30 AND 7.25 INCH ELEVATIONS (K=3). ZONE(KJ) IS A SUBZONE OF ZONE K FORMED BY VERTICAL PLANES HYPOTHETICALLY LOCATED AT DEPTHS OF 1.3 AND 6 INCHES FROM THE FRONT, OUTSIDE WALL SURFACE...THE SUBZONE LIES BETWEEN THE OUTSIDE SURFACE AND A 1-INCH DEPTH (J=1), OR BETWEEN A 1-INCH AND 3-INCH DEPTH (J=2), OR BETWEEN A 3-INCH AND 6-INCH DEPTH (J=3), OR BETWEEN A 6-INCH DEPTH AND THE WALL INSIDE SURFACE (J=4).

TEST NUMBER...GAP3-2-100

TEST DATE...FEB. 05, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 2 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY TABLE
 OF
 CONDUCTIVE THERMAL ENERGY STORAGE IN MASONRY WALL

TIME OF DAY

	<u>915</u>	<u>930</u>	<u>945</u>	<u>1000</u>	<u>1015</u>	<u>1030</u>	<u>1045</u>	<u>1100</u>	<u>1115</u>	<u>1130</u>	<u>1145</u>	<u>1200</u>
ETOTAL (BTU/FT)	197.60	231.77	180.70	206.30	185.23	210.90	198.51	191.15	205.14	197.72	183.19	

TIME OF DAY

	<u>1200</u>	<u>1215</u>	<u>1230</u>	<u>1245</u>	<u>1300</u>	<u>1315</u>	<u>1330</u>	<u>1345</u>	<u>1400</u>	<u>1415</u>	<u>1430</u>	<u>1445</u>
ETOTAL (BTU/FT)	163.45	172.40	180.59	155.16	142.68	135.20	135.96	130.35	125.34	120.17	100.33	

TIME OF DAY

	<u>1445</u>	<u>1500</u>
ETOTAL (BTU/FT)	42.30	

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP3-2-100 NOMINAL GAP = 2 IN ELEVATION = 73 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 5, 1979 036 JULIAN

THE ATMOSPHERIC PRESSURE CORRECTED TO SEA LEVEL WAS 29.88 IN HG

PROFILE NUMBER	1	2	3	4	5	6	7	8	9	10
VELOCITY PROFILE TIME	932	949	1006	1021	1037	1112	1136	1220	1246	1312
AVERAGE VELOCITY (FT/SEC)	.81	.97	1.06	1.08	1.17	1.35	1.43	1.45	1.45	1.37
AVERAGE AIR TEMPERATURE IN GAP (F)	81.2	86.2	90.0	92.7	95.9	101.7	105.5	109.9	112.0	112.2
AIR TEMPERATURE IN INLET DUCT (F)	59.2	61.0	62.5	63.8	65.2	67.7	69.5	72.6	74.3	75.5
AIR TEMPERATURE IN OUTLET DUCT (F)	68.9	71.9	74.4	76.7	79.2	84.0	86.9	91.4	93.8	95.1
MASS FLOW RATE (LBM/HR-FT)	37.5	43.5	47.2	47.9	51.2	58.6	60.9	61.2	61.3	58.2
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	87.3	113.9	134.8	148.3	172.1	229.3	254.2	276.2	286.8	273.8
SOLAR INSOLATION RATE (BTU/HR-FT**2)	228.2	239.1	249.9	258.0	265.5	277.4	281.8	277.4	275.4	247.1
AMBIENT AIR TEMPERATURE (F)	29.3	30.7	31.8	32.8	33.6	34.5	34.8	34.9	34.4	33.3

PROFILE NUMBER	11	12	13	14
VELOCITY PROFILE TIME	1347	1403	1437	1502
AVERAGE VELOCITY (FT/SEC)	1.29	1.24	1.08	1.01
AVERAGE AIR TEMPERATURE IN GAP (F)	113.5	114.6	114.4	111.5
AIR TEMPERATURE IN INLET DUCT (F)	77.2	77.8	78.9	79.1
AIR TEMPERATURE IN OUTLET DUCT (F)	97.2	97.8	98.6	98.0
MASS FLOW RATE (LBM/HR-FT)	54.1	52.2	45.3	42.0
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	255.6	250.4	214.3	190.5
SOLAR INSOLATION RATE (BTU/HR-FT**2)	246.7	249.7	226.8	158.7
AMBIENT AIR TEMPERATURE (F)	34.2	34.5	34.2	32.5

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP3-2-100 NOMINAL GAP = 2 IN ELEVATION = 73 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 5, 1979 036 JULIAN

TIME OF DAY	930	945	1000	1015	1030	1045	1100	1115	1130	1145
CONVECTIVE ENERGY TRANSFER (BTU/FT)	24.0	29.6	34.0	37.6	43.2	49.4	55.5	60.0	63.7	

TIME OF DAY	1145	1200	1215	1230	1245	1300	1315	1330	1345	1400
CONVECTIVE ENERGY TRANSFER (BTU/FT)	65.6	67.5	69.3	70.8	70.9	69.0	67.4	65.9	64.1	

TIME OF DAY	1400	1415	1430	1445	1500	1515
CONVECTIVE ENERGY TRANSFER (BTU/FT)	61.4	57.4	53.5	49.9	46.3	

APPENDIX C

SUMMARY OF RESULTS FOR 4" GAP WIDTH

APPENDIX C.1

TEST NO. GAP5-4-100

TEST NUMBER...GAP5-4-100

TEST DATE...FEB. 14, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 4 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY OF WALL EXPERIMENTAL DATA
 GAP BOUNDARY TEMPERATURES, GAP INLET/OUTLET AIR TEMPERATURES, AND AMBIENT CONDITIONS

TIME OF DAY	VERTICAL PYRANOMETER READING (BTU/HR-FT2)	THERMOCOUPLE READINGS (DEGREEE-F)										
	P1VER	AAMB	AINC	AOUTC	M13C00	M30C00	M79C00	M87C00	K13C02	K30C02	K79C02	K87C02
900	187.6	55.1	71.1	80.1	89.5	95.7	97.7	97.5	90.5	94.1	94.6	94.7
915	201.5	56.5	73.6	82.6	96.7	104.0	105.5	103.9	95.9	99.6	100.0	99.5
930	213.6	57.8	75.4	85.1	102.5	111.3	112.5	109.2	101.1	105.7	106.0	105.3
945	225.6	57.5	76.8	87.3	107.6	117.8	118.5	113.3	103.8	109.1	109.2	108.0
1000	233.3	58.2	78.5	89.4	112.0	123.5	124.0	117.2	107.6	113.3	113.0	112.0
1015	242.1	58.7	80.2	91.8	115.8	128.6	129.3	120.3	111.0	116.9	116.7	114.9
1030	249.3	58.8	81.2	93.8	119.5	133.1	134.6	123.0	113.7	120.6	120.9	118.4
1045	254.8	59.7	82.9	95.5	122.6	136.9	138.7	125.3	115.9	123.0	123.2	120.3
1100	261.6	61.1	84.2	97.7	125.9	140.9	142.5	127.7	118.1	126.5	126.4	123.8
1115	266.1	60.8	84.6	98.6	128.0	143.4	145.5	129.3	118.8	127.5	127.8	124.2
1130	268.2	60.8	86.4	101.2	131.1	147.3	149.2	131.7	123.1	132.0	132.4	128.5
1145	268.6	61.8	87.8	103.0	133.3	150.4	152.4	133.7	124.7	134.2	134.3	129.9
1200	268.7	61.3	88.5	104.4	135.1	152.2	154.6	134.8	124.4	134.8	134.9	130.3
1215	267.9	61.6	89.4	105.1	135.9	153.7	156.7	136.0	125.6	135.6	135.7	130.7
1230	265.6	60.9	90.6	106.8	137.8	154.9	158.4	137.0	126.1	136.4	137.0	131.6
1245	264.9	60.4	91.6	107.7	138.7	155.8	160.0	137.9	125.8	136.0	136.7	130.8
1300	261.8	60.2	92.0	108.9	139.7	156.9	161.1	139.0	126.8	137.6	138.6	132.2
1315	255.8	62.0	93.2	109.7	140.0	157.4	161.4	140.0	126.8	137.1	138.4	131.6
1330	253.7	59.6	93.9	110.2	140.4	157.2	160.9	140.9	126.0	135.9	137.3	130.7
1345	244.2	61.0	94.3	110.4	139.8	156.5	160.4	141.1	124.3	134.6	136.6	130.3
1400	235.4	59.1	94.4	110.3	139.5	155.4	159.8	141.3	122.2	131.7	134.1	127.7
1415	230.3	58.2	95.4	111.2	138.3	154.2	158.7	141.2	122.4	132.1	134.1	128.2
1430	32.9	55.5	93.1	108.0	130.6	144.3	148.5	133.9	106.2	114.2	118.0	113.1
1445	87.4	55.8	93.6	107.0	123.9	138.1	142.3	129.8	106.5	114.0	116.7	113.0
1500	43.3	54.2	92.7	105.2	119.6	131.7	136.1	125.0	98.0	104.2	108.0	104.7
1515	190.4	54.8	93.5	105.4	118.6	131.6	135.4	124.9	103.5	109.4	112.0	108.9
1530	195.0	54.8	93.8	107.4	121.8	135.5	140.3	128.5	106.5	114.6	119.9	116.6
1545	82.1	53.1	92.4	107.5	114.3	126.2	140.0	126.8	94.8	100.9	120.1	115.9
1600	168.0	53.1	93.0	106.5	111.9	124.2	135.7	124.0	94.7	100.9	113.5	112.1
1615	106.8	52.0	93.3	106.8	114.1	126.6	134.3	122.2	101.2	107.6	113.0	111.3
1630	6.5	51.2	92.2	105.4	107.9	117.9	125.9	117.2	86.3	91.1	98.4	97.8

TEST NUMBER...GAP5-4-100

TEST DATE...FEB. 14, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 4 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

AVERAGE TEMPERATURES FOR ZONES IN THE MASONRY WALL
 (TEMPERATURES IN UNITS OF DEGREES-F)

TIME	ZONE1	ZONE11	ZONE12	ZONE13	ZONE14	ZONE2	ZONE21	ZONE22	ZONE23	ZONE24	ZONE3	ZONE31	ZONE32	ZONE33	ZONE34
900	84.2	91.9	84.6	83.8	83.0	32.2	90.8	82.7	81.6	80.8	79.1	86.6	79.6	78.5	77.9
915	84.8	97.2	86.7	83.6	82.6	33.2	97.3	85.5	81.6	80.7	80.3	92.8	82.5	78.8	78.1
930	85.7	101.9	89.0	83.8	82.7	34.4	103.4	88.5	82.0	80.7	81.5	98.2	85.3	79.3	78.2
945	86.6	105.8	91.4	84.3	82.6	35.6	109.0	91.7	82.7	80.7	82.6	103.2	88.2	79.9	78.3
1000	87.6	109.7	94.1	84.9	82.8	36.9	114.2	95.1	83.5	80.9	83.9	107.8	91.2	80.8	78.5
1015	88.5	112.8	96.2	85.5	82.9	38.2	119.0	99.2	84.4	81.1	85.1	111.8	94.1	81.8	78.9
1030	89.5	115.6	98.3	86.5	83.3	39.6	123.6	101.5	85.6	81.5	86.5	115.8	97.0	83.0	79.3
1045	90.5	118.2	100.5	87.4	83.7	41.0	127.6	104.6	86.8	81.8	87.7	119.2	99.8	84.1	79.7
1100	91.8	120.8	102.8	88.6	84.4	42.5	131.4	107.6	88.2	82.4	89.1	122.6	102.5	85.4	80.2
1115	92.8	122.8	104.7	89.7	84.8	43.7	134.3	110.4	89.6	82.7	90.0	125.0	104.8	86.4	80.3
1130	94.1	125.3	106.9	90.9	85.6	45.3	138.0	113.3	91.1	83.5	91.5	128.2	107.4	87.9	81.2
1145	95.5	127.6	109.1	92.4	86.5	46.8	141.2	116.1	92.6	84.2	92.7	130.7	109.6	89.1	81.7
1200	96.6	129.2	110.9	93.6	87.1	48.2	143.6	118.7	94.2	84.8	93.9	132.9	111.9	90.5	82.2
1215	97.7	130.7	112.7	94.8	87.9	49.6	145.8	121.2	95.8	85.6	95.1	134.5	113.9	92.0	83.0
1230	98.8	132.0	114.3	96.1	88.7	50.8	147.6	123.3	97.2	86.3	96.3	136.4	116.0	93.3	83.6
1245	99.9	133.1	115.7	97.4	89.6	52.1	149.1	125.2	98.8	87.2	97.5	137.6	117.7	94.7	84.4
1300	101.2	134.4	117.4	98.9	90.6	53.4	150.5	127.0	100.4	88.1	98.5	138.9	119.3	96.0	85.0
1315	102.3	135.7	119.0	100.2	91.4	54.5	151.4	128.6	101.8	89.0	99.5	139.6	120.6	97.2	85.8
1330	103.4	136.9	120.7	101.5	92.2	55.6	151.7	129.9	103.2	89.9	100.6	140.2	121.9	98.7	86.8
1345	104.3	137.5	121.9	102.7	92.9	56.3	151.7	130.9	104.3	90.5	101.0	140.0	122.5	99.5	87.1
1400	105.4	138.0	123.1	104.0	93.9	57.3	151.4	131.8	105.7	91.5	102.0	140.0	123.5	100.8	88.0
1415	106.1	138.0	123.8	105.0	94.6	58.0	150.7	132.2	106.8	92.2	102.5	139.2	123.8	101.7	88.8
1430	106.4	133.8	123.9	106.1	95.3	58.3	145.0	132.1	108.1	93.2	102.9	134.4	123.7	102.9	89.7
1445	106.2	129.5	122.0	107.0	95.9	57.8	138.7	129.2	109.0	93.9	102.0	127.7	120.1	103.2	90.2
1500	105.9	126.0	120.8	107.1	96.3	57.5	134.3	127.8	109.4	94.5	102.0	124.3	119.3	103.7	90.9
1515	105.8	124.5	119.3	107.4	96.8	57.2	132.0	125.3	109.5	95.1	101.6	121.8	116.6	103.6	91.5
1530	106.6	126.8	119.4	107.7	97.7	58.0	134.7	125.5	109.7	96.0	102.3	124.2	117.0	103.8	92.3
1545	106.3	125.7	118.6	107.3	97.8	57.9	131.9	124.8	109.8	96.5	101.8	118.8	115.4	103.8	92.8
1600	106.6	123.7	118.3	107.9	98.6	57.7	129.0	123.5	110.1	97.0	101.2	116.0	113.2	103.4	93.0
1615	106.3	122.1	117.2	107.7	98.8	57.9	129.0	123.0	110.1	97.5	101.7	117.3	113.3	103.7	93.6
1630	106.3	119.0	116.9	108.2	99.2	57.5	123.6	121.7	110.2	98.0	101.3	112.8	112.0	103.6	94.1

NOTE...ZONE(K) IS THE HORIZONTAL LAYER OF WALL LYING BETWEEN 93.5 AND 79 INCH ELEVATIONS (K=1), OR BETWEEN 79 AND 30 INCH ELEVATIONS (K=2), OR BETWEEN 30 AND 7.25 INCH ELEVATIONS (K=3). ZONE(KJ) IS A SUBZONE OF ZONE K FORMED BY VERTICAL PLANES HYPOTHETICALLY LOCATED AT DEPTHS OF 1, 3 AND 6 INCHES FROM THE FRONT, OUTSIDE WALL SURFACE...THE SUBZONE LIES BETWEEN THE OUTSIDE SURFACE AND A 1-INCH DEPTH (J=1), OR BETWEEN A 1-INCH AND 3-INCH DEPTH (J=2), OR BETWEEN A 3-INCH AND 6-INCH DEPTH (J=3), OR BETWEEN A 6-INCH DEPTH AND THE WALL INSIDE SURFACE (J=4).

TEST NUMBER...GAP5-4-100

TEST DATE...FEB. 14, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 4 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY TABLE
 OF
 CONDUCTIVE THERMAL ENERGY STORAGE IN MASONRY WALL

TIME OF DAY

	900	915	930	945	1000	1015	1030	1045	1100	1115	1130	1145
	----	----	----	----	----	----	----	----	----	----	----	----
ETOTAL (BTU/FT)	124.73	145.97	146.85	165.94	155.66	177.04	165.55	183.31	144.64	199.67	180.48	

TIME OF DAY

	1145	1200	1215	1230	1245	1300	1315	1330	1345	1400	1415	1430
	----	----	----	----	----	----	----	----	----	----	----	----
ETOTAL (BTU/FT)	165.41	171.18	154.52	162.07	157.56	141.24	138.98	91.59	128.38	82.30	39.16	

TIME OF DAY

	1430	1445	1500	1515	1530	1545	1600	1615	1630
	----	----	----	----	----	----	----	----	----
ETOTAL (BTU/FT)	-69.78	-22.50	-39.58	97.05	-31.51	-27.04	24.08	-45.61	

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP5-4-100 NOMINAL GAP = 4 IN ELEVATION = 73 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 14, 1979 045 JULIAN

THE ATMOSPHERIC PRESSURE CORRECTED TO SEA LEVEL WAS 29.80 IN HG

PROFILE NUMBER	1	2	3	4	5	6	7	8	9	10
VELOCITY PROFILE TIME	1005	1021	1036	1051	1122	1136	1151	1221	1236	1251
AVERAGE VELOCITY (FT/SEC)	.92	.92	.94	1.03	1.04	1.04	1.05	1.05	1.06	1.07
AVERAGE AIR TEMPERATURE IN GAP (F)	105.9	107.6	109.7	111.9	115.5	117.7	119.2	122.5	123.1	124.0
AIR TEMPERATURE IN INLET DUCT (F)	79.2	80.6	81.9	83.4	85.4	87.0	88.1	89.9	91.0	91.8
AIR TEMPERATURE IN OUTLET DUCT (F)	90.3	92.6	94.5	96.3	99.8	101.9	103.6	105.8	107.2	108.2
MASS FLOW RATE (LBM/HR-FT)	69.3	69.7	70.2	77.1	76.8	76.4	76.9	76.5	77.0	76.7
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	184.7	199.1	212.3	238.8	265.4	273.4	286.1	292.1	299.5	301.9
SOLAR INSOLATION RATE (BTU/HR-FT**2)	230.8	245.3	254.8	257.5	267.1	268.4	268.6	267.0	265.3	263.7
AMBIENT AIR TEMPERATURE (F)	54.4	58.7	59.2	60.3	60.8	61.2	61.6	61.3	60.7	60.3

PROFILE NUMBER	11	12	13	14	15	16	17	18
VELOCITY PROFILE TIME	1306	1321	1351	1406	1530	1607	1622	1636
AVERAGE VELOCITY (FT/SEC)	1.08	1.08	.94	.93	.63	.49	.45	.22
AVERAGE AIR TEMPERATURE IN GAP (F)	124.8	125.6	125.9	124.8	118.0	115.2	113.2	108.6
AIR TEMPERATURE IN INLET DUCT (F)	92.5	93.5	94.3	94.8	93.8	93.1	92.8	91.6
AIR TEMPERATURE IN OUTLET DUCT (F)	109.2	109.9	110.4	110.7	107.4	106.6	106.1	104.6
MASS FLOW RATE (LBM/HR-FT)	78.7	72.5	67.6	66.5	46.6	36.5	33.4	16.4
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	315.4	285.2	261.1	253.7	152.1	118.3	106.5	51.2
SOLAR INSOLATION RATE (BTU/HR-FT**2)	259.4	255.0	240.7	233.4	195.0	139.4	60.0	5.2
AMBIENT AIR TEMPERATURE (F)	60.9	61.0	60.2	58.7	54.8	52.6	51.6	50.8

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP5-4-100 NOMINAL GAP = 4 IN ELEVATION = 73 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 14, 1979 045 JULIAN

TIME OF DAY	1000	1015	1030	1045	1100	1115	1130	1145	1200	1215
CONVECTIVE ENERGY TRANSFER (BTU/FT)	46.5	50.1	53.7	60.0	63.2	66.4	68.7	71.6	72.3	
TIME OF DAY	1215	1230	1245	1300	1315	1330	1345	1400	1415	1430
CONVECTIVE ENERGY TRANSFER (BTU/FT)	73.2	74.9	75.8	78.1	71.0	68.0	65.1	63.0	58.4	
TIME OF DAY	1430	1445	1500	1515	1530	1545	1600	1615	1630	1645
CONVECTIVE ENERGY TRANSFER (BTU/FT)	53.9	49.4	44.8	40.3	36.3	32.9	29.5	26.1	11.3	

APPENDIX C.2

TEST NO. GAP6 4-100

TEST NUMBER...GAP6-4-120

TEST DATE...FEB. 15, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 4 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY OF WALL EXPERIMENTAL DATA
 GAP BOUNDARY TEMPERATURES, GAP INLET/OUTLET AIR TEMPERATURES, AND AMBIENT CONDITIONS

TIME OF DAY	VERTICAL- PYRANOMETER READING (BTU/HR-FT2)	THERMOCOUPLE READINGS (DEGREES-F)										
	P1VER	AAMB	AINC	AOUTC	M13C00	M30C00	M79C00	M87C00	K13C02	K30C02	K79C02	K87C02
.....												
900	189.3	35.9	74.6	83.4	92.3	97.3	99.4	99.2	89.1	90.5	92.1	92.1
915	202.9	36.5	76.2	85.2	98.7	105.3	106.5	105.1	93.8	96.7	97.3	97.0
930	214.8	36.3	77.6	86.9	104.2	111.9	112.8	109.5	98.1	101.4	101.6	101.0
945	225.8	37.0	78.8	88.8	109.2	118.1	118.6	113.4	100.6	104.8	105.1	103.8
1000	234.8	38.5	79.1	90.4	113.5	123.5	123.8	116.8	102.9	107.6	107.5	106.2
1015	244.5	37.4	81.1	92.1	117.1	128.7	129.1	119.8	106.6	112.0	112.2	110.3
1030	250.9	39.2	82.4	94.1	120.6	133.7	134.3	122.4	109.8	116.0	116.3	114.0
1045	256.6	40.8	83.2	96.0	123.4	137.5	138.9	124.6	113.3	119.4	119.8	116.8
1100	259.5	31.4	83.7	97.3	125.9	140.5	142.0	126.3	111.2	118.2	118.9	115.3
1115	262.2	27.3	84.7	97.9	127.6	143.1	144.4	127.4	109.6	114.8	115.5	112.3
1130	262.2	25.5	86.0	98.3	129.3	145.2	146.1	127.8	108.0	113.1	114.0	110.7
1145	265.2	26.0	86.6	99.3	130.7	147.4	148.3	128.5	108.8	114.3	114.9	111.4
1200	266.2	25.9	87.3	100.0	132.3	148.7	150.0	128.7	109.4	115.2	115.9	111.9
1215	263.4	24.1	87.7	100.7	132.9	149.4	151.4	129.3	109.6	116.0	116.7	112.5
1230	260.8	23.9	88.1	101.8	134.2	150.0	152.5	130.0	109.8	116.4	117.5	112.7
1245	257.4	24.9	89.6	102.8	134.9	150.8	153.6	130.6	110.4	117.0	117.9	113.3
1300	254.9	23.7	89.2	102.4	135.1	151.8	154.2	131.5	110.4	117.6	118.8	113.9
1315	251.5	25.1	90.1	103.8	135.7	152.1	154.3	132.5	111.7	119.1	120.6	115.5
1330	245.1	24.6	91.1	103.8	135.5	151.7	153.9	133.1	110.3	117.6	119.3	114.1
1345	237.8	24.6	91.1	104.3	135.4	150.9	152.5	133.6	109.9	117.0	118.9	113.7
1400	229.4	24.4	91.9	104.7	135.1	150.1	152.7	133.5	108.5	115.8	117.9	112.6
1415	219.3	24.7	92.1	104.9	133.7	148.5	151.5	133.5	107.7	114.8	117.0	112.0
1430	210.4	23.7	92.0	105.0	132.5	147.3	150.2	133.4	106.9	114.7	116.8	112.0
1445	196.9	24.3	92.5	104.7	131.1	145.2	148.2	132.7	104.8	112.0	114.4	109.9
1500	185.8	23.5	91.7	104.2	129.0	143.3	146.3	131.5	102.2	109.0	111.7	107.7
1515	170.7	22.4	90.7	103.6	127.4	140.7	143.6	129.7	99.0	105.4	108.4	104.8
1530	153.5	20.6	91.3	103.5	122.9	137.1	140.4	126.6	91.8	100.1	104.8	101.9
1545	61.1	18.1	90.5	102.6	112.9	125.4	135.3	121.5	78.9	83.6	98.1	95.1
1600	126.2	16.8	90.6	101.9	109.4	121.0	130.7	117.1	77.5	83.0	94.9	92.7
1615	98.8	15.4	90.0	101.6	109.2	119.6	126.6	114.3	81.2	84.7	91.1	89.4
1630	14.1	14.1	87.5	98.5	102.8	111.9	119.1	110.0	69.5	73.6	81.2	80.7
1645	13.2	13.3	86.0	96.6	98.7	107.2	114.0	106.7	66.5	70.4	76.9	77.1

TEST NUMBER...GAP6-4-100

TEST DATE...FEB. 15, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 4 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

AVERAGE TEMPERATURES FOR ZONES IN THE MASONRY WALL
 (TEMPERATURES IN UNITS OF DEGREES-F)

TIME	ZONE1	ZONE11	ZONE12	ZONE13	ZONE14	ZONE2	ZONE21	ZONE22	ZONE23	ZONE24	ZONE3	ZONE31	ZONE32	ZONE33	ZONE34
900	87.0	93.7	86.7	86.7	86.1	85.2	92.5	84.9	84.7	84.3	82.5	89.0	82.5	81.9	81.8
915	87.5	98.6	88.8	86.5	86.7	86.0	98.7	87.5	84.6	84.0	83.5	94.8	84.9	82.0	81.8
930	88.1	102.6	90.8	86.5	86.4	87.1	104.2	90.3	84.9	84.0	84.7	99.9	87.6	82.5	82.0
945	88.9	106.5	93.1	86.7	86.3	88.2	109.7	93.5	85.5	83.9	85.9	104.8	90.7	83.3	82.1
1000	89.8	109.9	95.4	87.4	86.4	89.4	114.6	96.7	86.2	83.9	86.8	109.1	93.4	83.8	81.9
1015	90.6	112.9	97.5	88.0	85.5	90.6	119.4	99.7	87.2	84.0	87.9	113.0	96.0	84.8	82.2
1030	91.5	115.6	99.5	88.8	85.7	91.9	124.0	102.9	88.2	84.2	89.1	116.8	98.8	85.7	82.4
1045	92.2	118.1	101.4	89.5	85.8	93.3	128.2	106.0	89.4	84.5	90.3	120.0	101.5	86.9	82.7
1100	93.2	120.2	103.5	90.4	86.1	94.5	131.5	109.0	90.6	84.7	91.3	123.0	104.0	88.0	82.9
1115	94.2	121.8	105.3	91.6	86.7	95.8	134.3	111.7	92.1	85.2	92.4	125.2	106.2	89.2	83.2
1130	94.9	122.8	106.9	92.6	86.9	96.9	136.6	114.2	93.5	85.5	93.4	127.2	108.3	90.4	83.6
1145	95.9	123.9	108.2	93.7	87.6	98.2	138.9	116.5	95.0	86.1	94.4	129.0	110.1	91.6	84.0
1200	96.4	124.5	109.2	94.4	87.8	99.3	140.7	118.5	96.3	86.6	95.5	130.8	112.2	92.9	84.6
1215	97.2	125.4	110.4	95.3	88.3	100.3	142.2	120.4	97.6	86.9	96.2	131.9	113.7	93.9	84.6
1230	98.1	126.4	111.7	96.4	89.0	101.4	143.4	122.2	99.0	87.7	97.3	133.3	115.5	95.3	85.4
1245	98.8	127.2	112.8	97.3	89.4	102.4	144.7	123.8	100.3	88.3	98.4	134.4	117.0	96.6	86.1
1300	99.9	128.2	114.2	98.6	90.3	103.3	145.6	125.2	101.6	88.9	98.7	134.8	117.7	97.3	86.2
1315	100.9	129.4	115.7	99.8	91.0	104.3	146.3	126.5	102.8	89.7	99.8	135.7	119.0	98.4	87.1
1330	101.7	130.3	116.9	100.7	91.5	105.1	146.5	127.5	103.8	90.3	100.4	135.9	120.0	99.4	87.5
1345	102.5	131.0	118.0	101.8	92.2	105.9	146.4	128.4	105.0	91.1	101.4	136.1	121.0	100.7	87.5
1400	103.3	131.2	118.9	102.8	93.0	106.5	146.1	129.1	106.0	91.6	102.0	136.0	121.6	101.6	89.0
1415	104.0	131.4	119.8	103.8	93.5	107.2	145.3	129.5	107.1	92.5	102.5	135.1	121.8	102.5	89.8
1430	104.8	131.5	120.5	104.9	94.4	107.3	144.5	129.8	108.0	93.2	102.8	134.2	121.9	103.1	90.2
1445	105.5	131.2	121.0	105.8	95.0	108.2	143.1	129.7	108.8	93.9	103.3	133.1	122.0	103.9	90.8
1500	105.7	130.2	121.0	106.4	95.5	108.5	141.7	129.4	109.5	94.5	103.4	131.4	121.4	104.4	91.5
1515	106.0	128.9	120.7	107.0	96.1	108.7	139.7	128.9	110.2	95.1	103.7	130.0	121.1	105.0	91.9
1530	105.7	126.4	119.6	107.0	96.3	108.7	137.1	128.2	110.7	95.6	103.4	126.5	119.5	105.1	92.5
1545	105.0	122.4	117.7	106.7	96.5	108.2	131.2	126.4	110.9	96.0	102.1	118.8	116.5	104.6	92.7
1600	104.2	118.2	115.2	106.2	96.7	107.6	126.7	123.9	111.1	96.5	101.5	114.7	113.9	104.5	93.1
1615	103.9	115.8	114.0	106.1	97.0	107.3	124.1	122.2	111.0	97.0	101.6	113.7	113.0	104.7	93.6
1630	109.7	112.5	112.9	106.4	97.5	106.6	118.5	119.9	110.8	97.4	100.5	108.3	110.2	103.8	93.8
1645	103.1	109.3	110.9	106.1	97.5	105.7	113.8	117.1	110.4	97.6	99.2	104.0	107.0	102.7	93.6

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NOTE...ZONE(K) IS THE HORIZONTAL LAYER OF WALL LYING BETWEEN 93.5 AND 79 INCH ELEVATIONS (K=1), OR BETWEEN 79 AND 30 INCH ELEVATIONS (K=2), OR BETWEEN 30 AND 7.25 INCH ELEVATIONS (K=3). ZONE(KJ) IS A SUBZONE OF ZONE K FORMED BY VERTICAL PLANES HYPOTHETICALLY LOCATED AT DEPTHS OF 1.3 AND 6 INCHES FROM THE FRONT, OUTSIDE WALL SURFACE...THE SUBZONE LIES BETWEEN THE OUTSIDE SURFACE AND A 1-INCH DEPTH (J=1), OR BETWEEN A 1-INCH AND 3-INCH DEPTH (J=2), OR BETWEEN A 3-INCH AND 6-INCH DEPTH (J=3), OR BETWEEN A 6-INCH DEPTH AND THE WALL INSIDE SURFACE (J=4).

TEST NUMBER...GAP6-4-100

TEST DATE...FEB. 15, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 4 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY TABLE
 OF
 CONDUCTIVE THERMAL ENERGY STORAGE IN MASONRY WALL

TIME OF DAY

	900	915	930	945	1000	1015	1030	1045	1100	1115	1130	1145
ETOTAL (BTU/FT)	107.88	128.73	141.53	136.42	149.23	155.57	157.48	146.00	157.71	134.66	149.67	

TIME OF DAY

	1145	1200	1215	1230	1245	1300	1315	1330	1345	1400	1415	1430
ETOTAL (BTU/FT)	129.68	108.43	143.17	128.93	103.23	130.62	94.17	116.33	87.05	78.52	71.75	

TIME OF DAY

	1430	1445	1500	1515	1530	1545	1600	1615	1630	1645
ETOTAL (BTU/FT)	59.28	34.09	28.36	-15.77	-97.70	-70.75	-25.22	-97.08	-127.29	

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP6-4-10C NOMINAL GAP = 4 IN ELEVATION = 24 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 15, 1979 046 JULIAN

THE ATMOSPHERIC PRESSURE CORRECTED TO SEA LEVEL WAS 30.05 IN HG

PROFILE NUMBER	1	2	3	4	5	6	7	8	9	10
VELOCITY PROFILE TIME	908	923	938	952	1006	1021	1038	1052	1108	1124
AVERAGE VELOCITY (FT/SEC)	.55	.67	.74	.78	.79	.82	.83	.89	.82	.85
AVERAGE AIR TEMPERATURE IN GAP (F)	87.4	89.5	91.8	94.0	95.9	97.7	99.2	100.7	100.5	101.6
AIR TEMPERATURE IN INLET DUCT (F)	75.5	76.9	78.2	78.9	79.9	81.6	82.8	83.4	84.2	85.5
AIR TEMPERATURE IN OUTLET DUCT (F)	84.4	86.1	87.9	89.5	91.1	92.9	95.1	96.6	97.6	98.1
MASS FLOW RATE (LBM/HR-FT)	46.7	53.5	58.3	61.2	62.0	63.5	64.5	68.5	62.8	64.9
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	99.8	118.1	135.8	155.7	166.6	172.2	190.5	216.9	201.9	196.3
SOLAR INSOLATION RATE (BTU/HR-FT**2)	196.6	209.2	220.7	230.0	238.7	247.1	253.9	258.0	260.9	262.2
AMBIENT AIR TEMPERATURE (F)	36.2	36.4	36.7	37.7	33.1	33.1	40.1	36.4	29.2	26.2

PROFILE NUMBER	11	12	13	14	15	16	17	18	19	20
VELOCITY PROFILE TIME	1137	1222	1307	1337	1406	1436	1506	1522	1553	1607
AVERAGE VELOCITY (FT/SEC)	.81	.84	.83	.83	.77	.77	.65	.64	.29	.31
AVERAGE AIR TEMPERATURE IN GAP (F)	101.5	103.4	104.9	105.2	104.7	104.5	103.9	103.5	96.2	98.0
AIR TEMPERATURE IN INLET DUCT (F)	86.3	87.9	89.6	91.1	92.0	92.2	91.3	91.0	90.5	90.3
AIR TEMPERATURE IN OUTLET DUCT (F)	98.8	101.2	103.1	104.0	104.8	104.9	104.0	103.6	102.2	101.8
MASS FLOW RATE (LBM/HR-FT)	62.0	63.8	63.4	62.7	58.5	58.2	49.6	49.0	22.0	24.1
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	186.1	203.8	205.3	194.2	179.7	177.4	151.1	148.1	61.8	66.4
SOLAR INSOLATION RATE (BTU/HR-FT**2)	263.6	262.2	253.3	241.7	225.4	205.0	179.8	162.7	95.8	113.4
AMBIENT AIR TEMPERATURE (F)	25.7	24.0	24.4	24.6	24.5	23.9	23.1	21.6	17.4	16.1

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP6-4-100 NOMINAL GAP = 4 IN ELEVATION = 24 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 15, 1979 046 JULIAN

TIME OF DAY	900	915	930	945	1000	1015	1030	1045	1100	1115
CONVECTIVE ENERGY TRANSFER (BTU/FT)	24.8	29.4	33.8	39.0	41.8	43.5	47.5	54.1	50.6	
TIME OF DAY	1115	1130	1145	1200	1215	1230	1245	1300	1315	1330
CONVECTIVE ENERGY TRANSFER (BTU/FT)	49.2	46.6	48.0	49.5	51.0	51.1	51.2	51.3	49.9	
TIME OF DAY	1330	1345	1400	1415	1430	1445	1500	1515	1530	1545
CONVECTIVE ENERGY TRANSFER (BTU/FT)	48.5	46.6	44.9	44.6	44.0	40.7	37.7	36.7	26.2	
TIME OF DAY	1545	1600	1615							
CONVECTIVE ENERGY TRANSFER (BTU/FT)	15.8	16.6								

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APPENDIX D

SUMMARY OF RESULTS FOR 6" GAP WIDTH

APPENDIX D.1

TEST NO. GAP8-6-100

TEST NUMBER...GAP8-6-100

TEST DATE...FEB. 19, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN. INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

SUMMARY OF WALL EXPERIMENTAL DATA
 GAP BOUNDARY TEMPERATURES, GAP INLET/OUTLET AIR TEMPERATURES, AND AMBIENT CONDITIONS

TIME OF DAY	VERTICAL PYRANOMETER READING (BTU/HR-FT2)	THERMOCOUPLE READINGS (DEGREES-F)										
	P1VER	AAME	AINC	ADUTC	M13C00	M30C00	M79C00	M87C00	K13C02	K30C02	K79C02	K87C02
900	180.7	41.4	64.3	73.6	81.4	85.4	84.8	87.6	81.0	83.9	84.7	84.1
915	189.2	42.7	66.3	75.6	88.1	92.7	91.4	92.6	86.0	89.4	89.5	88.7
930	181.8	44.2	67.1	77.7	92.6	97.4	96.4	95.1	87.9	91.8	91.9	90.8
945	184.8	44.9	68.4	79.4	96.1	102.0	101.2	97.2	89.6	94.3	94.4	93.2
1000	106.7	42.5	68.2	78.7	93.1	98.3	98.1	93.2	79.1	83.0	84.8	83.9
1015	43.9	41.4	68.4	78.0	89.1	93.5	94.4	89.5	72.0	75.5	78.0	77.7
1030	123.6	41.3	68.3	77.3	86.9	92.1	93.4	87.9	74.1	76.5	78.6	78.1
1045	232.3	44.0	69.9	79.9	96.4	102.8	103.5	93.4	87.9	91.2	91.4	89.6
1100	71.8	40.7	69.8	79.5	96.1	101.4	102.5	92.5	81.0	84.8	86.1	84.7
1115	47.3	40.6	70.1	79.4	93.0	97.7	99.0	90.0	76.9	79.7	81.4	79.8
1130	162.8	42.2	71.3	81.4	100.4	106.9	108.1	94.8	91.5	95.4	95.0	93.1
1145	277.6	44.8	73.8	85.8	112.1	120.6	121.5	103.7	104.1	108.9	107.6	105.0
1200	278.4	44.8	75.0	88.2	117.5	128.1	129.0	107.0	108.4	114.6	112.9	109.8
1215	274.1	48.0	76.1	90.6	121.4	131.9	132.8	109.9	111.1	118.0	116.5	113.3
1230	277.5	50.3	78.0	93.1	125.0	136.2	137.3	113.1	115.8	123.6	121.8	117.7
1245	274.3	51.7	78.9	94.2	127.8	139.3	140.2	115.4	115.1	122.8	121.3	116.7
1300	269.6	51.1	80.2	95.8	129.9	140.8	141.7	117.0	115.5	124.5	123.5	118.0
1315	272.8	51.9	81.5	97.4	131.6	142.9	144.0	119.3	117.8	126.7	125.5	120.5
1330	276.5	49.4	82.9	99.0	132.4	144.6	146.1	121.1	119.3	128.5	127.4	122.0
1345	264.2	53.1	83.4	100.0	133.3	145.5	147.2	123.0	119.1	128.2	127.8	122.6
1400	268.9	52.1	84.3	100.0	131.2	143.8	145.4	122.9	115.6	123.8	123.3	118.3
1415	179.0	48.7	84.8	97.8	127.4	139.2	140.5	120.4	106.0	113.2	113.8	109.4
1430	61.0	47.3	83.1	95.6	117.3	127.2	129.1	113.6	91.8	97.4	99.9	95.7

TEST NUMBER...GAP8-6-100

TEST DATE...FEB. 19, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

AVERAGE TEMPERATURES FOR ZONES IN THE MASONRY WALL
 (TEMPERATURES IN UNITS OF DEGREES-F)

TIME	ZONE1	ZONE11	ZONE12	ZONE13	ZONE14	ZONE2	ZONE21	ZONE22	ZONE23	ZONE24	ZONE3	ZONE31	ZONE32	ZONE33	ZONE34
900	75.1	82.5	75.6	74.8	73.7	73.3	80.0	73.3	72.9	72.3	71.5	77.6	71.2	71.0	70.9
915	75.5	86.4	77.3	74.7	73.3	74.2	85.5	75.7	73.2	72.2	72.5	83.2	73.8	71.4	71.0
930	76.0	89.1	79.0	74.8	73.2	75.2	90.0	78.4	73.6	72.3	73.7	87.7	76.5	71.9	71.2
945	76.5	91.3	80.4	75.0	73.1	76.2	94.2	80.9	74.1	72.3	74.5	91.4	78.9	72.4	71.1
1000	76.7	90.0	81.5	75.4	73.2	76.7	93.7	82.8	74.9	72.5	75.2	90.8	80.7	73.2	71.4
1015	76.8	88.0	81.9	76.0	73.3	77.0	91.6	83.6	75.7	72.7	75.5	88.6	81.4	74.1	71.7
1030	76.6	86.3	81.2	76.2	73.3	76.9	90.1	83.1	76.3	72.7	75.2	86.4	80.4	74.4	71.6
1045	76.9	89.7	81.6	76.2	73.4	78.0	96.6	84.7	76.7	73.1	76.5	92.8	82.3	75.1	72.2
1100	77.3	90.3	82.8	76.4	73.4	78.6	97.7	86.8	77.1	73.1	77.1	94.3	84.5	75.5	72.2
1115	77.5	88.8	83.0	77.0	73.8	78.9	95.5	87.0	77.9	73.5	77.3	92.2	84.7	76.3	72.5
1130	77.9	91.8	83.4	77.1	73.8	79.7	101.2	88.4	78.3	73.5	78.1	97.1	85.9	76.7	72.6
1145	80.5	98.9	87.0	79.0	75.6	82.1	111.4	92.6	79.5	74.5	79.6	106.5	89.4	77.0	72.7
1200	80.6	102.4	88.7	78.5	74.9	83.4	118.4	96.6	80.0	74.2	81.1	112.4	93.1	78.0	72.9
1215	81.9	105.7	91.3	79.7	75.5	85.0	122.7	100.1	81.4	74.6	82.8	116.6	96.6	79.5	73.6
1230	83.3	108.8	93.8	80.9	76.2	86.7	126.9	103.5	82.9	75.4	84.4	120.3	99.7	80.9	74.2
1245	84.7	111.5	96.3	82.4	77.1	88.3	130.3	106.7	84.6	76.1	85.7	123.5	102.5	82.3	74.6
1300	85.9	113.3	98.3	83.6	77.7	89.5	132.4	109.2	86.0	76.7	87.0	125.8	105.1	83.8	75.2
1315	87.3	115.7	100.5	85.1	78.7	91.1	134.8	111.7	87.8	77.6	88.4	127.9	107.4	85.5	76.0
1330	88.4	117.5	102.3	86.3	79.3	92.5	136.9	114.0	89.4	78.5	89.8	129.4	109.4	87.1	77.1
1345	89.9	119.5	104.4	88.0	80.4	93.7	138.3	116.0	90.9	79.2	90.6	130.7	111.0	88.2	77.3
1400	91.1	119.9	105.9	89.5	81.4	94.7	137.6	117.1	92.4	80.2	91.4	129.6	111.7	89.4	78.3
1415	91.6	118.9	106.8	90.4	81.8	95.4	135.3	118.0	93.8	80.9	92.3	127.7	112.6	90.9	79.3
1430	91.7	114.3	106.6	91.6	82.4	95.2	127.5	116.8	95.1	81.6	92.0	120.4	111.3	92.0	79.9

NOTE...ZONE(K) IS THE HORIZONTAL LAYER OF WALL LYING BETWEEN 93.5 AND 79 INCH ELEVATIONS (K=1), OR BETWEEN 79 AND 30 INCH ELEVATIONS (K=2), OR BETWEEN 30 AND 7.25 INCH ELEVATIONS (K=3). ZONE(KJ) IS A SUBZONE OF ZONE K FORMED BY VERTICAL PLANES HYPOTHETICALLY LOCATED AT DEPTHS OF 1, 3 AND 6 INCHES FROM THE FRONT, OUTSIDE WALL SURFACE...THE SUBZONE LIES BETWEEN THE OUTSIDE SURFACE AND A 1-INCH DEPTH (J=1), OR BETWEEN A 1-INCH AND 3-INCH DEPTH (J=2), OR BETWEEN A 3-INCH AND 6-INCH DEPTH (J=3), OR BETWEEN A 6-INCH DEPTH AND THE WALL INSIDE SURFACE (J=4).

TEST NUMBER...GAP8-6-100

TEST DATE...FEB. 19, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

SUMMARY TABLE
 OF
 CONDUCTIVE THERMAL ENERGY STORAGE IN MASONRY WALL

TIME OF DAY

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	900	915	930	945	1000	1015	1030	1045	1100	1115	1130	1145
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ETOTAL (BTU/FT)	116.77	123.11	106.88	66.97	33.91	-18.94	135.18	69.95	31.46	98.65	286.05	

TIME OF DAY

.....

	1145	1200	1215	1230	1245	1300	1315	1330	1345	1400	1415	1430
	----	----	----	----	----	----	----	----	----	----	----	----
ETOTAL (BTU/FT)	143.84	212.05	204.06	193.68	164.40	192.58	178.52	145.59	129.80	91.08	-22.44	

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP8-6-100 NOMINAL GAP = 6 IN ELEVATION = 24 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 19, 1979 050 JULIAN

THE ATMOSPHERIC PRESSURE CORRECTED TO SEA LEVEL WAS 29.72 IN HG

PROFILE NUMBER	1	2	3	4	5	6	7	8	9	10
VELOCITY PROFILE TIME	924	954	1011	1040	1111	1140	1208	1224	1253	1324
AVERAGE VELOCITY (FT/SEC)	.48	.52	.41	.43	.40	.57	.69	.59	.72	.69
AVERAGE AIR TEMPERATURE IN GAP (F)	80.7	82.2	77.9	80.0	79.3	90.7	95.8	97.5	99.5	101.6
AIR TEMPERATURE IN INLET DUCT (F)	66.8	68.3	68.3	69.4	70.0	73.0	75.6	77.2	79.6	82.2
AIR TEMPERATURE IN OUTLET DUCT (F)	76.5	79.0	87.2	79.0	79.4	84.3	89.5	92.1	95.1	98.4
MASS FLOW RATE (LBM/HR-FT)	62.1	67.1	52.3	55.1	51.9	72.3	86.6	73.6	89.4	84.4
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	150.5	172.2	237.2	126.9	117.1	196.0	288.8	263.3	332.4	328.2
SOLAR INSOLATION RATE (BTU/HR-FT**2)	184.8	137.9	70.6	196.3	53.8	239.3	276.1	276.1	271.8	275.0
AMBIENT AIR TEMPERATURE (F)	43.6	43.5	41.7	43.1	40.6	44.0	42.2	46.2	51.4	50.4

PROFILE NUMBER	11	12
VELOCITY PROFILE TIME	1353	1409
AVERAGE VELOCITY (FT/SEC)	.71	.70
AVERAGE AIR TEMPERATURE IN GAP (F)	102.3	101.7
AIR TEMPERATURE IN INLET DUCT (F)	83.9	84.6
AIR TEMPERATURE IN OUTLET DUCT (F)	100.0	98.7
MASS FLOW RATE (LBM/HR-FT)	87.2	86.5
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	337.1	292.6
SOLAR INSOLATION RATE (BTU/HR-FT**2)	266.7	215.0
AMBIENT AIR TEMPERATURE (F)	52.6	50.1

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP8-6-100 NOMINAL GAP = 6 IN ELEVATION = 24 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 19, 1979 050 JULIAN

TIME OF DAY	915	930	945	1000	1015	1030	1045	1100	1115	1130
CONVECTIVE ENERGY TRANSFER (BTU/FT)	37.3	40.1	42.8	56.0	48.4	34.1	30.7	29.6	37.1	
TIME OF DAY	1130	1145	1200	1215	1230	1245	1300	1315	1330	1345
CONVECTIVE ENERGY TRANSFER (BTU/FT)	47.3	59.4	71.8	66.4	73.9	82.8	82.6	82.1	83.1	
TIME OF DAY	1345	1400	1415							
CONVECTIVE ENERGY TRANSFER (BTU/FT)	84.2	74.2								

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APPENDIX D.2

TEST NO. GAP9-6-100

TEST NUMBER...GAP9-6-100

TEST DATE...FEB. 23, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

SUMMARY OF WALL EXPERIMENTAL DATA
 GAP BOUNDARY TEMPERATURES, GAP INLET/OUTLET AIR TEMPERATURES, AND AMBIENT CONDITIONS

TIME OF DAY	VERTICAL PYRANOMETER READING (BTU/HR-FT2)	THERMOCOUPLE READINGS (DEGREES-F)										
	P1VER	AAMB	AIRC	AOUTC	M13C00	M30C00	M79C00	M87C00	K13C02	K30C02	K79C02	K87C02
												
900	118.4	26.0	60.9	69.0	76.9	79.6	78.9	80.6	72.2	74.6	75.7	75.6
915	184.8	28.8	62.1	71.1	83.2	86.8	85.1	85.1	77.6	80.1	80.8	80.3
930	206.3	29.3	63.1	72.4	88.4	92.8	91.4	88.2	81.7	84.5	84.3	83.6
945	222.6	31.2	65.1	74.9	94.8	99.9	98.1	91.5	86.3	89.8	89.2	87.9
1000	238.6	31.1	65.4	74.9	93.9	100.1	99.0	90.3	81.3	84.9	85.3	84.4
1015	247.3	32.5	66.6	76.7	97.7	104.6	103.0	91.8	84.4	88.3	88.4	87.2
1030	264.6	35.1	68.1	80.0	107.6	115.7	113.4	97.3	98.4	103.5	101.9	99.0
1045	273.9	38.7	69.8	83.0	113.0	121.9	120.2	100.9	104.1	109.9	108.0	104.9

TEST NUMBER...GAP9-6-100

TEST DATE...FEB. 23, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

AVERAGE TEMPERATURES FOR ZONES IN THE MASONRY WALL
 (TEMPERATURES IN UNITS OF DEGREES-F)

TIME	ZONE1	ZONE11	ZONE12	ZONE13	ZONE14	ZONE2	ZONE21	ZONE22	ZONE23	ZONE24	ZONE3	ZONE31	ZONE32	ZONE33	ZONE34
900	69.2	76.8	70.5	68.6	67.8	68.2	75.2	68.9	67.4	67.1	67.1	73.6	67.4	66.3	66.3
915	69.7	80.1	71.9	68.7	67.6	69.1	80.1	71.0	67.9	67.2	68.2	78.5	69.5	66.8	66.7
930	70.0	82.5	72.9	68.8	67.4	70.0	84.9	73.2	68.3	67.1	69.0	83.1	71.9	67.2	66.5
945	70.8	85.5	74.5	69.3	67.6	71.3	90.5	76.1	69.0	67.5	70.6	88.7	75.0	68.1	67.1
1000	71.2	85.8	75.7	69.6	67.8	72.1	92.5	78.4	69.7	67.5	71.2	89.8	76.9	68.7	67.1
1015	71.7	87.4	76.9	70.1	67.9	73.2	96.2	80.8	70.6	67.8	72.3	93.3	79.2	69.7	67.5
1030	72.7	91.8	78.8	70.7	68.2	74.7	104.1	84.1	71.4	67.9	73.7	100.8	82.3	70.3	67.5
1045	74.0	95.4	81.1	71.6	68.9	76.4	110.1	87.8	72.5	68.5	75.3	106.3	85.9	71.4	67.9

NOTE...ZONE(K) IS THE HORIZONTAL LAYER OF WALL LYING BETWEEN 93.5 AND 79 INCH ELEVATIONS (K=1), OR BETWEEN 79 AND 30 INCH ELEVATIONS (K=2), OR BETWEEN 30 AND 7.25 INCH ELEVATIONS (K=3). ZONE(KJ) IS A SUBZONE OF ZONE K FORMED BY VERTICAL PLANES HYPOTHETICALLY LOCATED AT DEPTHS OF 1, 3 AND 6 INCHES FROM THE FRONT, OUTSIDE WALL SURFACE...THE SUBZONE LIES BETWEEN THE OUTSIDE SURFACE AND A 1-INCH DEPTH (J=1), OR BETWEEN A 1-INCH AND 3-INCH DEPTH (J=2), OR BETWEEN A 3-INCH AND 6-INCH DEPTH (J=3), OR BETWEEN A 6-INCH DEPTH AND THE WALL INSIDE SURFACE (J=4).

TEST NUMBER...GAP9-6-100

TEST DATE...FEB. 23, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

SUMMARY TABLE
OF
CONDUCTIVE THERMAL ENERGY STORAGE IN MASONRY WALL
.....

	TIME OF DAY							
	<u>900</u>	<u>915</u>	<u>930</u>	<u>945</u>	<u>1000</u>	<u>1015</u>	<u>1030</u>	<u>1045</u>
ETOTAL (BTU/FT)	119.91	97.02	170.43	85.21	134.39	178.43	207.74	

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP9-6-100 NOMINAL GAP = 6 IN ELEVATION = 24 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 23, 1979 054 JULIAN

THE ATMOSPHERIC PRESSURE CORRECTED TO SEA LEVEL WAS 29.85 IN HG

PROFILE NUMBER	1	2	3	4	5	6	7	8
VELOCITY PROFILE TIME	910	939	1010	1040	1124	1209	1239	1311
AVERAGE VELOCITY (FT/SEC)	.41	.51	.50	.61	.64	.46	.37	.34
AVERAGE AIR TEMPERATURE IN GAP (F)	74.0	78.1	80.5	88.6	93.4	84.4	79.5	79.4
AIR TEMPERATURE IN INLET DUCT (F)	61.7	64.3	66.2	69.2	73.1	72.7	72.2	71.9
AIR TEMPERATURE IN OUTLET DUCT (F)	70.4	73.9	76.1	82.0	87.2	83.6	81.4	81.0
MASS FLOW RATE (LBM/HR-FT)	53.5	66.4	63.7	77.8	80.0	58.0	47.5	44.0
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	111.6	153.0	151.4	239.0	270.8	151.8	104.8	96.1
SOLAR INSOLATION RATE (BTU/HR-FT**2)	162.7	216.1	244.4	270.8	290.8	96.0	74.0	83.0
AMBIENT AIR TEMPERATURE (F)	27.8	30.5	32.0	37.5	41.6	35.3	33.4	33.4

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP9-6-10C NOMINAL GAP = 6 IN ELEVATION = 24 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 23, 1979 054 JULIAN

TIME OF DAY	900	915	930	945	1000	1015	1030	1045	1100	1115
CONVECTIVE ENERGY TRANSFER (BTU/FT)	27.0	32.4	37.7	38.1	37.9	47.0	57.9	62.0	64.7	
TIME OF DAY	1115	1130	1145	1200	1215	1230	1245	1300	1315	
CONVECTIVE ENERGY TRANSFER (BTU/FT)	67.4	58.8	48.9	38.9	32.7	26.8	25.3	24.3		

APPENDIX D.3

TEST NO. GAP10-6-100

TEST NUMBER...GAP10-6-100

TEST DATE...FEB. 24, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

SUMMARY OF WALL EXPERIMENTAL DATA
 GAP BOUNDARY TEMPERATURES, GAP INLET/OUTLET AIR TEMPERATURES, AND AMBIENT CONDITIONS

TIME OF DAY	VERTICAL PYRANOMETER READING (BTU/HR-FT ²)	THERMOCOUPLE READINGS (DEGREES-F)										
	P1VER	AAMB	AINC	AOUTC	M13C00	M30C00	M79C00	M87C00	K13C02	K30C02	K79C02	K87C02
1000	222.5	31.5	60.8	71.8	94.8	101.6	109.7	88.4	87.3	92.0	90.8	89.0
1015	240.0	32.4	62.4	74.0	100.2	108.1	105.8	91.0	90.8	95.5	94.3	92.2
1030	242.6	31.7	63.0	73.6	99.2	106.9	105.2	89.4	87.1	91.0	89.9	87.3
1045	244.3	32.2	64.7	75.5	106.1	114.1	112.7	92.5	93.2	97.5	96.0	92.8
1100	248.3	32.2	65.6	77.9	109.2	118.3	117.7	94.6	95.4	100.9	99.6	96.1
1115	247.5	31.4	67.0	79.7	112.2	121.2	121.3	96.7	98.6	104.2	102.5	98.9
1130	251.1	31.4	67.8	81.0	113.0	122.8	122.8	98.0	97.7	103.9	102.9	99.4
1145	190.9	31.9	69.0	81.3	111.6	121.1	121.1	97.7	93.7	99.7	99.2	95.5
1200	282.4	34.5	68.7	81.2	110.2	120.2	120.3	96.8	95.1	100.6	99.4	95.8
1215	254.4	31.3	70.5	83.7	115.1	125.5	125.5	99.2	100.7	106.6	104.7	100.7
1230	169.0	32.4	71.9	85.2	117.7	127.6	127.3	100.6	99.4	106.3	104.8	99.8
1245	203.3	33.8	72.2	84.6	114.5	124.2	124.2	100.3	95.8	101.6	100.7	96.1
1300	262.1	34.5	72.7	82.7	111.9	122.0	121.9	99.6	94.1	99.3	98.5	94.1
1315	256.6	34.6	74.0	83.9	116.9	126.9	127.1	101.8	100.2	105.9	104.0	99.1
1330	254.1	35.2	74.4	86.8	119.5	130.2	130.5	104.0	103.5	110.7	109.0	104.2
1345	218.1	34.0	75.3	87.9	120.0	130.3	130.8	105.1	102.4	108.9	107.7	103.1
1400	245.1	33.4	76.1	88.7	120.9	131.7	132.3	106.1	103.4	110.6	109.8	105.0
1415	224.4	32.9	76.1	88.8	117.9	127.4	128.1	105.0	95.6	102.3	102.3	97.7
1430	203.7	33.3	77.0	88.7	118.5	129.3	130.0	105.8	99.0	105.3	104.8	100.5
1445	201.5	31.4	77.5	89.9	117.3	128.5	129.3	105.3	98.3	5.1	104.9	100.9
1500	190.5	31.7	77.8	90.2	115.4	126.5	127.9	104.1	97.4	103.6	103.9	100.3
1515	179.4	31.0	78.0	89.4	112.1	123.5	124.9	102.3	93.1	98.3	98.7	94.7
1530	167.4	31.9	78.0	89.0	109.6	120.6	122.3	101.4	92.2	97.4	98.0	94.4
1545	149.6	30.6	78.1	86.8	104.5	111.8	118.1	100.8	84.5	84.3	93.5	90.7
1600	133.4	30.0	77.0	85.3	102.3	109.8	113.1	99.4	84.0	86.6	88.5	86.1
1615	110.4	29.7	77.1	86.9	100.8	107.3	109.8	98.7	85.2	87.8	89.5	87.8
1630	21.3	28.1	76.2	86.0	95.7	101.7	104.5	95.5	71.8	74.9	78.6	77.7
1645	9.9	27.6	75.9	81.9	90.6	96.0	99.0	91.4	65.7	68.1	71.6	71.3

TEST NUMBER...GAP10-6-100

TEST DATE...FEB. 24, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

AVERAGE TEMPERATURES FOR ZONES IN THE MASONRY WALL
 (TEMPERATURES IN UNITS OF DEGREES-F)

.....

TIME	ZONE1	ZONE11	ZONE12	ZONE13	ZONE14	ZONE2	ZONE21	ZONE22	ZONE23	ZONE24	ZONE3	ZONE31	ZONE32	ZONE33	ZONE34
....															
1000	65.7	82.7	70.7	63.7	61.9	66.6	91.3	74.0	63.7	61.1	65.3	88.6	72.3	62.4	60.1
1015	66.4	85.5	72.4	64.2	62.1	68.1	96.9	77.2	64.6	61.6	67.0	93.8	75.6	63.6	61.0
1030	66.9	85.0	73.2	65.0	62.4	68.6	97.1	78.9	65.7	61.7	67.4	93.8	76.9	64.5	60.8
1045	67.8	87.9	74.8	65.6	62.9	70.5	103.3	82.2	66.8	62.5	69.5	99.8	80.4	65.9	62.0
1100	68.8	90.2	76.6	66.5	63.4	72.0	107.8	85.5	68.2	62.8	70.6	103.5	83.3	67.0	62.1
1115	70.0	92.6	78.7	67.6	64.1	73.6	111.4	88.6	69.6	63.5	72.2	106.9	86.5	68.5	62.9
1130	71.2	94.4	80.7	68.9	64.9	74.6	113.7	91.2	71.0	64.0	73.0	108.6	88.5	69.5	63.0
1145	72.1	95.1	82.4	70.0	65.4	76.0	113.8	93.4	72.6	64.8	74.5	108.7	90.7	71.4	64.2
1200	72.6	94.2	82.6	71.0	66.0	76.7	112.8	93.8	74.0	65.4	74.8	107.3	90.6	72.6	64.6
1215	73.6	96.4	84.0	71.9	66.8	78.2	117.1	96.2	75.2	66.3	76.4	111.4	93.0	73.7	65.5
1230	74.7	98.1	85.6	72.9	67.5	79.3	119.4	98.4	76.4	66.9	77.4	114.1	95.2	74.8	65.9
1245	75.6	98.5	87.0	74.1	68.2	80.2	117.9	99.4	77.9	67.8	78.3	112.4	96.0	76.3	66.9
1300	76.1	97.8	87.4	75.1	68.7	80.6	116.0	99.3	79.0	68.4	78.5	110.2	95.6	77.2	67.4
1315	76.8	99.4	88.0	75.6	69.3	81.8	119.7	101.0	79.9	69.1	79.9	114.1	97.5	78.2	68.3
1330	78.0	101.6	89.6	76.8	70.3	83.1	122.7	102.9	81.0	69.9	80.8	116.6	99.1	79.0	68.7
1345	79.0	103.0	91.1	77.8	71.1	84.2	123.7	104.6	82.2	70.8	82.0	117.7	100.8	80.4	69.8
1400	79.9	103.9	92.1	78.8	71.8	85.2	124.3	105.8	83.4	71.6	82.9	118.6	101.8	81.4	70.4
1415	80.9	104.0	93.7	80.0	72.7	85.9	123.2	106.9	84.6	72.4	83.7	117.3	103.0	82.6	71.3
1430	81.5	104.4	93.9	80.8	73.3	86.7	124.1	107.5	85.7	73.1	84.2	117.6	103.1	83.4	71.9
1445	82.1	104.2	94.4	81.6	74.0	87.6	123.9	108.2	86.8	74.0	85.0	117.0	103.6	84.5	72.9
1500	82.6	103.4	94.5	82.2	74.8	88.1	122.9	108.5	87.7	74.8	85.4	115.8	103.6	85.2	73.5
1515	82.8	102.2	94.4	82.7	75.2	88.3	121.0	108.4	88.6	75.6	85.9	113.5	103.2	86.0	74.6
1530	83.4	101.6	94.7	83.6	76.0	88.9	119.0	108.1	89.3	76.3	86.0	111.6	102.6	86.5	75.1
1545	84.1	101.4	95.6	84.6	76.6	89.9	114.6	107.1	90.0	77.1	86.4	107.6	102.5	87.7	76.0
1600	84.6	100.4	96.0	85.6	77.1	89.7	111.4	105.7	90.5	77.5	86.0	105.1	100.8	87.8	76.3
1615	85.0	99.8	96.2	86.3	77.6	89.6	108.9	104.4	90.7	78.2	86.3	103.5	100.1	88.3	77.2
1630	84.9	97.3	95.4	86.7	78.0	89.2	104.8	102.8	90.8	78.7	85.8	99.4	98.2	88.1	77.6
1645	84.5	93.6	93.4	86.6	78.5	87.7	99.8	100.3	90.8	79.3	85.0	94.6	95.4	87.8	78.1

NOTE...ZONE(K) IS THE HORIZONTAL LAYER OF WALL LYING BETWEEN 93.5 AND 79 INCH ELEVATIONS (K=1), OR BETWEEN 79 AND 30 INCH ELEVATIONS (K=2), OR BETWEEN 30 AND 7.25 INCH ELEVATIONS (K=3). ZONE(KJ) IS A SUBZONE OF ZONE K FORMED BY VERTICAL PLANES HYPOTHETICALLY LOCATED AT DEPTHS OF 1, 3 AND 6 INCHES FROM THE FRONT OUTSIDE WALL SURFACE...THE SUBZONE LIES BETWEEN THE OUTSIDE SURFACE AND A 1-INCH DEPTH (J=1), OR BETWEEN A 1-INCH AND 3-INCH DEPTH (J=2), OR BETWEEN A 3-INCH AND 6-INCH DEPTH (J=3), OR BETWEEN A 6-INCH DEPTH AND THE WALL INSIDE SURFACE (J=4).

TEST NUMBER...GAP10-6-100

TEST DATE...FEB. 24, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR/PARTLY CLOUDY SKIES

SUMMARY TABLE
 OF
 CONDUCTIVE THERMAL ENERGY STORAGE IN MASONRY WALL

	TIME OF DAY											
	<u>1000</u>	<u>1015</u>	<u>1030</u>	<u>1045</u>	<u>1100</u>	<u>1115</u>	<u>1130</u>	<u>1145</u>	<u>1200</u>	<u>1215</u>	<u>1230</u>	<u>1245</u>
ETOTAL (BTU/FT)	183.37	69.09	224.64	170.51	193.56	147.73	159.36	68.38	186.21	146.56	112.78	

	TIME OF DAY											
	<u>1245</u>	<u>1300</u>	<u>1315</u>	<u>1330</u>	<u>1345</u>	<u>1400</u>	<u>1415</u>	<u>1430</u>	<u>1445</u>	<u>1500</u>	<u>1515</u>	<u>1530</u>
ETOTAL (BTU/FT)	48.65	150.97	151.13	147.62	119.94	106.93	90.06	103.09	65.24	53.54	38.32	

	TIME OF DAY					
	1530	1545	1600	1615	1630	1645
	----	----	----	----	----	----
ETOTAL (BTU/FT)	26.83	-13.86	12.22	-45.04	-77.71	

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP10-6-100 NOMINAL GAP = 6 IN ELEVATION = 73 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 24, 1970 055 JULIAN

THE ATMOSPHERIC PRESSURE CORRECTED TO SEA LEVEL WAS 30.23 IN HG

PROFILE NUMBER	1	2	3	4	5	6	7	8	9	10
VELOCITY PROFILE TIME	1010	1040	1110	1142	1211	1241	1310	1341	1410	1440
AVERAGE VELOCITY (FT/SEC)	.60	.69	.65	.59	.65	.58	.61	.61	.57	.58
AVERAGE AIR TEMPERATURE IN GAP (F)	87.7	89.5	95.0	94.8	98.6	97.2	99.2	103.5	104.0	103.8
AIR TEMPERATURE IN INLET DUCT (F)	61.9	64.1	66.5	68.8	70.0	72.1	73.6	75.0	76.1	77.3
AIR TEMPERATURE IN OUTLET DUCT (F)	73.3	74.9	79.1	81.2	83.0	84.8	83.5	86.8	88.8	89.5
MASS FLOW RATE (LBM/HR-FT)	77.1	83.4	81.9	75.5	81.6	73.2	77.0	76.3	71.6	72.4
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	210.8	222.1	247.6	224.8	254.8	223.0	182.9	216.2	217.9	212.1
SOLAR INSOLATION RATE (BTU/HR-FT**2)	234.2	243.7	247.8	202.9	261.9	194.2	258.4	227.7	238.2	202.2
AMBIENT AIR TEMPERATURE (F)	32.1	32.0	31.7	31.8	32.2	33.0	34.6	34.3	33.1	32.0

PROFILE NUMBER	11	12	13	14
VELOCITY PROFILE TIME	1511	1541	1611	1642
AVERAGE VELOCITY (FT/SEC)	.47	.36	.31	.26
AVERAGE AIR TEMPERATURE IN GAP (F)	102.0	99.4	94.5	85.9
AIR TEMPERATURE IN INLET DUCT (F)	77.3	73.1	77.1	76.0
AIR TEMPERATURE IN OUTLET DUCT (F)	89.5	87.4	86.5	82.7
MASS FLOW RATE (LBM/HR-FT)	59.0	44.7	39.8	33.4
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	165.7	99.8	89.7	53.7
SOLAR INSOLATION RATE (BTU/HR-FT**2)	182.4	154.3	116.5	12.2
AMBIENT AIR TEMPERATURE (F)	31.2	30.9	29.8	27.7

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP10-G-100 NOMINAL GAP = 6 IN ELEVATION = 73 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON FEBRUARY 24, 1979 055 JULIAN

TIME OF DAY	1000	1015	1030	1045	1100	1115	1130	1145	1200	1215
CONVECTIVE ENERGY TRANSFER (BTU/FT)	52.3	54.6	56.9	59.2	61.5	59.7	57.0	58.9	62.7	
TIME OF DAY	1215	1230	1245	1300	1315	1330	1345	1400	1415	1430
CONVECTIVE ENERGY TRANSFER (BTU/FT)	60.6	56.7	51.8	46.6	49.1	53.1	54.2	54.4	53.9	
TIME OF DAY	1430	1445	1500	1515	1530	1545	1600	1615	1630	1645
CONVECTIVE ENERGY TRANSFER (BTU/FT)	53.1	48.3	42.7	35.1	26.9	24.0	22.7	19.1	14.7	

APPENDIX D.4

TEST NO. GAP15-6-100

TEST NUMBER...GAP15-6-100

TEST DATE...MAR. 14, 1979

ENRGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY OF WALL EXPERIMENTAL DATA
 GAP BOUNDARY TEMPERATURES, GAP INLET/OUTLET AIR TEMPERATURES, AND AMBIENT CONDITIONS

TIME OF DAY	VERTICAL PYRANOMETER READING (BTU/HR-FT2)	THERMOCOUPLE READINGS (DEGREES-F)										
	P1VER	AAMB	AINC	AOUTC	M13C00	M30C00	M79C00	M87C00	K13C02	K30C02	K79C02	K87C02
.....												
845	147.1	33.3	65.4	72.8	78.6	81.8	82.4	76.9	77.4	79.3	79.4	78.6
900	161.2	37.0	66.9	74.9	83.3	85.8	85.2	79.1	82.1	84.8	84.2	83.1
915	173.6	38.6	68.2	76.5	88.1	90.5	88.7	81.1	86.1	89.6	88.1	86.8
930	184.9	40.6	69.6	78.1	92.9	95.7	93.2	83.2	89.5	93.2	91.2	89.5
945	194.4	44.1	70.6	79.9	97.5	100.9	98.3	85.3	92.6	96.7	94.4	92.1
1000	203.1	44.7	71.5	80.9	101.1	105.6	102.9	86.8	93.9	97.8	95.5	92.8
1015	210.2	46.0	72.6	82.3	105.1	110.6	107.2	88.4	96.5	100.4	97.7	94.7
1030	217.1	45.8	73.3	83.6	108.4	114.8	111.4	89.9	98.6	102.8	100.3	96.7
1045	221.1	46.5	74.4	84.8	111.4	118.7	115.4	91.5	101.1	105.3	102.7	99.2
1100	224.7	46.2	75.2	86.0	114.0	121.7	118.8	93.0	102.5	107.1	104.5	100.3
1115	227.9	46.2	76.2	87.3	116.4	124.5	121.6	94.5	103.4	108.2	106.0	101.4
1130	231.0	45.5	76.9	88.5	118.0	126.8	124.4	95.8	104.9	110.1	107.5	102.7
1145	234.0	45.1	78.3	89.6	119.8	129.4	126.6	97.2	106.4	111.5	108.9	103.8
1200	235.4	45.8	78.5	90.3	121.2	131.3	128.6	98.6	107.0	112.8	110.0	104.7

TEST NUMBER...GAP15-6-100

TEST DATE...MAR. 14, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
 NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

AVERAGE TEMPERATURES FOR ZONES IN THE MASONRY WALL
 (TEMPERATURES IN UNITS OF DEGREES-F)

TIME	ZONE1	ZONE11	ZONE12	ZONE13	ZONE14	ZONE2	ZONE21	ZONE22	ZONE23	ZONE24	ZONE3	ZONE31	ZONE32	ZONE33	ZONE34
845	73.1	76.4	74.0	72.8	72.2	73.6	79.7	75.1	73.2	72.2	72.2	77.3	73.2	71.9	71.2
900	73.5	78.2	75.0	73.2	72.3	74.2	82.5	76.6	73.5	72.3	73.3	80.9	75.2	72.5	71.7
915	73.9	79.8	75.8	73.4	72.4	74.9	85.6	78.1	73.9	72.3	74.1	84.6	76.9	73.0	71.8
930	74.3	81.5	76.7	73.8	72.5	75.6	89.1	79.7	74.4	72.4	74.8	88.3	78.6	73.4	71.8
945	74.8	83.2	77.5	74.1	72.7	76.6	93.1	81.6	74.9	72.7	75.9	92.2	80.7	74.1	72.3
1000	75.1	84.7	78.3	74.3	72.7	77.5	97.1	83.8	75.6	72.8	76.8	95.8	82.9	74.7	72.3
1015	75.8	86.4	79.3	74.8	73.1	78.6	101.1	86.2	76.3	73.1	77.9	99.6	85.1	75.4	72.7
1030	76.4	88.0	80.5	75.3	73.4	79.6	104.9	88.5	77.0	73.2	78.7	102.9	87.2	76.0	72.6
1045	76.9	89.7	81.6	75.7	73.7	80.8	108.6	91.0	77.9	73.7	80.0	106.2	89.7	77.2	73.4
1100	77.9	91.4	83.0	76.5	74.3	81.9	111.9	93.6	78.9	74.0	80.9	109.2	92.1	78.0	73.4
1115	78.9	93.1	84.5	77.5	75.0	83.1	114.9	96.0	80.1	74.3	81.7	111.9	94.2	78.7	73.2
1130	79.3	94.4	85.5	78.0	75.2	84.1	117.5	98.1	81.1	74.3	82.9	113.9	96.3	80.0	74.0
1145	80.2	96.0	86.8	78.9	75.8	85.3	119.9	100.3	82.3	75.4	84.0	116.1	98.3	81.2	74.6
1200	81.1	97.5	88.2	79.7	76.3	86.4	122.1	102.4	83.5	75.8	84.8	117.8	100.0	82.2	74.8

NOTE...ZONE(K) IS THE HORIZONTAL LAYER OF WALL LYING BETWEEN 93.5 AND 79 INCH ELEVATIONS (K=1), OR BETWEEN 79 AND 30 INCH ELEVATIONS (K=2), OR BETWEEN 30 AND 7.25 INCH ELEVATIONS (K=3). ZONE(KJ) IS A SUBZONE OF ZONE K FORMED BY VERTICAL PLANES HYPOTHETICALLY LOCATED AT DEPTHS OF 1, 3 AND 6 INCHES FROM THE FRONT, OUTSIDE WALL SURFACE...THE SUBZONE LIES BETWEEN THE OUTSIDE SURFACE AND A 1-INCH DEPTH (J=1), OR BETWEEN A 1-INCH AND 3-INCH DEPTH (J=2), OR BETWEEN A 3-INCH AND 6-INCH DEPTH (J=3), OR BETWEEN A 6-INCH DEPTH AND THE WALL INSIDE SURFACE (J=4).

TEST NUMBER...GAP15-6-100

TEST DATE...MAR. 14, 1979

ENERGY ENGINEERING GROUP, INC...GOLDEN, COLORADO

NOMINAL GAP = 6 IN INLET/OUTLET DUCTS = 100 PERCENT OPEN CENTERPLANE DATA
NO NIGHTTIME WALL INSULATION NO BACKDRAFT CONTROL CLEAR SKY CONDITIONS

SUMMARY TABLE
OF
CONDUCTIVE THERMAL ENERGY STORAGE IN MASONRY WALL
.....

	TIME OF DAY											
	845	930	915	930	945	1000	1015	1030	1045	1100	1115	1130
ETOTAL (BTU/FT)	96.48	80.40	90.65	120.33	103.76	134.69	108.99	147.61	138.24	130.69	131.72	

	TIME OF DAY		
	1130	1145	1200
ETOTAL (BTU/FT)	144.20	125.32	

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP-5-6-100 NOMINAL GAP = 6 IN. ELEVATION = 73 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON MARCH 14, 1979 073 JULIAN

THE ATMOSPHERIC PRESSURE CORRECTED TO SEA LEVEL WAS 30.33 IN HG

PROFILE NUMBER	1	2	3	4
VELOCITY PROFILE TIME	936	1013	1042	1143
AVERAGE VELOCITY (FT/SEC)	.45	.54	.60	.65
AVERAGE AIR TEMPERATURE IN GAP (F)	91.7	95.8	99.4	104.1
AIR TEMPERATURE IN INLET DUCT (F)	70.0	71.1	74.2	78.1
AIR TEMPERATURE IN OUTLET DUCT (F)	79.8	80.3	84.6	89.5
MASS FLOW RATE (LBM/HR-FT)	57.6	68.5	76.2	81.5
CONVECTIVE HEAT TRANSFER RATE (BTU/HR-FT)	121.6	154.5	190.2	222.9
SOLAR INSOLATION RATE (BTU/HR-FT**2)	188.7	201.9	220.3	233.6
AMBIENT AIR TEMPERATURE (F)	42.0	44.6	46.4	45.2

ENERGY ENGINEERING GROUP, INC. GOLDEN, COLORADO

TEST NO. GAP15-6-100 NOMINAL GAP = 6 IN. ELEVATION = 73 IN CENTERPLANE
INLET/OUTLET DUCTS = 100PC OPEN NO BACKDRAFT CONTROL

THIS DATA WAS TAKEN ON MARCH 14, 1979 073 JULIAN

TIME OF DAY	915	930	945	1000	1015	1030	1045	1100	1115	1130
CONVECTIVE ENERGY TRANSFER (BTU/FT)	27.4	30.7	34.1	37.4	41.5	46.2	49.0	51.0	53.0	

TIME OF DAY	1130	1145	1200
CONVECTIVE ENERGY TRANSFER (BTU/FT)	55.0	57.0	

APPENDIX E

BUILDING PERFORMANCE DATA, VENTED TROMBE WALL

TEST DESCRIPTION AND CONDITIONSTEST NUMBER: BP4-2-100 TEST TITLE: BUILDING PERFORMANCE, NO BACKDRAFT CONTROLTEST DATE: 01 / 04 / 79 ^{*} EEG STAFF: RL CASPERSON PROJECT NAME: DOE GRANT EG-77-G-04-4145TEST TIME SPAN: FROM: 004:
00 HR 00 MIN 00 SEC TO: 009:
18 HR 00 MIN 00 SECPRINTED CHANNELS 0-39 SCANNED AT 0 HR 30 MIN 0 SEC INTERVALS.
AVERAGED CHANNELS 0-1PRINTING OF INSTANTANEOUS VALUES AT 1 HR 0 MIN 0 SEC INTERVALS. (SEE REVERSE)PRINTING OF AVERAGED VALUES AT 0 HR 15 MIN 0 SEC INTERVALS; SAMPLE APPROX. _____* DATES: 01/04/79 ~ JULIAN DATE: 004 & 01/09/79 ~ JULIAN DATE 009I. WALL CONFIGURATION:

- A. NOMINAL WALL GAP: 2 Inches.
- B. WALL GAP AT PORT: N.A. Inches. (If Applicable)
- C. INLET/OUTLET AT: 100/100 % OPEN.

II. CHARACTERIZATION OF AMBIENT TEST CONDITIONS: (AT INITIATION OF TEST)

- A. INSOLATION: CLEAR SKY ☒ LIGHT FOG/HAZE _____
LIGHT CLOUD COVER _____ INTERMITTENT CLOUD COVER _____
CLOUD COVER TYPE (DESCRIBE): _____
- B. AMBIENT TEMPERATURE: _____ °F (Approx).
- C. WIND SPEED: CALM MPH STEADY _____ MPH GUSTS (Approx).
- D. WIND DIRECTION: _____

III. WEATHER AND BUILDING CONDITIONS PRIOR TO TEST:

- A. BUILDING CONDITIONS: MASONRY WALL FROM _____ °F OUTSIDE TO _____ °F INSIDE.
ROOM AIR TEMPERATURE AT _____ °F (Approx).

B. ONE DAY BEFORE TEST:10 °F TO 25 °F APPROX. AMBIENT AIR TEMP..CLEAR WITH SOME SKY CONDITIONS AND/OR SOLAR
P.M. LIGHT CLOUDS INSOLATION CHARACTERIZATIONNEARLY CALM WIND CONDITIONSTWO DAYS BEFORE TEST:-5 °F TO 20 °FCLEAR5-10 MPH FROM WESTIV. OTHER INFORMATION: SEE REVERSE SIDE..

- BACKDRAFT DAMPER REMOVED AT 9 30 PM ON 1/3/79, AND LEFT OFF FOR DURATION OF THE TEST.
- DURING DAYLIGHT HOURS, INSULATION IS SAMPLED AT 15 SEC INTERVALS AND AVERAGED / PRINTED AT 15 MIN; T-C CHANNELS ARE PRINTED INSTANTANEOUSLY AT 30 MIN INTERVALS.
- DURING PERIODS OF NO/LOW INSULATION VALUES, ALL T-C CHANNELS ARE PRINTED WITH INSTANTANEOUS VALUES AT 1 HOUR INTERVALS
- WEATHER / SKY CONDITIONS :
 - ◆ 01/04/79 : CLEAR SKIES IN A.M. & WINDY (5-20 MPH)
HAZE & OVERCAST BUILDING UP TO THE WEST AT MID-DAY
HAZE AND SNOW CLOUD BUILD-UP IN P.M., FROM THE WEST
 - ◆ 01/05/79 : LIGHT OVERCAST LOW W/ HIGH CUMULUS IN A.M. CLEARING IN P.M. LIGHT BREEZE - EASTERLY
 - ◆ 01/06/79 : HEAVY TO MODERATE OVERCAST IN A.M. FREEZING THROUGHOUT MOST OF DAY. INTERMITTENT CLOUDS CLEARING IN P.M. LIGHT BREEZE - WESTERLY
HIGH HUMIDITY.
 - ◆ 01/07/79 : CRYSTAL CLEAR ALL DAY.
LIGHT BREEZE IN A.M. FROM WEST. CALM IN P.M.
LOW HUMIDITY.
 - ◆ 01/08/79 : MOSTLY CLEAR IN A.M. WITH VERY LIGHT CLOUDS OFF AND ON. LIGHT CIRRUS & CUMULI IN P.M.
GUSTY, LIGHT WINDS FROM S TO SE NOT
 - ◆ 01/09/79 : HIGH, LIGHT CIRRUS IN A.M. - MOSTLY CLEAR
CLOUDS MOVED N IN LATE A.M. SNOW FORECAST?
CALM WINDS. HUMIDITY RISING.

EEG, INC

TEST No.
BP4-2-100TEST TITLE:
BUILD PERFORMANCE, NO BACKDRAFT CONTROL

E-4

AUXILIARY
ENERGYPAGE:
BP 22

AUXILIARY POWER SOURCE(S)	TOTAL AUXILIARY POWER (WATTS)	TIMES OF OCCURRENCE			THERMAL ENERGY (BTU)
		FROM :	TO :	TIME SPAN (HR)	
O/H LIGHT ¹ + LOGGER ²	195	004:00:00:00	004:08:21:00	8.35	5560.
O/H LIGHT + LOGGER + MAN (200)	395	08:21:00	08:30:00	0.15	200.
LOGGER	115	08:30:00	16:15:00	7.75	3040.
O/H LIGHT + LOGGER + MAN (250)	445	16:15:00	16:20:00	0.083	130.
O/H LIGHT + LOGGER	195	16:20:00	21:50:00	5.5	3660.
O/H LIGHT + LOGGER + LAMP ³ + MAN (250)	645	21:50:00	21:53:00	0.05	110.
O/H LIGHT + LOGGER + LAMP	395	21:53:00	005:08:10:00	10.28	13860.
O/H LIGHT + LOGGER + MAN (200)	395	005:08:10:00	08:19:00	0.15	200.
O/H LIGHT + LOGGER	195	08:19:00	17:51:00	9.53	6340.
O/H LIGHT + LOGGER + MAN (200)	395	17:51:00	18:00:00	0.15	200.
O/H LIGHT + LOGGER + LAMP	395	18:00:00	006:08:54:00	14.9	20090.
O/H LIGHT + LOGGER + LAMP + MAN (200)	595	006:08:54:00	09:07:00	0.217	440.
O/H LIGHT + LOGGER + LAMP	395	09:07:00	17:47:00	8.67	11690.
O/H LIGHT + LOGGER + LAMP + MAN (200)	595	17:47:00	18:00:00	0.217	440.
O/H LIGHT + LOGGER + LAMP	395	18:00:00	007:09:05:00	15.08	20330.
O/H LIGHT + LOGGER + LAMP + MAN (200)	595	007:09:05:00	09:15:00	0.167	340.
LOGGER	115	09:15:00	17:16:00	8.02	3150.
O/H LIGHT + LOGGER + MAN (250)	445	17:16:00	11:18:00	0.033	50.
LOGGER	115	17:18:00	008:07:51:00	14.55	5710.
LOGGER + MAN (200)	315	008:07:51:00	07:54:00	0.05	50.
O/H LIGHT + LOGGER + MAN (200)	395	07:54:00	08:01:00	0.117	160.
LOGGER	115	08:01:00	19:28:00	11.45	4490.
O/H LIGHT + LOGGER + MAN (250)	445	19:28:00	19:35:00	0.117	180.
O/H LIGHT + LOGGER + LAMP	395	19:35:00	009:08:07:00	13.53	18240.
O/H LIGHT + LOGGER + MAN (250)	445	009:08:07:00	08:11:00	0.067	100.
LOGGER	115	08:11:00	17:54:00	9.72	3820.
O/H LIGHT + LOGGER + MAN (250)	445	17:54:00	18:00:00	0.10	150.

1 80 WATTS 2 115 WATTS 3 200 WATTS

DATA SHEET - GENERAL

TEST NUMBER: BP4-2-100 TEST TITLE: BUILDING PERFORMANCE, NO BACKDRAFT CONTROL

TEST DATE: 01/04/79 EEG STAFF: RL CASPERSON PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			00:00:00	02:00:00	04:00:00	06:00:00	08:00:00	08:30:00	09:00:00	09:30:00
39	K79E02	°F	49.9	46.4	44.3	42.9	44.0	45.4	48.6	70.2
38	K30E02	↑	45.3	42.0	39.9	39.0	40.4	41.8	45.7	59.7
37	K79C02		50.1	46.7	44.7	43.5	44.5	45.8	48.8	70.6
36	K30C02		45.1	41.6	39.6	38.6	40.1	41.5	45.3	63.5
35	K13C02		43.1	40.2	38.2	37.3	38.8	40.2	43.9	59.9
34	M79E03		74.8	72.1	69.4	66.8	64.4	64.0	63.4	63.0
33	M79E00		68.0	65.2	62.5	60.1	58.9	58.7	59.2	66.3
32	M30E03		70.8	68.5	65.7	63.2	60.9	60.5	60.0	59.7
31	M30E00		63.7	61.1	58.6	56.4	55.1	55.1	55.8	64.2
30	M79C12		73.9	71.2	68.6	66.2	64.1	63.6	62.9	62.3
29	M79C06		78.0	75.7	73.1	70.7	68.2	67.5	67.0	66.4
28	M79C03		74.9	72.2	69.8	67.3	65.0	64.5	64.1	63.7
27	M79C01		70.9	68.1	65.6	63.2	61.4	61.1	61.3	63.4
26	M79C00		67.8	64.9	62.5	60.3	59.0	59.0	59.3	74.1
25	M30C12		70.2	67.1	64.8	62.3	60.1	60.1	59.5	59.1
24	M30C06		74.4	71.9	69.4	66.8	64.2	63.6	63.0	62.4
23	M30C03		70.7	68.1	65.6	63.2	60.9	60.3	59.9	59.6
22	M30C01		65.8	63.1	60.5	58.4	56.6	56.5	56.7	58.3
21	M30C00		63.2	60.4	58.1	56.0	54.7	54.8	55.5	67.0
20	M13C00		58.5	56.2	54.0	52.1	51.1	51.3	51.9	59.5
19	EFUWR		63.8	60.9	58.5	56.5	54.8	54.6	54.3	54.2
18	ECELL		66.3	62.8	60.4	58.1	56.1	55.6	55.3	54.9
17	ERDF		2.3	-3.1	-3.2	0.1	9.8	12.9	20.6	32.7
16	V48N04		43.1	41.3	39.2	37.5	36.4	36.1	36.7	37.1
15	V48W00		47.9	45.8	43.6	42.0	40.8	40.5	41.0	41.3
14	V48W04		64.5	61.2	58.7	56.5	54.5	54.2	53.8	53.4
13	E48N00		9.8	4.8	4.0	6.3	13.8	16.6	27.2	31.6
12	E48N08		65.5	62.1	59.5	57.2	55.2	54.9	54.7	54.2
11	E48W00		10.1	5.4	4.6	6.9	14.5	17.3	27.3	31.8
10	E48W08		66.0	62.4	59.9	57.5	55.5	55.4	55.0	54.6
9	E48E00		9.5	4.8	4.0	6.4	14.4	17.0	26.2	48.9
8	E48E08		65.3	62.0	59.5	57.2	55.4	54.9	54.9	54.5
7	ARMHI		66.5	63.2	60.7	58.4	56.8	56.6	56.0	56.4
6	ARMLF		60.4	57.7	55.4	53.3	52.3	52.3	52.6	53.3
5	ADWTC		69.6	66.9	64.4	61.9	60.1	59.6	59.9	61.6
4	AIRC		56.3	54.2	51.9	50.1	49.1	49.4	49.7	52.9
3	ACRLSP	↓	33.9	34.1	34.1	33.9	33.1	34.1	34.3	34.2
2	AAMB	°F	8.8	4.4	4.8	8.7	17.7	23.5	33.6	35.3
1	P2HBR	Btu/Hr.Ft	0.0	0.0	0.0	0.0	3.8	4.7	5.5	98.8
0	PIVER	↓	—	—	—	—	—	3.5	5.8	218.6

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			004: 10:00:00	10:30:00	11:00:00	11:30:00	12:00:00	12:30:00	13:00:00	13:30:00
39		°F	92.4	103.0	107.6	114.1	114.6	114.0	97.5	104.9
38		↑	86.2	96.6	102.1	108.1	108.2	107.9	90.7	99.7
37			93.3	103.7	107.8	113.8	114.0	113.2	97.2	104.1
36			90.5	100.3	104.1	109.5	109.0	107.7	90.7	99.0
35			86.0	93.3	95.3	98.8	97.2	96.5	81.8	90.2
34			65.2	70.7	76.9	82.6	87.9	92.1	95.2	96.2
33			85.9	103.2	117.3	128.9	133.2	134.5	122.2	129.5
32			61.4	66.0	71.4	76.4	81.4	85.4	88.2	89.2
31			84.1	94.4	104.2	116.2	122.1	123.8	112.7	119.2
30			62.8	63.5	64.7	65.9	67.1	68.1	68.9	69.4
29			65.8	65.5	65.9	67.0	68.6	70.7	73.0	75.3
28			65.7	71.0	76.9	82.6	88.0	92.4	95.7	96.6
27			81.0	94.2	104.1	112.6	118.1	120.4	118.0	116.6
26			100.8	115.9	125.1	134.2	137.0	136.9	124.0	129.4
25			59.5	60.0	60.8	61.8	62.7	63.7	64.5	64.9
24			61.8	61.6	62.1	63.3	64.8	66.9	69.1	71.2
23			61.7	67.3	73.5	79.3	84.7	88.8	91.9	92.6
22			77.9	91.8	101.8	110.3	115.4	117.1	113.9	112.4
21			97.7	112.5	120.0	127.7	129.3	129.4	116.5	122.5
20			85.4	96.7	103.0	109.3	110.1	109.8	100.0	104.7
19			54.6	55.8	57.1	58.6	60.2	61.8	62.9	63.8
18			56.9	59.5	62.1	64.4	67.0	68.9	69.7	70.0
17			46.4	57.6	62.1	66.0	68.2	70.9	64.6	57.5
16			38.7	40.1	41.3	41.8	42.5	42.9	43.5	44.0
15			42.8	44.2	45.4	46.0	46.9	47.4	48.1	48.4
14			54.5	56.5	58.7	60.8	62.8	64.5	65.6	65.9
13			35.4	38.1	40.3	40.8	41.9	45.7	45.2	39.4
12			55.4	57.4	59.4	61.5	63.7	65.3	66.4	66.9
11			37.9	41.8	44.2	44.7	46.9	53.7	54.7	61.3
10			55.7	57.5	59.7	61.9	64.1	65.7	66.9	67.4
9			70.2	70.9	65.2	57.8	49.3	46.3	45.1	38.5
8			55.3	57.1	59.3	61.5	63.4	65.3	66.3	66.9
7			63.2	67.8	71.0	74.6	76.9	78.2	76.4	77.2
6			56.3	58.3	60.2	62.5	63.9	65.4	65.7	66.3
5			68.9	74.9	79.0	83.7	86.3	87.9	86.2	87.3
4			57.1	59.7	62.1	64.6	66.3	67.8	67.4	68.6
3		↓	34.0	33.7	33.6	33.5	33.4	33.2	33.3	33.0
2		°F	37.1	38.5	38.1	38.3	38.4	39.8	37.5	25.3
1		Btu/hr·ft ²	117.7	133.9	133.0	145.3	138.8	161.9	92.6	124.0
0		↓	247.5	264.5	244.3	260.2	232.4	248.2	91.8	205.0

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			004: 14:00:00	14:30:00	15:00:00	15:30:00	16:00:00	17:00:00	18:00:00	19:00:00
39		°F	97.7	84.8	69.0	65.6	57.3	51.6	47.7	45.3
38		↑	92.0	79.1	61.9	59.2	51.4	46.4	42.8	40.5
37			96.2	84.0	69.4	65.9	58.0	52.5	48.6	46.1
36			90.6	77.9	61.7	58.6	51.1	46.1	42.5	40.2
35			82.7	72.5	57.8	54.7	48.2	43.9	41.1	39.0
34			97.2	98.2	97.7	95.8	93.4	88.3	83.9	80.3
33			128.2	119.5	103.3	96.2	87.8	79.3	74.4	70.5
32			90.2	91.2	91.2	89.4	87.2	82.6	78.4	75.1
31			118.5	111.7	96.1	89.2	81.4	73.6	68.6	65.4
30			70.3	70.7	70.8	70.9	70.9	71.3	71.3	71.1
29			77.4	79.1	80.9	82.2	83.1	83.4	82.5	81.0
28			98.0	99.1	99.0	96.7	94.2	88.6	84.2	80.5
27			118.2	114.8	107.2	100.2	93.8	85.2	79.6	75.4
26			126.8	118.1	103.8	96.5	88.5	79.9	74.8	70.8
25			65.9	66.4	66.7	67.0	67.3	67.6	67.4	66.9
24			73.1	74.6	76.2	77.6	78.3	78.4	77.5	75.9
23			93.8	94.7	94.4	92.2	89.3	83.6	78.9	75.2
22			113.8	110.1	101.7	94.1	87.4	78.4	72.8	68.8
21			119.7	111.4	96.8	89.8	81.8	73.4	68.5	65.0
20			103.7	97.9	86.3	80.7	74.0	67.2	63.3	60.3
19			64.6	65.0	65.1	65.1	64.5	63.2	61.9	60.7
18			70.7	70.3	69.3	68.0	66.7	65.2	63.9	62.8
17			43.2	31.1	22.5	17.1	10.1	2.5	-0.8	-2.3
16			43.5	42.6	41.8	41.7	41.1	39.2	38.5	37.3
15			47.8	46.4	45.4	45.2	44.5	42.8	42.0	40.8
14			66.7	66.6	66.1	65.5	64.5	63.0	61.8	60.6
13			28.8	22.1	18.9	16.4	11.9	6.1	3.9	2.0
12			67.5	67.6	67.3	66.8	66.0	64.5	63.3	62.0
11			54.2	46.6	30.8	23.7	15.5	8.0	5.2	3.3
10			68.1	68.3	67.9	67.4	66.7	65.2	63.7	62.5
9			28.3	20.3	17.0	14.8	11.1	5.7	3.3	1.6
8			67.5	67.6	67.2	66.5	65.8	64.3	63.2	61.9
7			76.9	74.7	71.3	69.3	67.6	65.6	64.5	63.2
6			66.5	66.2	65.3	64.7	63.2	61.2	59.3	57.9
5			87.3	84.7	81.4	79.9	76.6	72.9	70.4	68.4
4			69.0	68.4	67.0	65.7	63.8	59.8	57.0	55.4
3		↓	32.6	32.9	33.2	33.3	33.4	33.6	33.8	34.0
2		°F	18.9	15.5	14.2	12.4	8.8	4.0	2.2	0.6
1		BTU/HR·FT ²	101.8	68.8	26.1	13.8	3.6	0.0	0.0	0.0
0		↓	153.4	112.0	23.4	15.7	4.0	~	~	~

DATA SHEET - GENERAL

TEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~

TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			004: 20:00:00	22:00:00	005: 00:00:00	02:00:00	04:00:00	06:00:00	07:00:00	08:00:00
39		°F	44.7	42.9	44.6	43.8	44.8	44.5	44.6	47.1
38		↑	40.0	38.3	40.1	39.3	41.2	41.0	41.3	44.1
37			45.6	43.3	45.1	44.2	45.1	44.9	45.0	47.4
36			39.8	37.9	39.8	39.0	41.0	40.8	41.1	44.1
35			38.7	36.7	38.1	37.9	39.9	40.0	40.5	43.2
34			77.3	72.5	69.2	66.2	63.8	62.2	61.2	60.6
33			68.3	63.8	61.8	59.9	58.4	57.2	56.7	57.6
32			72.2	67.8	64.8	62.2	60.3	58.8	57.9	57.4
31			63.1	59.1	57.3	55.5	54.5	53.6	53.1	54.3
30			70.6	68.7	67.4	65.7	64.3	63.0	62.2	61.8
29			79.5	76.1	72.7	70.1	67.7	65.6	64.2	63.7
28			77.7	73.1	69.4	66.9	64.7	63.0	62.0	61.5
27			72.6	68.1	65.1	63.1	61.3	60.0	59.1	59.3
26			68.2	64.2	62.2	60.4	59.0	57.9	57.2	58.3
25			66.3	64.8	63.7	62.6	61.2	60.1	59.4	59.0
24			74.4	71.1	67.9	65.7	63.6	61.9	60.9	60.1
23			72.2	67.7	64.5	62.2	60.4	59.0	58.2	57.5
22			66.0	62.0	59.6	58.0	56.6	55.7	55.0	55.5
21			62.6	58.9	57.0	55.5	54.7	53.8	53.2	54.7
20			58.3	55.1	53.4	52.2	51.6	51.2	50.8	52.0
19			59.8	57.9	57.3	56.8	56.2	55.5	55.2	55.2
18			61.8	59.7	59.0	58.2	57.3	56.5	56.1	56.1
17			-4.0	-7.7	-1.3	0.0	9.5	12.2	13.2	19.3
16			36.6	35.0	33.9	33.2	33.1	33.5	33.8	34.3
15			40.3	39.1	38.3	37.9	38.1	38.4	38.4	38.9
14			59.5	57.3	57.0	56.4	55.6	54.9	54.6	54.6
13			1.4	-0.4	4.9	6.0	12.8	16.0	17.3	21.6
12			60.9	58.7	58.3	57.5	56.8	56.1	55.8	55.6
11			2.8	0.9	5.4	6.7	13.2	16.1	17.4	21.6
10			61.4	59.1	58.5	58.0	57.1	56.4	56.1	56.1
9			0.9	-0.7	3.9	5.1	12.5	14.9	16.5	23.1
8			60.7	58.6	57.9	57.0	56.2	55.7	55.3	55.2
7			62.1	60.2	59.9	59.0	58.2	57.5	57.1	57.0
6			56.8	55.1	55.0	54.2	53.7	53.4	53.0	53.4
5			67.0	64.5	62.9	61.5	60.2	59.2	58.7	58.6
4			54.1	52.0	51.7	50.7	50.4	50.1	49.7	50.2
3		↓	34.0	34.1	33.8	33.7	33.7	33.9	33.7	33.8
2		°F	0.4	-1.7	2.0	3.5	11.2	17.7	18.2	20.9
1		Btu/Hr·ft ²	0.0	0.0	0.0	0.0	0.0	0.0	0.0	?
0		↓	~	~	~	~	~	~	~	~

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			08:30:00	09:00:00	09:30:00	10:00:00	10:30:00	11:00:00	11:30:00	12:00:00
39		°F	48.6	48.6	61.0	84.4	84.6	97.0	101.3	99.0
38		↑	46.0	46.2	55.5	78.9	79.8	93.0	96.6	94.1
37			49.0	49.0	61.4	84.8	85.5	98.1	102.6	100.3
36			46.2	46.3	58.1	83.6	82.7	96.4	99.6	96.0
35			45.1	45.2	55.9	80.0	77.1	89.6	91.8	87.8
34			60.8	60.4	60.5	62.0	66.9	72.2	77.9	83.1
33			58.9	59.5	64.2	80.0	92.9	111.6	123.4	126.2
32			57.4	57.4	57.1	58.9	62.8	67.5	72.7	77.3
31			55.9	56.7	62.3	79.0	87.2	98.4	111.6	116.5
30			61.5	60.9	60.6	60.8	61.6	62.4	63.6	64.6
29			63.5	63.2	62.8	62.4	62.2	62.8	64.0	65.5
28			61.3	61.4	61.2	62.7	67.1	72.3	78.2	83.5
27			60.0	60.7	62.5	75.2	88.3	97.9	107.4	112.7
26			59.5	60.4	69.0	93.3	103.8	120.3	129.4	130.8
25			58.7	58.3	57.8	57.9	58.3	58.8	59.7	60.4
24			60.1	59.9	59.3	59.1	59.0	59.5	60.6	62.3
23			57.9	58.0	58.1	59.7	64.2	69.8	75.8	81.1
22			56.4	57.3	59.1	73.0	87.0	97.0	106.4	111.4
21			56.6	57.6	65.1	91.4	100.5	116.5	124.6	124.9
20			53.8	54.6	60.0	82.2	90.1	102.1	108.2	108.2
19			54.8	54.7	54.6	54.9	55.6	56.6	57.8	59.2
18			55.8	55.5	55.2	56.2	58.5	60.7	63.0	65.0
17			24.0	23.5	33.5	41.3	38.1	47.1	48.7	44.8
16			34.7	35.2	35.5	36.2	36.8	36.9	37.0	36.9
15			39.2	39.6	39.7	40.3	40.9	40.9	40.8	40.7
14			54.3	54.0	53.7	54.3	55.6	57.1	59.0	60.6
13			25.6	25.6	27.2	26.5	23.4	25.2	26.8	25.2
12			55.4	55.2	54.8	55.3	56.7	58.2	60.0	61.7
11			25.4	25.1	26.9	28.9	27.7	29.9	30.2	29.2
10			55.8	55.5	55.2	55.6	57.0	58.6	60.4	62.1
9			28.3	28.3	38.8	57.4	48.4	46.6	39.0	29.2
8			55.0	54.6	54.4	54.9	56.3	57.8	59.7	61.2
7			56.5	56.2	56.2	61.4	65.1	68.6	72.2	73.6
6			53.4	53.0	53.8	55.6	57.0	58.7	60.5	61.7
5			58.5	58.3	59.2	65.5	70.1	74.9	78.9	81.0
4			50.2	49.9	52.4	56.2	57.8	60.7	62.9	64.2
3		↓	33.8	33.8	33.5	33.5	33.5	33.4	33.4	33.0
2		°F	23.0	21.2	21.1	20.7	19.0	20.6	21.2	20.5
1		Btu/hr.ft ²	36.4	27.1	90.0	119.4	69.0	165.0	167.0	148.2
0		↓	20.8	21.6	142.8	236.2	84.3	285.6	284.9	244.5

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			008: 12:30:00	13:00:00	13:30:00	14:00:00	14:30:00	15:00:00	15:30:00	16:00:00
39		°F	107.7	111.9	103.5	86.8	80.3	73.2	65.7	62.2
38		↑	102.9	106.7	97.5	80.1	74.5	66.9	59.5	56.6
37			108.4	112.1	103.9	87.4	80.6	73.6	66.2	62.8
36			104.5	107.7	97.9	80.5	74.4	66.7	59.4	56.5
35			95.2	97.3	87.9	72.8	69.4	62.5	55.6	53.1
34			87.3	91.5	95.4	97.9	98.0	96.7	94.9	92.5
33			135.3	140.4	137.7	124.0	113.0	105.2	94.9	88.9
32			81.4	85.3	88.9	91.3	91.6	90.7	89.0	86.9
31			125.5	130.6	127.5	115.4	105.7	98.4	88.6	82.8
30			65.8	67.2	68.5	69.1	69.4	69.8	69.9	70.3
29			67.5	69.7	71.9	74.4	77.0	79.0	80.5	81.4
28			87.9	92.3	96.4	99.4	99.5	98.1	96.0	93.3
27			117.5	123.1	126.5	122.2	112.9	107.5	99.8	94.0
26			138.4	142.9	138.6	125.1	113.8	105.8	95.8	89.6
25			61.4	62.5	63.7	64.5	64.9	65.5	66.0	66.4
24			64.2	66.2	68.6	71.0	73.1	75.1	76.4	77.2
23			85.5	89.7	93.8	96.4	96.1	94.5	92.3	89.4
22			116.1	121.4	124.3	119.0	108.9	103.2	94.7	88.5
21			132.8	137.1	132.0	118.2	107.6	99.5	89.6	83.7
20			113.8	116.7	113.0	102.8	94.9	88.7	80.5	75.5
19			60.4	61.7	63.2	64.2	64.6	64.9	64.8	64.6
18			66.8	68.8	70.6	70.9	70.1	69.4	68.1	67.0
17			50.7	53.5	47.4	34.7	29.7	25.0	21.4	18.8
16			36.8	36.8	37.2	37.3	37.4	37.6	37.8	38.0
15			40.6	40.8	41.3	41.6	41.9	42.0	42.2	42.5
14			62.1	63.8	65.3	65.9	65.7	65.4	64.9	64.2
13			27.1	28.1	26.5	22.9	21.1	19.6	18.6	17.8
12			63.2	65.1	66.7	67.4	67.1	66.9	66.4	65.8
11			37.1	47.0	49.0	42.9	39.5	34.9	26.7	23.3
10			63.6	65.3	67.1	67.9	67.6	67.4	67.0	66.5
9			28.0	27.9	26.8	22.8	20.7	19.4	19.1	18.8
8			62.8	64.6	66.1	67.0	66.6	66.3	66.0	65.5
7			76.3	78.6	79.3	76.6	74.5	72.2	69.4	68.2
6			63.2	64.8	66.1	66.1	65.5	64.9	64.3	63.9
5			84.2	87.2	88.0	86.1	83.2	81.0	78.9	77.7
4			66.3	68.1	68.9	68.6	67.8	67.0	65.5	64.1
3		↓	33.0	33.0	32.6	32.7	32.9	32.9	32.9	33.2
2		°F	22.0	23.1	21.0	19.3	18.0	16.8	16.6	16.8
1		BTU/HR·FT ²	171.7	169.9	179.9	40.4	33.4	31.8	23.3	14.8
0		↓	286.9	281.2	276.0	55.2	32.5	39.9	16.6	9.9

E-11
DATA SHEET - GENERAL

TEST NUMBER: BP4-2-100 TEST TITLE: CONTINUATION SHEETTEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			005: 17:00:00	18:00:00	19:00:00	20:00:00	22:00:00	006: 00:00:00	02:00:00	04:00:00
39		°F	57.4	55.2	54.6	53.5	50.8	49.6	48.8	49.1
38		↑	52.3	50.6	50.2	49.4	47.5	46.2	44.9	45.2
37			57.8	55.6	54.8	53.7	51.2	50.0	49.2	49.4
36			52.0	50.3	49.7	49.1	47.0	45.7	44.5	45.1
35			49.0	47.5	47.4	47.2	45.7	44.8	43.8	44.1
34			87.6	83.6	80.1	77.7	73.8	70.7	68.2	66.3
33			80.6	75.9	72.8	70.8	67.4	64.6	62.6	61.4
32			82.4	78.5	75.3	73.1	69.5	67.0	64.9	63.0
31			75.1	70.7	68.0	66.2	63.2	60.9	59.1	57.9
30			70.7	71.0	71.4	71.3	70.8	69.5	68.3	67.1
29			81.8	81.1	79.8	78.5	76.1	73.6	71.4	69.4
28			87.9	83.7	80.4	77.9	74.2	71.1	68.9	66.9
27			85.6	80.2	76.7	74.2	70.6	67.6	65.5	63.9
26			81.0	76.2	73.3	71.1	67.7	64.9	63.2	61.7
25			67.0	67.3	68.2	68.2	67.8	66.6	65.4	64.2
24			77.5	76.6	75.5	74.1	71.7	69.7	67.8	65.9
23			83.7	79.1	75.7	73.1	69.7	67.0	64.9	63.1
22			79.7	74.5	71.1	69.0	65.7	63.0	61.2	59.9
21			75.4	70.8	68.0	65.9	63.0	60.8	59.1	58.0
20			69.0	65.1	63.1	61.9	59.5	57.7	56.2	55.3
19			63.9	63.1	62.8	62.8	62.0	61.1	60.3	59.6
18			65.6	64.6	64.2	64.2	63.4	62.6	61.8	60.9
17			12.0	9.6	10.0	11.9	12.3	11.9	12.8	14.0
16			38.4	38.6	38.5	38.7	38.9	39.1	39.0	38.9
15			42.9	43.2	43.1	43.5	43.7	43.6	43.5	43.3
14			63.2	62.4	62.0	62.3	61.6	61.0	60.2	59.4
13			14.9	14.0	14.5	15.9	16.1	15.3	16.8	17.6
12			64.7	63.8	63.6	63.8	63.0	62.0	61.3	60.5
11			17.4	15.8	15.7	17.1	16.7	15.8	17.0	17.9
10			65.6	64.6	64.1	64.1	63.5	62.6	61.7	61.0
9			15.8	13.7	14.5	15.9	16.6	15.8	16.8	17.7
8			64.5	63.6	63.2	63.2	62.6	61.9	61.0	60.1
7			66.5	65.2	65.3	65.1	64.5	63.6	62.6	61.8
6			62.0	61.5	61.7	61.3	60.2	58.9	58.1	57.6
5			75.1	72.1	70.4	69.3	67.4	65.9	64.7	63.6
4			62.1	59.7	58.5	58.1	57.1	55.8	54.7	54.0
3		↓	33.4	33.5	33.4	33.4	33.5	33.6	33.6	33.9
2		°F	15.5	13.6	13.5	14.1	15.4	14.5	16.1	16.0
1		Btu/hr-ft ²	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0		↓	—	—	—	—	—	—	—	—

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			06:00:00	07:00:00	08:00:00	09:00:00	09:30:00	10:00:00	10:30:00	11:00:00
39		°F	47.5	44.6	45.9	48.2	51.6	63.0	62.4	66.6
38		↑	43.7	40.4	42.3	45.3	49.3	60.6	59.5	64.1
37			47.8	45.2	46.5	48.7	52.7	64.0	63.4	67.1
36			43.5	40.4	42.0	45.5	50.9	62.8	60.4	65.1
35			42.9	40.2	41.6	44.4	49.9	61.3	58.4	62.8
34			64.4	63.7	62.8	62.4	62.4	62.8	64.7	64.4
33			57.8	58.8	59.0	60.4	63.3	69.1	74.3	76.6
32			61.4	60.7	59.8	59.4	59.5	60.0	61.6	63.3
31			56.5	55.4	55.5	57.4	60.7	67.1	70.9	72.5
30			65.7	65.2	64.5	63.9	63.7	63.6	63.6	63.6
29			67.8	67.0	66.2	65.5	65.2	64.8	64.7	64.6
28			65.4	64.7	63.8	63.3	63.5	63.8	65.8	67.4
27			62.5	61.6	61.3	61.8	63.2	67.4	73.6	73.4
26			60.5	59.6	59.8	61.3	65.3	74.1	78.1	79.3
25			63.1	62.6	62.0	61.5	61.4	61.2	61.4	61.3
24			64.5	64.0	63.1	62.5	62.1	61.8	61.7	61.6
23			61.7	61.1	60.2	60.0	60.1	60.8	63.0	64.8
22			58.5	57.8	57.4	58.3	60.2	65.2	71.9	71.7
21			56.7	55.8	56.2	58.1	62.5	72.2	76.0	77.6
20			54.2	53.5	53.8	55.4	59.3	67.9	71.0	72.0
19			58.8	58.4	57.8	57.6	57.7	58.3	58.8	59.1
18			60.1	59.7	59.2	58.8	58.8	58.8	59.5	59.8
17			12.9	9.1	7.3	12.4	17.4	20.8	21.4	26.0
16			38.8	38.6	38.2	37.9	38.1	38.4	39.0	39.1
15			43.0	42.8	42.3	41.9	42.1	42.3	42.9	43.2
14			58.7	58.4	57.9	57.5	57.5	57.5	58.0	58.2
13			16.6	13.0	12.9	19.6	24.8	27.3	26.5	31.3
12			57.7	59.4	58.7	58.4	58.5	58.4	58.9	59.2
11			16.9	13.3	13.5	20.1	25.4	28.7	30.3	35.2
10			60.1	59.7	59.2	58.9	58.8	58.9	59.4	59.6
9			17.0	13.3	14.7	21.5	29.4	39.3	37.6	39.5
8			59.4	58.8	58.3	58.1	58.0	58.1	58.5	58.7
7			61.0	60.4	59.9	59.7	59.9	60.8	61.6	62.0
6			56.5	55.7	55.3	55.3	56.6	58.7	59.5	59.9
5			62.4	61.9	61.2	61.2	61.6	62.9	64.8	65.7
4			53.1	52.2	52.0	52.7	53.2	56.0	57.2	58.2
3		↓	33.8	33.9	33.9	34.0	33.9	33.9	33.5	33.7
2		°F	15.1	13.0	11.8	15.6	17.1	19.1	18.5	21.1
1		BTU/HR·FT ²	0.0	0.0	4.2	16.2	27.4	36.6	25.3	40.6
0		↓	~	~	~	22.6	60.9	125.0	57.8	101.2

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			006: 11:30:00	12:00:00	12:30:00	13:00:00	13:30:00	14:00:00	14:30:00	15:00:00
39		°F	63.6	69.8	66.9	58.5	57.2	55.7	51.3	49.5
38		↑	61.0	67.5	64.2	56.0	55.2	54.8	50.0	47.9
37			63.8	70.3	67.8	59.1	58.0	56.0	52.0	50.3
36			61.2	68.4	65.2	56.6	55.7	54.9	50.3	48.1
35			58.9	66.2	62.7	53.9	53.5	53.1	49.4	47.3
34			67.4	68.2	69.7	70.9	70.7	70.3	69.7	69.1
33			75.6	81.5	82.3	75.0	74.0	72.5	69.3	67.9
32			64.4	65.2	66.8	67.9	67.8	67.6	67.1	66.6
31			72.2	77.8	78.9	71.9	71.3	70.1	67.1	65.6
30			63.6	63.6	64.0	64.0	64.0	64.1	64.1	64.0
29			65.0	65.3	65.5	66.1	66.7	67.2	67.5	67.6
28			68.6	69.5	70.8	71.9	71.7	71.4	71.0	70.2
27			74.3	76.7	80.1	76.4	75.2	73.2	71.5	70.1
26			77.9	83.7	84.1	76.4	75.5	73.6	70.7	68.9
25			61.6	61.6	61.8	61.9	62.0	62.1	62.3	62.1
24			62.2	62.5	62.9	63.6	64.2	64.7	65.0	65.1
23			66.2	67.1	68.7	69.8	69.6	69.3	68.8	68.1
22			72.5	75.2	78.9	74.5	73.6	71.4	69.8	68.2
21			75.7	81.9	82.3	74.2	73.4	71.9	68.8	66.7
20			70.6	75.4	76.0	69.4	69.1	67.9	65.1	63.3
19			59.4	59.9	60.4	60.6	60.6	60.8	60.5	60.2
18			60.1	60.5	61.2	61.2	61.0	61.1	61.0	60.9
17			27.1	30.0	31.1	28.5	26.5	24.3	21.8	16.7
16			39.5	39.7	40.2	40.4	40.5	40.3	40.3	40.0
15			43.5	43.6	44.1	44.3	44.1	43.9	43.7	43.3
14			58.7	59.0	59.6	59.8	59.9	59.8	59.9	59.7
13			32.0	34.5	36.2	32.2	29.3	26.9	24.1	18.9
12			59.5	59.8	60.5	60.7	60.8	60.8	60.9	60.8
11			35.9	40.4	42.0	35.7	33.9	32.5	27.4	22.9
10			60.0	60.3	61.1	61.2	61.3	61.2	61.3	61.3
9			37.2	37.8	37.9	32.5	29.8	26.3	23.2	18.8
8			59.1	59.3	59.9	60.2	60.4	60.4	60.3	60.3
7			62.1	62.9	63.7	62.8	62.8	62.8	62.3	62.0
6			60.1	60.7	61.3	61.0	61.0	60.5	59.6	58.9
5			65.6	67.4	68.2	65.2	64.9	64.3	63.9	63.4
4			58.3	59.4	60.0	58.7	58.6	57.9	56.4	56.3
3		↓	33.7	33.6	33.7	33.7	33.7	33.7	33.6	33.7
2		°F	21.1	22.7	23.8	22.8	20.4	18.6	17.4	14.9
1		BM/HR.F ²	38.7	53.3	38.5	32.7	22.1	29.6	22.7	9.5
0		↓	74.3	110.2	57.2	40.4	29.3	42.4	27.2	19.2

DATA SHEET - GENERAL

TEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~

TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			006: 15:30:00	16:00:00	17:00:00	18:00:00	19:00:00	20:00:00	22:00:00	007: 00:00:00
39		°F	49.5	47.7	44.2	45.5	43.3	40.9	39.7	39.1
38		↑	47.5	45.2	40.7	41.8	39.5	36.6	35.2	34.2
37			49.9	48.2	45.1	46.1	44.2	41.9	40.7	39.7
36			47.6	45.2	41.0	41.9	39.6	36.7	35.4	34.1
35			46.8	44.5	40.6	41.5	39.6	36.8	35.4	33.9
34			68.5	68.0	66.3	64.7	63.6	62.2	60.3	58.6
33	+		67.4	65.4	61.3	59.9	58.5	57.0	55.0	53.7
32			66.3	65.6	64.0	62.4	61.2	60.0	57.8	55.9
31			64.9	62.8	58.7	57.3	55.7	54.0	51.7	50.2
30			64.3	64.2	64.1	64.1	63.8	63.1	62.1	60.8
29			67.7	67.6	67.3	66.7	65.9	65.2	63.6	62.2
28			69.5	68.8	67.4	65.7	64.4	63.1	61.0	59.5
27			69.2	67.8	64.8	62.9	61.4	60.0	58.0	56.5
26			68.2	66.1	62.3	60.7	59.1	57.7	55.8	54.4
25			62.4	62.3	62.2	62.2	61.6	61.1	59.9	58.6
24			65.3	65.3	65.2	64.8	63.7	63.1	61.5	59.8
23			67.4	66.8	65.2	63.5	61.9	60.7	58.5	56.6
22			67.2	65.5	62.2	60.2	58.4	57.0	54.6	52.9
21			65.9	63.5	59.5	58.0	56.1	54.6	52.3	50.7
20			62.8	60.6	56.9	55.6	53.9	52.5	50.3	49.0
19			60.0	59.5	58.8	58.3	57.7	56.9	55.5	54.2
18			60.8	60.5	60.3	59.8	59.3	58.7	57.2	55.9
17			13.0	10.9	7.8	10.3	10.4	4.7	0.6	-4.9
16			39.7	39.5	39.0	38.6	37.9	37.1	35.6	34.2
15			43.0	42.7	42.2	42.0	41.7	40.7	39.5	38.4
14			59.4	59.2	58.9	58.4	57.9	57.3	55.6	54.4
13			15.9	14.6	10.6	13.2	12.8	7.9	5.6	1.8
12			60.6	60.4	59.9	59.5	58.9	58.2	56.8	55.2
11			19.5	17.3	12.0	14.0	13.4	8.4	5.7	1.8
10			61.2	60.9	60.5	60.4	59.4	58.7	57.1	55.7
9			16.1	14.4	11.4	13.4	12.6	7.9	5.2	2.3
8			60.0	60.0	59.4	59.1	58.3	57.8	56.3	54.9
7			61.8	61.6	60.9	61.1	59.8	59.2	57.7	56.6
6			58.5	58.0	56.4	56.3	55.2	54.2	52.7	51.4
5			63.2	62.8	62.0	62.0	61.0	60.3	58.8	57.6
4			55.9	55.6	54.0	53.6	52.1	51.0	49.4	48.1
3		↓	33.8	33.8	33.9	34.1	33.9	34.0	34.0	34.1
2		°F	13.8	13.1	10.8	11.7	10.8	7.5	5.7	1.7
1		BTU/HR·FT ²	4.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0
0		↓	12.9	10.1	—	—	—	—	—	—

TEST NUMBER: BP4-2-100 TEST TITLE: — CONTINUATION SHEET —

TEST DATE: / / EEG STAFF: _____ PROJECT NAME: DOE GRANT EG-77-G-04-4145

[illegible]

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			007: 10:30:00	11:00:00	11:30:00	12:00:00	12:30:00	13:00:00	13:30:00	14:00:00
39		°F	86.9	99.5	108.4	112.5	118.3	119.6	120.9	121.0
38		↑	81.4	94.7	102.1	106.2	111.4	112.3	113.0	113.5
37			88.9	100.2	108.4	112.4	117.5	119.3	119.8	119.6
36			86.9	98.4	104.5	107.8	111.9	113.2	112.2	111.4
35			81.5	89.5	93.1	95.7	98.6	99.6	98.0	97.3
34			60.1	66.4	72.7	78.8	84.3	89.7	93.5	97.2
33			43.3	110.7	124.3	133.2	140.2	144.9	147.9	150.3
32			55.7	61.3	67.0	72.6	77.6	82.2	86.0	89.3
31			85.3	97.3	111.5	121.9	128.3	132.4	134.6	136.2
30			54.5	55.4	56.8	58.3	59.9	61.6	63.1	64.9
29			54.2	55.0	56.4	58.3	60.7	63.4	66.2	69.1
28			60.4	66.6	73.0	79.2	85.0	90.1	94.7	98.6
27			85.3	96.2	106.0	113.7	120.0	125.1	128.7	131.1
26			108.1	120.3	130.5	138.0	143.5	147.0	148.6	148.3
25			51.3	52.0	53.0	54.2	55.5	56.9	58.3	59.6
24			51.1	51.9	53.2	55.2	57.6	60.0	62.7	65.5
23			57.5	64.2	70.8	76.9	82.4	87.3	91.4	95.0
22			84.3	95.6	105.3	112.7	118.2	122.7	125.5	126.9
21			106.6	117.1	125.8	131.4	136.0	139.0	140.2	139.5
20			92.4	100.6	106.7	110.9	114.0	115.6	116.1	116.5
19			48.6	49.8	51.3	52.8	54.7	56.5	58.2	59.7
18			52.1	54.6	57.4	59.7	62.4	64.8	66.8	68.7
17			12.6	18.0	23.1	26.2	28.9	29.8	29.3	27.8
16			27.7	28.1	29.1	29.9	30.4	30.9	31.3	31.9
15			32.4	33.0	34.2	35.0	35.8	36.3	37.0	37.8
14			48.8	50.6	53.1	55.2	57.5	59.7	61.5	63.2
13			11.7	15.7	19.2	20.9	22.9	23.5	23.2	22.7
12			49.5	51.3	53.8	56.1	58.6	60.6	62.5	64.1
11			19.1	24.2	26.5	28.4	37.5	50.0	57.3	64.2
10			49.9	51.7	54.1	56.5	58.9	61.1	63.0	64.8
9			47.1	47.0	41.0	32.2	27.9	26.0	24.3	23.2
8			49.2	51.0	53.5	55.7	58.0	60.2	62.1	63.7
7			59.6	63.8	67.8	70.9	74.0	76.2	78.0	79.4
6			50.6	52.7	55.0	56.9	58.9	60.8	62.3	63.8
5			65.6	71.3	76.5	80.8	84.5	87.6	89.9	91.6
4			52.3	55.0	57.7	59.9	62.2	64.1	65.9	67.4
3		↓	32.9	32.9	32.1	32.5	32.5	32.3	32.0	31.9
2		°F	9.3	16.5	17.7	18.2	19.9	19.6	19.6	18.9
1		Btu/hr-ft²	63.1	72.6	84.0	159.3	157.0	150.7	141.2	127.9
0		↓	289.1	305.3	308.7	309.6	305.1	295.8	282.6	265.1

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			007: 14:30:00	15:00:00	15:30:00	16:00:00	16:30:00	17:00:00	18:00:00	19:00:00
39		°F	120.2	115.8	107.1	75.5	67.4	62.9	56.6	53.2
38		↑	112.9	108.4	100.8	65.2	58.5	54.4	50.0	47.3
37			118.4	112.9	103.8	74.6	67.0	62.7	56.5	53.5
36			110.0	104.4	95.8	63.8	57.7	53.7	49.1	46.4
35			95.7	91.3	81.9	58.4	52.7	49.7	46.0	43.8
34			99.8	101.8	103.0	103.6	101.5	98.2	92.0	87.1
33			149.6	146.1	140.3	114.0	100.8	93.1	83.5	77.8
32			91.7	93.8	94.9	95.5	93.3	90.1	84.4	79.9
31			135.6	133.4	128.4	102.6	90.9	84.0	75.6	70.8
30			66.3	67.8	68.8	69.2	69.3	69.5	69.8	70.2
29			72.0	75.1	77.8	80.5	82.6	84.0	84.4	83.7
28			101.8	104.4	106.0	106.5	103.3	99.3	92.2	87.2
27			131.8	131.2	128.7	117.5	106.6	99.0	89.0	83.0
26			146.2	142.3	135.9	112.2	100.2	92.8	83.3	78.0
25			61.2	62.5	63.7	64.4	64.8	65.3	65.9	66.3
24			68.2	70.9	73.4	75.6	77.5	78.6	78.8	77.9
23			97.8	99.9	101.1	100.9	97.2	93.0	85.8	80.6
22			127.0	125.8	122.5	108.9	97.9	90.5	80.6	74.8
21			136.9	132.8	126.6	101.5	90.5	83.9	75.2	70.3
20			115.3	112.8	107.4	88.0	79.3	74.0	67.7	63.8
19			61.0	62.3	63.2	63.7	63.5	63.1	62.0	60.9
18			69.8	70.7	70.9	69.8	67.7	66.1	63.7	62.1
17			25.7	22.2	14.0	8.7	4.8	2.2	-2.3	-2.0
16			32.5	32.9	33.6	34.5	34.9	35.1	35.0	35.2
15			38.4	39.1	39.7	40.6	41.0	41.2	40.6	40.7
14			64.2	65.2	65.8	65.6	64.5	63.7	62.0	60.5
13			21.7	18.8	16.6	13.7	11.1	8.8	6.3	7.1
12			65.4	66.2	67.0	66.8	65.7	64.9	63.2	61.8
11			72.5	76.0	31.8	21.6	16.1	12.4	7.6	8.4
10			66.1	67.1	68.1	67.9	67.1	66.1	64.2	62.7
9			22.2	20.5	18.5	16.0	12.7	10.6	7.0	7.4
8			65.0	66.1	66.7	66.5	65.4	64.6	63.0	61.7
7			80.0	79.8	78.5	73.1	69.4	67.4	64.9	63.1
6			64.8	65.6	65.8	64.4	63.4	62.4	60.8	58.8
5			92.6	92.5	91.7	85.9	82.2	80.9	76.7	73.6
4			68.4	69.2	69.2	66.8	64.7	63.1	61.1	58.2
3		↓	32.0	31.8	30.9	31.8	32.2	32.3	32.4	32.6
2		°F	18.9	17.7	17.5	15.5	13.6	13.1	11.3	13.9
1		BTU/HR-FT ²	111.1	91.4	15.9	4.0	2.4	0.5	0.0	0.0
0		↓	242.5	214.5	90.5	5.0	2.1	0.0	—	—

E-18

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			007: 20:00:00	21:00:00	22:00:00	23:00:00	008: 00:00:00	01:00:00	02:00:00	03:00:00
39		°F	50.8	49.2	48.6	47.1	45.4	45.2	42.4	41.4
38		↑	44.8	43.8	43.5	42.1	40.8	40.6	38.0	37.1
37			50.8	49.2	48.6	47.2	45.6	45.3	42.7	41.9
36			44.1	43.0	42.8	41.5	40.2	40.2	37.4	36.7
35			42.0	41.4	41.3	40.2	39.0	39.0	36.6	35.5
34			83.4	79.9	77.3	75.0	72.8	70.9	69.0	67.4
33			73.8	70.8	68.6	66.5	64.7	63.2	61.6	60.0
32			76.4	73.5	71.1	69.0	67.1	65.4	63.8	62.3
31			67.1	64.6	62.7	60.8	59.2	57.9	56.4	55.0
30			70.1	69.4	68.6	67.8	66.5	65.4	64.2	63.2
29			82.3	80.6	78.9	77.2	75.5	73.8	72.1	70.5
28			83.2	79.8	77.4	75.1	73.0	71.1	69.4	67.8
27			78.5	75.2	72.6	70.4	68.4	66.8	65.1	63.4
26			73.8	70.8	68.6	66.6	64.7	63.3	61.6	60.0
25			66.0	65.3	64.6	63.5	62.5	61.5	60.4	59.3
24			76.3	74.6	73.0	71.2	69.7	68.3	66.7	65.3
23			76.6	73.4	70.8	68.7	66.8	65.1	63.6	62.1
22			70.4	67.4	65.0	63.2	61.3	59.9	58.5	57.0
21			66.6	63.9	62.1	60.2	58.6	57.4	55.9	54.4
20			60.9	58.8	57.3	55.9	54.4	53.3	52.0	50.8
19			59.5	58.3	57.1	56.1	55.1	54.2	53.3	52.5
18			60.7	59.5	58.4	57.3	56.3	55.3	54.3	53.5
17			-3.9	-1.0	3.2	3.0	3.1	2.5	-1.7	-4.5
16			35.6	35.8	36.0	36.7	37.0	37.0	36.6	35.7
15			40.7	40.2	40.8	41.0	41.1	40.8	40.2	39.4
14			59.1	58.1	57.1	56.1	55.1	54.2	53.4	52.5
13			5.7	8.3	12.2	11.2	10.7	12.1	6.9	4.9
12			60.5	59.4	58.2	57.2	56.1	55.1	54.2	53.2
11			6.9	10.5	14.3	13.4	13.3	13.1	7.9	5.5
10			61.2	59.9	58.7	57.5	56.4	55.4	54.6	53.5
9			5.8	8.4	12.1	11.8	11.1	11.8	7.9	5.7
8			60.4	59.4	58.4	57.4	56.3	55.3	54.4	53.6
7			61.6	60.4	59.3	58.4	57.1	56.2	55.2	54.2
6			57.3	55.9	54.7	53.7	52.1	51.9	51.0	50.1
5			71.0	68.5	66.1	65.0	63.7	62.0	60.6	59.5
4			55.8	54.1	53.0	51.9	50.7	50.0	48.7	47.8
3		↓	32.6	32.7	32.7	33.0	32.9	33.1	33.2	33.3
2		°F	11.8	15.6	17.7	14.2	15.3	18.1	10.5	8.4
1		Btu/hr-ft ²	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0		↓	~	~	~	~	~	~	~	~

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			04:00:00	05:00:00	06:00:00	07:00:00	08:00:00	08:30:00	09:00:00	09:30:00
39		°F	39.7	41.9	41.6	41.0	41.0	40.9	41.5	70.0
38		↑	35.7	37.9	37.8	37.5	37.7	37.5	38.4	61.3
37			40.2	42.0	41.8	41.2	41.2	41.0	41.7	70.8
36			35.2	37.6	37.3	37.1	37.4	37.3	38.0	68.0
35			34.3	36.6	36.4	36.1	36.5	36.4	37.2	66.4
34			65.7	64.0	62.8	61.6	60.2	59.7	59.3	58.7
33			58.3	57.5	56.8	55.8	54.8	54.7	54.6	65.1
32			60.9	59.5	58.3	57.3	56.1	55.7	55.3	54.8
31			53.5	52.9	52.2	51.4	50.7	50.7	50.7	64.7
30			61.9	60.9	59.8	58.8	57.6	57.3	56.8	56.5
29			69.1	67.4	66.2	64.6	63.3	62.9	62.1	61.6
28			66.2	64.5	63.3	62.0	60.8	60.3	59.9	59.4
27			61.8	60.6	59.6	58.5	57.5	57.4	56.9	61.0
26			58.5	57.6	56.7	55.7	55.1	54.9	54.8	75.2
25			58.3	57.2	56.3	55.2	54.5	54.3	53.6	53.3
24			63.8	62.4	61.3	60.1	58.8	58.4	57.8	57.2
23			60.6	59.2	58.2	57.0	56.1	55.7	55.3	54.9
22			55.7	54.6	53.9	52.9	52.2	52.2	52.0	55.4
21			53.1	52.5	51.9	51.0	50.5	50.6	50.5	70.0
20			49.5	49.0	48.4	47.7	47.4	47.4	47.3	62.3
19			51.6	51.0	50.2	49.5	48.8	48.6	48.3	48.2
18			52.5	51.8	50.9	50.1	49.4	49.0	48.8	48.7
17			-4.8	-0.2	2.1	4.3	8.8	8.3	10.1	26.5
16			34.7	34.5	34.2	34.1	34.2	34.1	34.1	34.4
15			38.5	38.1	37.8	37.7	37.7	37.4	37.5	37.6
14			51.5	50.7	50.0	49.3	48.6	48.2	48.1	47.8
13			3.9	11.6	13.3	13.7	16.5	15.8	17.4	21.8
12			52.3	51.5	50.8	50.1	49.4	49.1	48.6	48.6
11			4.7	11.7	13.4	14.8	17.3	16.3	18.2	23.1
10			52.5	51.8	51.0	50.2	49.7	49.2	48.9	48.8
9			4.2	11.1	12.9	14.0	16.6	16.5	18.2	49.9
8			52.5	51.7	50.9	50.2	49.3	49.3	49.0	48.6
7			53.2	52.7	51.8	50.9	51.0	50.1	49.7	51.4
6			49.0	49.0	48.3	47.5	47.2	46.9	46.6	48.0
5			58.2	57.2	56.4	55.4	54.5	54.2	53.8	57.0
4			47.0	46.8	46.2	45.3	45.2	44.9	44.8	49.1
3		↓	33.1	33.4	33.2	33.1	32.6	33.3	33.2	33.3
2		°F	10.1	19.6	20.0	20.6	22.3	20.4	22.5	25.2
1		Btu/lb. °F	0.0	0.0	0.0	0.0	2.9	3.9	4.9	103.8
0		↓	—	—	—	—	1.9	4.5	5.8	234.2

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: _____ PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			008: 10:00:00	10:30:00	11:00:00	11:30:00	12:00:00	12:30:00	13:00:00	13:30:00
39		°F	89.0	89.9	96.9	105.0	103.4	114.6	119.6	122.8
38		↑	82.6	84.3	91.7	99.3	97.9	108.7	113.0	115.7
37			90.4	91.3	97.2	105.5	104.2	114.2	118.6	121.6
36			88.6	88.0	93.8	102.0	100.0	109.1	112.5	114.8
35			83.9	82.3	86.1	92.5	90.4	97.7	99.9	101.6
34			61.4	67.4	72.4	77.0	81.7	85.9	90.5	94.7
33			83.8	95.3	107.4	119.4	123.6	136.3	142.6	147.3
32			56.9	62.1	66.6	70.9	75.1	79.0	83.4	87.2
31			82.5	87.7	95.1	106.9	113.4	125.0	130.7	134.4
30			57.0	57.9	58.7	59.9	61.1	62.6	64.1	65.8
29			60.8	60.5	61.0	62.0	63.4	65.5	67.5	69.6
28			61.8	67.2	72.2	76.8	81.6	86.0	90.9	95.6
27			79.0	89.4	96.2	103.5	108.8	116.9	123.2	127.7
26			100.4	107.6	115.3	124.8	127.8	139.1	144.0	147.1
25			54.0	54.4	55.0	55.8	56.8	58.2	59.5	60.9
24			56.5	56.4	57.0	58.1	59.7	61.4	63.2	65.6
23			57.5	63.3	68.5	73.2	78.0	82.4	87.1	91.5
22			76.0	87.0	93.8	101.1	106.1	114.2	120.1	124.0
21			96.9	104.2	110.6	119.0	120.7	131.6	136.4	139.4
20			85.0	89.8	94.8	101.6	103.2	111.2	114.4	116.4
19			48.9	50.2	51.5	52.8	54.3	56.1	57.8	59.5
18			51.0	53.9	55.9	58.2	60.4	63.2	65.8	68.2
17			38.7	44.1	50.1	54.7	53.0	56.6	58.4	60.9
16			35.8	36.7	37.4	37.8	38.1	38.4	38.7	39.2
15			39.0	40.1	40.9	41.3	41.8	42.3	42.7	43.2
14			49.2	51.3	53.0	55.0	56.9	59.0	61.2	63.2
13			26.5	28.2	29.5	30.9	30.6	31.7	31.8	32.6
12			50.0	51.9	53.3	55.7	57.6	59.8	62.0	64.1
11			29.2	30.9	32.2	34.1	33.0	39.1	48.0	61.6
10			50.1	52.1	53.9	56.0	58.0	60.2	62.4	64.5
9			66.3	60.4	55.8	49.0	38.9	34.8	34.4	34.0
8			50.0	51.8	53.6	55.6	57.6	59.6	62.0	63.9
7			58.6	61.6	64.1	67.7	70.1	73.8	76.7	78.9
6			50.9	52.8	54.5	56.5	58.1	60.1	62.2	63.9
5			65.0	68.4	72.0	76.6	79.1	83.5	87.3	90.1
4			52.7	54.6	56.6	59.0	60.7	63.1	65.4	67.4
3		↓	32.9	32.9	32.6	32.8	32.5	31.8	31.8	32.0
2		°F	27.7	29.2	29.2	31.0	30.0	29.9	30.0	30.7
1		BW/MFT	131.6	126.5	135.5	142.2	103.4	157.2	151.4	145.9
0		↓	265.1	234.3	249.2	267.1	217.0	290.9	284.7	274.9

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			008: 14:00:00	14:30:00	15:00:00	15:30:00	16:00:00	16:30:00	17:00:00	18:00:00
39		°F	123.5	120.2	114.1	106.1	78.2	71.4	67.3	60.2
38		↑	116.3	113.2	108.1	101.4	68.9	62.5	59.2	54.0
37			122.1	117.6	110.7	103.0	77.3	70.8	66.9	59.9
36			114.5	110.3	104.1	96.2	67.3	61.7	58.3	53.0
35			101.2	97.7	93.2	84.8	61.8	56.9	53.7	50.0
34			98.4	101.2	103.1	104.5	104.7	102.5	99.4	93.6
33			150.6	149.8	145.5	138.7	114.0	101.9	94.7	85.6
32			90.5	93.1	95.2	96.6	96.8	94.7	91.7	86.3
31			136.7	136.3	133.3	127.7	103.6	92.5	86.2	78.1
30			67.6	68.9	70.2	71.3	71.5	71.7	72.0	72.3
29			72.3	74.9	77.7	80.2	82.7	84.6	85.8	86.3
28			99.5	102.9	105.6	107.0	107.1	104.2	100.3	93.7
27			130.8	132.1	131.0	127.9	117.3	107.2	100.1	90.7
26			147.8	145.9	141.2	134.4	112.0	101.1	94.3	85.3
25			62.2	63.7	65.0	66.0	66.6	67.1	67.6	68.4
24			68.0	70.4	73.0	75.1	77.4	79.2	80.3	80.6
23			95.3	98.4	100.6	101.7	101.4	98.0	94.1	87.4
22			126.4	126.8	125.4	121.7	109.2	98.9	91.8	82.7
21			139.3	136.6	131.7	125.9	102.2	92.0	85.7	77.7
20			117.3	116.4	113.8	108.7	88.9	81.1	76.0	70.1
19			61.3	62.8	64.0	65.0	65.6	65.6	65.2	64.5
18			70.2	71.7	72.6	72.8	71.7	70.1	68.7	66.8
17			61.3	55.9	48.6	33.0	24.2	19.5	14.4	10.3
16			39.6	40.1	40.8	41.7	42.5	43.0	42.8	42.9
15			44.0	44.6	45.5	46.5	47.4	47.8	47.7	47.5
14			65.0	66.4	67.5	68.0	67.8	67.0	66.2	65.0
13			32.5	31.5	29.6	27.0	23.9	21.4	18.0	14.9
12			65.8	67.4	68.5	69.0	68.9	68.1	67.4	66.0
11			72.7	75.5	75.2	39.0	30.0	24.8	20.3	16.8
10			66.6	68.0	69.3	70.0	69.9	69.4	68.5	67.0
9			34.2	33.2	31.7	29.4	26.4	23.6	20.4	16.6
8			65.7	67.2	68.2	68.8	68.6	68.0	67.2	65.9
7			80.6	81.1	81.2	79.9	74.8	71.9	70.0	67.7
6			65.5	66.8	67.5	67.6	66.5	65.8	64.9	63.2
5			92.2	93.1	93.1	92.0	86.5	83.9	82.2	78.4
4			69.0	69.9	70.7	70.4	68.4	66.9	65.6	63.2
3		↓	31.8	31.8	31.8	31.8	31.9	32.1	32.3	32.5
2		°F	30.0	30.1	30.0	28.3	25.9	25.0	22.0	17.7
1		BTU/HR·FT ²	129.5	111.5	90.5	10.8	5.3	3.5	0.8	0.0
0		↓	257.6	232.6	200.9	82.1	4.9	1.9	0.0	~

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			008: 19:00:00	20:00:00	21:00:00	22:00:00	23:00:00	009: 00:00:00	02:00:00	04:00:00
39		°F	55.2	53.3	51.6	50.2	48.7	47.0	44.7	42.7
38		↑	49.7	47.5	46.2	44.9	43.7	42.3	40.2	37.8
37			55.6	53.1	51.4	50.1	49.0	47.4	45.2	43.5
36			49.0	46.7	45.4	44.4	43.3	41.8	39.6	37.5
35			46.4	44.7	43.7	42.7	41.9	40.6	38.7	37.0
34			88.8	84.9	81.8	79.1	76.9	74.9	71.4	68.3
33			79.8	75.7	73.1	70.8	69.0	67.1	63.8	61.2
32			82.1	78.3	75.5	73.2	71.2	69.5	66.5	64.0
31			73.1	69.3	66.9	65.0	63.2	61.6	58.9	56.6
30			72.6	72.6	72.8	72.6	72.0	71.3	69.7	67.8
29			85.5	84.0	82.3	80.7	79.3	77.8	74.8	72.2
28			88.7	84.8	81.6	79.1	77.0	75.0	71.6	68.8
27			84.5	80.3	76.9	74.4	72.2	70.4	67.2	64.7
26			79.6	75.8	72.8	70.7	68.8	67.1	64.0	61.7
25			68.6	69.0	69.0	68.8	68.5	67.8	66.1	64.5
24			79.6	78.2	76.5	75.0	73.7	72.3	69.8	67.6
23			82.3	78.3	75.2	72.8	70.9	69.3	66.2	63.8
22			76.7	72.7	69.9	67.7	65.9	64.3	61.4	59.3
21			72.2	68.8	66.3	64.4	62.7	61.2	58.7	56.6
20			65.8	63.3	61.5	60.0	58.8	57.5	55.2	53.2
19			63.4	62.8	62.5	62.1	61.6	61.1	59.7	58.4
18			65.3	64.4	64.1	63.8	63.4	63.0	61.5	60.0
17			4.1	-0.2	-4.1	-4.0	-5.8	-5.0	-6.7	-7.3
16			42.7	41.3	40.4	39.4	38.7	38.1	36.8	35.2
15			47.1	45.4	44.7	44.0	43.5	43.0	41.7	40.4
14			63.7	62.8	62.4	62.1	61.8	61.3	59.8	58.5
13			10.0	7.5	4.5	4.2	3.7	3.1	1.5	0.2
12			64.8	64.1	63.7	63.3	63.0	62.4	60.9	59.5
11			11.2	7.7	5.0	4.7	3.9	3.6	1.8	0.8
10			65.6	64.5	64.2	63.9	63.3	62.8	61.4	59.9
9			11.4	8.4	6.1	5.6	4.5	3.7	1.8	0.6
8			64.8	63.7	63.6	63.2	62.7	62.1	60.6	59.1
7			66.0	65.4	65.3	64.9	64.3	63.7	62.4	60.8
6			61.5	61.1	60.8	60.2	59.4	58.5	57.0	55.4
5			75.2	72.1	70.6	69.4	68.2	67.3	65.1	63.4
4			60.4	58.3	57.6	56.7	55.9	55.4	53.7	52.0
3		↓	32.7	32.6	32.9	32.8	32.7	32.8	32.9	32.9
2		°F	11.9	10.9	6.9	7.9	6.0	5.6	3.6	2.8
1		DRU/HR.FT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0		↓	~	~	~	~	~	~	~	~

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			009: 06:00:00	07:00:00	08:00:00	08:30:00	09:00:00	09:30:00	10:00:00	10:30:00
39		°F	41.2	41.1	41.5	42.4	43.6	61.2	74.4	62.0
38		↑	36.6	36.5	37.1	38.6	40.4	55.9	69.7	58.8
37			41.9	41.7	42.1	43.2	44.1	62.2	75.2	62.8
36			36.2	36.2	36.9	38.5	40.3	59.5	72.8	59.7
35			35.9	35.9	36.4	37.8	39.6	58.1	70.2	57.1
34			65.6	64.6	63.3	63.2	62.8	62.4	64.2	67.6
33			59.1	58.2	57.7	58.2	58.9	65.1	76.4	75.6
32			61.6	60.5	59.5	59.3	59.0	58.9	60.2	63.2
31			54.7	53.8	53.4	54.2	55.0	63.3	74.3	72.0
30			65.9	64.9	63.9	63.5	62.8	62.1	62.0	61.9
29			69.6	68.3	67.3	67.0	66.3	65.7	65.1	64.9
28			66.2	65.0	64.1	63.9	63.4	63.1	64.7	67.9
27			62.4	61.3	60.7	60.8	60.9	63.6	74.5	76.8
26			59.5	58.6	58.4	58.7	59.5	71.0	86.0	79.2
25			62.6	61.6	61.0	60.3	59.5	58.9	58.9	58.9
24			65.3	64.1	63.3	62.7	62.1	61.6	61.2	61.2
23			61.6	60.5	59.7	59.5	59.2	59.0	60.7	64.2
22			57.1	56.1	55.7	55.8	56.1	59.1	71.1	73.6
21			54.6	53.7	53.7	54.4	55.3	67.0	83.6	76.0
20			51.6	50.9	50.7	51.3	52.1	61.6	75.5	69.5
19			56.8	56.2	55.6	55.0	54.3	54.1	54.3	54.6
18			58.3	57.7	57.0	56.3	55.4	54.8	55.4	56.1
17			-3.9	-4.8	-2.3	1.1	5.0	17.1	30.6	34.8
16			33.9	33.4	33.1	32.9	32.9	33.1	34.0	34.9
15			39.0	38.5	38.2	37.9	37.8	38.0	39.0	40.1
14			56.9	56.2	55.6	54.8	54.1	53.4	53.7	54.2
13			1.9	2.1	4.0	6.5	9.3	13.2	18.7	25.6
12			57.9	57.3	56.5	55.8	55.0	54.3	54.6	55.1
11			1.9	1.8	4.3	6.5	9.1	13.6	21.2	27.9
10			58.3	57.6	56.9	56.3	55.4	54.7	54.8	55.4
9			1.6	1.9	5.1	8.6	12.7	34.3	52.2	43.5
8			57.6	56.8	56.2	55.6	54.8	54.2	54.5	55.1
7			59.3	58.4	57.9	56.8	56.0	56.3	59.2	58.5
6			54.0	53.2	52.8	52.2	51.9	53.1	54.8	54.9
5			61.5	60.8	60.0	59.5	58.9	60.1	64.2	64.0
4			50.6	50.0	49.5	49.5	49.1	52.4	55.3	55.0
3			32.7	32.8	32.9	33.1	33.1	33.1	33.0	33.0
2		°F	6.7	5.7	5.0	8.1	12.3	13.2	20.1	24.2
1		BTU/HR-FT ²	0.0	0.0	6.8	11.0	16.4	70.7	90.9	51.9
0		↓	—	—	—	9.4	18.0	141.4	167.5	43.5

DATA SHEET - GENERAL

TEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~

TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			009: 11:00:00	11:30:00	12:00:00	12:30:00	13:00:00	13:30:00	14:00:00	14:30:00
39		°F	57.8	56.6	56.7	58.6	58.1	77.0	96.4	100.1
38		↑	53.9	53.1	53.5	56.0	55.5	76.9	94.9	96.5
37			58.3	56.9	57.2	59.0	58.2	76.0	94.7	98.2
36			54.4	53.1	53.8	56.0	55.2	75.6	93.3	95.1
35			52.3	50.9	51.9	53.8	53.3	72.5	86.3	86.5
34			68.7	68.4	67.8	67.3	67.0	66.7	68.2	72.1
33			70.7	68.4	67.7	67.8	67.6	82.2	103.9	115.1
32			64.4	64.3	63.8	63.5	63.3	63.2	64.6	68.2
31			67.0	64.9	64.1	64.6	64.3	77.9	96.9	107.6
30			61.6	61.1	60.8	60.5	60.3	60.3	61.0	62.2
29			65.2	65.5	65.8	65.6	65.5	65.3	65.1	65.2
28			69.0	68.9	68.3	67.7	67.4	67.3	69.1	73.9
27			73.0	70.6	69.3	68.8	68.2	71.0	83.6	96.0
26			72.5	69.8	68.7	68.8	68.1	81.8	101.2	111.7
25			58.6	58.3	58.2	57.9	57.6	57.8	58.1	58.8
24			61.4	61.7	62.0	61.9	61.8	61.8	61.7	61.8
23			65.6	65.3	64.9	64.3	64.1	64.1	66.1	70.9
22			69.3	66.8	65.5	65.3	64.9	68.2	81.6	94.0
21			68.8	66.3	65.5	65.8	65.2	79.7	98.3	107.4
20			63.6	61.3	60.8	61.2	60.7	71.5	86.5	94.0
19			54.6	54.5	54.3	54.1	53.9	53.9	54.2	55.4
18			55.6	55.2	54.9	54.7	54.5	54.8	56.7	59.5
17			39.0	41.7	45.7	53.0	50.8	60.9	72.8	70.1
16			35.4	36.0	36.4	37.2	37.6	38.1	38.5	39.0
15			40.4	40.8	41.2	41.6	41.9	42.2	42.3	42.6
14			54.1	53.9	53.8	53.6	53.3	53.5	54.5	56.5
13			31.8	34.6	37.2	42.7	42.0	43.6	45.6	45.5
12			54.9	54.6	54.4	54.3	54.0	54.3	55.4	57.5
11			32.9	34.8	38.3	43.4	44.0	57.6	79.4	89.3
10			55.3	55.0	54.8	54.6	54.3	54.6	55.7	57.8
9			39.6	38.9	40.0	44.6	44.3	45.0	44.7	44.3
8			54.9	54.8	54.6	54.3	54.5	54.6	55.6	57.5
7			57.4	56.9	56.5	56.4	56.3	57.9	63.1	67.1
6			54.5	54.1	53.9	53.8	53.7	54.3	56.1	58.2
5			62.6	62.0	61.6	61.4	61.3	63.6	69.5	74.8
4			54.3	53.9	53.8	53.7	53.9	55.7	58.2	60.2
3		↓	33.0	33.0	33.1	33.0	33.2	33.2	32.9	32.9
2		°F	29.1	31.0	32.9	37.2	37.3	38.9	40.9	40.2
1		Btu/hr-ft²	51.6	51.5	60.9	69.8	61.4	127.7	175.2	116.0
0		↓	23.0	21.5	29.5	31.4	34.8	203.7	269.3	196.2

DATA SHEET - GENERALTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: PROJECT NAME: DOE GRANT EG-77-G-04-4145

CHANNEL NUMBER	SENSOR DESCRIPTION	SENSOR UNITS	TIME (HR:MIN:SEC)							
			009: 15:00:00	15:30:00	16:00:00	16:30:00	17:00:00	18:00:00		
39		°F	100.6	82.7	66.7	61.8	58.8	54.1		
38		↑	97.3	77.0	61.8	56.6	53.8	50.5		
37			97.6	81.8	66.5	62.0	58.9	54.3		
36			94.5	76.4	61.4	56.4	53.3	50.0		
35			85.8	69.8	57.8	53.5	50.2	47.6		
34			76.4	79.5	81.0	80.1	78.5	75.1		
33			116.0	106.2	89.2	81.7	76.7	70.5		
32			72.2	75.2	76.5	75.6	74.1	70.8		
31			109.0	99.6	83.6	76.4	71.7	66.2		
30			63.0	63.5	63.3	63.3	63.3	63.4		
29			66.1	67.4	69.1	70.4	71.2	71.6		
28			78.8	82.5	83.8	82.2	80.1	76.1		
27			98.7	100.3	91.3	85.2	80.6	74.3		
26			112.5	104.0	89.0	82.1	77.0	70.8		
25			59.5	60.1	60.2	60.3	60.5	60.7		
24			62.8	64.0	65.7	66.9	67.8	68.0		
23			75.8	79.2	80.3	78.7	76.5	72.3		
22			96.0	96.8	87.0	80.6	75.7	69.4		
21			107.6	98.1	84.0	76.9	71.9	66.2		
20			93.9	87.3	75.0	69.3	65.5	61.2		
19			56.4	57.5	57.9	58.1	57.9	57.7		
18			60.9	62.1	61.5	60.7	59.9	59.1		
17			64.2	47.1	40.6	34.2	28.1	22.5		
16			39.5	39.9	40.3	40.6	40.8	41.1		
15			43.0	43.5	43.8	44.1	44.1	44.3		
14			57.7	59.0	58.9	58.7	58.3	57.6		
13			42.4	39.2	36.1	32.5	28.6	23.9		
12			58.8	60.1	60.1	59.9	59.5	58.9		
11			91.6	57.2	45.1	38.1	32.2	26.2		
10			59.2	60.5	60.8	60.8	60.5	60.0		
9			41.6	38.1	35.0	32.1	28.9	24.9		
8			58.7	59.8	59.9	59.5	59.4	58.7		
7			67.8	67.4	63.6	62.0	61.2	60.2		
6			59.0	59.5	58.8	58.3	58.0	56.8		
5			75.8	75.2	71.3	69.4	68.6	66.1		
4			61.5	60.8	59.8	59.1	58.0	56.5		
3		↓	32.9	32.8	32.9	33.0	33.2	33.4		
2		°F	38.8	36.9	34.4	32.1	29.8	24.7		
1		BRU/HR-FT ²	115.6	29.2	25.3	7.6	0.3	0.0		
0		↓	211.4	26.0	17.1	4.8	0.0	—		

DATA SHEET - PYRANOMETERSTEST NUMBER: BP4-2-100 TEST TITLE: BUILDING PERFORMANCE, NO BACKDRAFT CONTROLTEST DATE: 01/04/79 - EEG STAFF: RL CASPERSON PROJECT NAME: DOE-EG-77-G-04-4145

<u>PYRANOMETER TYPE</u>	<u>MOUNTING ORIENTATION</u>	<u>AVERAGING PERIOD</u>	<u>RANGE</u>	<u>CONVERSION FACTOR</u>
EPPLEY BLACK&WHITE	VERT (✓) HORIZ ()	15 MIN 00 SEC	30 MV	30.937 Btu / Ft ² ·HR / MV
HOLLIS OBSERVATORY	VERT () HORIZ (✓)	15 MIN 00 SEC	300 MV	4.424

TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR	
004: 07:00:00		—		0.0	1
08:00:00		—		3.8	1
08:30:00		3.5		4.7	1
08:30:00-08:45:00		4.4		5.1	60
08:45:00-09:00:00		5.3		5.5	60
09:00:00		5.8		5.5	1
09:00:00-09:15:00		6.0		5.6	60
09:15:00-09:30:00		86.8		46.6	60
09:30:00		218.6		98.8	1
09:30:00-09:45:00		228.1		103.1	60
09:45:00-10:00:00		241.6		112.9	60
10:00:00		247.5		117.7	1
10:00:00-10:15:00		251.4		121.7	60
10:15:00-10:30:00		260.2		129.6	60
10:30:00		264.5		133.9	1
10:30:00-10:45:00		269.7		141.4	60
10:45:00-11:00:00		257.3		141.3	60
11:00:00		244.3		133.0	1
11:00:00-11:15:00		271.2		145.4	60
11:15:00-11:30:00		274.3		150.3	60
11:30:00		260.2		145.3	1
11:30:00-11:45:00		272.0		148.3	60
11:45:00-12:00:00		249.8		142.9	60
12:00:00		232.4		138.8	1
12:00:00-12:15:00		247.0		149.6	60
12:15:00-12:30:00		212.3		137.4	60
12:30:00		248.2		161.9	1
12:30:00-12:45:00		205.7		138.6	60
12:45:00-13:00:00		121.7		99.2	60
13:00:00		91.8		92.6	1
13:00:00-13:15:00		133.9		109.1	60
13:15:00-13:30:00		194.1		123.7	60
13:30:00		205.0		124.0	1
13:30:00-13:45:00		183.8		119.6	60
13:45:00-14:00:00		181.9		120.5	60

DATA SHEET - PYRANOMETERS

TEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEETTEST DATE: / / EEG STAFF: RLC PROJECT NAME: DOE-EG-77-G-04-4145

PYRANOMETER TYPE MOUNTING ORIENTATION AVERAGING PERIOD RANGE CONVERSION FACTOR

EPPLEY BLACK&WHITE VERT(✓) HORIZ() MIN SEC MV Btu / Ft²·Hr / MV
 HOLLIS OBSERVATORY VERT() HORIZ(✓) MIN SEC MV

TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR	
004: 14:00:00		153.4		101.8	1
14:00:00 - 14:15:00		147.1		96.1	60
14:15:00 - 14:30:00		125.9		79.5	60
14:30:00		112.0		68.8	1
14:30:00 - 14:45:00		86.9		57.3	60
14:45:00 - 15:00:00		36.5		31.2	60
15:00:00		23.4		26.1	1
15:00:00 - 15:15:00		29.8		24.9	60
15:15:00 - 15:30:00		30.7		19.9	60
15:30:00		15.7		13.8	1
15:30:00 - 15:45:00		9.2		9.6	60
15:45:00 - 16:00:00		4.6		4.5	60
16:00:00		4.0		3.6	1
16:00:00 - 16:15:00		3.3		3.1	60
17:00:00		~		0.0	1
005: 07:00:00		~		0.0	1
08:00:00		~		(?) 23.6	1
08:15:00 - 08:30:00		18.3		33.8	58
08:30:00		20.8		36.4	1
08:30:00 - 08:45:00		22.1		36.1	60
08:45:00 - 09:00:00		22.8		35.3	60
09:00:00		21.6		27.1	1
09:00:00 - 09:15:00		28.0		31.8	60
09:15:00 - 09:30:00		76.6		66.9	60
09:30:00		142.8		90.0	1
09:30:00 - 09:45:00		148.2		91.3	60
09:45:00 - 10:00:00		223.3		116.7	60
10:00:00		236.2		119.4	1
10:00:00 - 10:15:00		244.7		125.8	60
10:15:00 - 10:30:00		229.6		125.2	60
10:30:00		84.3		69.0	1
10:30:00 - 10:45:00		243.0		138.3	60
10:45:00 - 11:00:00		277.2		157.4	60
11:00:00		285.6		165.0	1

E-28

DATA SHEET - PYRANOMETERSTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: RLC PROJECT NAME: DOE-EG-77-G-04-4145

PYRANOMETER TYPE MOUNTING ORIENTATION AVERAGING PERIOD RANGE CONVERSION FACTOR

EPPLEY BLACK&WHITE VERT(☒) HORIZ(☐) MIN SEC MV Btu / Ft²·Hr / MV

HOLLIS OBSERVATORY VERT(☐) HORIZ(☒) MIN SEC MV

005:

TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR	
11:00:00-11:15:00		284.5		167.2	60
11:15:00-11:30:00		280.9		168.2	60
11:30:00		284.9		167.0	1
11:30:00-11:45:00		260.2		148.8	60
11:45:00-12:00:00		255.4		148.8	60
12:00:00		244.5		148.2	1
12:00:00-12:15:00		250.9		152.7	60
12:15:00-12:30:00		286.5		177.0	60
12:30:00		286.9		171.7	1
12:30:00-12:45:00		285.1		170.6	60
12:45:00-13:00:00		282.8		169.8	60
13:00:00		281.2		169.9	1
13:00:00-13:15:00		281.4		169.0	60
13:15:00-13:30:00		238.5		149.9	60
13:30:00		276.0		179.9	1
13:30:00-13:45:00		186.9		115.0	60
13:45:00-14:00:00		157.3		97.8	60
14:00:00		55.2		40.4	1
14:00:00-14:15:00		57.9		40.0	60
14:15:00-14:30:00		99.4		64.3	60
14:30:00		32.5		33.4	1
14:30:00-14:45:00		97.2		63.4	60
14:45:00-15:00:00		61.3		42.7	60
15:00:00		39.9		31.8	1
15:00:00-15:15:00		29.8		28.9	60
15:15:00-15:30:00		19.5		24.9	60
15:30:00		16.6		23.3	1
15:30:00-15:45:00		15.6		23.8	60
15:45:00-16:00:00		12.0		17.4	60
16:00:00		9.9		14.8	1
16:00:00-16:15:00		8.1		12.8	60
16:15:00-16:30:00		4.5		7.3	60
16:30:00		3.3		5.4	1
16:30:00-16:45:00		2.0		3.1	60
16:45:00-17:00:00		0.1		0.4	60

E-29

DATA SHEET - PYRANOMETERSTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: RLC PROJECT NAME: DOE-EG-77-G-04-4145PYRANOMETER TYPE MOUNTING ORIENTATION AVERAGING PERIOD RANGE CONVERSION FACTOREPPLEY BLACK&WHITE VERT(☒) HORIZ(☐) MIN SEC MV $\frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Hr}} / \text{MV}$
HOLLIS OBSERVATORY VERT(☐) HORIZ(☒) MIN SEC MV

TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	HR:MIN:SEC	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR
005: 17:00:00			~		0.0
006: 07:00:00			~		0.0
08:00:00			~		4.2
08:45:00-09:00:00			6.3		3.5
09:00:00			22.6		16.2
09:00:00-09:15:00			27.0		18.8
09:15:00-09:30:00			46.7		24.9
09:30:00			60.9		27.4
09:30:00-09:45:00			65.3		26.2
09:45:00-10:00:00			100.6		32.2
10:00:00			125.0		36.6
10:00:00-10:15:00			133.2		36.6
10:15:00-10:30:00			103.2		31.4
10:30:00			57.8		25.3
10:30:00-10:45:00			55.6		30.1
10:45:00-11:00:00			90.6		40.3
11:00:00			101.2		40.6
11:00:00-11:15:00			75.3		36.0
11:15:00-11:30:00			67.1		37.0
11:30:00			74.3		38.7
11:30:00-11:45:00			77.9		34.6
11:45:00-12:00:00			110.2		48.2
12:00:00			110.2		53.3
12:00:00-12:15:00			139.3		61.1
12:15:00-12:30:00			85.8		48.4
12:30:00			57.2		38.5
12:30:00-12:45:00			39.9		32.6
12:45:00-13:00:00			21.1		24.9
13:00:00			40.4		32.7
13:00:00-13:15:00			48.2		37.2
13:15:00-13:30:00			50.2		34.3
13:30:00			29.3		22.1
13:30:00-13:45:00			26.4		23.1
13:45:00-14:00:00			41.2		23.3

E-30

DATA SHEET - PYRANOMETERSTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: RLC PROJECT NAME: DOE-EG-77-G-04-4145

PYRANOMETER TYPE MOUNTING ORIENTATION AVERAGING PERIOD RANGE CONVERSION FACTOR

EPPLEY BLACK&WHITE VERT(☒) HORIZ(☐) MIN SEC MV $\frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Hr}} / \text{MV}$
 HOLLIS OBSERVATORY VERT(☐) HORIZ(☒) MIN SEC MV

TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR	
006: 14:00:00		42.4		29.6	1
14:00:00-14:15:00		27.8		23.9	60
14:15:00-14:30:00		21.9		18.3	60
14:30:00		27.2		22.7	1
14:30:00-14:45:00		26.9		18.5	60
14:45:00-15:00:00		17.6		9.1	60
15:00:00		19.2		9.5	1
15:00:00-15:15:00		21.7		8.8	60
15:15:00-15:30:00		22.8		8.0	60
15:30:00		12.9		4.9	1
15:30:00-15:45:00		11.8		5.3	60
15:45:00-16:00:00		10.6		5.4	60
16:00:00		10.1		5.5	1
16:00:00-16:15:00		7.3		3.9	60
16:15:00-16:30:00		3.2		1.9	60
16:30:00		1.5		1.1	1
16:30:00-16:45:00		0.9		0.8	60
16:45:00-17:00:00		0.1		0.1	60
17:00:00		—		0.0	1
007: 07:00:00		—		0.0	1
08:00:00		—		1.9	1
09:00:00		—		3.0	1
09:00:00-09:15:00		1.9		1.4	56
09:15:00-09:30:00		130.5		26.8	59
09:30:00		237.2		113.6	1
09:30:00-09:45:00		249.5		46.5	60
09:45:00-10:00:00		263.2		51.8	60
10:00:00		269.5		54.2	1
10:00:00-10:15:00		274.1		56.5	60
10:15:00-10:30:00		284.4		61.0	60
10:30:00		289.1		63.1	1
10:30:00-10:45:00		292.4		65.5	60
10:45:00-11:00:00		299.9		70.1	60
11:00:00		305.3		72.6	1

E-31

DATA SHEET - PYRANOMETERSTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEETTEST DATE: / / EEG STAFF: RLC PROJECT NAME: DOE-EG-77-G-04-4145PYRANOMETER TYPE MOUNTING ORIENTATION AVERAGING PERIOD RANGE CONVERSION FACTOR

EPPLEY BLACK&WHITE VERT(☒) HORIZ(☐) MIN SEC MV $\frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Hr}} / \text{MV}$
 HOLLIS OBSERVATORY VERT(☐) HORIZ(☒) MIN SEC MV

TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR	
007: 11:00:00 - 11:15:00		306.0		75.5	60
11:15:00 - 11:30:00		307.8		81.0	60
11:30:00		308.7		84.0	1
11:30:00 - 11:45:00		308.6		147.8	60
11:45:00 - 12:00:00		309.7		159.7	60
12:00:00		309.6		159.3	1
12:00:00 - 12:15:00		309.1		158.9	60
12:15:00 - 12:30:00		306.9		157.9	60
12:30:00		305.1		157.0	1
12:30:00 - 12:45:00		303.3		155.6	60
12:45:00 - 13:00:00		298.7		152.8	60
13:00:00		295.8		150.7	1
13:00:00 - 13:15:00		293.7		148.7	60
13:15:00 - 13:30:00		286.5		144.0	60
13:30:00		282.6		141.2	1
13:30:00 - 13:45:00		279.0		138.2	60
13:45:00 - 14:00:00		270.2		131.7	60
14:00:00		265.1		127.9	1
14:00:00 - 14:15:00		259.6		124.3	60
14:15:00 - 14:30:00		248.5		115.8	60
14:30:00		242.5		111.1	1
14:30:00 - 14:45:00		235.9		106.7	60
14:45:00 - 15:00:00		221.5		96.8	60
15:00:00		214.5		91.4	1
15:00:00 - 15:15:00		205.8		86.2	60
15:15:00 - 15:30:00		135.6		30.7	60
15:30:00		90.5		15.9	1
15:30:00 - 15:45:00		28.1		12.9	60
15:45:00 - 16:00:00		6.1		4.6	60
16:00:00		5.0		4.0	1
16:00:00 - 16:15:00		4.6		3.8	60
16:15:00 - 16:30:00		2.8		3.0	60
16:30:00		2.1		2.4	1
16:30:00 - 16:45:00		1.5		2.0	60
16:45:00 - 17:00:00		0.4		1.0	60

E-32

DATA SHEET - PYRANOMETERSTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: RLC PROJECT NAME: DOE-EG-77-G-04-4145

PYRANOMETER TYPE	MOUNTING ORIENTATION	AVERAGING PERIOD	RANGE	CONVERSION FACTOR
EPPLEY BLACK&WHITE	VERT(☒) HORIZ(☐)	MIN SEC	MV	$\frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Hr}} / \text{MV}$
HOLLIS OBSERVATORY	VERT(☐) HORIZ(☒)	MIN SEC	MV	

	TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	HR:MIN:SEC	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR	
007:	17:00:00		0.0		0.5	1
	18:00:00		0.0		0.0	1
008:	07:00:00		—		0.0	1
	08:00:00		1.9		2.9	1
	08:00:00-08:15:00		2.2		3.1	60
	08:15:00-08:30:00		3.9		3.7	60
	08:30:00		4.5		3.9	1
	08:30:00-08:45:00		4.9		4.2	60
	08:45:00-09:00:00		5.5		4.6	60
	09:00:00		5.8		4.9	1
	09:00:00-09:15:00		6.2		5.2	60
	09:15:00-09:30:00		142.2		69.3	60
	09:30:00		234.2		103.8	1
	09:30:00-09:45:00		244.1		111.7	60
	09:45:00-10:00:00		260.2		127.0	60
	10:00:00		265.1		131.6	1
	10:00:00-10:15:00		263.0		133.0	60
	10:15:00-10:30:00		214.4		117.0	60
	10:30:00		234.3		126.5	1
	10:30:00-10:45:00		210.2		116.1	60
	10:45:00-11:00:00		239.5		131.1	60
	11:00:00		249.2		135.5	1
	11:00:00-11:15:00		243.0		130.7	60
	11:15:00-11:30:00		255.2		137.6	60
	11:30:00		267.1		142.2	1
	11:30:00-11:45:00		246.8		134.2	60
	11:45:00-12:00:00		230.5		124.6	60
	12:00:00		217.0		103.4	1
	12:00:00-12:15:00		280.7		151.6	60
	12:15:00-12:30:00		281.6		152.3	60
	12:30:00		290.9		157.2	1
	12:30:00-12:45:00		289.2		155.7	60
	12:45:00-13:00:00		279.9		149.7	60
	13:00:00		284.7		151.4	1

E-33

DATA SHEET - PYRANOMETERSTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~TEST DATE: / / EEG STAFF: RLC PROJECT NAME: DOE-EG-77-G-04-4145PYRANOMETER TYPE MOUNTING ORIENTATION AVERAGING PERIOD RANGE CONVERSION FACTOR

EPPLEY BLACK&WHITE VERT(☒) HORIZ(☐) MIN SEC MV $\frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Hr}} / \text{MV}$
 HOLLIS OBSERVATORY VERT(☐) HORIZ(☒) MIN SEC MV

TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR	
008: 13:00:00-13:15:00		280.6		149.1	60
13:15:00-13:30:00		276.3		146.6	60
13:30:00		274.9		145.9	1
13:30:00-13:45:00		270.9		142.7	60
13:45:00-14:00:00		260.3		132.8	60
14:00:00		257.6		129.5	1
14:00:00-14:15:00		252.3		126.0	60
14:15:00-14:30:00		238.6		116.7	60
14:30:00		232.6		111.5	1
14:30:00-14:45:00		224.4		106.9	60
14:45:00-15:00:00		208.6		96.3	60
15:00:00		200.9		90.5	1
15:00:00-15:15:00		190.9		83.8	60
15:15:00-15:30:00		128.7		30.6	60
15:30:00		82.1		10.8	1
15:30:00-15:45:00		33.6		14.0	60
15:45:00-16:00:00		6.0		6.1	60
16:00:00		4.9		5.3	1
16:00:00-16:15:00		4.2		4.9	60
16:15:00-16:30:00		2.6		3.9	60
16:30:00		1.9		3.5	1
16:30:00-16:45:00		1.4		3.1	60
16:45:00-17:00:00		0.5		1.8	60
17:00:00		0.0		0.8	1
18:00:00		~		0.0	1
009: 07:00:00		~		0.0	1
08:00:00		~		6.8	1
08:15:00-08:30:00		7.2		9.7	60
08:30:00		9.4		11.0	1
08:30:00-08:45:00		11.7		12.6	60
08:45:00-09:00:00		15.6		15.3	60
09:00:00		18.0		16.4	1
09:00:00-09:15:00		23.4		18.8	60
09:15:00-09:30:00		91.5		45.3	60

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DATA SHEET - PYRANOMETERSTEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEETTEST DATE: / / EEG STAFF: RCC PROJECT NAME: DOE-EG-77-G-04-4145

PYRANOMETER TYPE MOUNTING ORIENTATION AVERAGING PERIOD RANGE CONVERSION FACTOR

EPPLEY BLACK&WHITE VERT(☒) HORIZ(☐) MIN SEC MV $\frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Hr}} / \text{MV}$
 HOLLIS OBSERVATORY VERT(☐) HORIZ(☒) MIN SEC MV

009:

TIME	EPPLEY PYRANOMETER OUTPUT		HOLLIS PYRANOMETER OUTPUT		NUMBER OF SAMPLES IN AVERAGE
	MV	BTU/FT ² ·HR	MV	BTU/FT ² ·HR	
09:30:00		141.4		70.7	1
09:30:00 - 09:45:00		161.0		80.2	60
09:45:00 - 10:00:00		159.2		83.8	60
10:00:00		167.5		90.9	1
10:00:00 - 10:15:00		147.6		88.4	60
10:15:00 - 10:30:00		48.9		54.8	60
10:30:00		43.5		59.9	1
10:30:00 - 10:45:00		31.8		55.8	60
10:45:00 - 11:00:00		21.8		51.4	60
11:00:00		23.0		51.6	1
11:00:00 - 11:15:00		21.4		50.9	60
11:15:00 - 11:30:00		20.0		48.1	60
11:30:00		21.5		51.5	1
11:30:00 - 11:45:00		20.6		49.7	60
11:45:00 - 12:00:00		23.0		53.7	60
12:00:00		29.5		60.9	1
12:00:00 - 12:15:00		31.6		74.2	60
12:15:00 - 12:30:00		32.8		74.2	60
12:30:00		31.4		69.8	1
12:30:00 - 12:45:00		29.4		64.2	60
12:45:00 - 13:00:00		25.4		55.2	60
13:00:00		34.8		61.4	1
13:00:00 - 13:15:00		50.5		72.3	60
13:15:00 - 13:30:00		103.4		95.2	60
13:30:00		203.7		121.7	1
13:30:00 - 13:45:00		186.5		119.5	60
13:45:00 - 14:00:00		203.3		137.1	60
14:00:00		269.3		175.2	1
14:00:00 - 14:15:00		262.6		166.4	60
14:15:00 - 14:30:00		228.1		144.0	60
14:30:00		196.2		116.0	1
14:30:00 - 14:45:00		160.9		100.0	60
14:45:00 - 15:00:00		193.9		110.2	60
15:00:00		211.4		115.6	1
15:00:00 - 15:15:00		178.4		96.2	60

TEST NUMBER: BP4-2-100 TEST TITLE: ~ CONTINUATION SHEET ~

TEST DATE: / / EEG STAFF: RLC PROJECT NAME: DOE-EG-77-G-04-4145

EPPLEY BLACK&WHITE VERT(✓) HORIZ() $\frac{\text{MIN}}{\text{MIN}}$ $\frac{\text{SEC}}{\text{SEC}}$ $\frac{\text{MV}}{\text{MV}}$ $\frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Hr}} / \text{MV}$
 HOLLIS OBSERVATORY VERT() HORIZ(✓)

[illegible]