Portland Cement Association

Research & Development Information

PCA R&D Serial No. 0884

Calibrated Hot Box Test Results Data Manual - Volume II

by M. G. VanGeem and S. C. Larson

©Portland Cement Association 1985
All rights reserved

5420 Old Orchard Road
Skokie, Illinois 60077-1083
847.966.6200 Fax 847.966.9481

www.cement.org

PCA R&D Serial No. 0884

ORNL/SUB/79-42539/5

CALIBRATED HOT BOX TEST RESULTS
DATA MANUAL - VOLUME II

Final Report

by

M. G. Van Geem and S. C. Larson

Report Prepared by

CONSTRUCTION TECHNOLOGY LABORATORIES
A Division of the Portland Cement Association
5420 Old Orchard Road
Skokie, Illinois 60077

Prepared for
Building Thermal Envelope Systems and Materials Program
OAK RIDGE NATIONAL LABORATORIES
Oak Ridge, Tennessee 37830
Operated by
MARTIN MARIETTA ENERGY SYSTEMS INC.
for the
U.S. DEPARTMENT OF ENERGY
Under Subcontract No.
DE-AC05-84OR21400

August 1985

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes--Printed Copy: A08 Microfiche A01

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

CALIBRATED HOT BOX TEST RESULTS

DATA MANUAL - VOLUME II

by

M. G. Van Geem and S. C. Larson*

ABSTRACT

This manual summarizes results from six wall assemblies tested under steady-state and dynamic temperature conditions in the calibrated hot box facility at Construction Technology Laboratories, a Division of the Portland Cement Association.

The calibrated hot box provides data on the heat transmission characteristics of full-size wall assemblies under steady-state and dynamic temperature conditions. Total thermal resistance and thermal transmittance are measured during steady-state tests. Dynamic tests provide data on thermal performance under controlled conditions that simulate actual temperature changes in building envelopes. Calibrated hot box tests are performed generally following procedures described in ASTM Designation: C976, "Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box."

This manual summarizes test results of two reference "standard" walls, two masonry cavity walls, a concrete wall with insulation board on the outdoor surface, and a wood frame wall. One reference standard wall was comprised of 4-in. (100-mm) polystyrene board insulation and one was 1-3/8 in. (35-mm) fiberglass board insulation. A description of wall geometry and

*Respectively, Research Engineer and Assistant Construction Engineer, Construction Methods Department, Construction Technology Laboratories, a Division of the Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077

material properties is given for each specimen. The manual presents steady-state, transient, and dynamic (periodic) test results in tabular form, in figures, and in summary tables. Heat transfer characteristics of different wall assemblies can be compared by using figures and summary tables for each wall. Data presented in numerical form can be used to validate models or further analyze results.

CALIBRATED HOT BOX TEST RESULTS

DATA MANUAL - VOLUME II

by

Martha G. Van Geem and Steven C. Larson*

INTRODUCTION

The calibrated hot box provides data on heat transmission characteristics of full-size wall assemblies under steady-state and dynamic temperature conditions. Heat transmission characteristics of walls must be determined to evaluate thermal performance of building envelopes.

The ASHRAE Handbook - 1981 Fundamentals[1]** summarizes steady-state properties of five commonly used types of wall construction. Thermal and physical properties of building materials used in wall construction are also listed.

There is a need for a document to summarize data from tests on wall assemblies under dynamic temperature conditions. Massive materials, such as concrete and masonry, store and release heat energy under changing temperature conditions. Only dynamic tests can be used to determine the effect of heat storage characteristics of building components.

Laboratory results of building envelope components tested under steady-state and dynamic conditions in principle can be used to develop methods of accurately predicting losses and gains through the building envelope.

---

*Respectively, Research Engineer and Assistant Construction Engineer, Construction Methods Department, Construction Technology Laboratories, a Division of the Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077

**Superscript numbers in parenthesis refer to references listed at the end of the descriptive portion of the manual.

Publishing test data in a consistent format will aid researchers developing dynamic analysis algorithms. Accurately predicting energy consumption will allow architects and engineers to size HVAC equipment optimally and select alternative wall systems on the basis of actual rather than steady-state performance.

This manual summarizes results of six wall assemblies tested under steady-state and dynamic temperature conditions in the calibrated hot box facility at Construction Technology Laboratories (CTL), a division of the Portland Cement Association. Wall descriptions and test dates are listed in Table 1. Total thermal resistance, R_T, and thermal transmittance, U, are measured during steady-state tests. Dynamic tests provide data on thermal performance under controlled conditions that simulate actual temperature changes in building envelopes.

Dynamic test data are applicable only for the temperature cycles used during testing. Dynamic temperature cycles applied to walls summarized in this manual cover a variety of temperature conditions. Test results illustrate the significance of dynamic testing.

Test results for 15 additional walls are covered in a report entitled, "Calibrated Hot Box Test Results Data Manual - Volume I."[2] Descriptions of walls in Volume I are listed in Table 2.

CALIBRATED HOT BOX TEST FACILITY

Tests were conducted in the calibrated hot box facility shown in Figs. 1 and 2. Tests were performed generally following procedures described in ASTM Designation: C976, "Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box,"[3] approved in 1983. Three of the walls described in this manual were tested before the standard was approved. Results for all

TABLE 1 - CALIBRATED HOT BOX TEST DATES

Wall Designation	Wall Description	Date of Calibrated Hot Box Tests
S1	1-3/8-in. (35-mm) Fiberglass Board Insulation	September-October 1981
S2	4-in. (100-mm) Polystyrene Beadboard	July-November 1982
M9	12-in. (300-mm) Block-Brick Cavity Wall	January-March 1983
M10	12-in. (300-mm) Block-Brick Cavity Wall with Insulation in Cavity	March-September 1983
C4	8-in. (200-mm) Normal Weight Concrete with Insulation on Outside Surface	February-May 1984
F1	2x4-in. (50x100-mm) Wood Frame with R-13 Fiberglass Insulation, R-5 Board Insulation, and Aluminum Siding	March-April 1982

TABLE 2 - DESCRIPTIONS OF WALLS SUMMARIZED IN THE "CALIBRATED HOT BOX TEST RESULTS DATA MANUAL - VOLUME I"

Wall Designation	Wall Description
M1	8-in. (200-mm) Medium Weight Concrete Block
M2	8-in. (200-mm) Medium Weight Concrete Block with Insulation in Cores
M5	8-in. (200-mm) Normal Weight Concrete Block with Reflective Insulation
M6	8-in. (200-mm) Lightweight Concrete Block with Insulation on Inside Surface
M7	6-in. (150-mm) Lightweight Concrete Block with Insulation on Inside Surface
M8	8-in. (200-mm) Normal Weight Concrete Block with Insulation on Inside Surface
M3	10-in. (250-mm) Block-Brick Cavity Wall
M4	10-in. (250-mm) Block-Brick Cavity Wall with Insulation in Cavity
C1	8-in. (200-mm) Normal Weight Concrete
C2	8-in. (200-mm) Structural Lightweight Concrete
C3	8-in. (200-mm) Low Density Concrete
F3	2x4-in. (50x100-mm) Wood Frame with R-11 Fiberglass Insulation and Cedar Siding
F4	2x4-in. (50x100-mm) Wood Frame with R-11 Fiberglass Insulation and Cedar Siding
F5	2x4-in. (50x100-mm) Wood Frame with R-11 Fiberglass Insulation and Hardboard Siding
V1	10-in. (250-mm) Brick Veneer

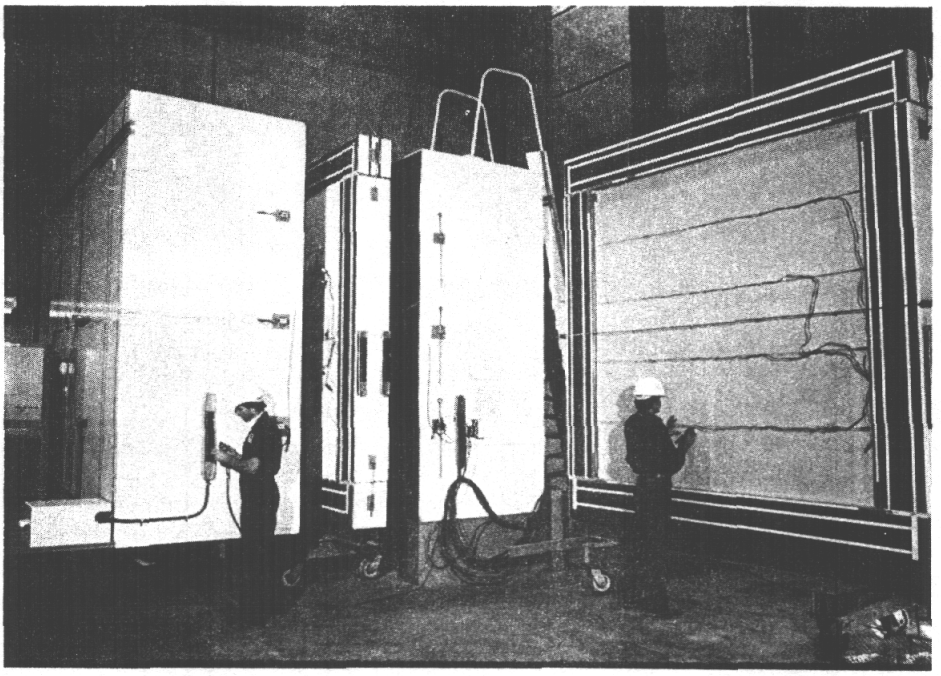


Fig. 1 Calibrated Hot Box Test Facility

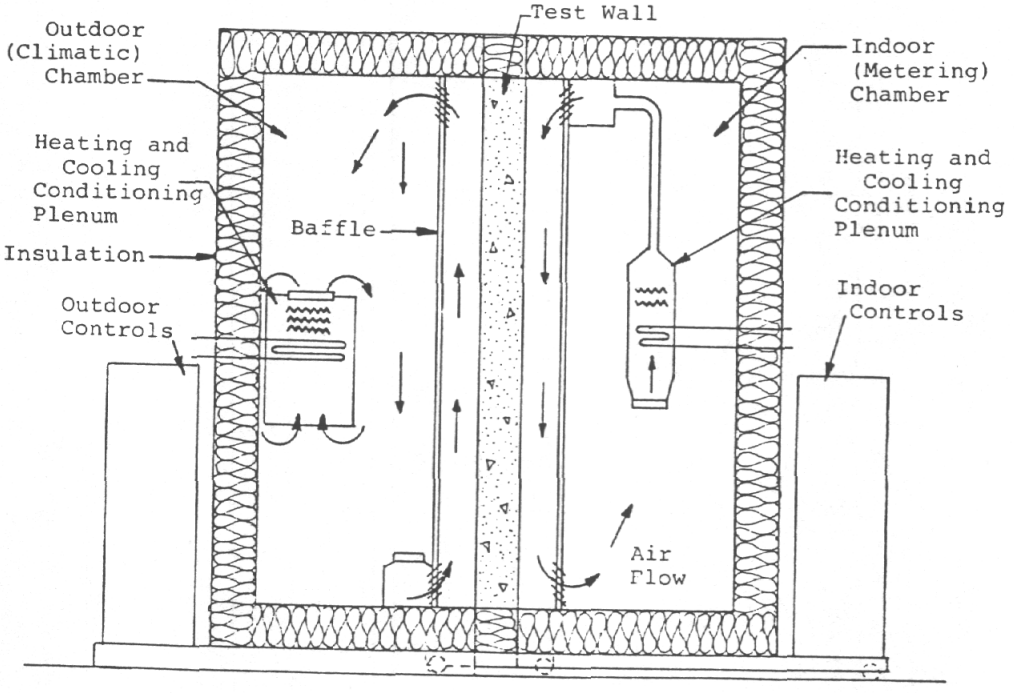


Fig. 2 Schematic of Calibrated Hot Box

walls described in this manual are comparable because the same test procedures, measurement techniques, and data analysis were used for each specimen.

Description

The following is a brief description of the calibrated hot box. Details are available in Reference 4. The facility consists of two highly insulated chambers as shown in Fig. 2. Walls, ceiling, and floors of each chamber are insulated with foamed urethane sheets to obtain a nominal thickness of 12 in. (300 mm). During tests, the chambers are clamped tightly against an insulated frame that surrounds the test wall. Air in each chamber is conditioned by heating and cooling equipment to obtain desired temperatures on each side of the test wall.

The outdoor (climatic) chamber can be held at a constant temperature or cycled between -15 and 130°F (-26 and 54°C). Temperature cycles can be programmed to obtain the desired time-temperature relationship. The indoor (metering) chamber, which simulates an indoor environment, can be maintained at a constant room temperature between 65 and 80°F (18 and 27°C).

The facility was designed to accommodate walls with thermal resistance values ranging from 1.5 to 20 $hr \cdot ft^2 \cdot °F/Btu$ (0.26 to 3.52 $m^2 \cdot K/W$).

Basic Instrumentation

Instrumentation was greater on some walls than on others. Those items common to all wall tests are referred to as basic instrumentation. Supplementary instrumentation was used in selected wall tests. Generally, wall tests done later in the program have more supplementary instrumentation.

Instrumentation was designed to monitor temperatures inside and outside the indoor chamber, air and surface temperatures on both sides of the test wall, and heating energy input to the indoor chamber. Additional measure-

ments monitor indoor cooling system performance. Basically, the instrumentation provides a means of monitoring the energy required to maintain constant temperature in the indoor chamber while temperatures in the outdoor chamber are varied. This energy, when corrected for thermal losses, provides a measure of heat flow through the test wall.

Thermocouples corresponding to ASTM Designation: E230, "Standard Temperature-Electromotive Force (EMF) Tables for Thermocouples,"[3] Type T, were used to measure temperatures. There were 16 thermocouples in the air space of each chamber and 16 on each face of the test wall. Thermocouples were uniformly distributed on a 20-3/5-in. (525-mm) square grid over the wall area.

Surface thermocouples were securely attached to the wall over a length of 3 to 4 in. (75 to 100 mm). Tape that covered sensors mounted on surfaces of painted walls was painted the same color as the test wall surfaces. Thermocouples in air were located approximately 3 in. (75 mm) from the face of the test wall.

Two heat flow meters were mounted on each wall specimen. One was applied to the indoor wall surface and one to the outdoor wall surface.

Exterior and interior surface temperatures of the calibrated hot box indoor chamber walls were measured. These temperatures provided data for evaluating heat transfer between the chamber and the laboratory. Temperature data were supplemented with heat flow meter measurements.

A watt-hour transducer was used to measure cumulative electrical energy input to the indoor chamber.

A digital humidity and temperature measurement system was used to measure relative humidity and temperature in air streams on each side of test specimens. Probes were located in the air streams approximately at the specimen mid-point.

Air flow rates in each chamber were measured with air flow meters located approximately at the wall geometric center. Each flow rate meter was mounted perpendicular to the air flow. Data from air flow meters were monitored periodically and were not part of the automated data acquisition apparatus. Air flow rates in each chamber for all wall tests were approximately 20 ft/min. (0.1 m/s).

Measurements were monitored with a programmable digital data acquisition system capable of sampling and recording up to 124 independent channels of data in less than one minute. The data acquisition system is interfaced with a microcomputer that is programmed to reduce and store data.

Thermocouple channels were scanned every two minutes. Average temperature and supplementary data were obtained from average readings for one hour. The cumulative watt-hour transducer output was scanned every hour.

Supplementary Instrumentation

Supplementary thermocouples were used to measure temperatures at selected locations of Walls M9, M10, and C4.

For the masonry cavity walls, M9 and M10, 16 thermocouples were placed on the brick surface facing the cavity and 16 were placed on the block surface facing the cavity. These internal thermocouples were uniformly distributed over approximately the same 20-3/5-in. (525-mm) grid as surface and air thermocouples. Thermocouples were embedded 1/4 in. (6 mm) or more into mortar joints or taped to brick or block surfaces. Exact thermocouple location and placement technique are given in the report for Walls M9 and M10.[5]

For the concrete wall with outside insulation, Wall C4, 16 thermocouples were embedded approximately at mid-thickness of the concrete. Sixteen additional thermocouples were placed between the concrete and insulation and 8 thermocouples were embedded 1/8 in. (3 mm) into the indoor surface of the

wall. These supplementary thermocouples were uniformly distributed over approximately the same 20-3/5-in. (525-mm) grid as surface and air thermocouples. Details of exact thermocouple location and placement technique are given in the report for Wall C4.[6]

Calibration Procedure

The following is a brief description of calibration procedures. Details are available in individual wall reports.[5,6]

Heat flow through a test wall is determined from measurements of the amount of energy input to the indoor chamber to maintain a constant temperature. The measured energy input must be adjusted for heat losses. Figure 3 shows sources of heat losses and gains by the indoor chamber where:

Q_w = heat transfer through test wall

Q_c = heat removed by indoor chamber cooling

Q_h = heat supplied by indoor electrical resistance heaters

Q_{fan} = heat supplied by indoor circulation fan

Q_ℓ = heat loss/gain from laboratory

Q_f = heat loss/gain from flanking path around specimen

Since net energy into the control volume of the indoor chamber equals zero, heat transfer through the test wall can be expressed by the following energy balance equation:

$$Q_w = Q_c - Q_h - Q_{fan} - Q_\ell - Q_f \qquad (1)$$

The directions of arrows in Fig. 3 indicate positive heat flow.

The need for cooling in the indoor chamber results from requirements for dynamic tests. In cases where outdoor temperatures exceed indoor temperatures, cooling capacity is required to maintain indoor temperature control.

Indoor chamber cooling equipment operates continuously and is designed to remove heat at a constant rate. Control of indoor chamber temperature is

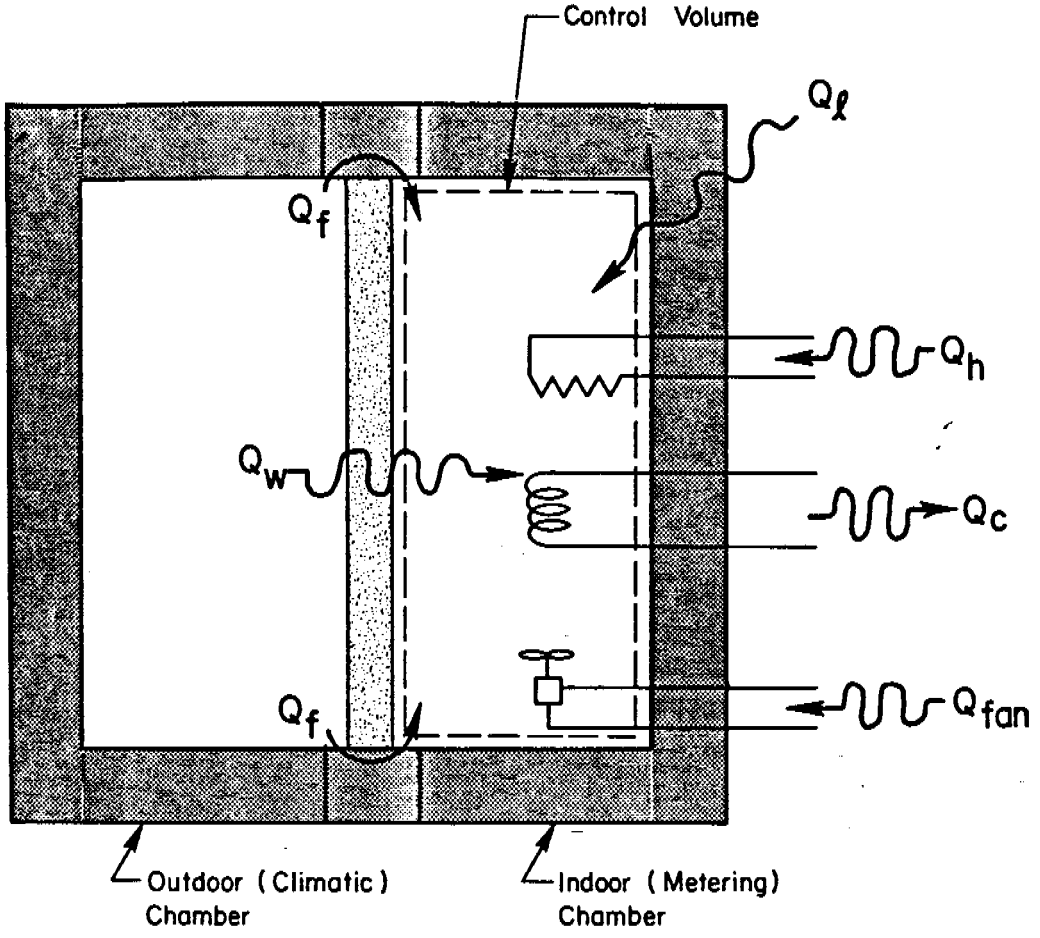


Fig. 3 Indoor (Metering) Chamber Energy Balance

obtained by varying the amount of input heat required to balance the amount of heat removed by the refrigeration system, the amount of heat that flows through the test specimen, and the amount of heat lost to laboratory space.

Steady-state calibrated hot box tests of two "standard" calibration specimens were used to refine calculations of heat removed by indoor chamber cooling, Q_c, and flanking losses, Q_f. The first calibration specimen, Wall S1, has a relatively low thermal resistance of 6.8 hr•ft^2•°F/Btu (1.2 m^2•K/W). It consists of 1-3/8-in. (35-mm) thick fiberglass and was specially fabricated to insure uniformity.

The second calibration wall, S2, has a relatively high thermal resistance of 16.8 hr•ft^2•°F/Btu (3.0 m^2•K/W). Material for Wall S2 was selected as part of the ASTM Committee C16 Hot Box Round Robin program. It consists of expanded polystyrene board that is specially produced and cut to insure uniformity. Board faces are coated to provide surfaces suitable for attachment of instrumentation.

Heat removed by indoor chamber cooling, Q_c, was calculated from refrigerant enthalpy and mass flow rate, assuming an ideal basic vapor compression refrigeration cycle. Results from steady-state calibrated hot box tests on the two "standard" calibration specimens were used to adjust for inefficiencies in the actual refrigeration cycle.

Losses from the indoor chamber to the laboratory, Q_ℓ, were calculated from thermal properties of component materials making up walls and ceilings of the indoor chamber and temperature conditions on the inner and outer surfaces of the indoor chamber. Heat flow meters mounted on the inside surface of the indoor chamber were used to check calculations. Indoor chamber air and laboratory air temperatures were generally maintained at the same nominal value, 72°F (22°C), to minimize laboratory losses. Thus, the value of Q_ℓ is small relative to other terms of the energy balance equation.

A watt-hour transducer was used to measure heat supplied to the indoor chamber by heaters and a fan, $Q_h + Q_{fan}$.

Heat loss or gain from flanking around the test specimen, Q_f, was determined from steady-state tests of the "standard" calibration walls. Since thermal conductance of each standard calibration wall is known, Q_w for a given steady-state test can be calculated using the following equation:

$$Q_w = A \cdot C \cdot (t_2 - t_1) \qquad (2)$$

where:

Q_w = heat transfer through test wall, Btu/hr (W•hr/hr)

A = area of wall surface normal to heat flow, ft^2 (m^2)

C = average thermal conductance, Btu/hr•ft^2•°F (W/m^2•K)

t_2 = average temperature of outside wall surface, °F (C)

t_1 = average temperature of inside wall surface, °F (C)

Thus, Q_f was determined from Eq. (1) using calculated values of Q_w, Q_c, and Q_ℓ, and measured values of Q_h and Q_{fan}.

For both standard calibration walls, values of Q_f were observed to follow the relationship:

$$Q_f = 0.802\ (t_2 - t_1) \qquad \text{U.S. Units} \qquad (3)$$

$$Q_f = 0.131\ (t_2 - t_1) \qquad \text{(SI Units)}$$

where:

Q_f = heat loss or gain from flanking around test specimen, Btu/hr (W•hr/hr)

t_2 = average temperature of outside wall surface, °F (°C)

t_1 = average temperature of inside wall surface, °F (°C)

Since Q_f is the residual from Eq. (1), it may include other undetermined losses from the indoor chamber.

Heat flows measured by the calibrated hot box and listed in this manual were calculated using Eq. (1) and the value of Q_f found from Eq. (3).

USE OF MANUAL

In the section "Test Data", beginning on page 35 of this manual, results for each wall are presented in tabular form, in figures, and in summary tables. Heat transfer characteristics of different wall assemblies can be easily compared by using figures and summary tables for each wall. Data presented in numerical form can be used to validate models or further analyze results.

Each table or figure designation in the "Test Data" section identifies the wall tested and the type of data presented. Designation formats are

XX-Y

where

XX = wall tested

Y = table or figure type as described in Table 3 on the following page.

For example, Table M9-4 summarizes steady-state test results for Wall M9.

If data for a particular table or figure type were not available for a given wall assembly, that table or figure was omitted. However, the numbering system applied to other tables or figures for that wall remains as listed in Table 3. For example, Table S1-5, Table S1-6, and Fig. S1-1 for transient test data are not included for Wall S1.

Data for different wall assemblies are easily comparable because table formats are consistent throughout the manual. Table formats were not altered when data were not available or headings were not applicable. In these cases, columns and rows were left blank, not deleted. For example, the t_3 and t_4 columns of Table S1-7(a) are blank because internal wall temperatures were not measured for Wall S1.

Contents of individual sections, tables, and figures are described in the following paragraphs.

TABLE 3 - TABLE AND FIGURE DESCRIPTIONS

Table or Figure No.	Description
Table XX-1*	Physical Properties of Wall at Time of Test
Table XX-2	Material Properties
Table XX-3	Design Heat Transmission Coefficients
Table XX-4	Steady-State Test Results
Figure XX-1	Transient Test Results
Table XX-5	Transient Test Results
Table XX-6	Summary of Transient Test Results
Figure XX-2	Dynamic Test Results (Periodic) for NBS Test Cycle
Table XX-7	Dynamic Test Results (Periodic) for NBS Test Cycle
Figures XX-3 and XX-4	Dynamic Test Results (Periodic) for Test Cycles Other Than the NBS Cycle
Tables XX-8 and XX-9	Dynamic Test Results (Periodic) for Test Cycles Other Than the NBS Cycle
Table XX-10	Summary of Dynamic Test Results (Periodic), Thermal Lag
Table XX-11	Summary of Dynamic Test Results (Periodic), Reduction in Amplitude
Table XX-12	Summary of Dynamic Test Results (Periodic), Energy Requirements

* Characters in the "XX" position are wall designations.

Description, Reference, and Wall Composition

The first sheet of data for each wall assembly contains a brief wall description, the reference report, and details of wall composition. Calibrated hot box test results for Walls M9, M10, and C4 were originally published in the report listed as a reference. Results for Walls S1, S2, and F1 were not previously published. Related papers for these walls are listed as references.

In the section labeled "Composition," an isometric sketch illustrates wall construction, and materials used for construction.

Physical Properties of Wall (Table XX-1)

Table XX-1 in the "Test Data" section lists physical properties of the test specimen at the time of calibrated hot box tests. Measured unit weight of the wall is listed in weight per unit area. Average thickness and wall area are measured dimensions of the calibrated hot box test specimen. Measured wall moisture content is listed for masonry and concrete walls.

Material Properties (Table XX-2)

Walls were constructed using materials listed in the "Composition" section on the first sheet of data for each wall assembly. When additional data are available on the properties of any construction material, the additional data are listed in Table XX-2 of the section for each wall assembly. In the case where more than one Material Properties Table may exist for a given wall, Tables are designated XX-2(a), XX-2(b), etc.

Design Heat Transmission Coefficients (Table XX-3)

Design values of total resistance and transmittance are shown in Table XX-3 of the section for each wall assembly. These were calculated in

accordance with procedures established by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.[1]

Surface resistances were taken as 0.68 hr•ft^2•°F/Btu (0.12 m^2•K/W) for inside and 0.17 hr•ft^2•°F/Btu (0.03 m^2•K/W) for outside. These values are commonly used in design and are considered to represent still air on the indoor wall surface and an air flow of 15 mph (24 km/hr) on the outdoor wall surface.

Resistances for construction materials were taken from the ASHRAE Handbook - 1981 Fundamentals[1] or other similar listings of thermal properties. Resistances used in this table were not measured.

Steady-State Test Results (Table XX-4)

Steady-state tests were conducted by maintaining indoor and outdoor chamber temperatures constant. Results were calculated from data collected when specimen temperatures reached equilibrium and the rate of heat flow through the test wall was constant.

Table XX-4 of the "Test Data" section summarizes results of steady-state tests for each wall assembly. Results are for an average of sixteen consecutive hours of data accumulated after steady-state equilibrium is achieved. Data are recorded and stored hourly as explained in the "Basic Instrumentation" section.

The first column of Table XX-4 lists the mean wall temperature, t_m, during each steady-state test. Mean wall temperature is determined from the average of the indoor and outdoor wall surface temperatures.

The second column shows wall heat flux determined from each steady-state calibrated hot box test.

The third and fourth columns list total thermal resistance and transmittance coefficients calculated using measured values of heat flux and the

design surface resistance coefficients given in Table XX-3. Design heat transmission coefficients, from Table XX-3, are shown in the last row of Table XX-4 for comparison.

Outdoor air, outdoor surface, indoor air, and indoor surface temperatures are average readings of 16 thermocouples placed in the uniform grid described in the "Basic Instrumentation" section of this manual. Additional temperature readings as described in the "Supplementary Instrumentation" section are listed for Walls M9, M10, and C4.

Average measured relative humidities for the indoor and outdoor chambers are listed. Relative humidity within the two chambers is not controlled by Construction Technology Laboratories' (CTL's) calibrated hot box. However, relative humidity has been measured for most tests performed since October 1979.

Maximum and minimum laboratory air temperatures obtained during each steady-state test are also listed in Table XX-4. The laboratory acts as a guard for the indoor chamber for tests conducted in CTL's calibrated hot box. Therefore, maintaining a small temperature differential between the laboratory air temperature and the indoor chamber air temperature minimizes heat loss to and from the indoor chamber. For example, the steady-state test performed on Wall S1 at a mean wall temperature of 32°F (0°C), had heat gain from the laboratory to the indoor chamber, Q_{ℓ}, equal to 1.5% of the total heat flow through the wall, Q_w.

Transient Test Results (Fig. XX-1, Tables XX-5 and XX-6)

Time required for a wall to reach a steady-state condition can be determined from transient tests. This time is affected by both thermal resistance and heat storage capacity of the test wall.

Results of a transient test are determined from data collected in the period of time between two steady-state tests. After a wall is in a steady-state condition, denoted time 0, the outdoor chamber temperature setting is changed. The transient test continues until the wall reaches an equilibrium for the new outdoor chamber air temperature. The rate of heat flow through a test specimen is determined from hourly averages of data. A transient test was not performed on Wall S1.

Figure XX-1 illustrates measured temperatures, temperature differentials, and heat flux through the wall for a transient test. Tables XX-5(a) and XX-5(b), respectively, list measured temperatures and heat flux in U.S. units and SI units. Values are shown as a function of time.

Table 4 in this section lists brief descriptions of symbols used in test data figures and tables. Symbols are described more thoroughly in the "Dynamic Test Results" section of this report.

Table XX-6 lists time required to reach 99.5, 95, and 90% of the final steady-state heat flux achieved during a transient test for each wall assembly. Results show steady-state predictions underestimate the amount of time required for massive walls to reach steady-state conditions.

Dynamic Test Results

Dynamic tests are a means of evaluating thermal response under controlled conditions that simulate temperature changes actually encountered in building envelopes. Response of walls to temperature changes is a function of both thermal resistance and heat storage capacity.

Dynamic tests were conducted by maintaining calibrated hot box indoor air temperature constant while outdoor air temperatures were cycled over a predetermined temperature versus time relationship. The rate of heat flow through a test specimen was determined from hourly averages of data.

TABLE 4 - ABBREVIATIONS

Heat Flux

q_{hfm} = heat flux measured by heat flow meter mounted on indoor wall surface

q'_{hfm} = heat flux measured by heat flow meter mounted on outdoor wall surface

q_{ss} = heat flux predicted from steady-state analysis

q_w = heat flux measured by calibrated hot box

Basic Temperatures

t_i = indoor chamber air temperature

t_1 = wall surface temperature, indoor side

t_2 = wall surface temperature, outdoor side

t_o = outdoor chamber air temperature

t_m = average of wall surface temperatures on indoor and outdoor sides

Supplementary Temperatures

Walls M9 and M10

t_3 = block temperature on surface facing cavity

t_4 = brick temperature on surface facing cavity

Wall C4

t_3 = internal wall temperature at approximate midthickness of concrete

t_4 = internal wall temperature at interface of concrete and insulation

t_5 = wall surface temperature on indoor side measured using embedded thermocouples

One 24-hour (diurnal) temperature cycle, denoted the NBS test cycle, was applied to every wall tested in the calibrated hot box. This cycle was based on a simulated sol-air* cycle used by the National Bureau of Standards in their evaluation of dynamic thermal performance of an experimental masonry building.[7] It represents a large variation in outdoor temperature over a 24-hour period. The mean outdoor temperature of the cycle was approximately equal to the mean indoor temperature. The use of this cycle permits the comparison of dynamic test results with those from other wall assemblies.

Additional sol-air diurnal temperature cycles were performed on most test specimens. Descriptions of dynamic temperature cycles and walls tested using the cycles are given in Table 5. Additional information on test cycles is available in the references given in Table 5.

For all tests, dynamic temperature cycles were repeated until conditions of equilibrium were obtained. Equilibrium conditions were evaluated by consistency of applied temperatures and measured energy response. After equilibrium conditions were reached, tests were generally continued for a period of three days. Results in tables and figures are based on average readings for three consecutive 24-hour cycles, unless otherwise noted. Each test required approximately four to six days for completion.

Hourly Test Data (Figures XX-2 thru XX-4, Tables XX-7 thru XX-9)

Measured temperatures, temperature differentials, and heat flux for the NBS temperature cycle are illustrated in Fig. XX-2 and listed in Table XX-7 of the section for each wall assembly. Figures XX-3 and XX-4 and Tables XX-8 and XX-9 give results from other temperature cycles, when available.

*Sol-air temperature is that temperature of outdoor air that, in the absence of all radiation exchanges, would give the same rate of heat entry into the surface as would exist with the actual combination of incident solar radiation, radiant energy exchange, and convective heat exchange with outdoor air.[1]

TABLE 5 - CALIBRATED HOT BOX DYNAMIC TEMPERATURE CYCLES

Test Cycle Designation	Walls Tested Using Cycle	Cycle Description
NBS	All Walls	Used by NBS in evaluation of dynamic thermal performance of an experimental masonry building.[7] See text.
Gaithersburg April	M9,M10	Derived from measured surface temperatures of NBS Test Building No. 6 in Gaithersburg, Md., during April 1982.[5]
Gaithersburg May	M9,M10	Derived from measured surface temperatures of NBS Test Building No. 6 in Gaithersburg, Md., during May 1982.[5]
Modified Phoenix August	S1	Similar to Phoenix August cycle[2] but with cooler average temperatures.
NBS+10	S2,C4	Similar to NBS Cycle, but outdoor temperatures increased by 10°F (6°C).
NBS-10	S2,C4	Similar to NBS Cycle, but outdoor temperatures decreased by 10°F (6°C).

Brief descriptions of symbols used in figures and tables are listed in Table 4. Symbols are described in detail in the following paragraphs. Tables denoted XX-Y(a) and XX-Y(b) list results in U.S. and SI units, respectively.

Measured Temperatures

Outdoor air (t_0), outdoor surface (t_2), indoor air (t_i), and indoor surface (t_1), temperatures are average readings of 16 thermocouples placed in the uniform grid described in the "Basic Instrumentation" section of this manual.

For Walls M9 and M10, two supplementary temperatures are reported. Internal block temperatures (t_3) are average readings of 16 thermocouples placed on the block surface facing the cavity. Internal brick temperatures (t_4) are average readings of 16 thermocouples placed on the brick surface facing the cavity.

For Wall C4, three supplementary temperatures are reported. Internal temperatures (t_3) are average readings of 16 thermocouples embedded at approximately the mid-thickness of the concrete. Internal temperatures (t_4) are average readings of 16 thermocouples placed at the interface of concrete and insulation. Indoor surface temperatures (t_5) are average readings of 8 thermocouples embedded 1/8 in. (3 mm) into the indoor surface of Wall C4.

Values of measured temperatures are listed in Tables XX-7 through XX-9 and illustrated in the portion of Figs. XX-2 through XX-4 denoted (a).

Temperature Differentials

Air-to-air (t_o-t_i), surface-to-surface (t_2-t_1), and surface-to-air (t_o-t_2,t_1-t_i) temperature differentials are illustrated in the portion of Figs. XX-2 through XX-4 denoted (b).

Heat Flux

Measured and calculated heat flux values are listed in Tables XX-7 through XX-9 and illustrated in the portion of Figs. XX-2 through XX-4 denoted (c). Heat flux is positive when heat flows from the outdoor chamber to the indoor chamber.

Heat flux determined from calibrated hot box tests is denoted q_w.

Heat flux measurements were also determined using 4x4-in. (100x100-mm) heat flow meters. Measurements from heat flow meters located on indoor and outdoor wall surfaces were denoted q_{hfm} and q'_{hfm}, respectively. Heat flow meter data were calibrated using results of steady-state calibrated hot box tests for the given wall.

Heat flux predicted by steady-state analysis is denoted q_{ss}. Values were calculated on an hourly basis from wall surface temperatures using the following equation:

$$q_{ss} = (t_2 - t_1)/R \qquad (4)$$

where:

q_{ss} = heat flux through test wall predicted by steady-state analysis, Btu/hr•ft^2 (W/m^2)

R = average measured thermal resistance, hr•ft^2•°F/Btu (m^2•K/W)

t_2 = average temperature of outdoor wall surface, °F (°C)

t_1 = average temperature of indoor wall surface, °F (°C)

Wall resistances are derived from steady-state calibrated hot box test results. Measured wall resistance is equal to the total resistance, R_T, listed in Table XX-4 for each wall assembly, minus the sum of the design air film resistances, 0.85 hr•ft^2•°F/Btu (0.15 m^2•K/W).

Tables XX-7 through XX-9 also footnote the calibrated hot box indoor and outdoor chamber relative humidities, and maximum and minimum laboratory air temperatures measured during tests.

Thermal Lag (Table XX-10)

Thermal lag is a measure of the response of both indoor surface temperatures and heat flow to fluctuations in outdoor air temperature. Lag is related to the ratio of the wall's ability to store energy to its ability to conduct energy.

For each dynamic test cycle, Table XX-10 lists measured thermal lag determined from calibrated hot box test results and heat flow meter readings. Calibrated hot box thermal lag is quantified by two methods. In one measure, denoted t_o vs t_1, lag was calculated as the time required for the maximum or minimum indoor surface temperature to be reached after the maximum or minimum outdoor air temperature was attained. In the second measure, denoted q_{ss} vs q_w, lag was calculated as the time required for the maximum or minimum heat flow rate, q_w, to be reached after the maximum or minimum heat flow rate based on steady-state predictions, q_{ss}, was attained. This is illustrated in Fig. 4. Both measures give similar results. The second measure was also used to determine thermal lag for heat flow meter data.

The calculated time constant for each wall assembly is also listed in Table XX-10 for each wall assembly. A time constant is a theoretical value of heat flow delay calculated from the conductivity, specific heat, density, and thickness for each layer of building material in a wall system.

If the difference in temperature across a wall is changed abruptly from the steady-state condition, as in a step change, then the heat flow through the wall will theoretically equal 63.2% of the next steady-state equilibrium heat flow after a time period equal to the time constant.[8]

The following equation was used to calculate time constants:[8]

$$t_c = \frac{a_k}{\pi^2}\left(\sum_{n=1}^{N}(g_n X_n)\right)^2 \qquad (5)$$

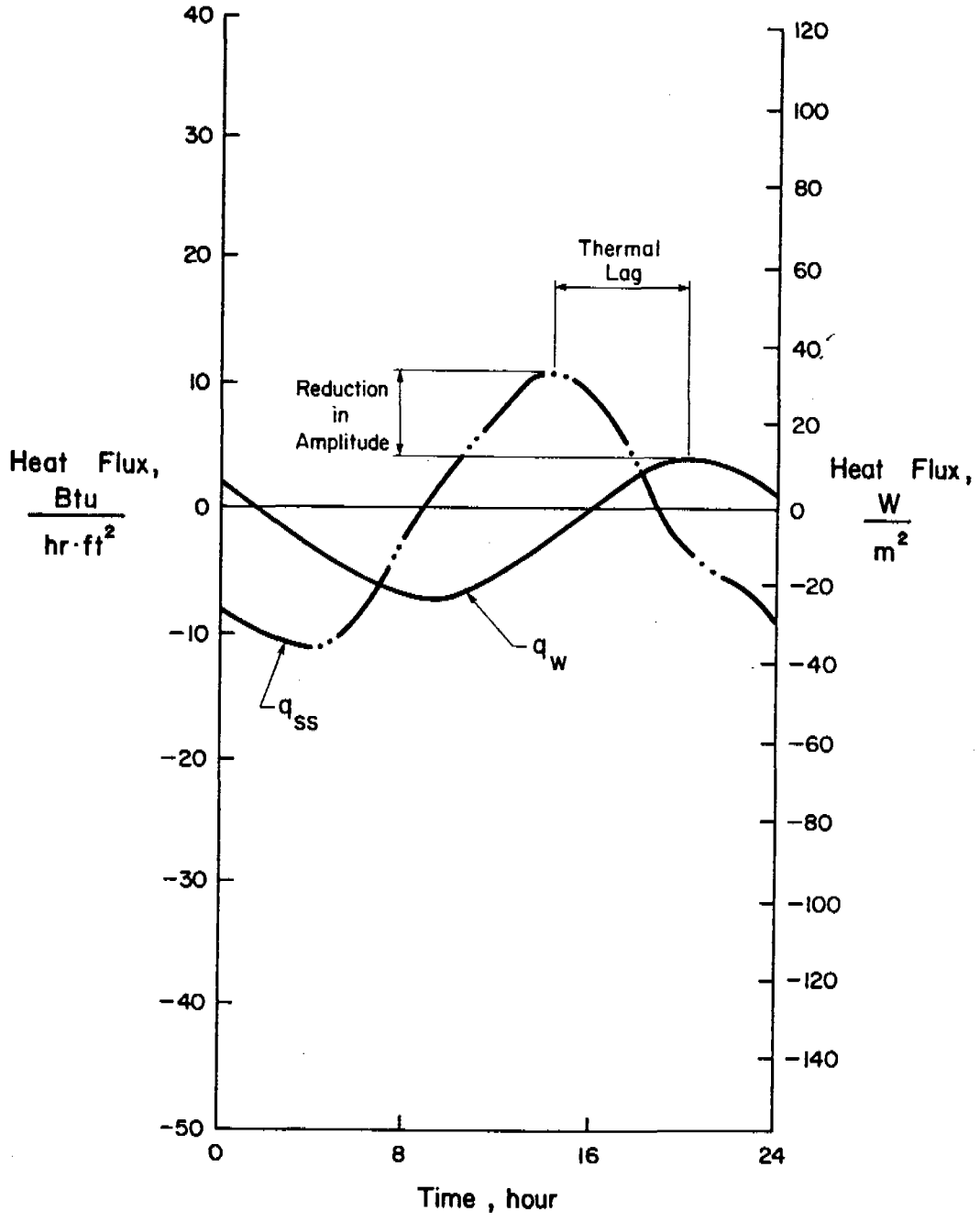


Fig. 4 Definition of Thermal Lag and Reduction in Amplitude

where:

t_c = characteristic time constant of building component, hr (s)

$g_n = (a_n/a_k)^{1/2}$, conversion constant adjusting thickness of layer to make material uniform throughout wall

$a_n = r_n c_n d_n$, reciprocal of diffusivity of n-th layer, hr/ft^2 (s/m^2)

a_k = a_n at layer k chosen for normalization

r_n = resistivity of n-th layer, or reciprocal of conductivity of n-th layer, hr•ft•°F/Btu (m•K/W)

c_n = specific heat of n-th layer, Btu/lb•°F (J/kg•K)

d_n = density of n-th layer, lb/ft^3 (kg/m^3)

X_n = thickness of n-th layer, ft (m)

When available, measured thermal properties listed in Table XX-2 in the section for each wall assembly were used to calculate time constants. Properties from the ASHRAE Handbook - 1981 Fundamentals[1] were used when measured values were not available.

Details on the derivation, calculation, and significance of time constants are available in Reference 8.

Reduction in Amplitude (Table XX-11)

Table XX-11 in the "Test Data" section lists reduction in amplitude values for each dynamic temperature cycle for each wall assembly. Percent reduction in amplitude is defined as the percent reduction in peak heat flow when compared to peak heat flow predicted by steady-state analysis. Values for percent reduction in amplitude were calculated using the following equation:

$$A = [1-(q' - \bar{q})/(q'_{ss} - \bar{q}_{ss})]\cdot 100 \qquad (6)$$

where:

A = percent reduction in amplitude

q' = maximum or minimum measured heat flux through wall

$\bar{q}$ = mean measured heat flux through wall

q'_{ss} = maximum or minimum heat flux through wall predicted by steady-state analysis

$\bar{q}_{ss}$ = mean heat flux through wall predicted by steady-state analysis

Reduction in amplitude is illustrated in Fig. 4 of this section. Reduction in amplitude values are listed for measurements determined by the calibrated hot box, q_w, and by a heat flow meter mounted on the indoor surface, q_{hfm}.

Amplitudes for heat flow meter data, q_{hfm}, are generally not the same as those for calibrated hot box data, q_w. Heat flow meter measurements are affected by discontinuities in contact between the heat flux transducer and wall surface. Heat flux amplitudes also differ because of the physical presence of the instrument mounted on a wall. A wall's thermal properties are altered at the location of a heat flow meter. In addition, heat flow meter calibration using steady-state results does not correct for dynamic effects of the instrument location.

Actual maximum heat flow through a wall is important in determining the peak energy load for a building envelope. If peak heat flows are reduced, peak energy demands will decrease. Storage capacity as well as thermal transmittance of each wall in a building envelope influences peak energy requirements.

Energy Requirements (Table XX-12)

Results of dynamic tests were also compared using measures of energy expended in maintaining constant indoor temperature while outdoor tempera-

tures were varied. Energy expended is a measure of heat flow through the test wall.

It should be noted that comparison of measured energy values for the test walls is limited to specimens and dynamic cycles evaluated in this program. Results are for diurnal test cycles and should not be arbitrarily assumed to represent annual heating and cooling loads. In addition, results are for individual opaque wall assemblies. As such, they are representative of only one component of the building envelope.

Two parameters were derived as measures of energy expended, or heat flow through test walls, during dynamic cycles. These are illustrated in Fig. 5. The curve marked "q_w" is heat flux through the test wall measured by the calibrated hot box.

Areas enclosed by a measured heat flux curve and the horizontal axis were used to provide an indication of total energy expended. These areas are denoted as q'_{a+} and q'_{a-} in Fig. 5. The sum of the absolute values of positive and negative areas is taken to represent total energy over a 24-hr period. This value is denoted as a q_w^T in Table XX-12 for each wall assembly.

A similar procedure is used to calculate total energy over a 24-hr period for measured heat flow meter data and predictions based on steady-state analysis. These are also denoted by the superscript "T" in Table XX-12 for each wall assembly.

"Total Energy Comparisons" list measured energy calculations as a percentage of predicted energy based on steady-state analysis.

Net energy for a 24-hr periodic cycle is equal to the sum of hourly measured rates of heat flow. These values can be found by totaling values of "q" from columns of Tables XX-7 through XX-9. Net energy values are denoted by the superscript "N" in Table XX-12.

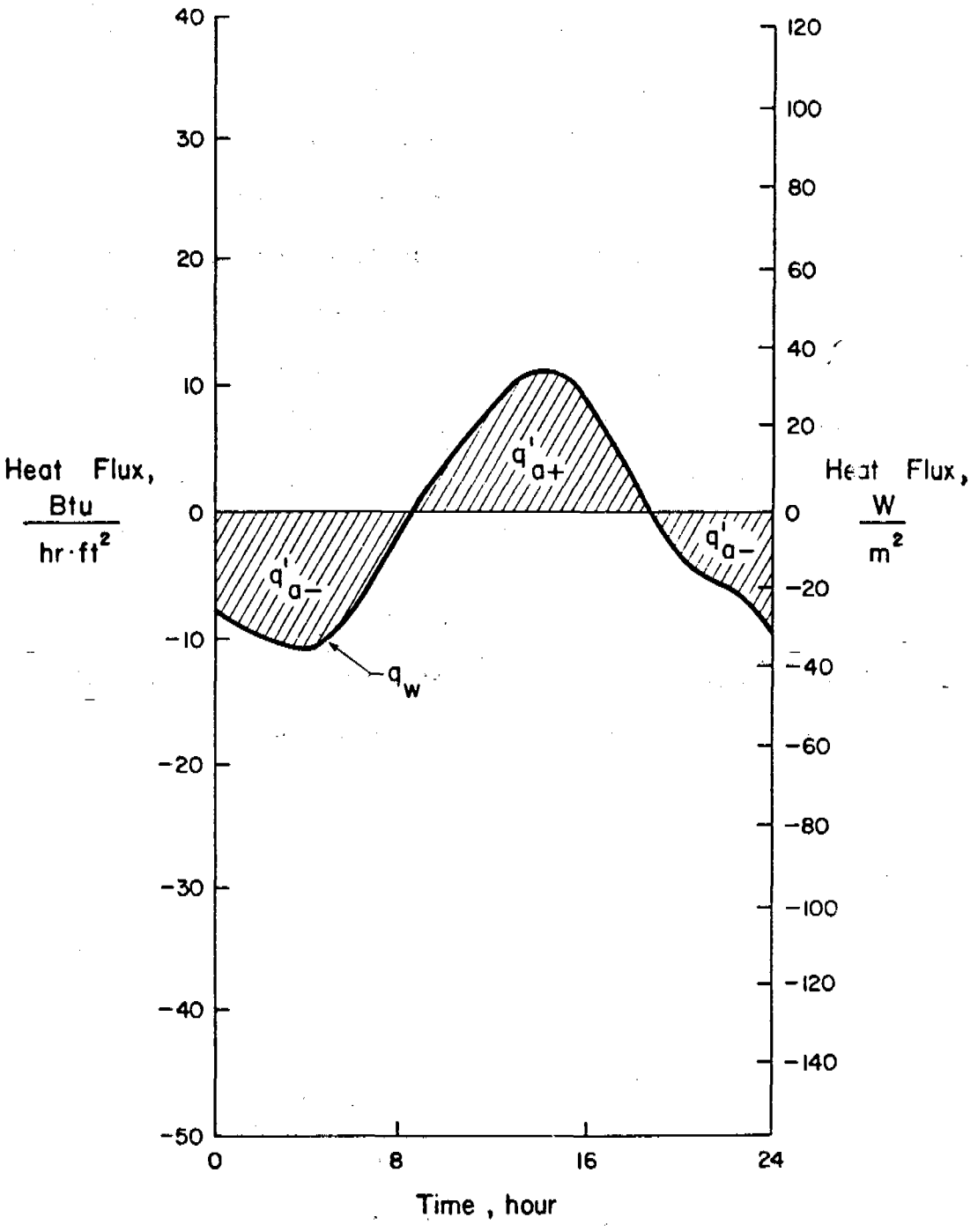


Fig. 5 Definition of Measured Energy

"Net Energy Comparisons" list measured energy calculations as a percentage of predicted energy based on steady-state analysis. Measured calibrated hot box net energy theoretically should be equal to net energy based on steady-state predictions. Differences between net energy measured using the calibrated hot box and net energy based on steady-state predictions may be attributed to inaccuracies in calibration procedures. These procedures are described in the "Calibration Procedures" section of the manual.

When the first set of calibrated hot box tests were performed in 1978, CTL maintained the only hot box in North America with the capability to perform tests under dynamic temperature conditions. Since procedures for reducing data from dynamic calibrated hot boxes with indoor chamber cooling have not been defined in industry standards, CTL has continually refined analysis procedures and added equipment to increase accuracy of test results.

Tests Performed on Wall Assemblies

Steady-state, transient, and dynamic tests performed on each wall assembly are listed in Table 6. A transient test was not performed on Wall S1.

SUMMARY

This manual summarizes results of two reference "standard" walls, two masonry cavity walls, a concrete wall with insulation board, and a wood frame wall tested in CTL's calibrated hot box. A description of wall geometry and material properties is given for each specimen. The manual presents steady-state, transient, and dynamic (periodic) test results in tabular form, in figures, and in summary tables. Heat transfer characteristics of different wall assemblies can be compared by using figures and summary tables for each wall. Data presented in numerical form can be used to validate models or further analyze results.

TABLE 6 - STEADY-STATE, TRANSIENT, AND DYNAMIC TESTS PERFORMED ON EACH WALL ASSEMBLY

Wall Designation	Wall Description	Steady-State	Transient		Dynamic
		Wall Mean Temperature °F (°C)	Temperature, °F (°C)		Test Cycle Designation
			@ Test Start	@ Test End	
S1	1-3/8-in. (35-mm) Fiberglass Board Insulation	32 (0) 103 (40)	--	--	NBS Mod. Phoenix August
S2	4-in. (100-mm) Polystyrene Beadboard	37 (3) 53 (12) 101 (38)	88 (31)	53 (12)	NBS NBS+10 NBS-10
M9	12-in. (300-mm) Block-Brick Cavity Wall	32 (0) 100 (38)	72 (22)	32 (0)	NBS Gaith. April Gaith. May
M10	12-in. (300-mm) Block-Brick Cavity Wall With Insulation in Cavity	32 (0) 100 (38)	73 (23)	30 (-1)	NBS Gaith. April Gaith. May
C4	8-in. (200-mm) Normal Weight Concrete With Insulation on Outside Surface	32 (0) 101 (38)	72 (22)	32 (0)	NBS NBS+10 NBS-10
F1	2x4-in. (50x100-mm) Wood Frame With R-13 Fiberglass Insulation, R-5 Board Insulation, and Aluminum Siding	30 (-1) 101 (39)	73 (23)	30 (-1)	NBS

Laboratory results of building envelope components tested under steady-state and dynamic conditions can be used to develop methods of accurately predicting losses and gains through the building envelope. Publishing test data in a consistent format will aid researchers developing dynamic analysis algorithms. Accurately predicting energy consumption will allow architects and engineers to size HVAC equipment optimally and select alternative wall systems on the basis of actual rather than steady-state performance.

Conclusions concerning storage capacities of masonry and concrete wall assemblies are included in referenced reports.

ACKNOWLEDGMENTS

This manual was prepared as part of a project sponsored jointly by the U.S. Department of Energy, Office of Buildings Energy Research and Development, and the Portland Cement Association. The work is under subcontract 86X-42539C with Oak Ridge National Laboratory (ORNL). It is part of the National Program Plan for Building Thermal Envelope Systems and Materials.

The work was performed in the Engineering and Resource Development Division of the Construction Technology Laboratories (CTL), a Division of the Portland Cement Association, under the direction of Dr. W. G. Corley, Executive Director, and Mr. D. W. Musser, Director of the Construction Methods Department.

Mr. R. K. Reichenbach, Mr. R. Kuhart, and Mr. C. Steer drafted the figures.

Dr. A. E. Fiorato, Director, Concrete Materials Research Department, provided helpful comments and suggestions on the manual contents and organization.

Dr. G. Courville, Program Manager of the Energy Division at ORNL, reviewed the manual and provided helpful comments and suggestions.

Mrs. E. Ringquist provided editorial assistance in preparation of the manual. The manual was typed by personnel of the Portland Cement Association's Word Processing Department.

REFERENCES

1. ASHRAE Handbook - 1981 Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, 1981.

2. Van Geem, M. G., "Calibrated Hot Box Test Results Data Manual - Volume I," Construction Technology Laboratories, Portland Cement Association, Skokie, 1984, 336 pages.

3. 1984 Annual Book of ASTM Standards, American Society for Testing and Materials, Philadelphia, 1984.

4. Fiorato, A. E., "Laboratory Tests of Thermal Performance of Exterior Walls," Proceedings of the ASHRAE/DOE-ORNL Conference on Thermal Performance of the Exterior Envelopes of Buildings, Orlando, Florida, Dec. 1979, ASHRAE SP28, Atlanta, 1981, pp. 221-236.

5. Van Geem, M. G., and Larson, S. C., "Heat Transfer Characteristics of a Masonry Cavity Wall With and Without Expanded Perlite Insulation," Construction Technology Laboratories, Portland Cement Association, Skokie, 1985, 142 pages.

6. Larson, S. C., and Van Geem, M. G., "Heat Transfer Characteristics of Walls With Similar Thermal Resistance Values," Construction Technology Laboratories, Portland Cement Association, Skokie, 1985, 145 pages.

7. Peavy, B. A., Powell, F. J., and Burch, D. M., "Dynamic Thermal Performance of an Experimental Masonry Building," Building Science Series 45, U.S. Department of Commerce, National Bureau of Standards, Washington, D.C., 1973.

8. Flanders, S. N., "Time Constraints on Measuring Building R-Values," CRREL Report 80-15, United States Army, Corps of Engineers, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, 1980, 30 pages.

TEST DATA

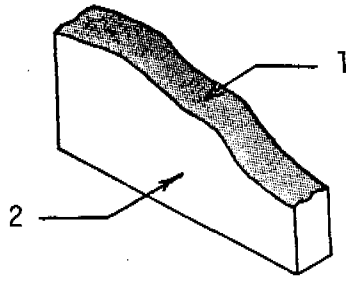
WALL S1: 1-3/8-in. (35-mm) FIBERGLASS BOARD INSULATION

DESCRIPTION: 1-3/8-in. (35-mm) fiberglass board insulation with foil facing.

REFERENCE: Larson, S. C., and Van Geem, M. G., "Heat Transfer Characteristics of Walls with Similar Thermal Resistance Values," Construction Technology Laboratories, a Division of the Portland Cement Association, Skokie, 1985, __ pages.

Fiorato, A. E., "Laboratory Tests of Thermal Performance of Exterior Walls," Proceedings of the ASHRAE/DOE-ORNL Conference on Thermal Performance of the Exterior Envelopes of Buildings, Orlando, Florida, Dec. 1979, ASHRAE SP28, Atlanta, 1981, pp. 221-236.

COMPOSITION:



1. 1-3/8-in. (35-mm) Fiberglass Board Insulation
2. Fiber-Reinforced Foil Facing (each face), painted off-white

TABLE S1-1 - PHYSICAL PROPERTIES OF WALL AT TIME OF TEST*

Property	Measured Value
Unit weight, psf (kg/m^2)	1.07 (5.22)
Average Thickness, in. (mm)	1.46 (37.1)
Area, ft^2 (m^2)	73.21 (6.80)

*Wall was tested September through October 1981. Properties were measured January 1985.

TABLE S1-2 - MATERIAL PROPERTIES, FIBERGLASS

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Thickness*, in. (mm)	--	--	--	1.40 (35.6)
Unit Weight*, pcf (kg/m^3)	--	--	--	8.42 (135)
Thermal Conductivity*, $Btu \cdot in./hr \cdot ft^2 \cdot °F$ ($W/m \cdot K$)	ASTM C518	air dry	75 (24)	0.243 (0.0350)

*Properties determined by Owens-Corning Fiberglas Corporation.

TABLE S1-3 - DESIGN HEAT TRANSMISSION COEFFICIENTS

Component	R, Thermal Resistance $hr \cdot ft^2 \cdot °F/Btu$ $(m^2 \cdot K/W)$
1. Outside Air Film	0.17* (0.03)
2. 1-3/8-in. (35-mm) Fiberglass Board Insulation	5.50* (0.97)
3. Inside Air Film	0.68* (0.12)
Total R	6.35 (1.12)
Total U**	0.16 (0.89)

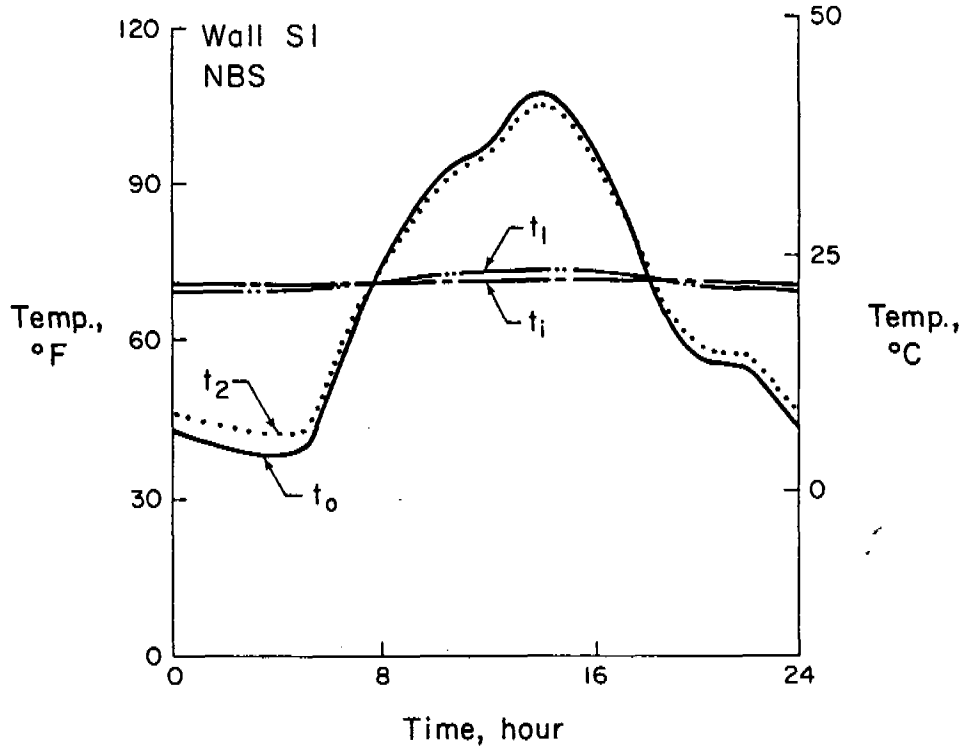
*Source: ASHRAE Handbook-1981 Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, 1981, Chapter 23.

**Units for thermal transmittance are $Btu/hr \cdot ft^2 \cdot °F$ $(W/m^2 \cdot K)$

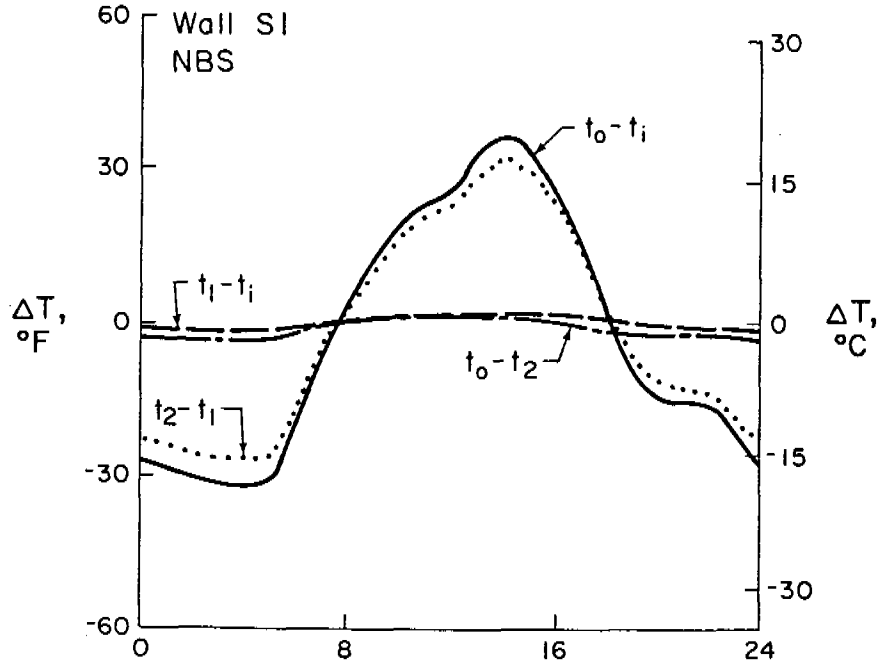
TABLE S1-4 - STEADY-STATE TEST RESULTS

Nominal Test Condition	q Heat Flux, Btu/hr·ft^2 (W/m^2)	R_T,* hr·ft^2·°F/Btu (m^2·K/W)	U,* Btu/hr·ft^2·°F (W/m^2·K)	Measured Temperatures, °F (°C)						Relative Humidity		Laboratory Air Temperature	
				t_o Outdoor Air	t_2 Outdoor Surface	t_3** Internal	t_4** Internal	t_1 Indoor Surface	t_i Indoor Air	Indoor Chamber, %	Outdoor Chamber, %	Max. °F (°C)	Min. °F (°C)
t_m = 32°F (0°C)	-11.1 (-35.1)	7.10 (1.25)	0.14 (0.80)	-10 (-23)	-3 (-19)	-	-	67 (19)	70 (21)	48	22	74 (23)	72 (22)
t_m = 103°F (40°C)	9.7 (30.6)	6.50 (1.14)	0.15 (0.87)	134 (57)	131 (55)	-	-	76 (24)	72 (22)	49	26	69 (21)	67 (19)
Design values (Predicted)+	-	6.61 (1.16)	0.15 (0.86)	-	-	-	-	-	-	-	-	-	-
Design values (ASHRAE)++	-	6.35 (1.12)	0.16 (0.89)	-	-	-	-	-	-	-	-	-	-

*Total thermal resistance, R_T, and transmittance, U, for steady-state tests were calculated using the design surface resistance coefficients from Table S1-3 and measured values of heat flux.
**Internal thermocouples were not used on this wall assembly.
+Calculated from properties measured by Owens-Corning Fiberglass Corporation and listed in Table S1-2.
++From Table S1-3.

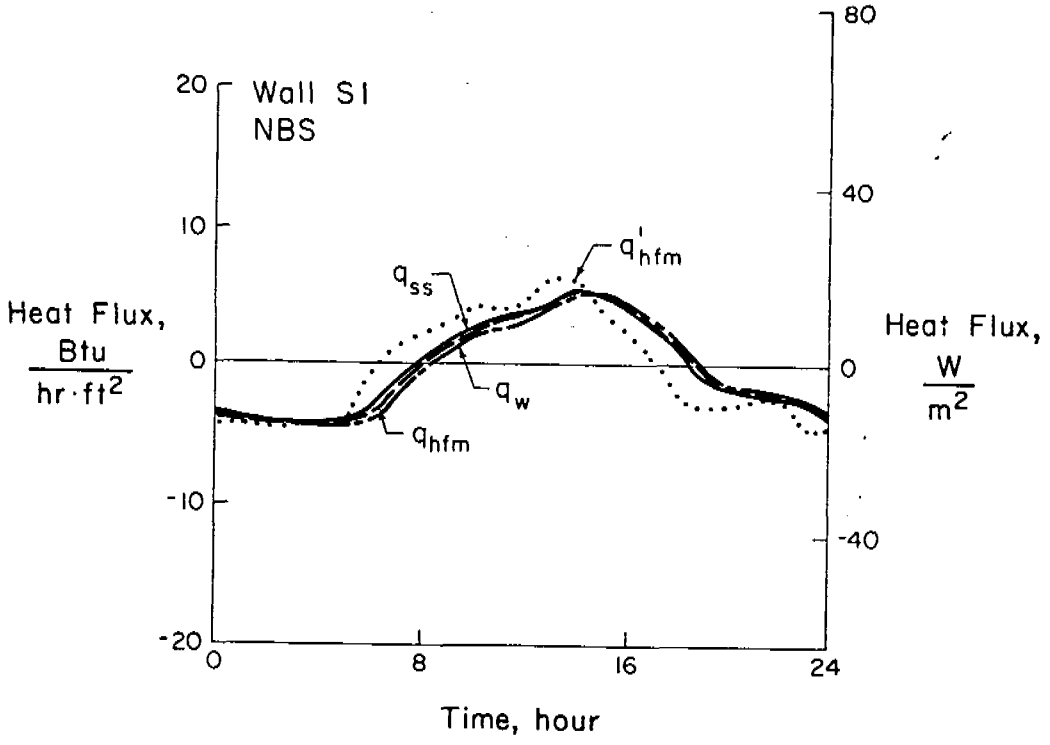


(a) Measured Temperatures



(b) Temperature Differentials

Fig. S1-2 Wall S1 Dynamic Test Results for NBS Test Cycle



(c) Heat Flux

Fig. S1-2 Wall S1 Dynamic Test Results for NBS Test Cycle

TABLE S1-7(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3^* Inter-nal	t_4^* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q'_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	42.2	45.3			69.6	70.7	-3.84	-4.00	-4.33	-4.03
2	40.4	43.7			69.5	70.8	-4.30	-4.28	-4.66	-4.28
3	39.3	42.6			69.5	70.8	-4.51	-4.48	-4.60	-4.47
4	39.2	42.4			69.5	70.7	-4.71	-4.46	-4.51	-4.50
5	39.5	42.7			69.4	70.7	-4.30	-4.47	-4.32	-4.43
6	49.6	51.0			69.8	70.8	-4.14	-3.79	-0.71	-3.14
7	64.5	64.9			70.8	71.0	-2.31	-1.57	1.44	-1.00
8	73.9	73.8			71.4	71.1	-0.50	-0.01	2.08	0.41
9	81.6	81.1			71.9	71.2	0.61	1.16	2.91	1.57
10	90.0	88.9			72.4	71.3	2.02	2.44	4.19	2.84
11	94.0	93.0			72.8	71.4	2.52	3.26	3.86	3.47
12	96.7	95.4			73.0	71.5	3.09	3.64	4.43	3.85
13	103.5	101.5			73.4	71.5	4.23	4.46	6.35	4.86
14	107.9	106.1			73.7	71.5	4.76	5.41	6.07	5.64
15	104.2	103.2			73.7	71.6	5.29	5.23	3.83	5.10
16	97.5	96.9			73.2	71.5	4.35	4.32	2.38	4.10
17	88.2	88.5			72.7	71.5	3.35	3.09	0.33	2.72
18	74.2	75.8			71.9	71.3	1.65	1.31	-2.63	0.66
19	62.9	64.9			71.0	71.1	-0.10	-0.67	-3.15	-1.03
20	57.1	59.2			70.6	71.0	-1.53	-1.74	-3.08	-1.92
21	55.4	57.3			70.4	70.9	-1.93	-2.20	-2.58	-2.20
22	55.3	57.3			70.4	71.0	-2.22	-2.28	-2.40	-2.20
23	48.7	51.8			70.2	70.9	-2.67	-2.71	-4.82	-3.07
24	43.2	46.4			69.6	70.7	-3.63	-3.74	-4.52	-3.85
Mean	68.7	69.7			71.3	71.1	-0.37	-0.25	-0.35	-0.20

*Internal thermocouples were not used on this wall assembly.

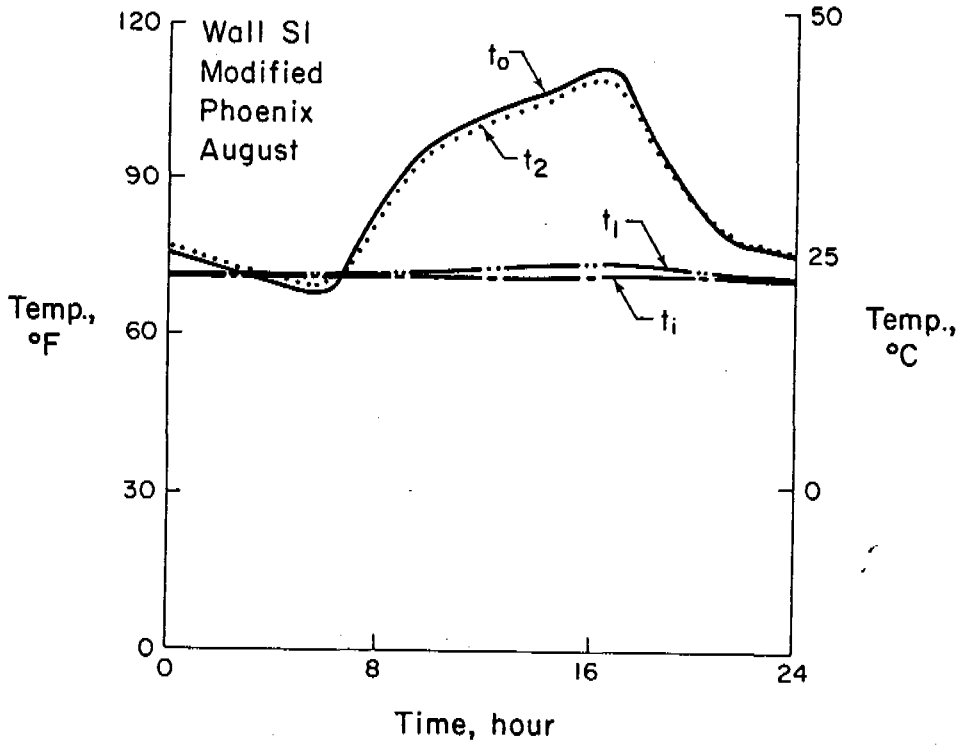
Calibrated Hot Box Relative Humidity:
Indoor Chamber - 44%
Outdoor Chamber - 20%

Laboratory Air Temperature:
Max. - 74°F (23°C)
Min. - 70°F (21°C)

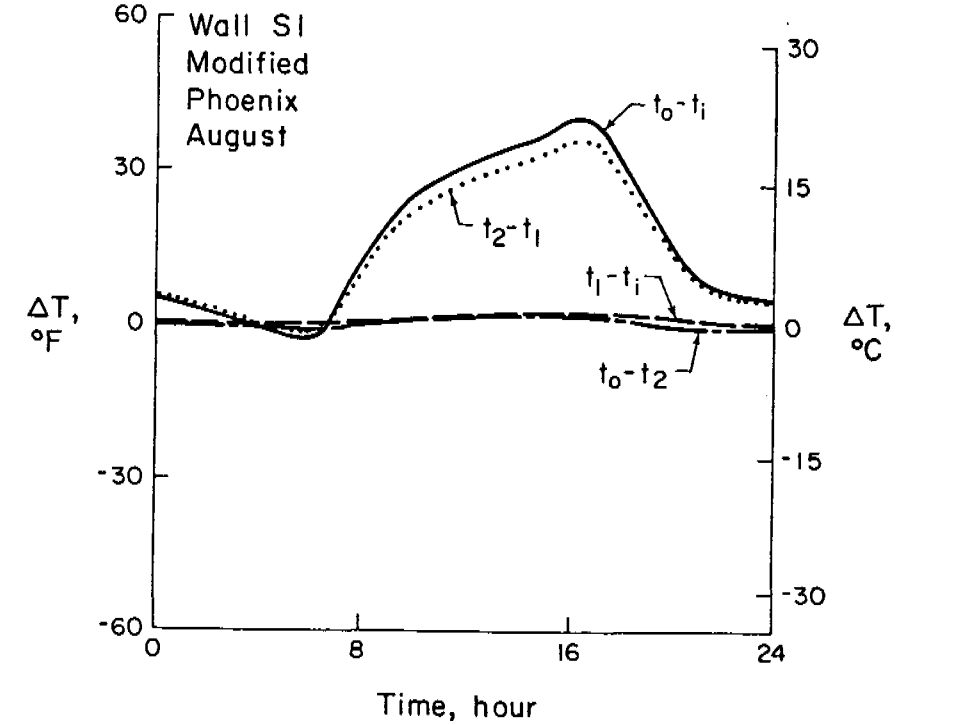
TABLE S1-7(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3^* Inter-nal	t_4^* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	5.6	7.3			20.9	21.5	-12.13	-12.61	-13.65	-12.71
2	4.7	6.4			20.8	21.5	-13.57	-13.50	-14.71	-13.50
3	4.1	5.9			20.8	21.6	-14.24	-14.14	-14.52	-14.10
4	4.0	5.8			20.8	21.5	-14.86	-14.08	-14.22	-14.20
5	4.2	6.1			20.8	21.5	-13.56	-14.09	-13.63	-13.97
6	9.8	11.8			21.0	21.5	-13.06	-11.94	-2.24	-9.91
7	18.1	19.1			21.6	21.7	-7.27	-4.94	4.54	-3.15
8	23.3	23.9			21.9	21.7	-1.57	-0.02	6.56	1.29
9	27.6	27.8			22.2	21.8	1.92	3.67	9.17	4.95
10	32.2	31.6			22.5	21.8	6.38	7.68	13.21	8.96
11	34.5	33.9			22.7	21.9	7.94	10.29	12.18	10.95
12	35.9	35.2			22.8	21.9	9.76	11.47	13.98	12.15
13	39.7	38.6			23.0	21.9	13.34	14.07	20.02	15.33
14	42.1	41.2			23.2	22.0	15.02	17.06	19.14	17.79
15	40.1	39.6			23.2	22.0	16.69	16.51	12.09	16.09
16	36.4	36.1			22.9	22.0	13.73	13.62	7.51	12.93
17	31.2	31.4			22.6	21.9	10.58	9.75	1.03	8.58
18	23.4	24.3			22.2	21.8	5.21	4.12	-8.30	2.08
19	17.2	18.3			21.7	21.7	-0.30	-2.13	-9.94	-3.25
20	13.9	15.1			21.4	21.7	-4.81	-5.48	-9.70	-6.06
21	13.0	14.1			21.3	21.6	-6.08	-6.95	-8.14	-6.94
22	13.0	14.1			21.3	21.7	-7.00	-7.20	-7.59	-6.94
23	9.3	11.0			21.2	21.6	-8.43	-8.55	-15.22	-9.68
24	6.2	8.0			20.9	21.5	-11.46	-11.80	-14.27	-12.15
Mean	20.4	21.0			21.8	21.7	-1.16	-0.80	-1.11	-0.64

*Internal thermocouples were not used on this wall assembly.

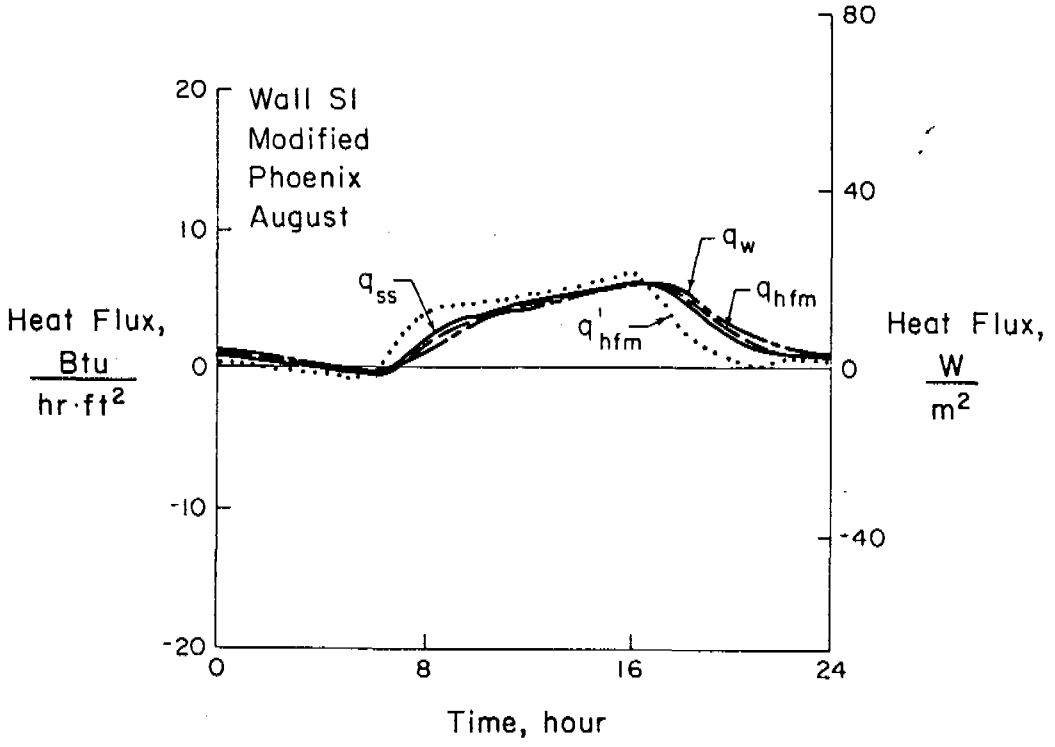


(a) Measured Temperatures



(b) Temperature Differentials

Fig. S1-3 Wall S1 Dynamic Test Results for Modified Phoenix August Test Cycle



(c) Heat Flux

Fig. S1-3 Wall S1 Dynamic Test Results for Modified Phoenix August Test Cycle

TABLE S1-8(a) - DYNAMIC TEST RESULTS (PERIODIC), MODIFIED PHOENIX AUGUST TEST CYCLE*

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3** Internal	t_4** Internal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q'_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	74.3	74.9			71.2	70.7	0.99	0.64	0.13	0.63
2	72.9	73.5			71.0	70.6	0.83	0.45	-0.04	0.43
3	71.1	71.9			71.0	70.6	0.38	0.18	-0.36	0.15
4	69.8	70.7			70.9	70.6	-0.10	-0.05	-0.46	-0.03
5	68.2	69.2			70.8	70.6	-0.16	-0.25	-0.74	-0.27
6	67.8	68.7			70.8	70.6	-0.16	-0.44	-0.45	-0.35
7	73.2	73.3			71.0	70.6	0.08	0.01	1.56	0.39
8	83.2	82.4			71.5	70.7	1.05	1.33	3.76	1.86
9	91.7	90.5			72.2	70.9	2.12	2.67	4.56	3.15
10	96.3	95.0			72.5	71.0	3.56	3.57	4.55	3.87
11	99.3	97.9			72.7	71.0	3.91	4.09	4.81	4.36
12	102.0	100.4			72.9	71.0	4.15	4.49	5.12	4.76
13	104.0	102.4			73.0	71.1	4.93	4.86	5.35	5.09
14	106.0	104.3			73.2	71.1	4.87	5.16	5.69	5.41
15	108.5	106.6			73.4	71.2	5.48	5.50	6.23	5.78
16	111.3	109.3			73.6	71.3	6.01	5.99	6.75	6.21
17	110.8	109.2			73.7	71.3	6.05	6.15	5.67+	6.18
18	103.5	102.7			73.3	71.2	5.61	5.40	2.97	5.09
19	93.8	93.6			72.7	71.1	4.24	3.93	1.38	3.59
20	86.3	86.5			72.2	71.0	3.17	2.71	0.68	2.45
21	80.0	80.4			71.8	70.9	2.14	1.66	0.13	1.47
22	77.8	78.2			71.5	70.9	1.52	1.15	0.58	1.14
23	76.6	77.1			71.5	70.9	1.25	0.91	0.52	0.95
24	75.7	76.2			71.4	70.8	1.10	0.79	0.41	0.82
Mean	87.7	87.3			72.1	70.9	2.63	2.54	2.45	2.63

*Average indoor and outdoor air temperatures approximately 7°F (4°C) less than for Phoenix August Test Cycle.
**Internal thermocouples were not used on this wall assembly.
+One day of data, not average of three days.

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 41%
Outdoor Chamber - 20%

Laboratory Air Temperature:
Max. - 74°F (23°C)
Min. - 70°F (21°C)

TABLE S1-8(b) - DYNAMIC TEST RESULTS (PERIODIC), MODIFIED PHOENIX AUGUST TEST CYCLE,* SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3** Inter-nal	t_4** Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	23.5	23.8			21.8	21.5	3.13	2.01	0.40	1.99
2	22.7	23.1			21.7	21.4	2.63	1.41	-0.13	1.36
3	21.7	22.2			21.6	21.4	1.20	0.57	-1.12	0.47
4	21.0	21.5			21.6	21.5	-0.30	-0.16	-1.45	-0.09
5	20.1	20.7			21.6	21.5	-0.49	-0.79	-2.34	-0.85
6	19.9	20.4			21.5	21.5	-0.52	-1.38	-1.40	-1.10
7	22.9	22.9			21.6	21.5	0.26	0.03	4.91	1.23
8	28.5	28.0			21.9	21.5	3.30	4.19	11.87	5.87
9	33.2	32.5			22.3	21.6	6.70	8.43	14.39	9.94
10	35.7	35.0			22.5	21.6	11.25	11.26	14.35	12.21
11	37.4	36.6			22.6	21.7	12.32	12.90	15.17	13.75
12	38.9	38.0			22.7	21.7	13.09	14.16	16.17	15.02
13	40.0	39.1			22.8	21.7	15.56	15.35	16.89	16.06
14	41.1	40.2			22.9	21.7	15.36	16.27	17.96	17.07
15	42.5	41.5			23.0	21.8	17.28	17.36	19.66	18.23
16	44.1	42.9			23.1	21.8	18.96	18.91	21.29	19.59
17	43.8	42.9			23.2	21.8	19.08	19.41	17.88+	19.50
18	39.7	39.3			23.0	21.8	17.70	17.03	9.37	16.06
19	34.3	34.2			22.6	21.7	13.37	12.40	4.34	11.32
20	30.2	30.3			22.3	21.7	10.01	8.55	2.15	7.73
21	26.6	26.9			22.1	21.6	6.74	5.24	0.40	4.64
22	25.5	25.7			22.0	21.6	4.79	3.63	1.81	3.60
23	24.8	25.0			21.9	21.6	3.96	2.88	1.64	3.00
24	24.3	24.5			21.9	21.6	3.47	2.49	1.30	2.59
Mean	30.9	30.7			22.3	21.6	8.29	8.01	7.73	8.30

*Average indoor and outdoor air temperatures approximately 7°F (4°C) less than for Phoenix August Test Cycle.
**Internal thermocouples were not used on this wall assembly.
+One day of data, not average of three days.

TABLE S1-10 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), THERMAL LAG

Test Cycle	Thermal Lag, hrs								Calc. Time Constant,* hrs
	Measured								
	Calibrated Hot Box					Heat Flow Meter			
	t_o vs t_1		q_{ss} vs q_w		Avg.	q_{ss} vs q_{hfm}		Avg.	
	@ Max.	@ Min.	@ Max.	@ Min.		@ Max.	@ Min.		
NBS	0	1	1	0	0.5	0	0	0	0.13
Modified Phoenix August	1	0	0	0	0.5	0.5	0	0.5	0.13

*Calculated from properties measured by Owens-Corning Fiberglas Corporation and listed in Table S1-2.

TABLE S1-11 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), REDUCTION IN AMPLITUDE

Test Cycle	Measured, %					
	Calibrated Hot Box			Heat Flow Meter		
	@ Max.	@ Min.	Avg.	@ Max.	@ Min.	Avg.
NBS	3	-1	1	3	2	3
Modified Phoenix August	4	6	5	-1	0	0

TABLE S1-12 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), ENERGY REQUIREMENTS

Test Cycle	Total Energy, Btu/ft^2 (W·hr/m^2)			Total Energy Comparisons, %		Net Energy, Btu/ft^2 (W·hr/m^2)			Net Energy Comparisons, %	
	Measured		Calculated	$\frac{q_w^T}{q_{ss}^T}$	$\frac{q_{hfm}^T}{q_{ss}^T}$	Measured		Calculated	$\frac{q_w^N}{q_{ss}^N}$	$\frac{q_{hfm}^N}{q_{ss}^N}$
	q_w^T	q_{hfm}^T	q_{ss}^T			q_w^N	q_{hfm}^N	q_{ss}^N		
NBS	72.6 (228.9)	74.7 (235.7)	75.3 (237.7)	96	99	-8.8 (-27.8)	-6.1 (-19.2)	-4.9 (-15.5)	180	124
Modified Phoenix August	63.9 (201.5)	62.4 (196.8)	64.4 (203.3)	99	97	63.0 (198.8)	60.9 (192.1)	63.1 (199.1)	100	96

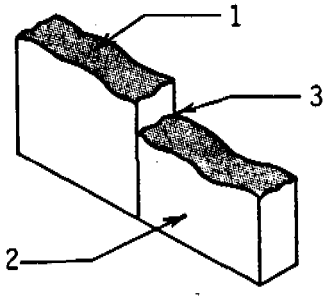
WALL S2: 4-in. (100-mm) POLYSTYRENE BEADBOARD

DESCRIPTION: Expanded polystyrene beadboard wall with carpet adhesive applied to each face.

REFERENCES: Bales, E.L., "Plan for a Round Robin of Hot Boxes," NBSIR 81-2443, National Bureau of Standards, Washington, DC, 1982, 35 pages.

Orlandi, R. and others, "Hot Box Round Robin Participant's Manual," W. R. Grace, Cambridge, MA, 1983, 10 pages.

COMPOSITION:



1. 4-in. (100-mm) Expanded Polystyrene Beadboard
2. Carpet Adhesive (each face), painted dull yellow
3. Vertical Joints (2 total) containing 3M Scotch-Grip Mastic Adhesive No. 4289

TABLE S2-1 - PHYSICAL PROPERTIES OF WALL AT TIME OF TEST

Property	Measured Value
Unit Weight, psf (kg/m^2)	0.55 (2.70)
Average Thickness, in. (mm)	3.97 (101)
Area, ft^2 (m^2)	73.67 (6.84)

TABLE S2-3 - DESIGN HEAT TRANSMISSION COEFFICIENTS

Component	R, Thermal Resistance $hr \cdot ft^2 \cdot °F/Btu$ $(m^2 \cdot K/W)$
1. Outside Air Film	0.17* (0.03)
2. 4-in. (100-mm) Expanded Polystyrene Beadboard	16.67* (2.94)
3. Inside Air Film	0.68* (0.12)
Total R	17.52 (3.09)
Total U**	0.057 (0.32)

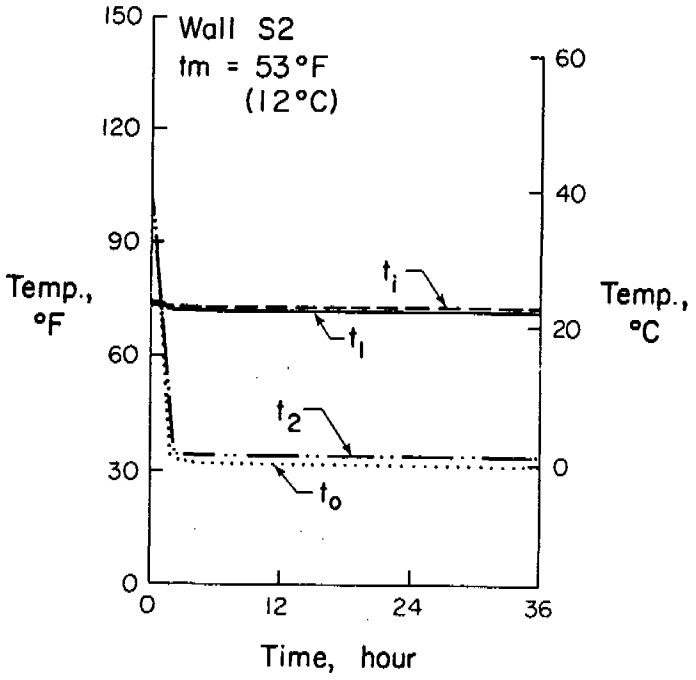
*Source: ASHRAE Handbook - 1981 Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, 1981, Chapter 23.

**Units for thermal transmittance are $Btu/hr \cdot ft^2 \cdot °F$ $(W/m^2 \cdot K)$

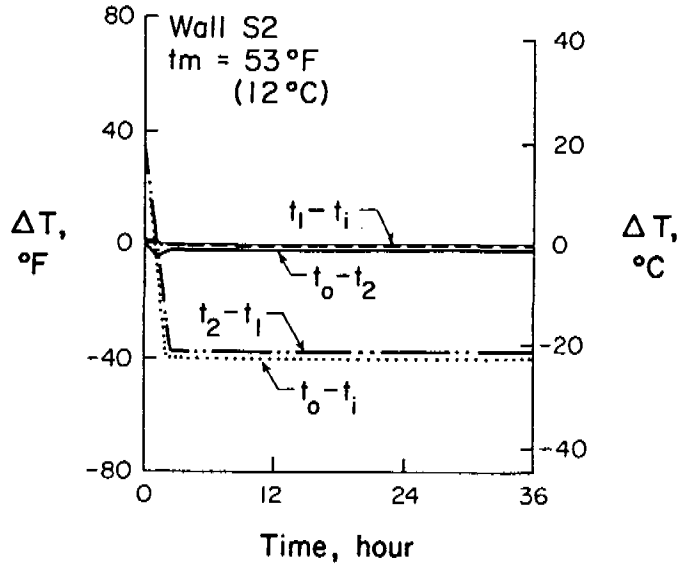
TABLE S2-4 - STEADY-STATE TEST RESULTS

Nominal Test Condition	q Heat Flux, Btu/hr·ft^2 (W/m^2)	R_T,* hr·ft^2·°F/Btu (m^2·K/W)	U,* Btu/hr·ft^2·°F (W/m^2·K)	Measured Temperatures, °F (°C)						Relative Humidity		Laboratory Air Temperature	
				t_o Outdoor Air	t_2 Outdoor Surface	t_3** Internal	t_4** Internal	t_1 Indoor Surface	t_i Indoor Air	Indoor Chamber, %	Outdoor Chamber, %	Max. °F (°C)	Min. °F (°C)
t_m = 37°F (3°C)	-4.86 (-15.5)	19.8 (3.49)	0.051 (0.29)	-13 (-25)	-9 (-23)	-	-	83 (28)	84 (29)	33	22	72 (22)	71 (22)
t_m = 53°F (12°C)	-2.33 (-7.37)	17.5 (3.08)	0.057 (0.32)	32 (0)	34 (1)	-	-	72 (22)	73 (23)	39	20	73 (23)	72 (22)
t_m = 101°F (38°C)	3.45 (10.9)	16.5 (2.90)	0.061 (0.35)	128 (54)	128 (53)	-	-	75 (24)	73 (23)	41	15	72 (22)	71 (21)
Design Values	-	17.5 (3.09)	0.057 (0.32)	-	-	-	-	-	-	-	-	-	-

*Total thermal resistance, R_T, and transmittance, U, for steady-state tests were calculated using the design surface resistance coefficients from Table S2-3 and measured values of heat flux.
**Internal thermocouples were not used on this wall assembly.

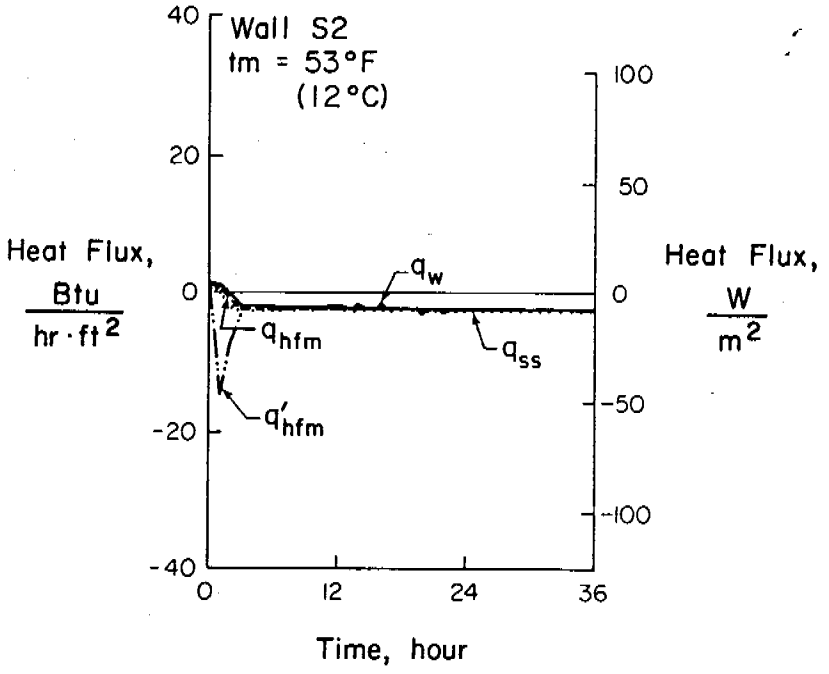


(a) Measured Temperatures



(b) Temperature Differentials

Fig. S2-1 Wall S2 Transient Test Results



(c) Heat Flux

Fig. S2-1 Wall S2 Transient Test Results

TABLE S2-5(a) - TRANSIENT TEST RESULTS

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	102.2	102.5			74.3	73.3	1.3	1.7	1.7	1.8
1	66.7	71.1			73.9	73.2	1.2	1.3	-14.4	-0.2
2	33.2	36.0			72.7	72.8	-0.7	-1.1	-6.3	-2.2
3	32.2	34.3			72.4	72.8	-1.6	-2.0	-2.4	-2.3
4	32.0	34.1			72.3	72.6	-1.8	-2.1	-2.2	-2.3
5	31.9	34.0			72.3	72.8	-2.1	-2.1	-2.1	-2.3
6	31.8	33.9			72.3	72.8	-2.1	-2.1	-2.1	-2.3
7	31.7	33.9			72.3	72.8	-2.1	-2.1	-2.2	-2.3
8	31.8	33.9			72.3	72.8	-2.1	-2.1	-2.1	-2.3
9	31.8	33.8			72.3	72.8	-2.2	-2.1	-2.2	-2.3
10	31.8	33.8			72.3	72.8	-2.1	-2.2	-2.1	-2.3
11	31.7	33.8			72.3	72.8	-2.0	-2.1	-2.1	-2.3
12	31.8	33.8			72.3	72.8	-1.9	-2.1	-2.1	-2.3
13	31.7	33.8			72.3	72.7	-2.3	-2.1	-2.1	-2.3
14	31.7	33.8			72.3	72.7	-1.8	-2.1	-2.1	-2.3
15	31.7	33.8			72.3	72.7	-2.1	-2.1	-2.1	-2.3
16	31.8	33.8			72.3	72.7	-1.5	-2.1	-2.1	-2.3
17	31.7	33.8			72.2	72.7	-2.3	-2.1	-2.1	-2.3
18	31.8	33.8			72.2	72.8	-1.8	-2.2	-2.1	-2.3
19	31.9	33.8			72.2	72.7	-2.3	-2.1	-2.1	-2.3
20	31.9	33.7			72.2	72.6	-2.7	-2.1	-2.1	-2.3
21	31.9	33.7			72.3	72.7	-2.3	-2.1	-2.1	-2.3
22	31.9	33.7			72.2	72.7	-2.6	-2.1	-2.1	-2.3
23	31.9	33.8			72.3	72.7	-2.5	-2.1	-2.1	-2.3
24	31.8	33.8			72.3	72.7	-2.6	-2.1	-2.1	-2.3
26	31.7	33.8			72.3	72.8	-2.5	-2.1	-2.1	-2.3
28	31.8	33.9			72.3	72.8	-2.4	-2.1	-2.1	-2.3
30	31.7	33.8			72.3	72.8	-2.4	-2.1	-2.1	-2.3
32	31.8	33.8			72.3	72.8	-2.4	-2.1	-2.1	-2.3
34	31.7	33.8			72.3	72.8	-2.3	-2.1	-2.1	-2.3
36	31.8	33.8			72.2	72.7	-2.2	-2.0	-2.1	-2.3

*Internal thermocouples were not used for this wall assembly.

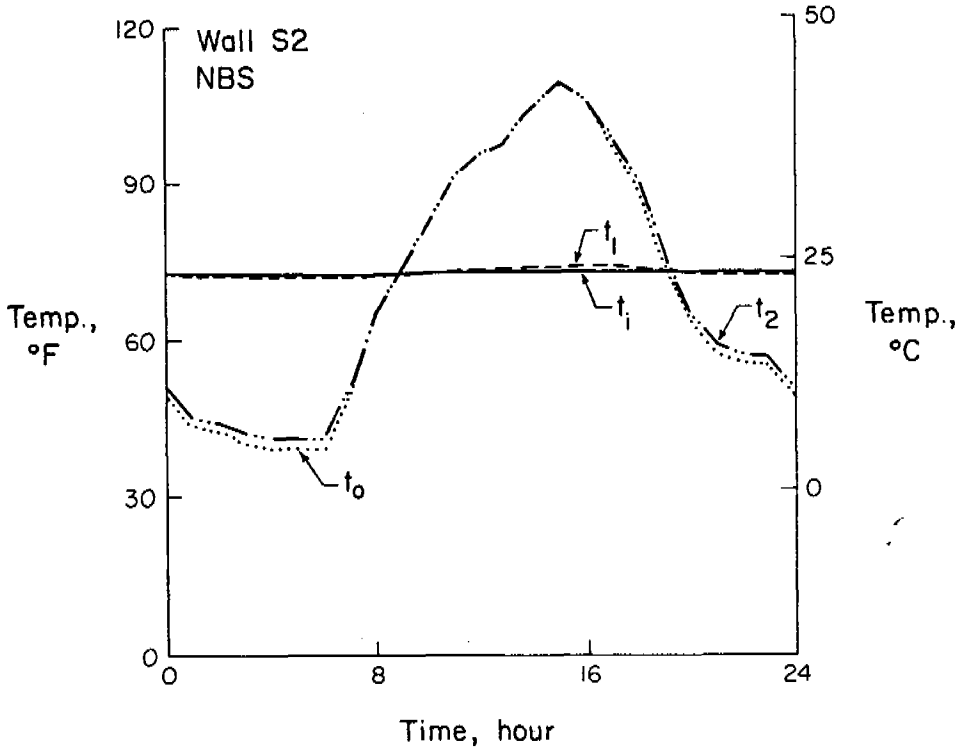
TABLE S2-5(b) - TRANSIENT TEST RESULTS, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	39.0	39.2			23.5	22.9	4.1	5.4	5.3	5.6
1	19.3	21.7			23.3	22.9	3.9	4.1	-45.3	-0.5
2	0.7	2.2			22.6	22.7	-2.3	-3.5	-20.0	-7.0
3	0.1	1.3			22.4	22.7	-4.9	-6.3	-7.5	-7.3
4	0.0	1.2			22.4	22.6	-5.6	-6.7	-6.8	-7.3
5	-0.1	1.1			22.4	22.7	-6.6	-6.7	-6.7	-7.3
6	-0.1	1.1			22.4	22.7	-6.6	-6.7	-6.8	-7.3
7	-0.2	1.1			22.4	22.7	-6.7	-6.7	-6.8	-7.3
8	-0.1	1.1			22.4	22.7	-6.5	-6.6	-6.6	-7.3
9	-0.1	1.0			22.4	22.7	-6.9	-6.6	-6.8	-7.3
10	-0.1	1.0			22.4	22.7	-6.5	-6.8	-6.7	-7.3
11	-0.2	1.0			22.4	22.7	-6.3	-6.7	-6.7	-7.3
12	-0.1	1.0			22.4	22.7	-6.0	-6.6	-6.6	-7.3
13	-0.2	1.0			22.4	22.6	-7.1	-6.7	-6.7	-7.3
14	-0.2	1.0			22.4	22.6	-5.6	-6.7	-6.7	-7.3
15	-0.2	1.0			22.4	22.6	-6.8	-6.5	-6.7	-7.3
16	-0.1	1.0			22.4	22.6	-4.7	-6.7	-6.7	-7.3
17	-0.2	1.0			22.3	22.6	-7.2	-6.7	-6.6	-7.3
18	-0.1	1.0			22.3	22.7	-5.7	-6.8	-6.7	-7.3
19	-0.1	1.0			22.3	22.6	-7.2	-6.6	-6.7	-7.3
20	-0.1	0.9			22.3	22.6	-8.4	-6.7	-6.7	-7.3
21	-0.1	0.9			22.4	22.6	-7.3	-6.5	-6.7	-7.3
22	-0.1	0.9			22.3	22.6	-8.2	-6.7	-6.7	-7.3
23	-0.1	1.0			22.4	22.6	-8.0	-6.6	-6.6	-7.3
24	-0.1	1.0			22.4	22.6	-8.3	-6.6	-6.7	-7.3
26	-0.2	1.0			22.4	22.7	-8.0	-6.6	-6.8	-7.3
28	-0.1	1.1			22.4	22.7	-7.4	-6.6	-6.7	-7.3
30	-0.2	1.0			22.4	22.7	-7.7	-6.7	-6.6	-7.3
32	-0.1	1.0			22.4	22.7	-7.5	-6.6	-6.7	-7.3
34	-0.2	1.0			22.4	22.7	-7.2	-6.7	-6.7	-7.3
36	-0.1	1.0			22.3	22.6	-6.8	-6.4	-6.7	-7.3

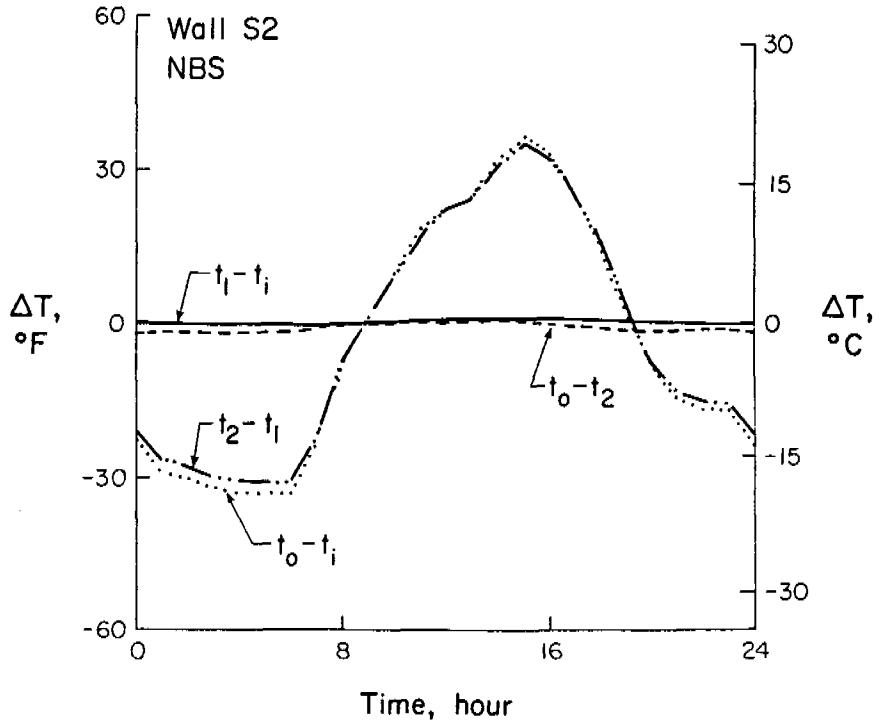
*Internal thermocouples were not used for this wall assembly.

TABLE S2-6 - SUMMARY OF TRANSIENT TEST RESULTS

Heat Flux	Measured				Calculated	
	Calib. Hot Box		HFM @ Indoor Surf.		Steady-State	
	q_w, Btu/hr·ft^2 (W/m^2)	Time to Reach q_w, hr	q_{hfm}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{hfm}, hr	q_{ss}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{ss}, hr
99.5% of Final Heat Flux	-2.3 (-7.3)	13	-2.1 (-6.6)	4	-2.3 (-7.3)	3
95% of Final Heat Flux	-2.2 (-7.0)	9	-2.0 (-6.3)	3	-2.2 (-7.0)	2
90% of Final Heat Flux	-2.1 (-6.6)	5	-1.9 (-5.9)	3	-2.1 (-6.6)	2

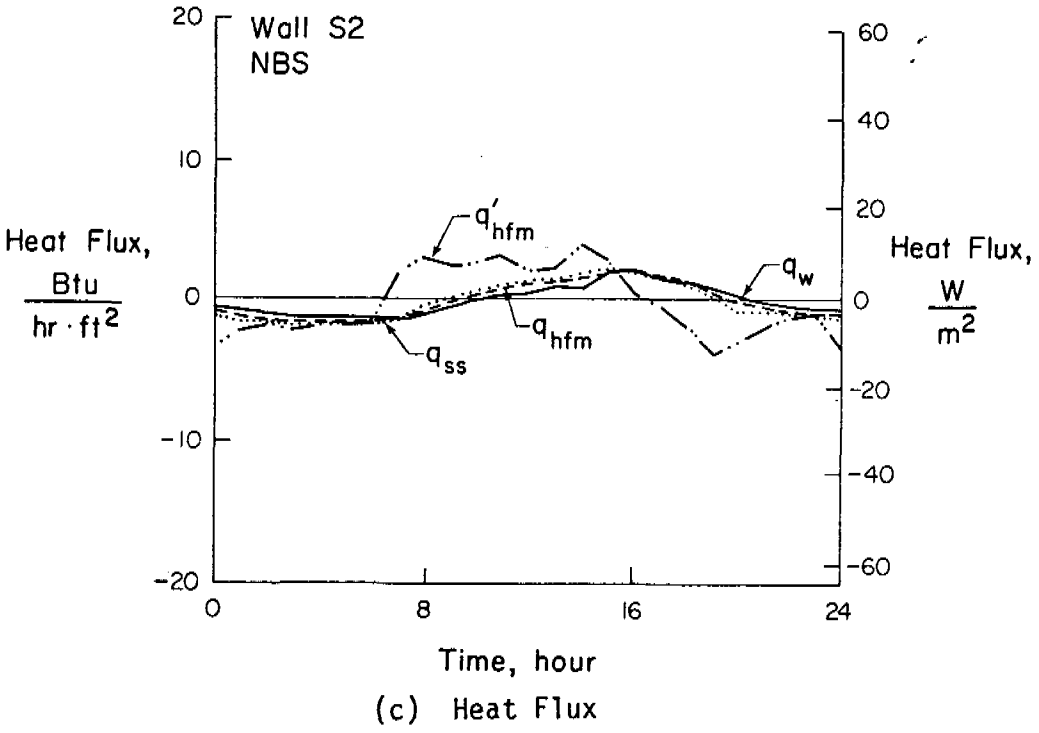


(a) Measured Temperatures



(b) Temperature Differentials

Fig. S2-2 Wall S2 Dynamic Test Results for NBS Test Cycle



(c) Heat Flux

Fig. S2-2 Wall S2 Dynamic Test Results for NBS Test Cycle

TABLE 52-7(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	43.7	45.5			72.4	72.7	-0.90	-1.33	-2.33	-1.63
2	42.6	44.4			72.4	72.7	-1.17	-1.49	-1.87	-1.69
3	40.6	42.5			72.3	72.7	-1.31	-1.58	-2.19	-1.80
4	39.6	41.4			72.2	72.6	-1.45	-1.65	-1.89	-1.86
5	39.5	41.2			72.2	72.6	-1.28	-1.69	-1.74	-1.87
6	39.6	41.3			72.2	72.6	-1.45	-1.71	-1.60	-1.87
7	49.1	49.8			72.2	72.6	-1.57	-1.56	1.97	-1.35
8	64.4	64.8			72.6	72.7	-1.17	-0.90	3.13	-0.47
9	74.2	74.3			72.8	72.8	-0.61	-0.20	2.55	0.09
10	82.1	82.1			73.0	72.8	-0.02	0.29	2.61	0.57
11	90.7	90.6			73.3	72.8	0.36	0.79	3.08	1.09
12	94.9	95.1			73.5	72.9	0.48	1.16	2.08	1.36
13	97.6	97.5			73.6	72.9	0.96	1.32	2.34	1.51
14	104.5	104.0			73.7	72.9	0.90	1.57	4.02	1.91
15	109.1	108.9			73.9	73.0	1.88	1.99	2.92	2.21
16	105.6	106.0			73.9	73.0	1.95	2.10	0.55	2.02
17	98.7	99.3			73.8	73.0	1.50	1.77	-0.42	1.61
18	89.4	90.5			73.6	73.0	1.49	1.35	-1.75	1.06
19	75.3	76.8			73.4	73.0	0.88	0.74	-3.88	0.21
20	63.7	65.3			73.1	72.9	0.32	-0.04	-3.10	-0.47
21	57.8	59.3			72.9	72.9	-0.17	-0.53	-2.17	-0.82
22	55.9	57.2			72.7	72.8	-0.42	-0.76	-1.22	-0.94
23	55.7	57.0			72.7	72.8	-0.63	-0.84	-0.99	-0.95
24	49.2	51.2			72.7	72.8	-0.63	-0.94	-3.36	-1.30
Mean	69.3	70.3			73.0	72.8	-0.09	-0.09	-0.14	-0.14

*Internal thermocouples were not used on this wall assembly.

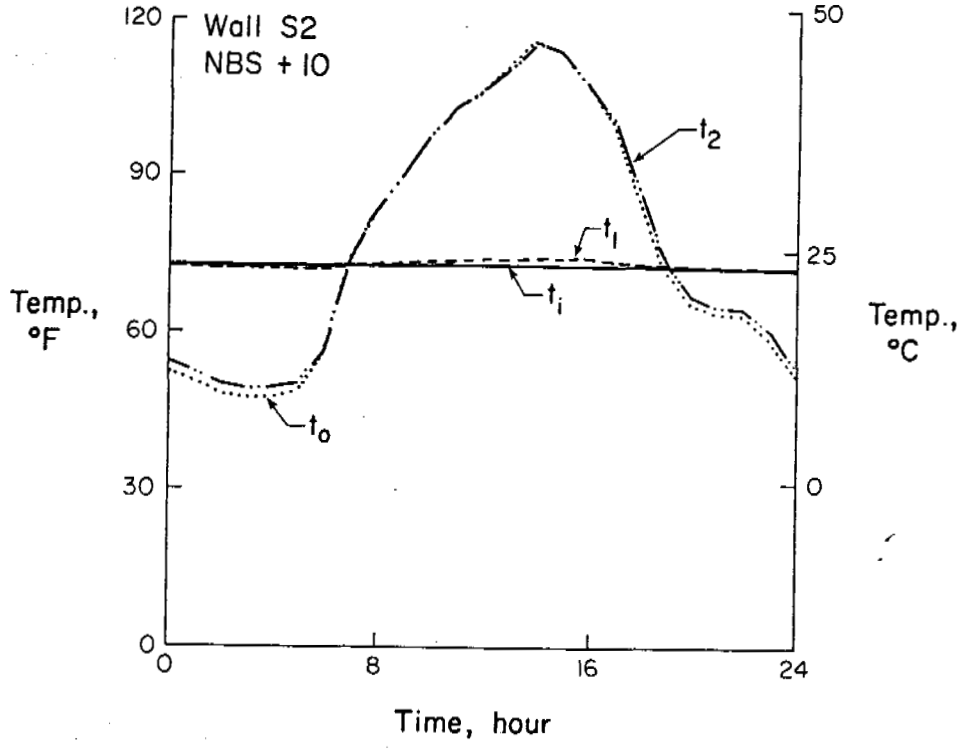
Calibrated Hot Box Relative Humidity:
Indoor Chamber - 40%
Outdoor Chamber - 19%

Laboratory Air Temperature:
Max. - 72°F (22°C)
Min. - 68°F (20°C)

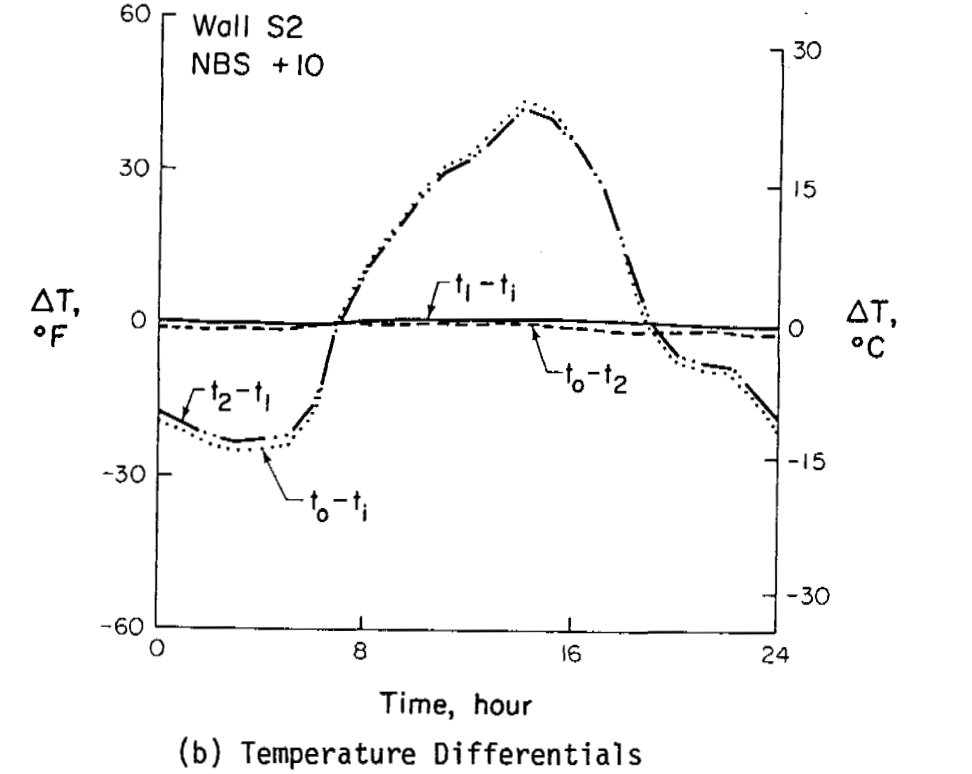
TABLE S2-7(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	6.5	7.5			22.5	22.6	-2.83	-4.19	-7.34	-5.13
2	5.9	6.9			22.4	22.6	-3.70	-4.69	-5.91	-5.34
3	4.8	5.8			22.4	22.6	-4.12	-4.97	-6.91	-5.68
4	4.2	5.2			22.4	22.6	-4.59	-5.21	-5.96	-5.87
5	4.1	5.1			22.3	22.6	-4.05	-5.32	-5.49	-5.91
6	4.2	5.2			22.3	22.5	-4.56	-5.40	-5.04	-5.89
7	9.5	9.9			22.3	22.6	-4.95	-4.94	6.21	-4.27
8	18.0	18.2			22.5	22.6	-3.69	-2.84	9.89	-1.49
9	23.4	23.5			22.7	22.6	-1.93	-0.62	8.04	0.29
10	27.8	27.8			22.8	22.6	-0.06	0.90	8.22	1.81
11	32.6	32.6			23.0	22.7	1.12	2.50	9.72	3.44
12	35.0	35.0			23.1	22.7	1.51	3.65	6.55	4.29
13	36.4	36.4			23.1	22.7	3.04	4.17	7.39	4.75
14	40.3	40.0			23.2	22.7	2.85	4.96	12.69	6.02
15	42.8	42.7			23.3	22.8	5.94	6.28	9.20	6.96
16	40.9	41.1			23.3	22.8	6.17	6.61	1.72	6.38
17	37.0	37.4			23.2	22.8	4.73	5.60	-1.33	5.07
18	31.9	32.5			23.1	22.8	4.69	4.26	-5.53	3.36
19	24.0	24.9			23.0	22.8	2.78	2.33	-12.23	0.65
20	17.6	18.5			22.8	22.7	1.01	-0.12	-9.77	-1.49
21	14.3	15.2			22.7	22.7	-0.54	-1.69	-6.84	-2.59
22	13.3	14.0			22.6	22.7	-1.34	-2.40	-3.83	-2.96
23	13.2	13.9			22.6	22.7	-1.98	-2.65	-3.12	-2.99
24	9.5	10.7			22.6	22.6	-1.99	-2.95	-10.59	-4.10
Mean	20.7	21.3			22.8	22.7	-0.27	-0.28	-0.43	-0.45

*Internal thermocouples were not used on this wall assembly.

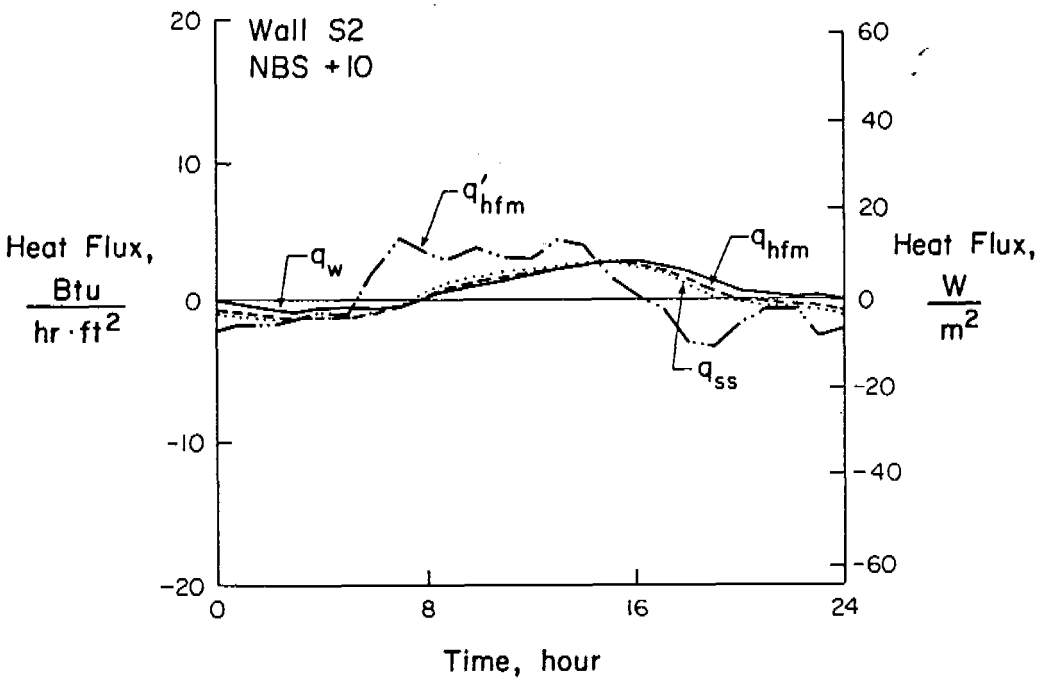


(a) Measured Temperatures



(b) Temperature Differentials

Fig. S2-3 Wall S2 Dynamic Test Results for NBS+10 Test Cycle



(c) Heat Flux

Fig. S2-3 Wall S2 Dynamic Test Results for NBS+10 Test Cycle

TABLE S2-8(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS+10 TEST CYCLE

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	50.6	52.2			72.3	72.5	-0.45	-1.06	-1.78	-1.22
2	48.1	49.8			72.2	72.5	-0.70	-1.18	-1.77	-1.35
3	47.1	48.7			72.2	72.4	-0.95	-1.25	-1.59	-1.42
4	47.4	49.0			72.1	72.4	-0.76	-1.30	-1.10	-1.40
5	48.5	50.0			72.2	72.5	-0.68	-1.27	-1.18	-1.34
6	55.4	56.0			72.2	72.5	-0.86	-1.15	1.89	-0.98
7	72.7	72.5			72.6	72.6	-0.61	-0.48	4.23	-0.01
8	82.9	83.1			73.0	72.6	0.18	0.25	3.16	0.64
9	90.3	90.4			73.2	72.6	0.70	0.78	2.87	1.08
10	97.6	97.5			73.4	72.8	1.14	1.18	3.50	1.52
11	103.3	103.2			73.6	72.8	1.38	1.60	2.96	1.86
12	106.0	105.9			73.7	72.8	1.84	1.84	2.86	2.03
13	111.3	110.9			73.8	72.9	2.04	2.04	4.17	2.34
14	116.5	116.1			74.0	72.9	2.38	2.42	3.61	2.65
15	114.4	114.6			74.0	72.9	2.64	2.59	1.53	2.56
16	108.4	108.7			73.9	72.9	2.71	2.37	0.30	2.19
17	100.8	101.5			73.7	72.8	2.33	1.95	-0.84	1.75
18	87.1	88.5			73.4	72.8	1.98	1.40	-3.15	0.95
19	72.8	74.1			73.0	72.7	1.30	0.55	-3.40	0.07
20	65.8	67.1			72.8	72.6	0.48	-0.08	-1.87	-0.34
21	64.0	65.2			72.7	72.6	0.39	-0.34	-0.74	-0.45
22	63.7	64.8			72.7	72.6	0.08	-0.40	-0.56	-0.48
23	59.1	60.7			72.6	72.6	0.33	-0.47	-2.54	-0.72
24	52.4	54.0			72.4	72.5	-0.16	-0.83	-2.18	-1.11
Mean	77.8	78.5			73.0	72.7	0.70	0.38	0.35	0.37

*Internal thermocouples were not used on this wall assembly.

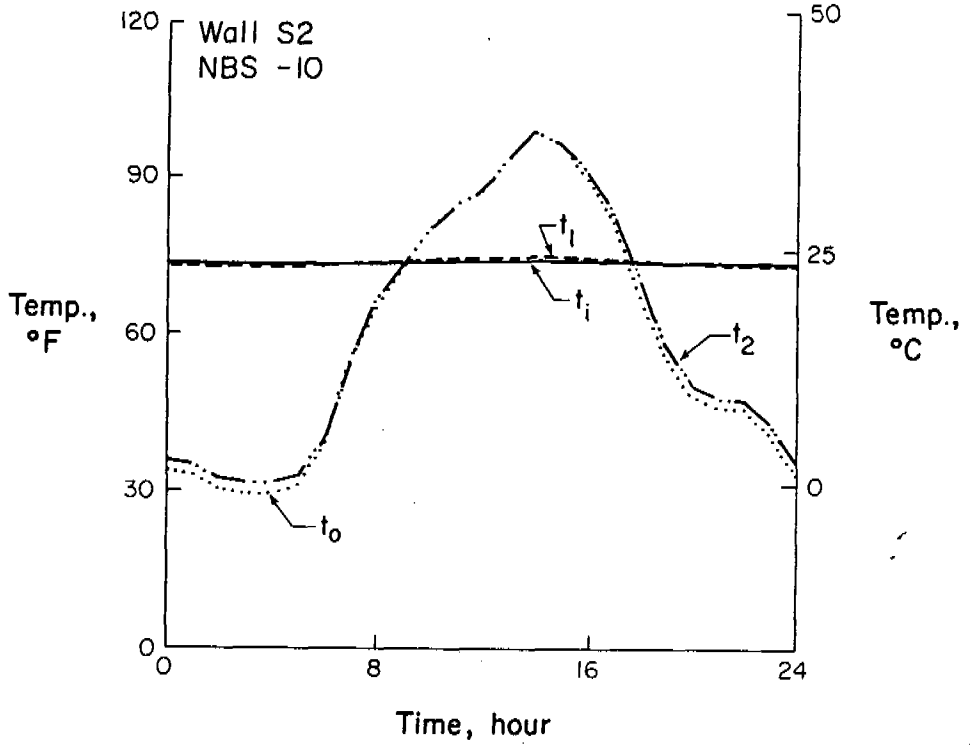
Calibrated Hot Box Relative Humidity:
Indoor Chamber - 31%
Outdoor Chamber - 18%

Laboratory Air Temperature:
Max. - 72°F (22°C)
Min. - 65°F (18°C)

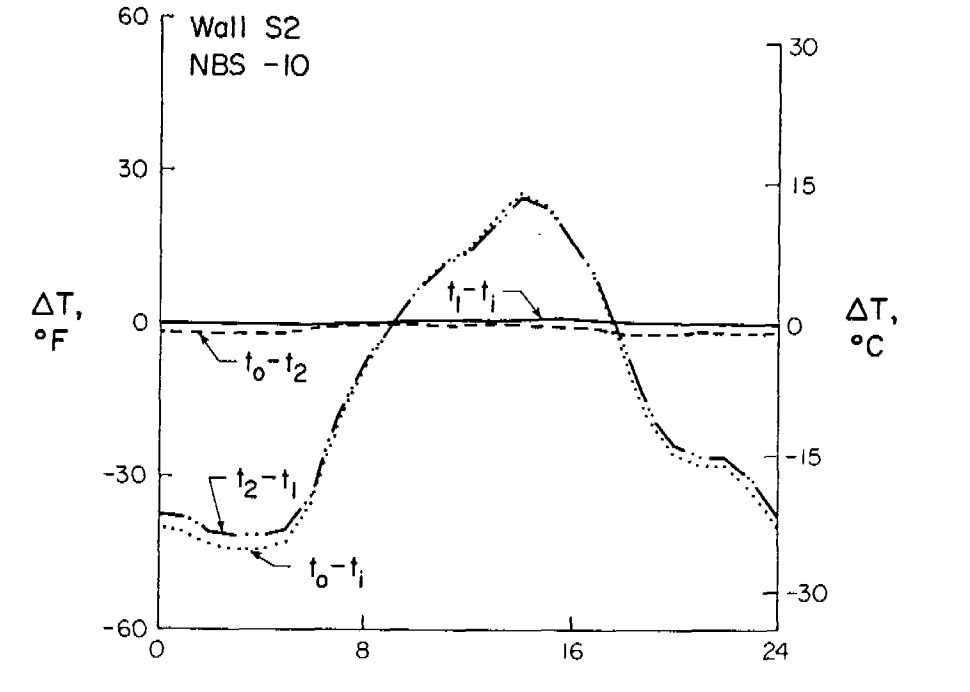
TABLE S2-8(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS+10 TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	10.3	11.2			22.4	22.5	-1.42	-3.34	-5.61	-3.83
2	8.9	9.9			22.3	22.5	-2.22	-3.73	-5.59	-4.27
3	8.4	9.3			22.3	22.5	-2.99	-3.96	-5.00	-4.48
4	8.6	9.4			22.3	22.4	-2.38	-4.11	-3.45	-4.41
5	9.1	10.0			22.3	22.5	-2.14	-3.99	-3.72	-4.23
6	13.0	13.4			22.3	22.5	-2.71	-3.63	5.96	-3.09
7	22.6	22.5			22.6	22.5	-1.92	-1.53	13.36	-0.02
8	28.3	28.4			22.8	22.6	0.57	0.79	9.96	2.01
9	32.4	32.4			22.9	22.6	2.21	2.46	9.06	3.42
10	36.5	36.4			23.0	22.7	3.61	3.74	11.03	4.79
11	39.6	39.6			23.1	22.7	4.34	5.04	9.33	5.88
12	41.1	41.1			23.2	22.7	5.80	5.80	9.01	6.40
13	44.1	43.8			23.2	22.7	6.42	6.42	13.15	7.37
14	46.9	46.7			23.3	22.7	7.50	7.63	11.40	8.36
15	45.8	45.9			23.3	22.7	8.31	8.18	4.84	8.07
16	42.4	42.6			23.3	22.7	8.56	7.49	0.95	6.91
17	38.2	38.6			23.2	22.7	7.34	6.17	-2.66	5.52
18	30.6	31.4			23.0	22.7	6.24	4.41	-9.94	3.00
19	22.6	23.4			22.8	22.6	4.09	1.74	-10.73	0.21
20	18.8	19.5			22.7	22.6	1.50	-0.24	-5.91	-1.09
21	17.8	18.4			22.6	22.6	1.23	-1.06	-2.32	-1.43
22	17.6	18.2			22.6	22.6	0.24	-1.25	-1.77	-1.51
23	15.1	16.0			22.6	22.6	1.03	-1.48	-8.02	-2.27
24	11.3	12.2			22.4	22.5	-0.51	-2.63	-6.89	-3.51
Mean	25.4	25.8			22.8	22.6	2.20	1.20	1.10	1.16

*Internal thermocouples were not used on this wall assembly.

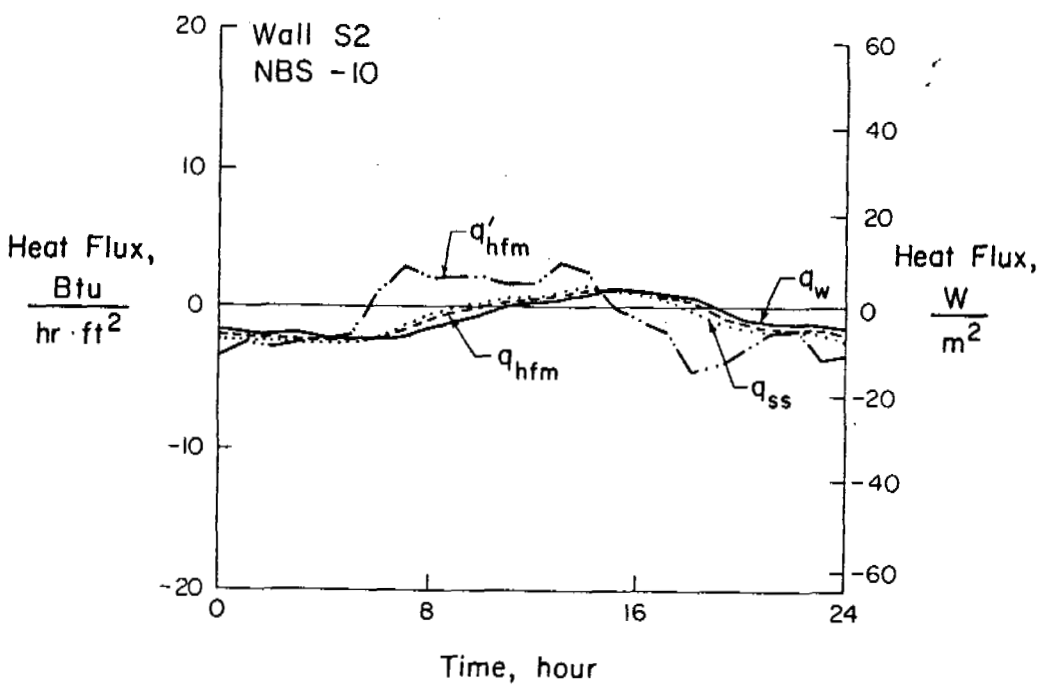


(a) Measured Temperatures



(b) Temperature Differentials

Fig. S2-4 Wall S2 Dynamic Test Results for NBS-10 Test Cycle



(c) Heat Flux

Fig. S2-4 Wall S2 Dynamic Test Results for NBS-10 Test Cycle

TABLE S2-9(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS-10 TEST CYCLE

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	32.5	34.6			72.9	73.3	-1.92	-2.04	-2.49	-2.32
2	29.9	32.0			72.9	73.3	-2.02	-2.14	-2.79	-2.47
3	28.9	30.9			72.7	73.3	-1.79	-2.26	-2.39	-2.53
4	28.9	31.0			72.8	73.3	-2.20	-2.28	-2.33	-2.53
5	30.2	32.2			72.8	73.3	-2.11	-2.24	-1.83	-2.45
6	37.8	38.9			72.9	73.3	-2.33	-2.11	0.97	-2.06
7	54.4	54.9			73.3	73.4	-2.09	-1.51	2.93	-1.11
8	65.0	65.5			73.6	73.5	-1.47	-0.74	2.22	-0.49
9	73.2	73.5			73.9	73.6	-1.03	-0.22	2.12	-0.02
10	80.0	80.0			74.0	73.7	-0.55	0.17	2.27	0.38
11	84.8	85.0			74.2	73.7	0.15	0.51	1.67	0.68
12	87.4	87.7			74.3	73.8	0.37	0.72	1.72	0.84
13	93.3	93.2			74.4	73.8	0.51	0.94	3.21	1.18
14	99.3	99.3			74.7	73.9	0.82	1.34	2.53	1.55
15	96.5	97.0			74.7	73.9	1.48	1.48	0.17	1.40
16	89.9	90.7			74.6	73.8	1.40	1.24	-0.85	1.01
17	82.6	83.5			74.4	73.8	1.12	0.85	-1.65	0.57
18	68.8	70.7			74.1	73.7	0.80	0.33	-4.45	-0.21
19	55.4	57.4			73.7	73.5	-0.12	-0.45	-4.00	-0.99
20	47.9	49.9			73.5	73.5	-0.77	-1.04	-3.04	-1.43
21	45.6	47.3			73.4	73.5	-1.10	-1.35	-1.72	-1.58
22	45.4	47.1			73.3	73.4	-1.09	-1.40	-1.54	-1.58
23	40.6	42.8			73.2	73.4	-1.15	-1.46	-3.58	-1.84
24	33.3	35.4			73.0	73.3	-1.58	-1.86	-3.27	-2.27
Mean	59.6	60.9			73.6	73.5	-0.69	-0.65	-0.67	-0.76

*Internal thermocouples were not used on this wall assembly.

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 27%
Outdoor Chamber - 19%

Laboratory Air Temperature:
Max. - 74°F (24°C)
Min. - 71°F (22°C)

TABLE S2-9(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS-10 TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	0.3	1.4			22.7	22.9	-6.07	-6.42	-7.84	-7.30
2	-1.2	0.0			22.7	22.9	-6.36	-6.75	-8.81	-7.80
3	-1.8	-0.6			22.6	22.9	-5.64	-7.13	-7.54	-7.97
4	-1.7	-0.6			22.7	22.9	-6.94	-7.18	-7.35	-7.97
5	-1.0	0.1			22.7	22.9	-6.67	-7.07	-5.77	-7.74
6	3.2	3.8			22.7	22.9	-7.34	-6.67	3.06	-6.48
7	12.5	12.7			22.9	23.0	-6.58	-4.76	9.25	-3.51
8	18.3	18.6			23.1	23.0	-4.63	-2.34	7.00	-1.54
9	22.9	23.0			23.3	23.1	-3.26	-0.70	6.68	-0.08
10	26.6	26.7			23.3	23.1	-1.74	0.54	7.16	1.19
11	29.3	29.4			23.4	23.2	0.47	1.62	5.28	2.15
12	30.8	30.9			23.5	23.2	1.17	2.27	5.44	2.66
13	34.1	34.0			23.6	23.2	1.59	2.96	10.14	3.73
14	37.4	37.4			23.7	23.3	2.57	4.25	7.99	4.89
15	35.8	36.1			23.7	23.3	4.66	4.68	0.54	4.43
16	32.2	32.6			23.7	23.2	4.43	3.92	-2.67	3.20
17	28.1	28.6			23.6	23.2	3.52	2.69	-5.21	1.81
18	20.5	21.5			23.4	23.2	2.51	1.04	-14.04	-0.65
19	13.0	14.1			23.2	23.1	-0.37	-1.43	-12.61	-3.11
20	8.8	9.9			23.0	23.0	-2.43	-3.28	-9.59	-4.50
21	7.5	8.5			23.0	23.0	-3.46	-4.25	-5.43	-4.98
22	7.4	8.4			22.9	23.0	-3.45	-4.42	-4.87	-5.00
23	4.8	6.0			22.9	23.0	-3.63	-4.61	-11.30	-5.80
24	0.7	1.9			22.8	23.0	-4.99	-5.88	-10.32	-7.17
Mean	15.4	16.0			23.1	23.1	-2.19	-2.04	-2.12	-2.40

*Internal thermocouples were not used on this wall assembly.

TABLE S2-10 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), THERMAL LAG

Test Cycle	Thermal Lag, hrs								Calc. Time Constant, hrs
	Measured								
	Calibrated Hot Box					Heat Flow Meter			
	t_o vs t_1		q_{ss} vs q_w		Avg.	q_{ss} vs q_{hfm}		Avg.	
	@ Max.	@ Min.	@ Max.	@ Min.		@ Max.	@ Min.		
NBS	0.5	0.5	1	1.5	1	1	0.5	1	0.27
NBS+10	0.5	1	2	0	1	1	1	1	0.27
NBS-10	0.5	0	1	2.5	1	1	0.5	1	0.27

TABLE S2-11 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), REDUCTION IN AMPLITUDE

Test Cycle	Measured					
	Calibrated Hot Box			Heat Flow Meter		
	@ Max.	@ Min.	Avg.	@ Max.	@ Min.	Avg.
NBS	13	14	14	7	6	7
NBS+10	12	8	10	3	6	5
NBS-10	6	7	7	8	8	8

TABLE S2-12 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), ENERGY REQUIREMENTS

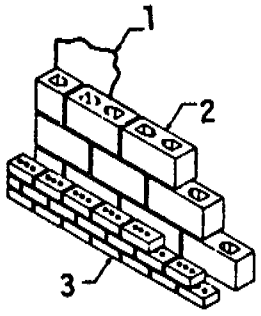
Test Cycle	Total Energy, Btu/ft^2 (W·hr/m^2)			Total Energy Comparisons, %		Net Energy, Btu/ft^2 (W·hr/m^2)			Net Energy Comparisons, %	
	Measured		Calculated	$\frac{q_w^T}{q_{ss}^T}$	$\frac{q_{hfm}^T}{q_{ss}^T}$	Measured		Calculated	$\frac{q_w^N}{q_{ss}^N}$	$\frac{q_{hfm}^N}{q_{ss}^N}$
	q_w^T	q_{hfm}^T	q_{ss}^T			q_w^N	q_{hfm}^N	q_{ss}^N		
NBS	23.5 (74.1)	28.3 (89.3)	30.7 (96.7)	77	92	-2.1 (-6.5)	-2.1 (-6.8)	-3.4 (-10.7)	61	63
NBS+10	27.0 (85.3)	28.8 (90.8)	30.5 (96.1)	89	95	16.7 (52.7)	9.2 (28.9)	8.8 (27.8)	190	104
NBS-10	30.0 (94.5)	30.7 (96.9)	33.5 (105.7)	89	92	-16.7 (-52.6)	-15.5 (-48.9)	-18.2 (-57.5)	91	85

WALL M9: 12-in. (300-mm) BLOCK-BRICK CAVITY WALL

DESCRIPTION: Uninsulated, unreinforced 12-in. (300-mm) cavity wall consisting of 6-in. (150-mm) hollow core concrete block and 4-in. (100-mm) clay brick separated by a 2-3/4-in. (70-mm) air space.

REFERENCE: Van Geem, M. G. and Larson, S. C., "Heat Transfer Characteristics of a Masonry Cavity Wall With and Without Expanded Perlite Insulation," Construction Technology Laboratories, Portland Cement Association, Skokie, 1985, 142 pages.

COMPOSITION:



1. 1/8-in. (3-mm) Plaster: one part Type S masonry cement to 2-1/2 parts masonry sand by volume, painted off-white
2. 6x8x16-in. (150x200x400-mm) Normal Weight Hollow Core Concrete Block - 2 cores per block
3. 4x2-1/2x8-in. (100x60x200-mm) Clay Brick - 3 cores per brick
4. Metal Rectangular Ties Between Wythes - one in every other mortar joint between block

TABLE M9-1 - PHYSICAL PROPERTIES OF WALL AT TIME OF TEST

Property	Measured Value
Unit Weight, psf (kg/m^2)	80.96 (395.2)
Average Thickness, in. (mm)	12.0 (305)
Air Space Thickness, in. (mm)	2.75 (70)
Area, ft^2 (m^2)	73.65 (6.84)
Estimated Moisture Content of Block,* % by ovendry weight	1.2
Estimated Moisture Content of Brick,* % by ovendry weight	0.3

* Measured on masonry, including mortar joints, after test.

TABLE M9-2(a) - MATERIAL PROPERTIES, NORMAL WEIGHT CONCRETE BLOCK

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Standard Dimensions, in. (mm)	--	--	--	5-5/8x7-5/8x15-5/8 (143x194x397)
Measured Dimensions, in. (mm)	ASTM C140	--	--	5.64x7.65x15.61 (143x194x396)
Percent Solid Volume	--	--	--	56
Ovendry Unit Weight, pcf (kg/m^3)	--	--	--	124 (1984)
Moisture Content, % ovendry weight	ASTM C140	--	--	1.75
Absorption, % ovendry weight	ASTM C140	--	--	8.1

TABLE M9-2(b) - MATERIAL PROPERTIES, CLAY BRICK

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Standard Dimensions, in. (mm)	--	--	--	3-3/8x2-1/4x8 (86x57x203)
Measured Dimensions, in. (mm)	ASTM C67	--	--	3.39x2.27x7.80 (86x58x198)
Percent Solid Volume	--	--	--	82
Ovendry Unit Weight, pcf (kg/m^3)	--	--	--	135 (2160)
Moisture Content, % ovendry weight	ASTM C67	--	--	0.1
Absorption, % ovendry weight	ASTM C67	--	--	5.3

TABLE M9-2(c) - MATERIAL PROPERTIES, MORTAR*

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Average Mortar Bed Joint Spacing for Block, in. (mm)	--	--	--	0.28 (7)
Average Mortar Bed Joint Spacing for Brick, in. (mm)	--	--	--	0.37 (9)
Compressive Strength**, psi (MPa)	--	air dry	--	2270 (15.6)
Compressive Strength**, psi (MPa)	--	moist	--	1850 (12.8)

*One part Type S masonry cement to three parts masonry sand by volume.
**Measured on 2-in. (50-mm) cubes cured for 28 ± 3 days.

TABLE M9-3 - DESIGN HEAT TRANSMISSION COEFFICIENTS

Component	R, Thermal Resistance $hr \cdot ft^2 \cdot °F/Btu$ $(m^2 \cdot K/W)$
1. Outside Air Film	0.17* (0.03)
2. 4x2-1/2x8-in. (100x60x200-mm) Clay Brick	0.44* (0.08)
3. 2-3/4-in. (70-mm) Nonreflective Air Space	0.97* (0.17)
4. 6x8x16-in. (150x200x400-mm) Hollow Core Concrete Block	1.18** (0.21)
5. 1/8-in. (3-mm) Plaster	0.03* (0.01)
6. Inside Air Film	0.68* (0.12)
Total R	3.47 (0.61)
Total U+	0.29 (1.64)

With Metal Ties

R_T = 3.46 $hr \cdot ft^2 \cdot °F/Btu$ (0.61 $m^2 \cdot K/W$)

U = 0.29 $Btu/hr \cdot ft^2 \cdot °F$ (1.64 $W/m^2 \cdot K$)

*Source: ASHRAE Handbook - 1981 Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, 1981.

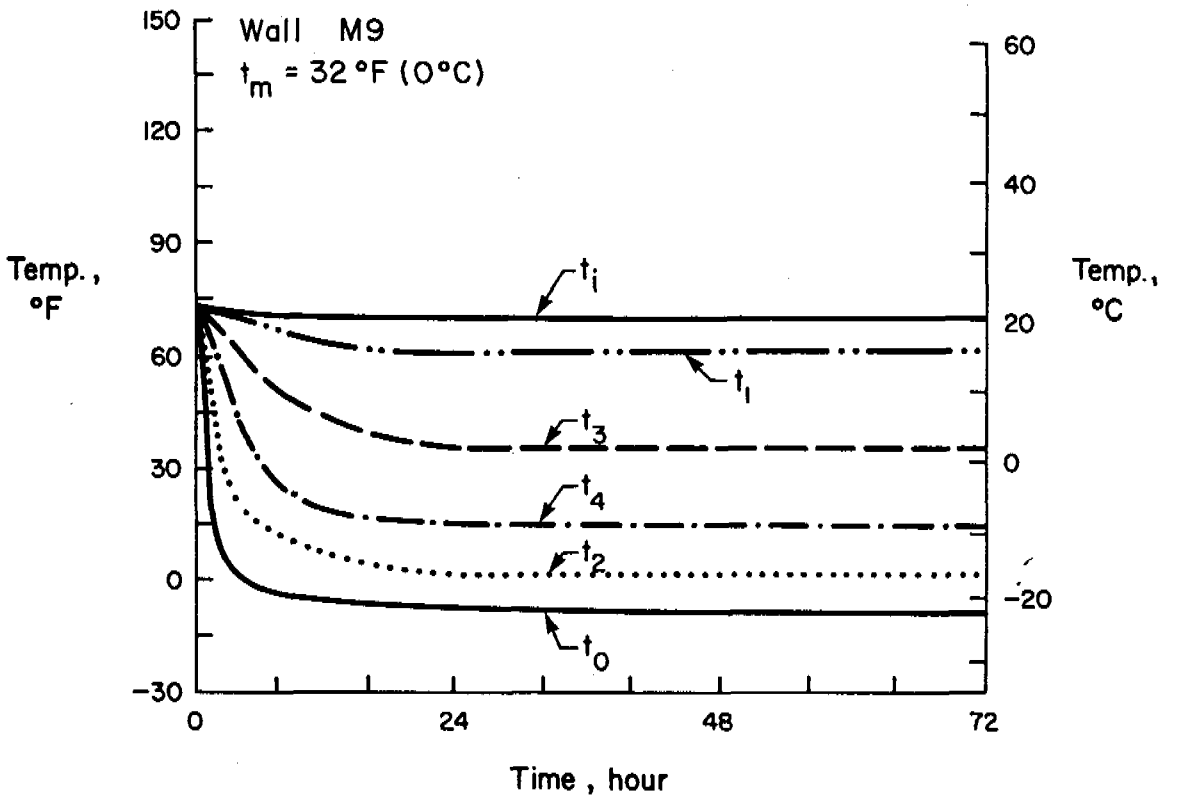
**Source: Randall, F. A., Jr., and Panarese, W. C., Concrete Masonry Handbook, Portland Cement Association, Bulletin EB008.04M, Skokie, 1980.

+Units for thermal transmittance are $Btu/hr \cdot ft^2 \cdot °F$ $(W/m^2 \cdot K)$

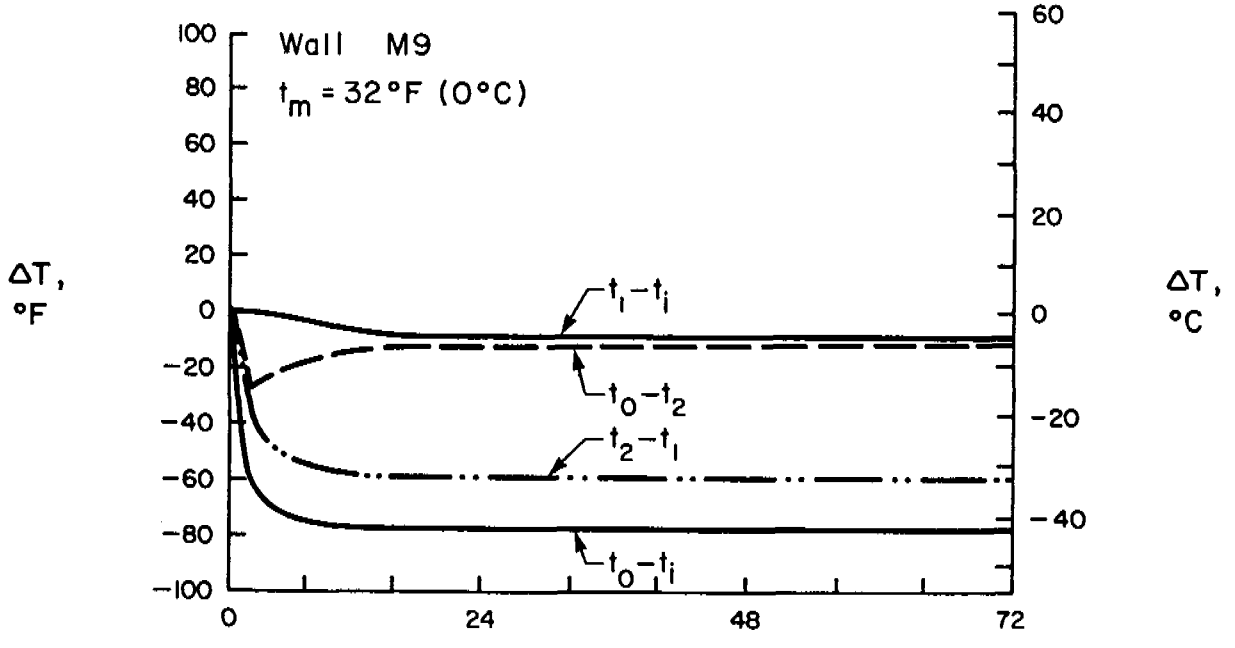
TABLE M9-4 - STEADY-STATE TEST RESULTS

Nominal Test Condition	q Heat Flux, $\frac{Btu}{hr \cdot ft^2}$ (W/m^2)	R_T*, $\frac{hr \cdot ft^2 \cdot °F}{Btu}$ ($m^2 \cdot K/W$)	U*, $\frac{Btu}{hr \cdot ft^2 \cdot °F}$ ($W/m^2 \cdot K$)	Measured Temperatures, °F (°C)						Relative Humidity		Laboratory Air Temperature	
				t_o Outdoor Air	t_2 Outdoor Surface	t_4 Internal Brick Surface	t_3 Internal Block Surface	t_1 Indoor Surface	t_i Indoor Air	Indoor Chamber, %	Outdoor Chamber, %	Max. °F (°C)	Min. °F (°C)
t_m = 100°F (38°C)	15.9 (50.0)	3.37 (0.59)	0.30 (1.68)	125 (52)	120 (49)	111 (44)	98 (37)	80 (27)	74 (23)	27	22	73 (23)	72 (22)
t_m = 32°F (0°C)	-21.4 (-67.4)	3.64 (0.64)	0.27 (1.56)	-8 (-22)	3 (-16)	13 (-11)	37 (3)	62 (17)	70 (21)	24	23	74 (23)	73 (23)
Design Values	--	3.47 (0.61)	0.29 (1.64)	--	--	--	--	--	--	--	--	--	--

*Total thermal resistance, R_T, and transmittance, U, for steady-state tests were calculated using the design surface resistance coefficients from Table M9-3 and measured values of heat flux.

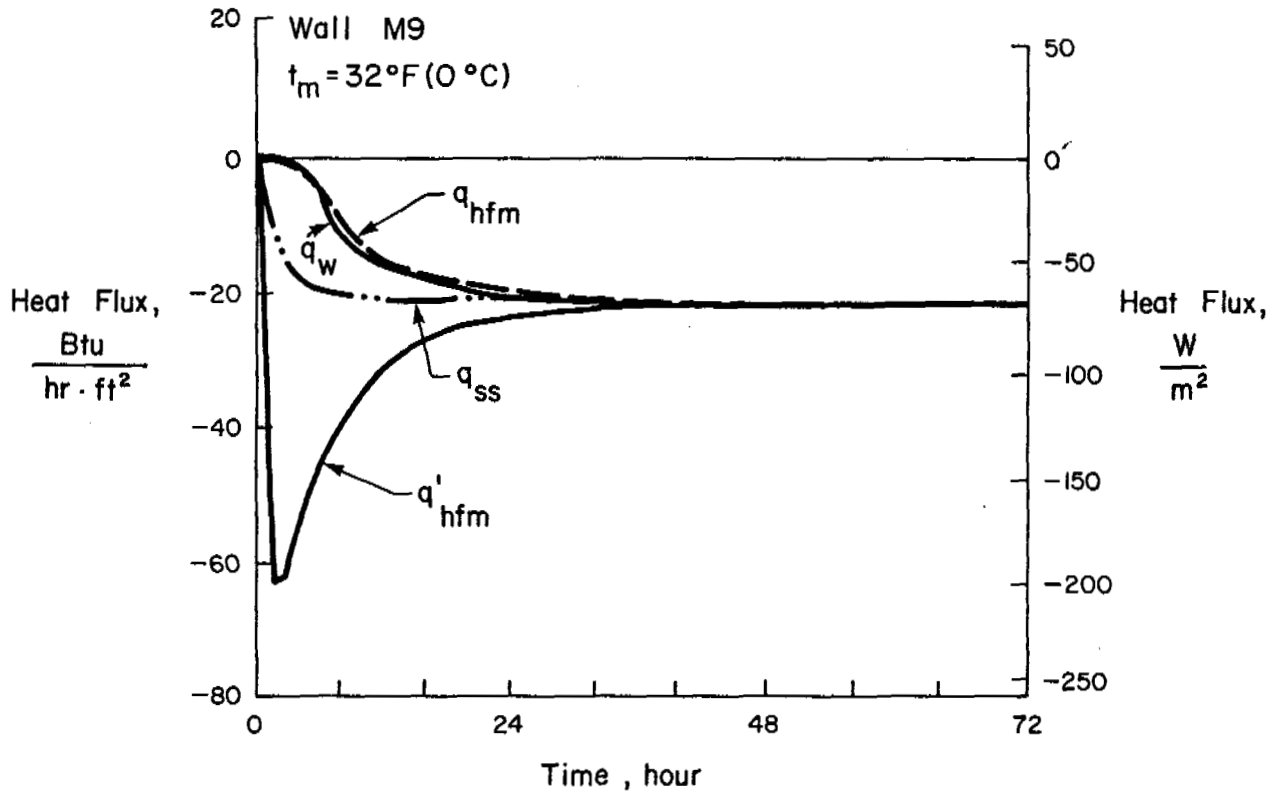


(a) Measured Temperatures



(b) Temperature Differentials

Fig. M9-1 Wall M9 Transient Test Results



(c) Heat Flux

Fig. M9-1 Wall M9 Transient Test Results

TABLE M9-5(a) - TRANSIENT TEST RESULTS

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	72.6	72.8	72.2	72.4	72.2	71.9	-0.1	0.2	-0.6	0.2
1	36.2	57.2	70.7	72.3	72.2	71.9	-0.2	0.2	-41.9	-5.7
2	11.9	39.6	63.0	70.8	72.2	71.7	-0.6	0.1	-63.3	-12.1
3	4.4	30.5	54.2	67.7	71.9	71.8	-0.5	-0.2	-62.2	-15.3
4	0.8	24.4	46.6	64.2	71.4	71.7	-1.2	-1.2	-57.4	-17.3
5	-1.2	20.1	40.5	60.7	70.7	71.6	-2.5	-2.6	-51.7	-18.5
6	-2.5	16.9	35.6	57.5	69.8	71.4	-4.0	-4.3	-47.3	-19.3
7	-3.6	14.4	31.8	54.6	69.0	71.2	-6.6	-6.1	-43.2	-19.9
8	-4.6	12.2	28.4	52.0	68.1	71.0	-8.6	-7.9	-40.1	-20.3
9	-5.1	10.6	26.0	49.8	67.4	70.7	-10.4	-9.6	-37.5	-20.6
10	-5.5	9.4	23.9	47.8	66.5	70.6	-11.5	-11.2	-34.9	-20.7
11	-5.9	8.3	22.2	46.1	65.9	70.5	-13.0	-12.6	-32.9	-20.8
12	-6.2	7.4	20.8	44.7	65.3	70.4	-14.5	-13.8	-31.2	-20.9
13	-6.6	6.7	19.5	43.5	64.9	70.2	-15.6	-14.9	-29.8	-21.0
14	-6.8	6.0	18.5	42.5	64.5	70.1	-16.3	-16.0	-28.8	-21.1
15	-7.0	5.4	17.7	41.6	64.1	70.1	-16.8	-16.8	-27.6	-21.2
16	-7.1	5.0	17.0	40.8	63.8	70.0	-17.5	-17.5	-26.8	-21.2
17	-7.2	4.7	16.4	40.2	63.5	69.9	-18.2	-18.0	-26.1	-21.2
18	-7.3	4.4	15.9	39.7	63.3	69.9	-18.7	-18.5	-25.5	-21.2
19	-7.3	4.1	15.5	39.2	63.1	69.6	-19.1	-18.9	-25.2	-21.2
20	-7.3	3.9	15.1	38.8	62.9	69.8	-19.4	-19.4	-24.5	-21.2
21	-7.5	3.7	14.9	38.5	62.8	69.8	-20.1	-19.7	-24.3	-21.3
22	-7.5	3.5	14.6	38.2	62.7	69.8	-20.5	-19.9	-24.0	-21.3
23	-7.6	3.4	14.3	37.9	62.5	69.7	-20.5*	-20.2	-23.6	-21.2
24	-7.6	3.3	14.2	37.4	62.5	69.7	-20.5	-20.3	-23.5	-21.3
26	-7.9	3.0	13.9	37.4	62.3	69.7	-20.9	-20.6	-23.0	-21.3
28	-8.0	2.8	13.6	37.2	62.2	69.7	-21.1	-20.9	-23.1	-21.3
30	-7.9	2.8	13.5	37.0	62.2	69.7	-21.3	-21.1	-22.5	-21.3
32	-7.8	2.8	13.4	36.9	62.2	69.7	-20.7	-21.2	-22.5	-21.3
34	-7.8	2.7	13.3	36.8	62.1	69.7	-21.3	-21.3	-22.6	-21.3
36	-7.8	2.7	13.3	36.7	62.1	69.7	-21.4	-21.3	-22.2	-21.3
38	-7.8	2.7	13.2	36.7	62.1	69.7	-21.1	-21.5	-21.9	-21.3
40	-7.8	2.7	13.2	36.7	62.1	69.7	-21.6	-21.4	-22.2	-21.3
42	-7.8	2.7	13.3	36.7	62.1	69.6	-21.3	-21.4	-22.2	-21.3
44	-7.8	2.7	13.2	36.7	62.1	69.7	-21.1	-21.5	-22.4	-21.3
46	-8.0	2.6	13.1	36.7	62.1	69.6	-21.5	-21.4	-22.2	-21.4
48	-7.9	2.6	13.0	36.6	62.1	69.6	-21.3	-21.5	-22.2	-21.4
50	-8.0	2.6	13.0	36.6	62.0	69.6	-22.0	-21.4	-22.2	-21.3
52	-7.9	2.5	12.9	36.6	61.9	69.7	-21.0	-21.4	-22.3	-21.3
54	-7.9	2.6	13.0	36.6	62.0	69.6	-21.5	-21.4	-22.1	-21.3
56	-8.0	2.5	13.0	36.6	62.0	69.7	-21.3	-21.6	-22.2	-21.4
58	-8.0	2.6	13.0	36.3	61.9	69.2	-21.1	-21.4	-22.2	-21.3
60	-8.0	2.5	13.0	36.6	62.0	69.6	-21.7	-21.5	-22.2	-21.4
62	-8.0	2.5	13.1	36.5	62.0	69.7	-21.1	-21.6	-22.2	-21.4
64	-8.0	2.6	13.0	36.2	62.0	69.6	-21.7	-21.5	-22.0	-21.3
66	-8.0	2.5	13.0	36.5	62.0	69.7	-21.1	-21.5	-22.2	-21.4
68	-8.0	2.5	13.0	36.5	62.0	69.7	-21.3	-21.7	-22.3	-21.4
70	-8.0	2.5	13.0	36.5	62.0	69.7	-21.4	-21.4	-22.2	-21.4

*Calibrated hot box heat flux for hour 23 was derived from linear interpolation of data from hours 22 to 24.

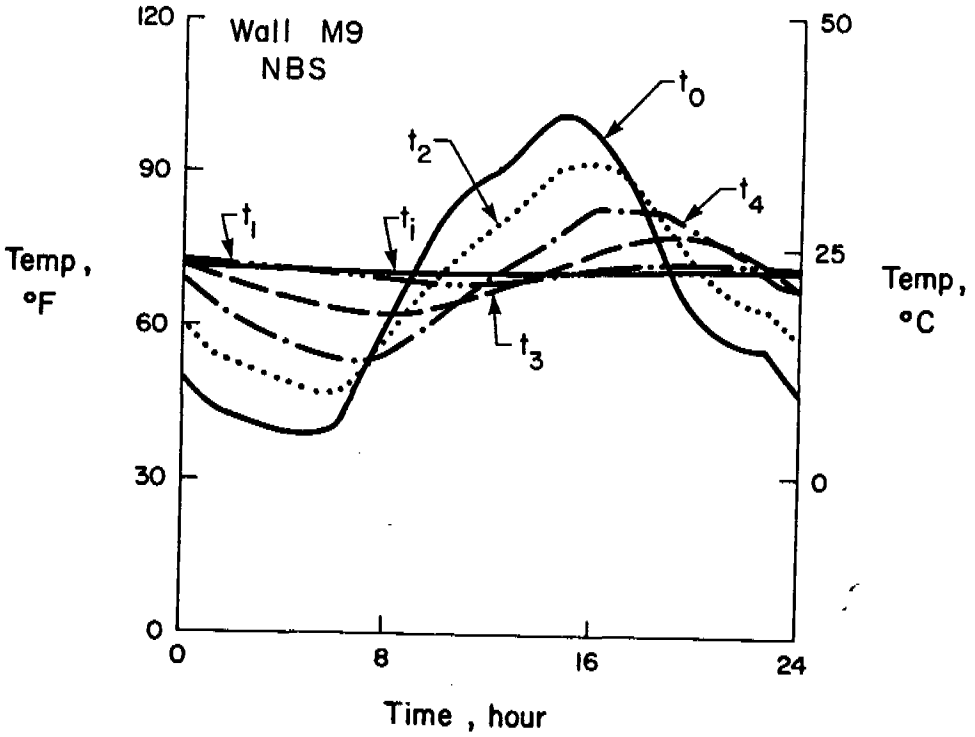
TABLE M9-5(b) - TRANSIENT TEST RESULTS, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	22.6	22.7	22.3	22.4	22.3	22.2	-0.4	0.5	-1.8	0.7
1	2.3	14.0	21.5	22.4	22.3	22.2	-0.6	0.6	-132.1	-17.9
2	-11.2	4.2	17.2	21.6	22.3	22.1	-1.7	0.4	-199.6	-38.3
3	-15.3	-0.8	12.3	19.8	22.2	22.1	-1.5	-0.8	-196.1	-48.3
4	-17.3	-4.2	8.1	17.9	21.9	22.1	-3.7	-3.7	-181.0	-54.5
5	-18.4	-6.6	4.7	15.9	21.5	22.0	-8.0	-8.3	-163.2	-58.5
6	-19.2	-8.4	2.0	14.2	21.0	21.9	-12.5	-13.6	-149.4	-60.9
7	-19.8	-9.8	-0.1	12.6	20.6	21.8	-20.8	-19.1	-136.2	-62.7
8	-20.3	-11.0	-2.0	11.1	20.1	21.7	-27.2	-25.0	-126.6	-64.1
9	-20.6	-11.9	-3.3	9.9	19.7	21.5	-32.8	-30.3	-118.4	-65.0
10	-20.8	-12.6	-4.5	8.8	19.2	21.4	-36.4	-35.4	-110.0	-65.2
11	-21.1	-13.2	-5.4	7.8	18.8	21.4	-41.0	-39.8	-103.9	-65.7
12	-21.2	-13.7	-6.2	7.1	18.5	21.3	-45.7	-43.7	-98.6	-66.0
13	-21.4	-14.1	-6.9	6.4	18.3	21.2	-49.3	-47.1	-94.0	-66.3
14	-21.6	-14.4	-7.5	5.8	18.1	21.2	-51.3	-50.3	-90.9	-66.5
15	-21.7	-14.8	-7.9	5.3	17.8	21.2	-53.0	-52.9	-87.1	-66.7
16	-21.7	-15.0	-8.3	4.9	17.7	21.1	-55.3	-55.3	-84.5	-66.8
17	-21.8	-15.2	-8.7	4.6	17.5	21.1	-57.3	-56.8	-82.3	-66.8
18	-21.8	-15.3	-8.9	4.3	17.4	21.1	-58.9	-58.4	-80.6	-66.9
19	-21.8	-15.5	-9.2	4.0	17.3	20.9	-60.4	-59.5	-79.6	-66.9
20	-21.8	-15.6	-9.4	3.8	17.2	21.0	-61.2	-61.1	-77.4	-66.9
21	-21.9	-15.7	-9.5	3.6	17.1	21.0	-63.3	-62.3	-76.7	-67.0
22	-21.9	-15.8	-9.7	3.4	17.1	21.0	-64.7	-62.9	-75.6	-67.1
23	-22.0	-15.9	-9.8	3.3	16.9	20.9	-64.7*	-63.7	-74.6	-67.0
24	-22.0	-15.9	-9.9	3.0	16.9	20.9	-64.8	-64.1	-74.3	-67.1
26	-22.2	-16.1	-10.1	3.0	16.8	20.9	-66.1	-65.0	-72.6	-67.2
28	-22.2	-16.2	-10.2	2.9	16.8	20.9	-66.6	-66.0	-72.8	-67.3
30	-22.2	-16.2	-10.3	2.8	16.8	20.9	-67.2	-66.5	-70.9	-67.3
32	-22.1	-16.2	-10.3	2.7	16.8	20.9	-65.4	-66.9	-70.8	-67.3
34	-22.1	-16.3	-10.4	2.7	16.7	20.9	-67.1	-67.2	-71.2	-67.3
36	-22.1	-16.3	-10.4	2.6	16.7	20.9	-67.6	-67.3	-69.9	-67.3
38	-22.1	-16.3	-10.4	2.6	16.7	20.9	-66.7	-67.8	-69.2	-67.3
40	-22.1	-16.3	-10.4	2.6	16.7	20.9	-68.2	-67.5	-70.1	-67.3
42	-22.1	-16.3	-10.4	2.6	16.7	20.9	-67.1	-67.5	-70.0	-67.3
44	-22.1	-16.3	-10.4	2.6	16.7	20.9	-66.6	-67.9	-70.5	-67.3
46	-22.2	-16.3	-10.5	2.6	16.7	20.9	-67.9	-67.6	-69.9	-67.4
48	-22.2	-16.3	-10.6	2.6	16.7	20.9	-67.1	-67.8	-70.1	-67.4
50	-22.2	-16.3	-10.6	2.6	16.7	20.9	-69.4	-67.5	-70.0	-67.3
52	-22.2	-16.4	-10.6	2.6	16.6	20.9	-66.4	-67.5	-70.4	-67.2
54	-22.2	-16.3	-10.6	2.6	16.7	20.9	-67.9	-67.5	-69.8	-67.3
56	-22.2	-16.4	-10.6	2.6	16.7	20.9	-67.2	-68.0	-70.1	-67.4
58	-22.2	-16.3	-10.6	2.4	16.6	20.7	-66.5	-67.7	-70.2	-67.1
60	-22.2	-16.4	-10.6	2.6	16.7	20.9	-68.5	-67.7	-70.1	-67.4
62	-22.2	-16.4	-10.5	2.5	16.7	20.9	-66.6	-68.0	-70.0	-67.4
64	-22.2	-16.3	-10.6	2.3	16.7	20.9	-68.5	-67.8	-69.4	-67.3
66	-22.2	-16.4	-10.6	2.5	16.7	20.9	-66.8	-67.9	-70.1	-67.4
68	-22.2	-16.4	-10.6	2.5	16.7	20.9	-67.2	-68.3	-70.2	-67.4
70	-22.2	-16.4	-10.6	2.5	16.7	20.9	-67.5	-67.5	-70.0	-67.4

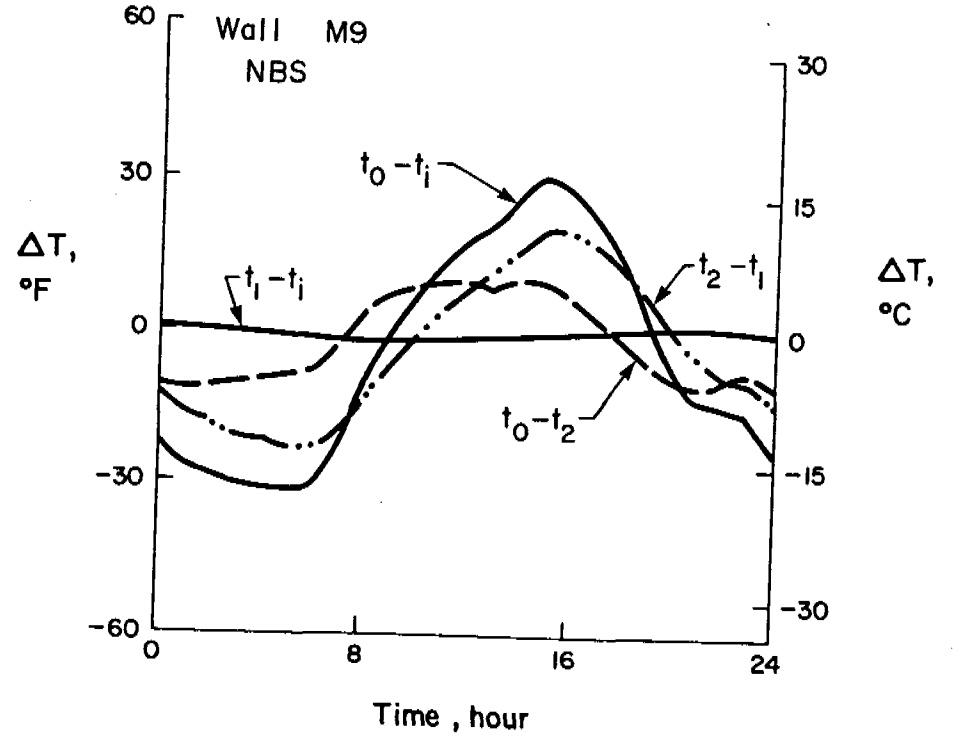
*Calibrated hot box heat flux for hour 23 was derived from linear interpolation of data from hours 22 to 24.

TABLE M9-6 - SUMMARY OF TRANSIENT TEST RESULTS

Heat Flux	Measured				Calculated	
	Calib. Hot Box		HFM @ Indoor Surf.		Steady-State	
	q_w, Btu/hr·ft^2 (W/m^2)	Time to Reach q_w, hr	q_{hfm}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{hfm}, hr	q_{ss}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{ss}, hr
99.5% of Final Heat Flux	-21.3 (-67.1)	30	-21.4 (-67.5)	37	-21.2 (-67.0)	21
95% of Final Heat Flux	-20.3 (-64.0)	22	-20.4 (-64.4)	25	-20.3 (-64.0)	8
90% of Final Heat Flux	-19.2 (-60.7)	20	-19.3 (-61.0)	20	-19.2 (-60.6)	6

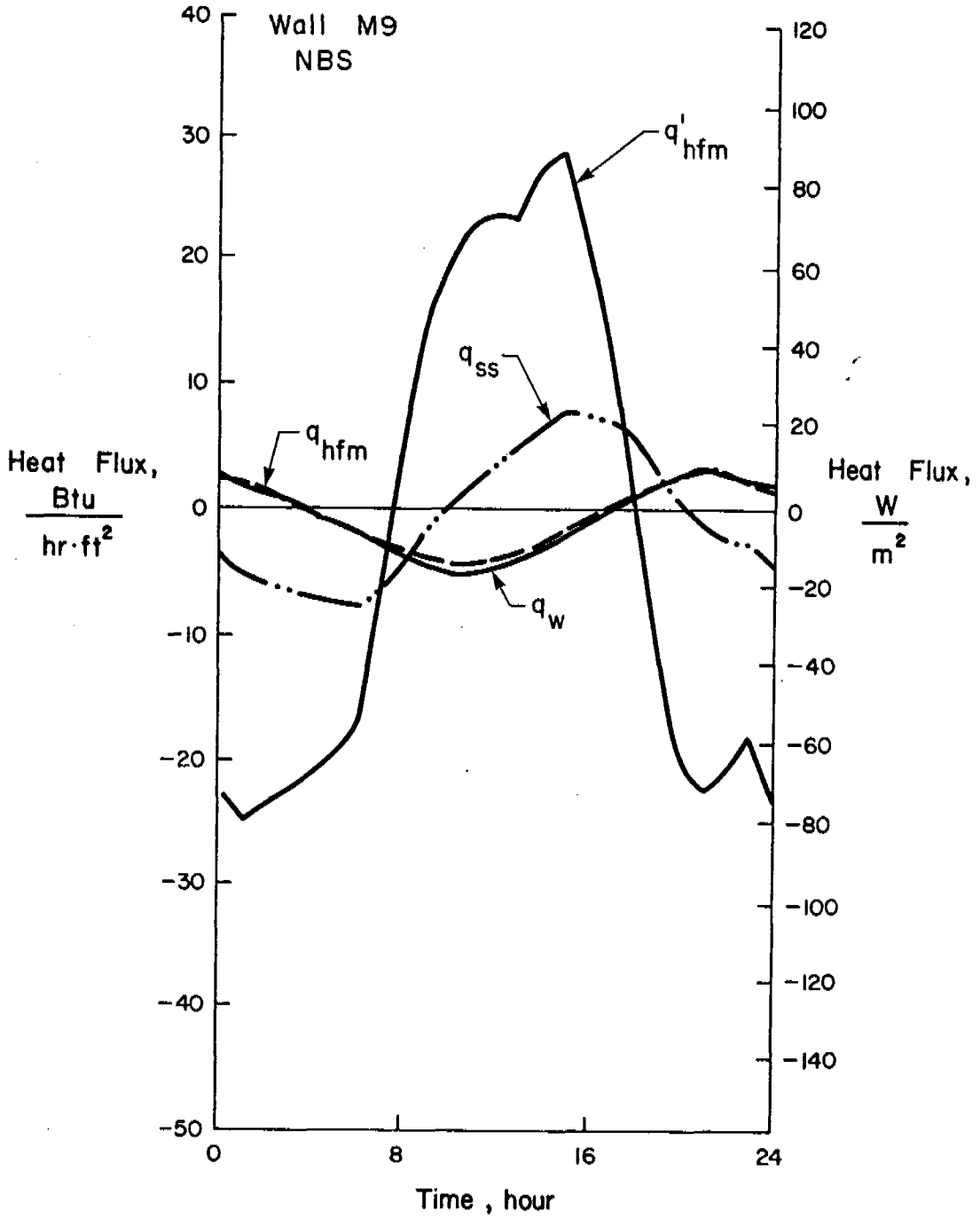


(a) Measured Temperatures



(b) Temperature Differentials

Fig. M9-2 Wall M9 Dynamic Test Results for NBS Test Cycle



(c) Heat Flux

Fig. M9-2 Wall M9 Dynamic Test Results for NBS Test Cycle

TABLE M9-7(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE

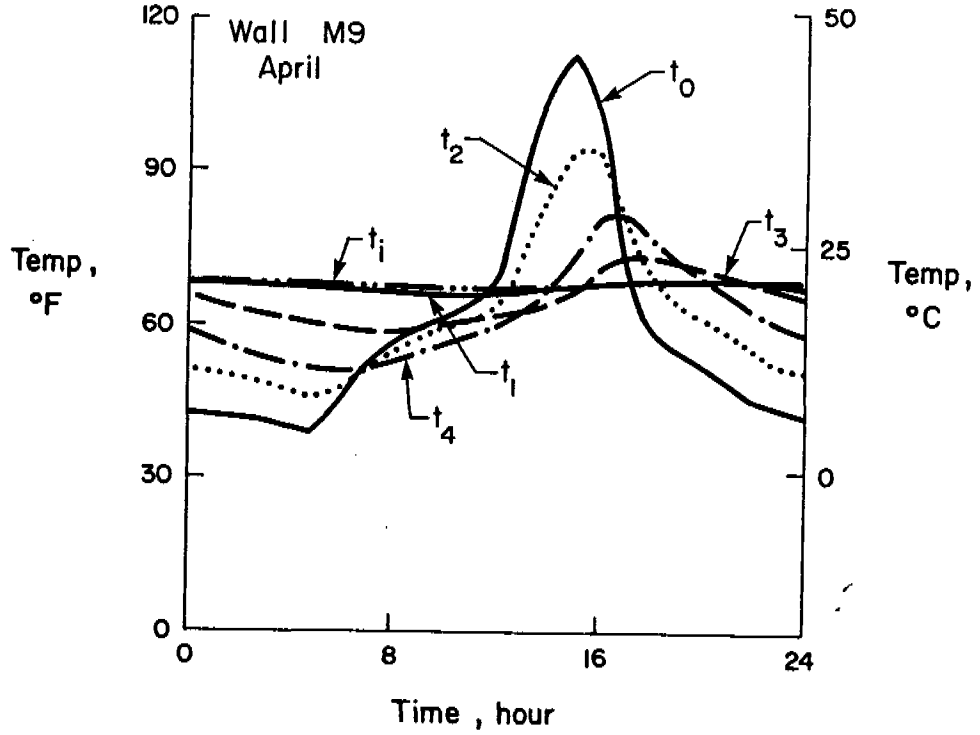
Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	45.2	56.4	65.2	71.5	72.8	72.0	1.47	1.71	-25.88	-6.18
2	43.7	54.1	62.4	69.9	72.4	71.9	0.79	0.94	-24.00	-6.90
3	41.6	51.8	60.0	68.4	72.0	71.8	0.31	0.13	-23.30	-7.59
4	40.6	50.0	57.9	67.0	71.5	71.7	-0.81	-0.71	-21.82	-8.07
5	40.3	48.9	56.1	65.7	71.1	71.6	-1.73	-1.58	-19.75	-8.34
6	40.8	48.3	54.7	64.5	71.7	71.5	-2.56	-2.45	-17.34	-8.40
7	50.2	51.8	54.1	63.6	70.3	71.4	-3.36	-3.23	-5.84	-6.95
8	62.9	58.6	55.5	63.1	70.0	71.3	-4.32	-3.94	7.89	-4.28
9	72.4	65.2	58.8	63.6	69.8	71.2	-5.17	-4.55	15.67	-1.74
10	79.2	70.3	62.3	64.6	69.7	71.2	-5.87	-4.78	20.18	0.25
11	85.7	75.6	66.1	66.0	69.8	71.2	-5.50	-4.71	24.06	2.23
12	89.8	79.9	70.0	67.6	70.0	71.3	-5.21	-4.34	24.69	3.79
13	93.0	83.3	73.5	69.4	70.3	71.4	-4.78	-3.69	24.20	4.99
14	99.2	87.9	76.7	71.2	70.7	71.5	-3.88	-2.91	28.00	6.63
15	103.4	92.2	80.2	73.3	71.2	71.6	-2.80	-1.99	28.88	8.11
16	100.3	92.7	83.2	75.3	71.8	71.7	-1.73	-0.92	21.30	8.10
17	95.1	91.0	84.6	77.0	72.3	71.9	-0.35	0.19	12.51	7.24
18	87.2	87.4	84.9	78.1	72.7	72.0	1.16	1.30	2.31	5.67
19	74.9	80.9	83.5	78.6	73.3	72.1	2.35	2.22	-11.49	2.94
20	64.8	74.1	80.6	78.2	73.6	72.2	3.23	2.88	-20.93	0.20
21	59.1	69.1	76.8	77.2	73.7	72.2	3.43	3.22	-23.66	-1.72
22	57.4	66.3	73.4	75.8	73.6	72.2	3.18	3.22	-21.57	-2.79
23	56.8	64.5	70.6	74.4	73.4	72.1	2.95	2.88	-18.91	-3.37
24	50.0	60.5	68.2	73.0	73.1	72.1	2.50	2.35	-23.94	-4.78
Mean	68.1	69.2	69.1	70.7	71.7	71.7	-1.11	-0.78	-2.03	-0.87

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 24%
Outdoor Chamber - 21%

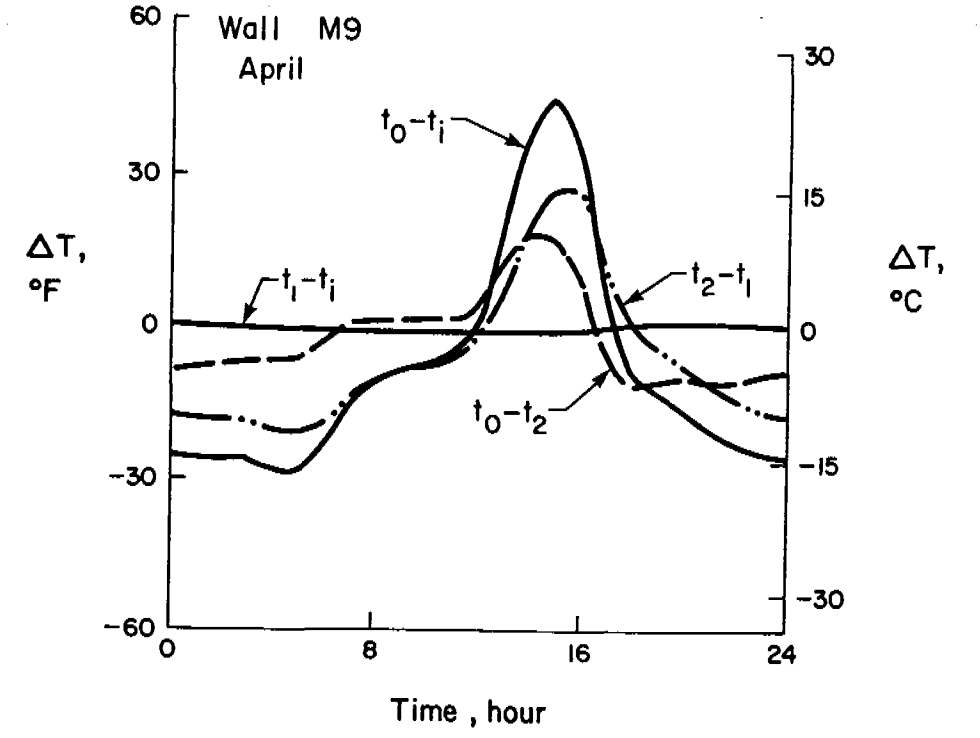
Laboratory Air Temperature:
Max. - 74°F (23°C)
Min. - 71°F (22°C)

TABLE M9-7(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	7.3	13.6	18.5	21.9	22.7	22.2	4.65	5.41	-81.66	-19.50
2	6.5	12.3	16.9	21.1	22.4	21.2	2.49	2.97	-75.73	-21.75
3	5.3	11.0	15.6	20.2	22.2	22.1	0.97	0.42	-73.50	-23.93
4	4.8	10.0	14.4	19.4	21.9	22.1	-2.56	-2.25	-68.84	-25.44
5	4.6	9.4	13.4	18.7	21.7	22.0	-5.45	-4.97	-62.33	-26.29
6	4.9	9.1	12.6	18.1	21.5	21.9	-8.08	-7.72	-54.70	-26.49
7	10.1	11.0	12.3	17.6	21.3	21.9	-10.59	-10.19	-18.44	-21.93
8	17.2	14.8	13.1	17.3	21.1	21.9	-13.62	-12.43	24.91	-13.50
9	22.4	18.4	14.9	17.6	21.0	21.8	-16.32	-14.37	49.45	-5.48
10	26.2	21.3	16.8	18.1	20.9	21.8	-18.52	-15.07	63.68	0.79
11	29.6	24.2	18.9	18.9	21.0	21.8	-17.36	-14.86	75.92	7.03
12	32.1	26.6	21.1	19.8	21.1	21.8	-16.45	-13.68	77.91	11.96
13	33.9	28.5	23.1	20.8	21.3	21.9	-15.08	-11.64	76.36	15.75
14	37.3	31.1	24.8	21.8	21.5	21.9	-12.24	-9.17	88.33	20.92
15	39.7	33.4	26.8	22.9	21.8	22.0	-8.85	-6.29	91.11	25.57
16	37.9	33.8	28.4	24.1	22.1	22.1	-5.46	-2.90	67.19	25.55
17	35.1	32.8	29.2	25.0	22.4	22.2	-1.12	0.61	39.46	22.84
18	30.7	30.7	29.4	25.6	22.6	22.2	3.66	4.10	7.27	17.89
19	23.8	27.2	28.6	25.9	22.4	22.3	7.41	6.99	-36.27	9.28
20	18.2	23.4	27.0	25.7	23.1	22.3	10.18	9.08	-66.03	0.63
21	15.1	20.7	24.9	25.1	23.2	22.3	10.83	10.16	-74.66	-5.43
22	14.1	19.1	23.0	24.3	23.1	22.3	10.03	10.14	-68.05	-8.79
23	13.8	18.1	21.4	23.6	23.0	22.3	9.32	9.08	-59.65	-10.62
24	10.0	15.8	20.1	22.8	22.8	22.3	7.88	7.41	-75.52	-15.07
Mean	20.1	20.7	20.6	21.5	22.1	22.1	-3.51	-2.47	-6.41	-2.75

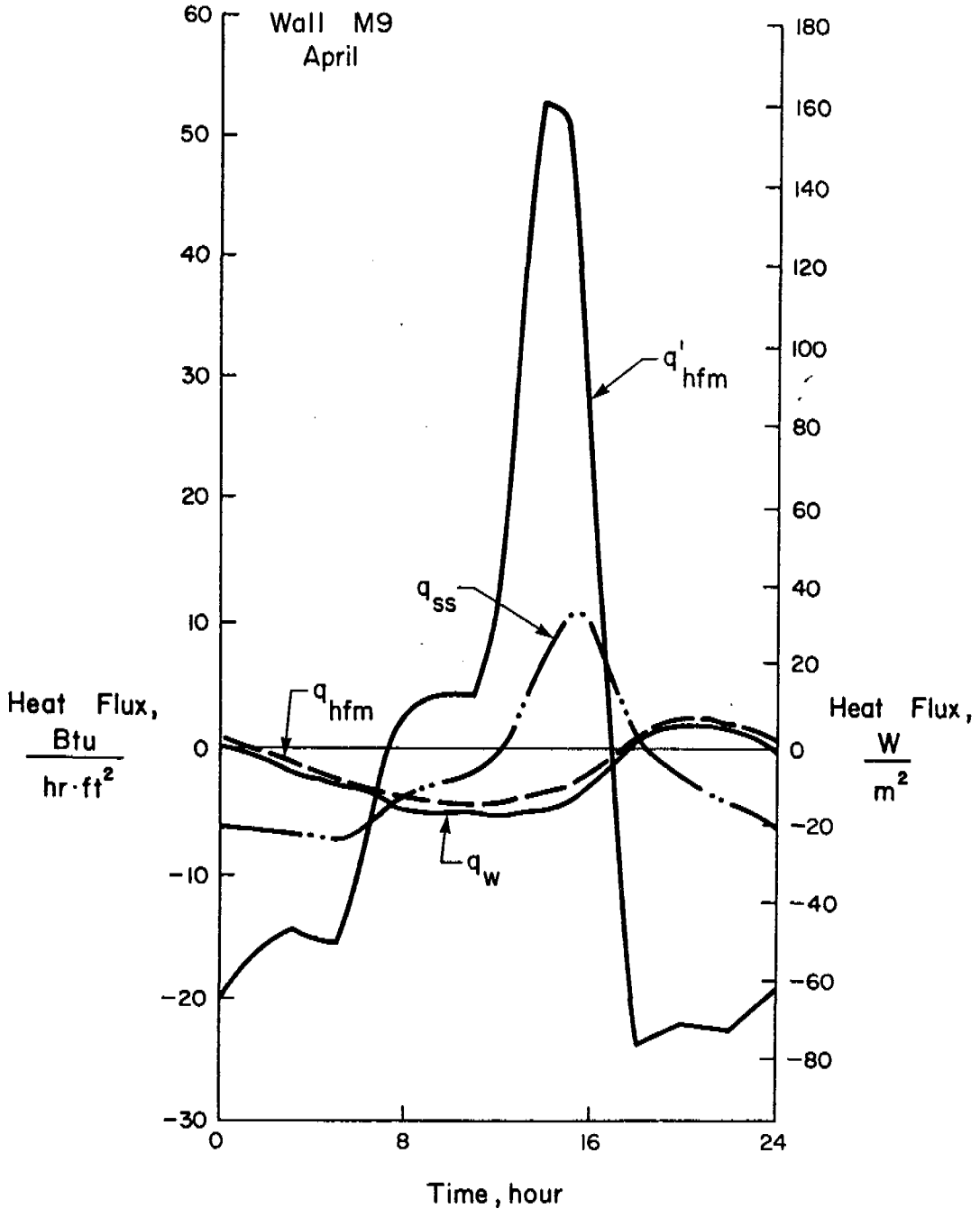


(a) Measured Temperatures



(b) Temperature Differentials

Fig. M9-3 Wall M9 Dynamic Test Results for Gaithersburg April Test Cycle



(c) Heat Flux

Fig. M9-3 Wall M9 Dynamic Test Results for Gaithersburg April Test Cycle

TABLE M9-8(a) - DYNAMIC TEST RESULTS (PERIODIC), GAITHERSBURG APRIL TEST CYCLE

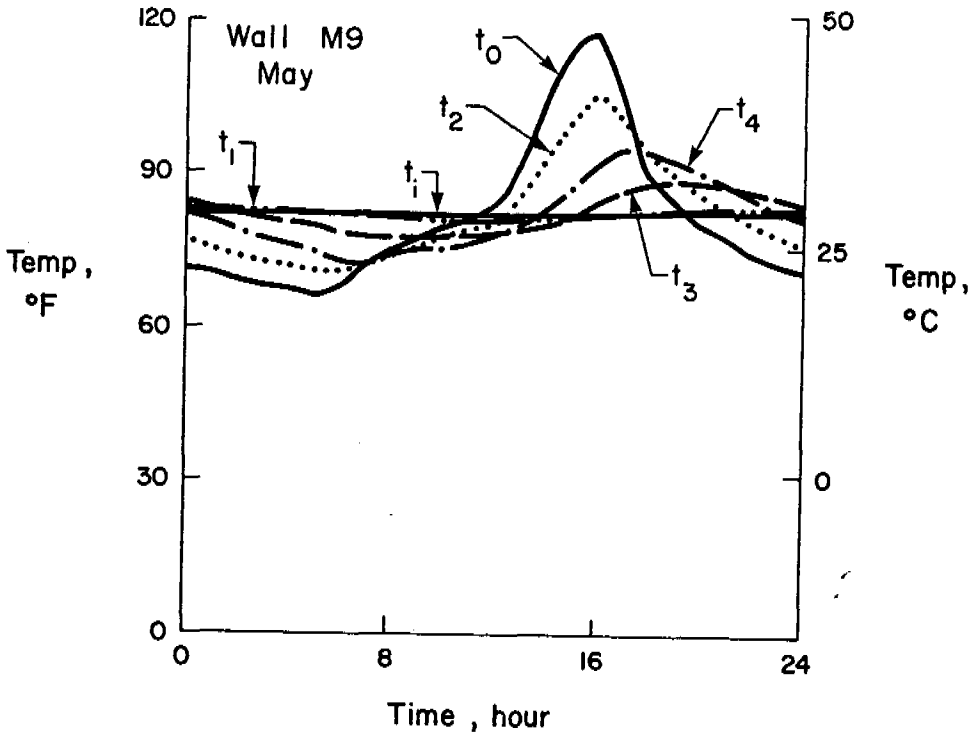
Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q'_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	42.6	50.4	56.9	64.8	68.2	68.0	-0.38	-0.03	-18.14	-6.66
2	42.4	49.6	55.4	63.6	67.9	67.9	-1.39	-0.77	-16.39	-6.83
3	42.0	48.7	54.2	62.5	67.5	67.7	-2.35	-1.55	-15.26	-7.00
4	39.6	47.1	53.2	61.6	67.1	67.7	-2.85	-2.29	-16.53	-7.49
5	38.1	45.5	51.8	60.7	66.8	67.6	-3.83	-2.90	-16.64	-7.94
6	43.6	47.2	50.9	59.9	66.6	67.6	-3.92	-3.57	-9.38	-7.21
7	51.9	51.5	51.4	59.4	66.3	67.5	-5.13	-4.08	-0.34	-5.53
8	56.2	54.6	52.9	59.4	66.1	67.4	-5.41	-4.58	3.11	-4.32
9	58.5	56.7	54.6	59.8	66.0	67.4	-5.78	-4.86	4.19	-3.48
10	60.1	58.3	56.1	60.3	65.9	67.4	-6.04	-4.95	4.37	-2.87
11	61.6	59.8	57.5	60.9	66.0	67.4	-5.60	-4.95	4.69	-2.34
12	69.4	63.9	59.0	61.5	66.1	67.4	-6.15	-4.75	11.97	-0.84
13	88.7	74.2	62.2	62.5	66.3	67.5	-5.53	-4.52	33.45	3.03
14	107.2	87.1	68.2	64.5	66.5	67.5	-5.20	-4.10	53.19	7.90
15	113.6	95.0	75.5	67.5	66.9	67.5	-4.70	-3.40	52.33	10.87
16	105.2	95.0	81.3	70.8	67.4	67.7	-3.23	-2.24	29.96	10.65
17	75.1	81.9	82.8	73.4	68.1	67.9	-1.83	-0.74	-8.97	5.29
18	59.4	70.8	78.7	74.1	68.9	68.2	0.54	0.83	-24.62	0.72
19	55.8	66.3	74.0	73.3	69.4	68.3	1.61	1.89	-24.06	-1.18
20	53.0	62.8	70.2	72.1	69.6	68.3	2.15	2.34	-23.01	-2.57
21	49.0	59.2	66.9	70.6	69.5	68.3	2.12	2.32	-23.64	-3.89
22	45.4	55.8	63.9	69.1	69.3	68.2	1.53	2.00	-23.93	-5.07
23	43.8	53.4	61.1	67.6	69.0	68.1	1.16	1.45	-22.26	-5.83
24	42.8	51.6	58.8	66.1	68.6	68.0	0.00	0.77	-20.45	-6.36
Mean	60.2	61.9	62.4	65.3	67.5	67.8	-2.51	-1.78	-2.77	-2.04

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 26%
Outdoor Chamber - 21%

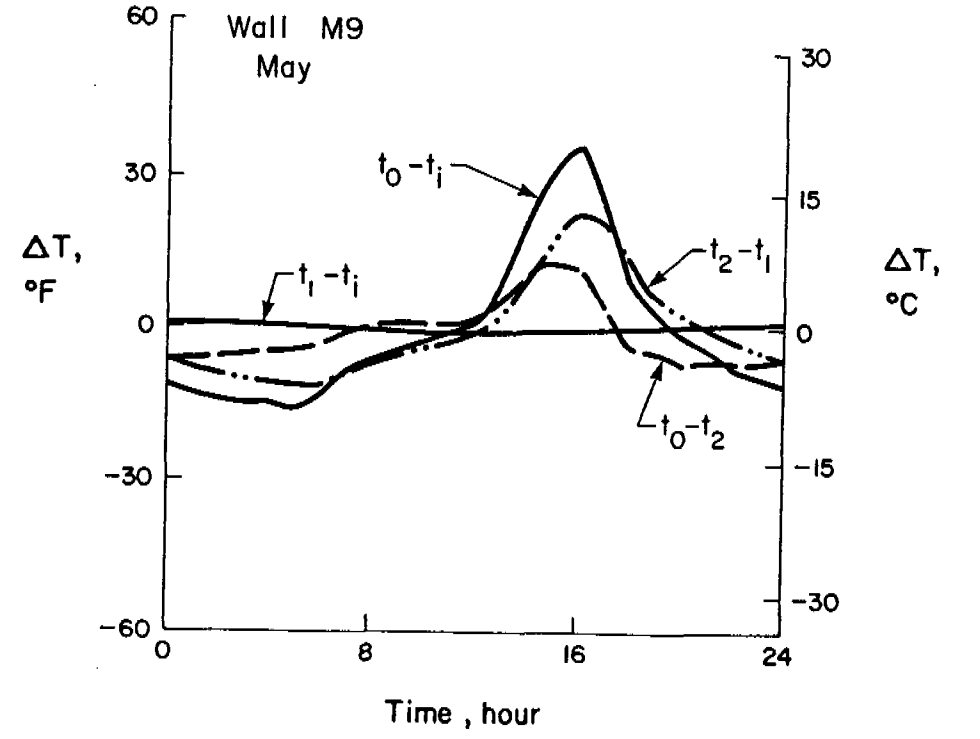
Laboratory Air Temperature:
Max. - 74°F (23°C)
Min. - 71°F (22°C)

TABLE M9-8(b) - DYNAMIC TEST RESULTS (PERIODIC), GAITHERSBURG APRIL TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q'_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	5.9	10.2	13.8	18.2	20.1	20.0	-1.19	-0.08	-57.23	-21.00
2	5.8	9.8	13.0	17.6	19.9	19.9	-4.39	-2.42	-51.72	-21.55
3	5.6	9.3	12.3	16.9	19.7	19.8	-7.41	-4.89	-48.14	-22.08
4	4.2	8.4	11.8	16.4	19.5	19.8	-8.99	-7.22	-52.17	-23.62
5	3.4	7.5	11.0	15.9	19.3	19.8	-12.07	-9.15	-52.51	-25.03
6	6.4	8.4	10.5	15.5	19.2	19.8	-12.35	-11.25	-29.59	-22.75
7	11.1	10.8	10.8	15.2	19.1	19.7	-16.17	-12.86	-1.07	-17.43
8	13.4	12.6	11.6	15.2	18.9	19.7	-17.08	-14.46	9.82	-13.63
9	14.7	13.7	12.6	15.4	18.9	19.7	-18.23	-15.34	13.21	-10.99
10	15.6	14.6	13.4	15.7	18.8	19.7	-19.07	-15.60	13.79	-9.05
11	16.4	15.4	14.2	16.1	18.9	19.7	-17.66	-15.62	14.80	-7.37
12	20.8	17.7	15.0	16.4	18.9	19.7	-19.41	-14.98	37.77	-2.64
13	31.5	23.4	16.8	16.9	19.1	19.7	-17.45	-14.26	105.54	9.56
14	41.8	30.6	20.1	18.1	19.2	19.7	-16.40	-12.93	167.82	24.90
15	45.3	35.0	24.2	19.7	19.4	19.7	-14.84	-10.73	165.09	34.27
16	40.7	35.0	27.4	21.6	19.7	19.8	-10.20	-7.08	94.52	33.57
17	23.9	27.7	28.2	23.0	20.1	19.9	-5.77	-2.34	-28.31	16.70
18	15.2	21.6	25.9	23.4	20.5	20.1	1.72	2.63	-77.68	2.27
19	13.2	19.1	23.3	23.0	20.8	20.2	5.07	5.96	-75.91	-3.71
20	11.7	17.1	21.2	22.3	20.9	20.2	6.78	7.39	-72.60	-8.10
21	9.4	15.1	19.4	21.4	20.8	20.2	6.68	7.31	-74.59	-12.26
22	7.4	13.2	17.7	20.6	20.7	20.1	4.81	6.31	-75.48	-16.00
23	6.6	11.9	16.2	19.8	20.6	20.1	3.67	4.56	-70.23	-18.38
24	6.0	10.9	14.9	18.9	20.3	20.0	0.00	2.44	-64.53	-20.06
Mean	15.7	16.6	16.9	18.5	19.7	19.9	-7.92	-5.61	-8.73	-6.43

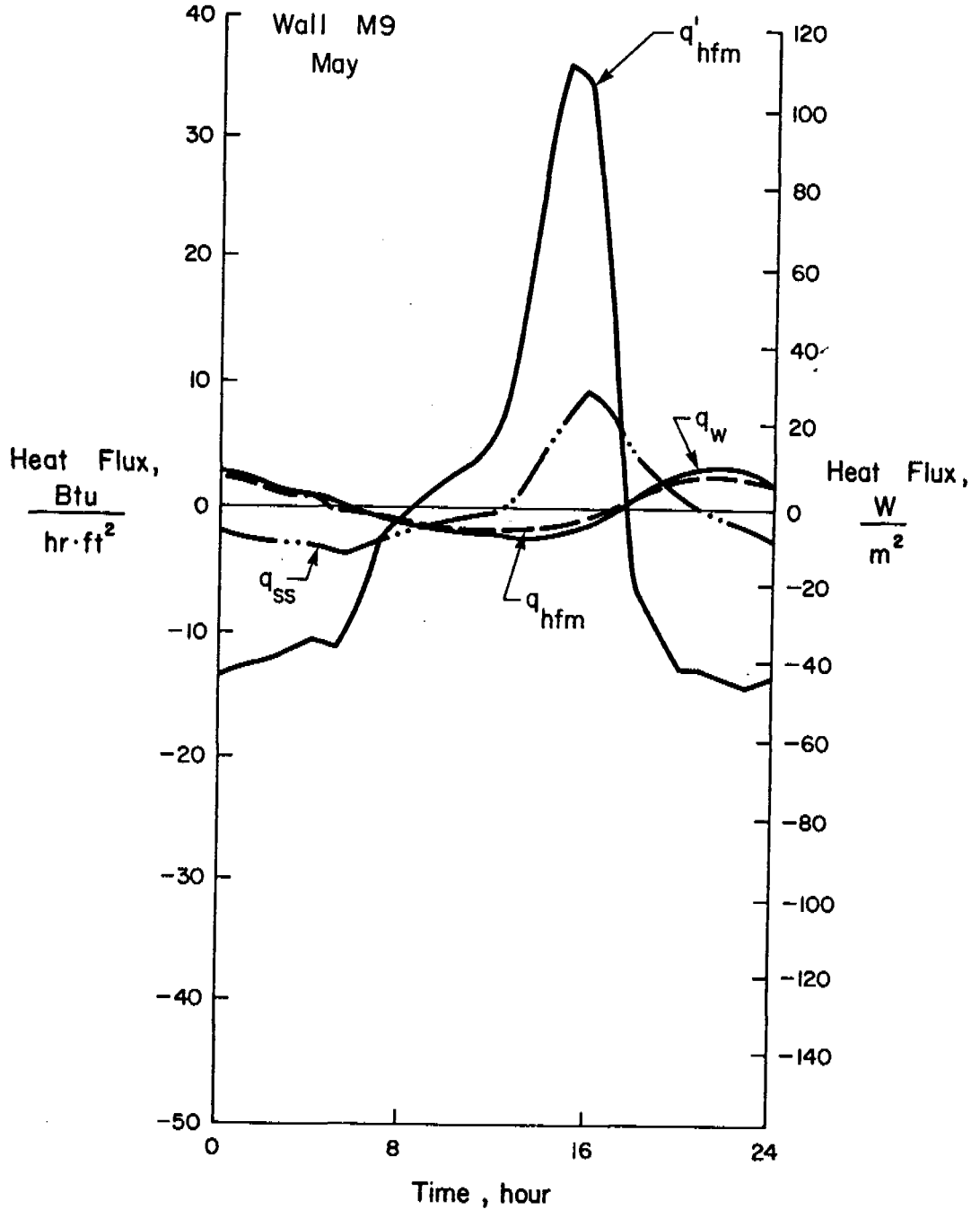


(a) Measured Temperatures



(b) Temperature Differentials

Fig. M9-4 Wall M9 Dynamic Test Results for Gaithersburg May Test Cycle



(c) Heat Flux

Fig. M9-4 Wall M9 Dynamic Test Results for Gaithersburg May Test Cycle

TABLE M9-9(a) - DYNAMIC TEST RESULTS (PERIODIC), GAITHERSBURG MAY TEST CYCLE

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	70.8	76.4	80.8	84.1	84.0	83.1	2.34	2.07	-13.67	-2.94
2	69.3	74.9	79.3	83.1	83.7	83.1	1.71	1.53	-13.48	-3.41
3	68.6	73.9	77.9	82.2	83.5	83.0	1.13	0.97	-12.58	-3.69
4	68.3	73.1	76.8	81.1	83.2	83.0	0.37	0.45	-11.46	-3.87
5	66.9	71.9	75.8	80.5	82.9	82.9	-0.06	-0.09	-11.88	-4.21
6	69.1	72.2	74.9	79.8	82.7	82.8	-0.87	-0.58	-8.12	-4.01
7	74.4	74.7	74.9	79.3	82.4	82.8	-1.17	-1.08	-1.53	-3.00
8	76.0	75.9	75.5	79.1	82.2	82.7	-1.83	-1.49	-0.25	-2.46
9	77.8	77.0	76.2	79.0	82.1	82.7	-1.91	-1.79	1.12	-1.96
10	80.1	78.6	77.0	79.2	82.0	82.6	-2.48	-1.98	2.92	-1.32
11	81.8	80.0	78.0	79.5	82.0	82.7	-2.50	-2.05	3.95	-0.77
12	84.5	81.8	79.1	79.9	82.0	82.7	-2.47	-2.09	6.08	-0.11
13	92.8	86.3	80.5	80.4	82.1	82.7	-2.65	-2.00	14.28	1.62
14	105.9	94.2	83.4	81.3	82.2	82.7	-2.44	-1.83	27.33	4.68
15	115.8	101.9	87.7	83.0	82.4	82.7	-2.14	-1.52	36.97	7.66
16	119.7	107.0	92.6	85.2	82.7	82.8	-1.53	-0.96	35.64	9.58
17	107.4	103.8	96.1	87.6	83.2	82.9	-0.80	-0.07	14.44	8.12
18	90.7	95.1	95.8	89.1	83.8	83.1	0.76	0.97	-6.53	4.44
19	86.5	91.4	93.5	89.3	84.2	83.2	2.21	1.98	-9.46	2.80
20	81.2	87.3	91.0	88.9	84.5	83.3	2.96	2.68	-13.59	1.07
21	78.8	84.6	88.5	88.1	84.6	83.3	3.64	3.00	-13.72	-0.02
22	75.7	81.9	86.4	87.2	84.6	83.3	3.82	3.03	-14.90	-1.04
23	73.4	79.6	84.3	86.2	84.4	83.2	3.35	2.85	-15.08	-1.89
24	72.1	77.9	82.5	85.1	84.3	83.2	2.84	2.49	-14.25	-2.45
Mean	82.8	83.4	82.9	83.3	83.2	82.9	0.10	0.19	-0.74	0.12

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 24%
Outdoor Chamber - 19%

Laboratory Air Temperature:
Max. - 75°F (24°C)
Min. - 71°F (22°C)

TABLE M9-9(b) - DYNAMIC TEST RESULTS (PERIODIC), GAITHERSBURG MAY TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	21.6	24.7	27.1	28.9	28.9	28.4	7.39	6.53	-43.13	-9.28
2	20.7	23.8	26.3	28.4	28.7	28.4	5.40	4.83	-42.53	-10.75
3	20.3	23.3	25.5	27.9	28.6	28.3	3.57	3.05	-39.70	-11.64
4	20.2	22.8	24.9	27.3	28.4	28.3	1.18	1.43	-36.15	-12.21
5	19.4	22.2	24.3	26.9	28.3	28.3	-0.20	-0.27	-37.48	-13.29
6	20.6	22.3	23.8	26.6	28.2	28.2	-2.76	-1.82	-25.63	-12.65
7	23.6	23.7	23.8	26.3	28.0	28.2	-3.70	-3.41	-4.83	-9.46
8	24.4	24.4	24.2	26.2	27.9	28.2	-5.76	-4.69	-0.77	-7.75
9	25.4	25.0	25.6	26.1	27.8	28.2	-6.02	-5.65	3.53	-6.19
10	26.7	25.9	25.0	26.2	27.8	28.1	-7.83	-6.23	9.21	-4.16
11	27.7	26.7	25.6	26.4	27.8	28.2	-7.89	-6.48	12.46	-2.44
12	29.2	27.7	26.2	26.6	27.8	28.2	-7.81	-6.59	19.19	-0.34
13	33.8	30.2	26.9	26.9	27.8	28.2	-8.36	-6.30	45.04	5.12
14	41.0	34.6	28.6	27.4	27.9	28.2	-7.70	-5.77	86.22	14.77
15	46.6	38.8	30.9	28.3	28.0	28.2	-6.76	-4.79	116.64	24.17
16	48.7	41.7	33.7	29.6	28.2	28.2	-4.82	-3.02	112.45	30.20
17	41.9	39.9	35.6	30.9	28.4	28.3	-2.54	-0.23	45.55	25.61
18	32.6	35.1	35.4	31.7	28.8	28.4	2.40	3.05	-20.60	14.02
19	30.3	33.0	34.2	31.8	29.0	28.4	6.98	6.26	-29.83	8.84
20	27.3	30.7	32.8	31.6	29.2	28.5	9.33	8.44	-42.88	3.38
21	26.0	29.2	31.4	31.2	29.2	28.5	11.49	9.45	-43.29	-0.06
22	24.3	27.7	30.2	30.7	29.2	28.5	12.06	9.55	-46.99	-3.26
23	23.0	26.4	29.1	30.1	29.1	28.4	10.58	8.98	-47.58	-5.97
24	22.3	25.5	28.1	29.5	29.1	28.4	8.97	7.86	-44.97	-7.73
Mean	28.2	28.6	28.3	28.5	28.4	28.3	0.30	0.59	-2.34	0.37

TABLE M9-10 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), THERMAL LAG

Test Cycle	Thermal Lag, hrs								Calc. Time Constant, hrs
	Measured								
	Calibrated Hot Box					Heat Flow Meter			
	t_o vs t_1		q_{ss} vs q_w		Avg.	q_{ss} vs q_{hfm}		Avg.	
	@ Max.	@ Min.	@ Max.	@ Min.		@ Max.	@ Min.		
NBS	6	5	6	4	5.5	7	4	5	1.4
Gaith. April	5	5	5	5	5	8	5.5	5.5	1.4
Gaith. May	5.5	6	6	8	6.5	6	7	6.5	1.4

TABLE M9-11 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), REDUCTION IN AMPLITUDE

Test Cycle	Measured, %					
	Calibrated Hot Box			Heat Flow Meter		
	@ Max.	@ Min.	Avg.	@ Max.	@ Min.	Avg.
NBS	49	37	43	55	47	51
Gaith. April	64	38	51	68	46	57
Gaith. May	61	37	49	70	47	59

TABLE M9-12 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), ENERGY REQUIREMENTS

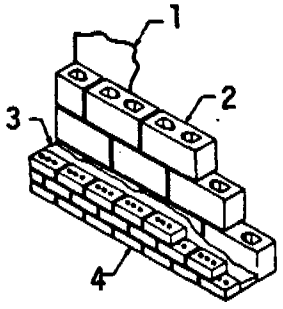
Test Cycle	Total Energy, Btu/ft^2 (W·hr/m^2)			Total Energy Comparisons, %		Net Energy, Btu/ft^2 (W·hr/m^2)			Net Energy Comparisons, %	
	Measured		Calculated			Measured		Calculated		
	q_w^T	q_{hfm}^T	q_{ss}^T	$\frac{q_w^T}{q_{ss}^T}$	$\frac{q_{hfm}^T}{q_{ss}^T}$	q_w^N	q_{hfm}^N	q_{ss}^N	$\frac{q_w^N}{q_{ss}^N}$	$\frac{q_{hfm}^N}{q_{ss}^N}$
NBS	69.5 (219.1)	60.8 (191.9)	121.2 (382.4)	57	50	-26.7 (-84.3)	-18.8 (-59.2)	-20.9 (-66.0)	128	89
Gaith. April	78.4 (247.4)	65.9 (207.8)	125.8 (396.9)	62	52	-60.2 (-190.0)	-42.7 (-134.6)	-48.9 (-154.4)	123	87
Gaith. May	48.0 (151.5)	39.5 (124.7)	77.1 (243.3)	62	51	2.3 (7.2)	4.5 (14.2)	2.8 (8.9)	81	160

WALL M10: 12-in. (300-mm) BLOCK-BRICK CAVITY WALL WITH INSULATION IN CAVITY

DESCRIPTION: Unreinforced 12-in. (300-mm) cavity wall consisting of 6-in. (150-mm) hollow core concrete block and 4-in. (100-mm) clay brick separated by a 2-3/4-in. (70-mm) cavity containing expanded perlite loose fill insulation.

REFERENCE: Van Geem, M.G. and Larson, S.C., "Heat Transfer Characteristics of a Masonry Cavity Wall With and Without Expanded Perlite Insulation," Construction Technology Laboratories, Portland Cement Association, Skokie, 1985, 142 pages.

COMPOSITION:



1. 1/8-in. (3-mm) Plaster: one part Type S masonry cement to 2-1/2 parts masonry sand by volume, painted off-white
2. 6x8x16-in. (150x200x400-mm) Normal Weight Hollow Core Concrete Block - 2 cores per block
3. Silicone-Treated Expanded Perlite Loose Masonry Insulation
4. 4x2-1/2x8-in. (100x60x200-mm) Clay Brick - 3 cores per brick
5. Metal Rectangular Ties Between Wythes - one in every other mortar joint between block

TABLE M10-1 - PHYSICAL PROPERTIES OF WALL AT TIME OF TEST

Property	Measured Value
Unit Weight, psf (kg/m^2)	81.96 (400.2)
Average Thickness, in. (mm)	12.0 (305)
Area, ft^2 (m^2)	73.65 (6.84)
Estimated Moisture Content of Block,* % by ovendry weight	1.2
Estimated Moisture Content of Brick,* % by ovendry weight	0.3

*Measured on masonry, including mortar joints, after test.

TABLE M10-2(a) - MATERIAL PROPERTIES, NORMAL WEIGHT CONCRETE BLOCK

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Standard Dimensions, in. (mm)	--	--	--	5-5/8x7-5/8x15-5/8 (143x194x397)
Measured Dimensions, in. (mm)	ASTM C140	--	--	5.64x7.65x15.61 (143x194x396)
Percent Solid Volume	--	--	--	56
Ovendry Unit Weight, pcf (kg/m^3)	--	--	--	124 (1984)
Moisture Content, % ovendry weight	ASTM C140	--	--	1.75
Absorption, % ovendry weight	ASTM C140	--	--	8.1

TABLE M10-2(b) - MATERIAL PROPERTIES, CLAY BRICK

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Standard Dimensions, in. (mm)	--	--	--	3-3/8x2-1/4x8 (86x57x203)
Measured Dimensions, in. (mm)	ASTM C67	--	--	3.39x2.27x7.80 (86x58x198)
Percent Solid Volume	--	--	--	82
Ovendry Unit Weight, pcf (kg/m^3)	--	--	--	135 (2160)
Moisture Content, % ovendry weight	ASTM C67	--	--	0.1
Absorption, % ovendry weight	ASTM C67	--	--	5.3

TABLE M10-2(c) - MATERIAL PROPERTIES, MORTAR*

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Average Mortar Bed Joint Spacing for Block, in. (mm)	--	--	--	0.28 (7)
Average Mortar Bed Joint Spacing for Brick, in. (mm)	--	--	--	0.37 (9)
Compressive Strength**, psi (MPa)	--	air dry	--	2270 (15.6)
Compressive Strength**, psi (MPa)	--	moist	--	1850 (12.8)

*One part Type S masonry cement to three parts masonry sand by volume.
**Measured on 2-in. (50-mm) cubes cured for 28 ± 3 days.

TABLE M10-2(d) - MATERIAL PROPERTIES, EXPANDED PERLITE LOOSE FILL MASONRY INSULATION

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Net Weight in Wall, lb (kg)	--	--	--	73.4 (33.4)
Density, as received, pcf (kg/m^3)	--	--	--	4.3 (69)

TABLE M10-3 - DESIGN HEAT TRANSMISSION COEFFICIENTS

Component	R, Thermal Resistance $hr \cdot ft^2 \cdot °F/Btu$ $(m^2 \cdot K/W)$
1. Outside Air Film	0.17* (0.03)
2. 4x2-1/2x8-in. (100x60x200-mm) Clay Brick	0.44* (0.08)
3. 2-3/4-in. (70-mm) Expanded Perlite Loose Fill Masonry Insulation	8.59* (1.51)
4. 6x8x16-in. (150x200x400-mm) Hollow Core Concrete Block	1.18** (0.21)
5. 1/8-in. (3-mm) Plaster	0.03* (0.01)
6. Inside Air Film	0.68* (0.12)
Total R	11.09 (1.95)
Total U+	0.09 (0.51)

With Metal Ties

R_T = 10.30 $hr \cdot ft^2 \cdot °F/Btu$ (1.81 $m^2 \cdot K/W$)

U = 0.10 $Btu/hr \cdot ft^2 \cdot °F$ (0.55 $W/m^2 \cdot K$)

With Metal Ties and Insulation Settlement

R_T = 8.83 $hr \cdot ft^2 \cdot °F/Btu$ (1.56 $m^2 \cdot K/W$)

U = 0.11 $Btu/hr \cdot ft^2 \cdot °F$ (0.64 $W/m^2 \cdot K$)

*Source: ASHRAE Handbook - 1981 Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, 1981.

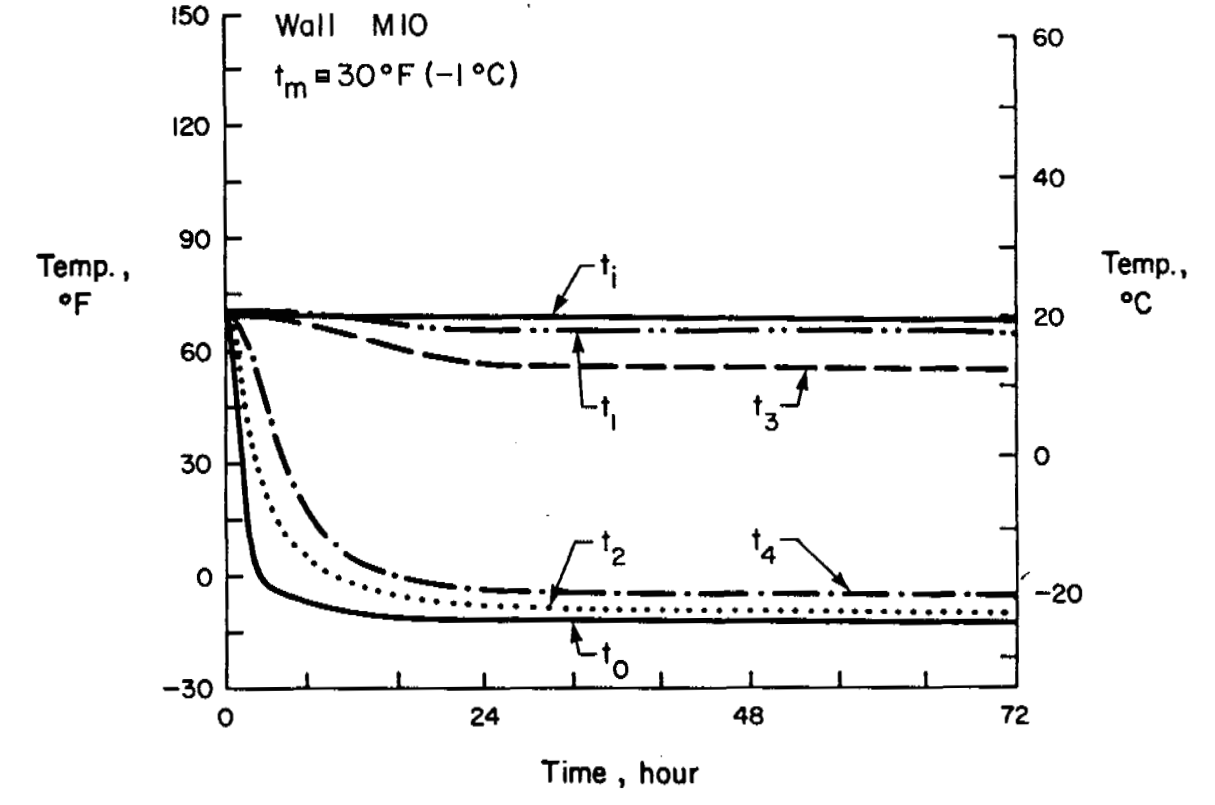
**Source: Randall, F. A., Jr., and Panarese, W. C., Concrete Masonry Handbook, Portland Cement Association, Bulletin EB008.04M, Skokie, 1980.

+Units for thermal transmittance are $Btu/hr \cdot ft^2 \cdot °F$ $(W/m^2 \cdot K)$

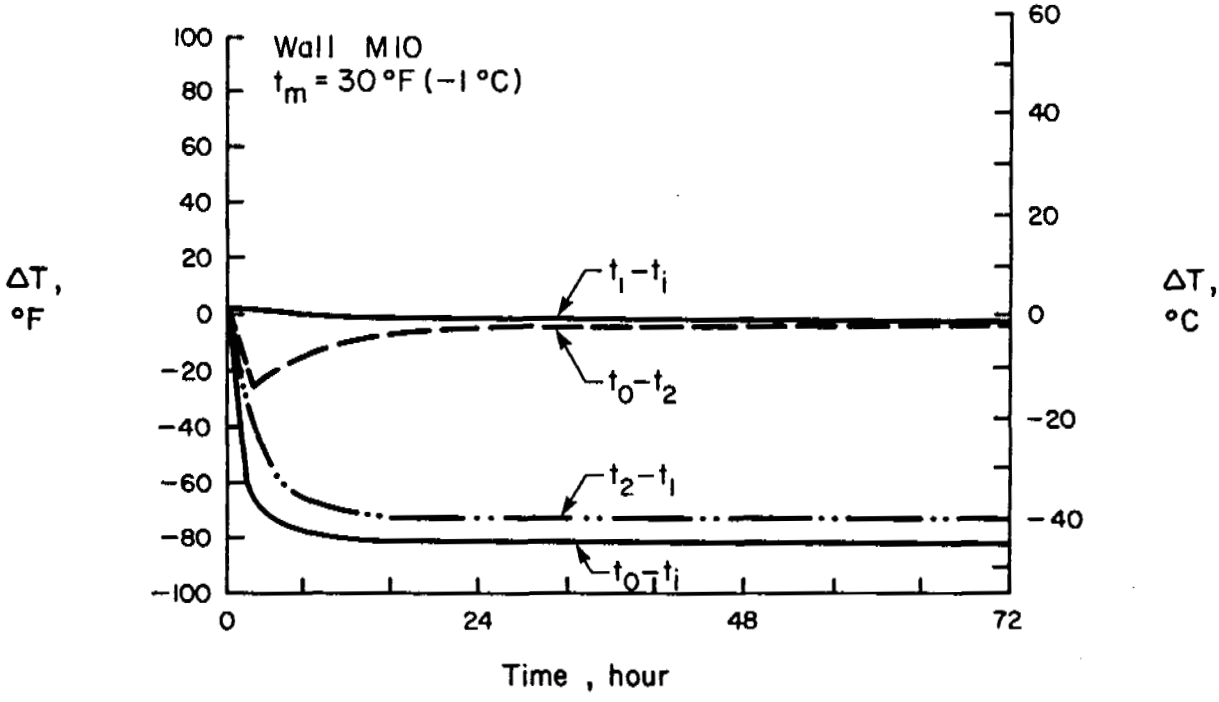
TABLE M10-4 - STEADY-STATE TEST RESULTS

Nominal Test Condition	q Heat Flux, Btu/hr·ft² (W/m²)	* R_T, hr·ft²·°F/Btu (m²·K/W)	* U, Btu/hr·ft²·°F (W/m²·K)	Measured Temperatures, °F (°C)						Relative Humidity		Laboratory Air Temperature	
				t_o Outdoor Air	t_2 Outdoor Surface	t_4 Internal Brick Surface	t_3 Internal Block Surface	t_1 Indoor Surface	t_i Indoor Air	Indoor Chamber, %	Outdoor Chamber, %	Max. °F (°C)	Min. °F (°C)
t_m = 100°F (38°C)	5.9 (18.7)	9.47 (1.67)	0.11 (0.60)	128 (53)	126 (52)	123 (51)	83 (37)	75 (24)	73 (23)	38	27	72 (24)	71 (23)
t_m = 32°F (0°C)	-9.0 (-28.4)	9.32 (1.64)	0.11 (0.61)	-12 (-24)	-8 (-22)	-4 (-20)	58 (14)	69 (21)	71 (22)	38	25	71 (22)	71 (22)
Design Values	--	8.83 (1.56)	0.11 (0.64)	--	--	--	--	--	--	--	--	--	--

*Total thermal resistance, R_T, and transmittance, U, for steady-state tests were calculated using the design surface resistance coefficients from Table M10-3 and measured values of heat flux.

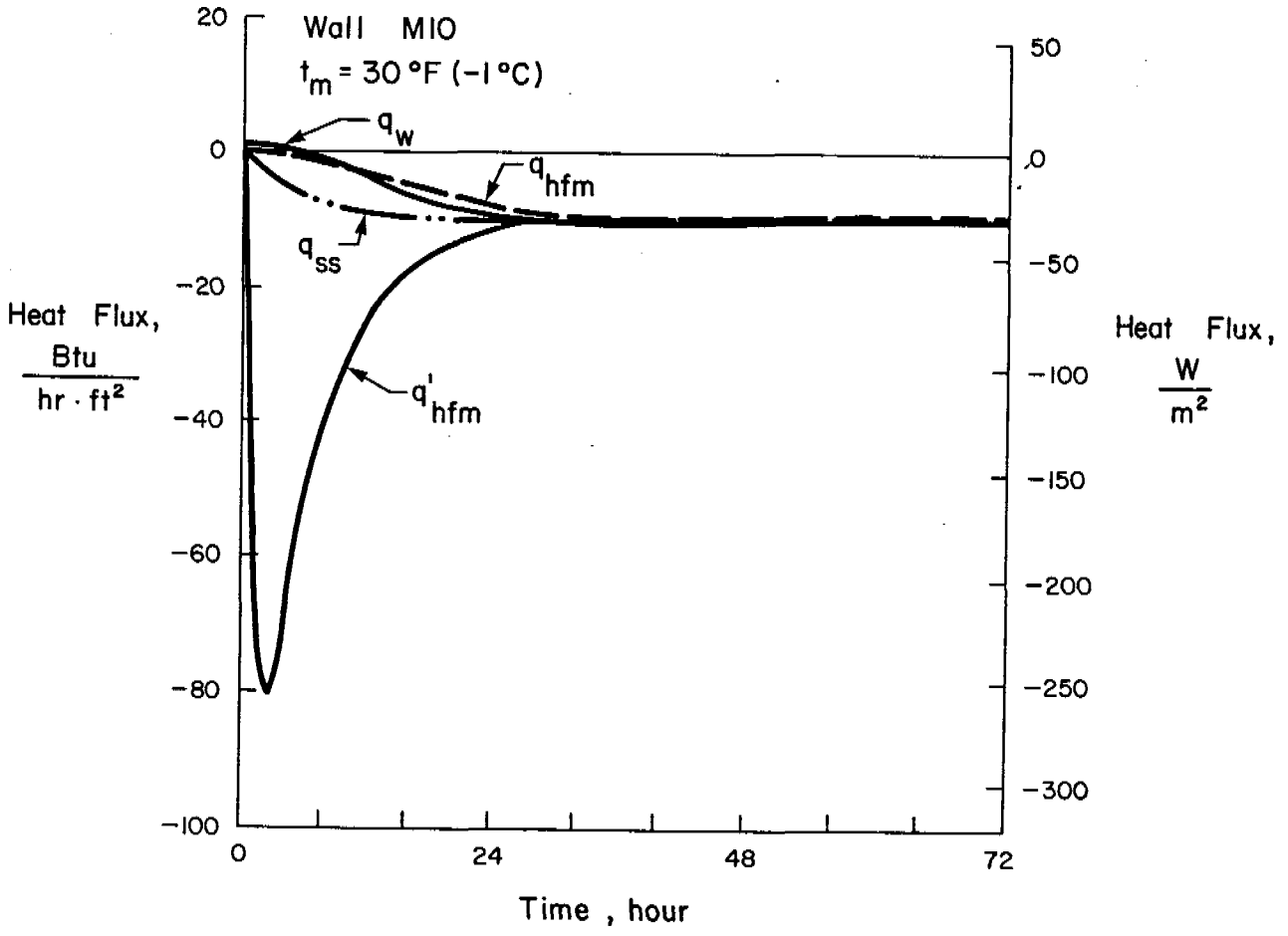


(a) Measured Temperatures



(b) Temperature Differentials

Fig. M10-1 Wall M10 Transient Test Results



(c) Heat Flux

Fig. M10-1 Wall M10 Transient Test Results

TABLE M10-5(a) - TRANSIENT TEST RESULTS

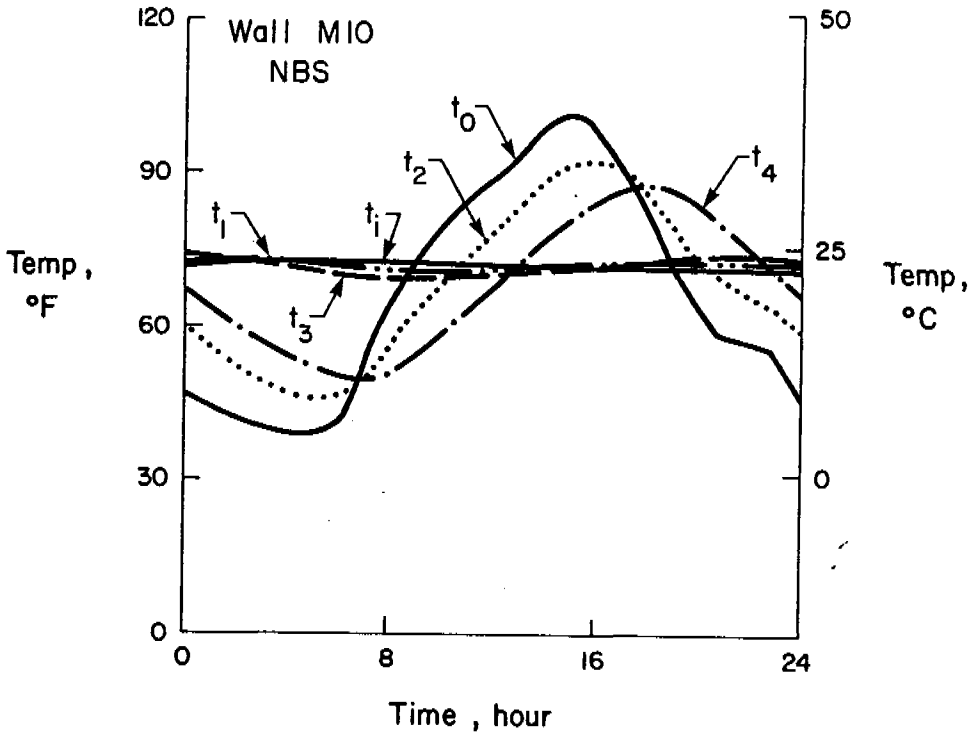
Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	73.2	73.5	73.0	72.5	72.3	71.9	0.7	0.1	0.1	0.1
1	42.8	60.3	71.8	72.4	72.3	72.0	1.0	0.0	-41.2	-1.4
2	14.7	41.9	64.6	72.2	72.3	72.0	1.2	0.0	-76.2	-3.6
3	3.2	30.0	54.2	71.6	72.3	72.0	1.0	0.0	-80.7	-5.0
4	-1.8	22.2	43.8	70.7	72.2	71.9	0.5	-0.1	-74.2	-5.9
5	-4.8	16.3	34.8	69.6	71.9	71.8	-0.1	-0.3	-66.2	-6.5
6	-6.6	11.8	27.5	68.5	71.8	71.8	-0.6	-0.7	-57.6	-7.0
7	-7.8	8.1	21.5	67.4	71.6	71.6	-1.3	-1.1	-49.6	-7.4
8	-8.7	5.3	16.9	66.4	71.4	71.6	-1.7	-1.5	-43.3	-7.7
9	-9.3	3.0	13.2	65.5	71.1	71.7	-2.3	-2.1	-37.8	-8.0
10	-9.8	1.1	10.2	64.7	70.9	71.6	-2.6	-2.6	-32.8	-8.2
11	-10.1	-0.4	7.6	63.9	70.7	71.5	-2.3	-3.2	-28.6	-8.3
12	-10.4	-1.7	5.6	63.2	70.4	71.4	-3.9	-3.7	-25.3	-8.4
13	-10.6	-2.7	3.8	62.6	70.2	71.3	-4.6	-4.2	-22.5	-8.5
14	-10.8	-3.5	2.4	62.1	70.1	71.2	-5.4	-4.7	-19.9	-8.6
15	-11.0	-4.2	1.3	61.7	69.9	71.2	-5.4	-5.1	-18.3	-8.7
16	-11.1	-4.7	0.4	61.2	69.7	71.2	-6.0	-5.5	-16.5	-8.7
17	-11.2	-5.2	-0.4	60.8	69.5	71.1	-7.2	-5.9	-15.3	-8.7
18	-11.3	-5.6	-1.0	60.5	69.5	71.1	-6.8	-6.2	-14.0	-8.8
19	-11.3	-5.9	-1.4	60.2	69.4	71.1	-6.9	-6.5	-13.2	-8.8
20	-11.4	-6.2	-1.8	59.5	69.2	71.1	-6.8	-6.8	-12.5	-8.8
21	-11.4	-6.5	-2.3	59.7	69.1	71.0	-7.2	-7.0	-11.6	-8.9
22	-11.5	-6.7	-2.5	59.4	69.0	71.0	-7.3	-7.3	-11.2	-8.9
23	-11.6	-6.8	-2.8	59.3	69.0	71.0	-7.2	-7.4	-10.7	-8.9
24	-11.6	-7.0	-2.9	59.1	68.9	71.1	-7.7	-7.6	-10.5	-8.9
26	-11.6	-7.2	-3.2	58.9	68.7	71.0	-7.9	-7.8	-9.8	-8.9
28	-11.7	-7.3	-3.5	58.7	68.7	71.0	-8.3	-8.0	-9.3	-8.9
30	-11.6	-7.4	-3.5	58.6	68.7	71.1	-8.3	-8.2	-9.1	-8.9
32	-11.6	-7.4	-3.7	58.6	68.5	71.1	-8.5	-8.3	-9.0	-8.9
34	-11.5	-7.4	-3.7	58.5	68.7	71.1	-8.6	-8.4	-8.8	-8.9
36	-11.7	-7.5	-3.8	58.4	68.6	71.0	-8.7	-8.4	-8.8	-8.9
38	-11.7	-7.6	-3.8	58.4	68.6	71.1	-8.4	-8.4	-8.6	-8.9
40	-11.7	-7.6	-3.9	58.4	68.6	71.1	-8.6	-8.6	-8.6	-8.9
42	-11.7	-7.6	-3.9	58.4	68.6	71.1	-8.6	-8.6	-8.5	-8.9
44	-11.7	-7.7	-4.1	58.3	68.5	71.0	-8.7	-8.6	-8.6	-8.9
46	-11.6	-7.6	-3.9	58.3	68.4	71.1	-8.1	-8.6	-8.5	-8.9
48	-11.6	-7.6	-3.9	58.3	68.5	71.1	-8.0	-8.5	-8.5	-8.9
50	-11.6	-7.6	-3.9	58.4	68.4	71.1	-7.3	-8.6	-8.4	-8.9
52	-11.7	-7.6	-3.9	58.3	68.4	71.1	-8.6	-8.6	-8.4	-8.9
54	-11.6	-7.6	-3.9	58.4	68.6	71.1	-8.8	-8.6	-8.5	-8.9
56	-11.6	-7.6	-3.9	58.3	68.6	71.1	-8.6	-8.6	-8.4	-8.9
58	-11.6	-7.5	-3.8	58.4	68.6	71.2	-9.4	-8.6	-8.4	-8.9
60	-11.6	-7.5	-3.9	58.3	68.6	71.1	-8.7	-8.6	-8.4	-8.9
62	-11.6	-7.6	-3.9	58.4	68.6	71.2	-8.8	-8.6	-8.5	-8.9
64	-11.6	-7.6	-3.9	58.4	68.6	71.2	-8.6	-8.6	-8.4	-8.9
66	-11.7	-7.6	-3.9	58.4	68.6	71.2	-9.6	-8.5	-8.4	-8.9
68	-11.6	-7.6	-3.9	58.4	68.6	71.1	-8.6	-8.6	-8.3	-8.9
70	-11.6	-7.6	-3.9	58.3	68.5	71.1	-8.2	-8.5	-8.4	-8.9
72	-11.7	-7.6	-3.9	58.3	68.6	71.1	-8.5	-8.6	-8.4	-8.9

TABLE M10-5(b) - TRANSIENT TEST RESULTS, SI UNITS

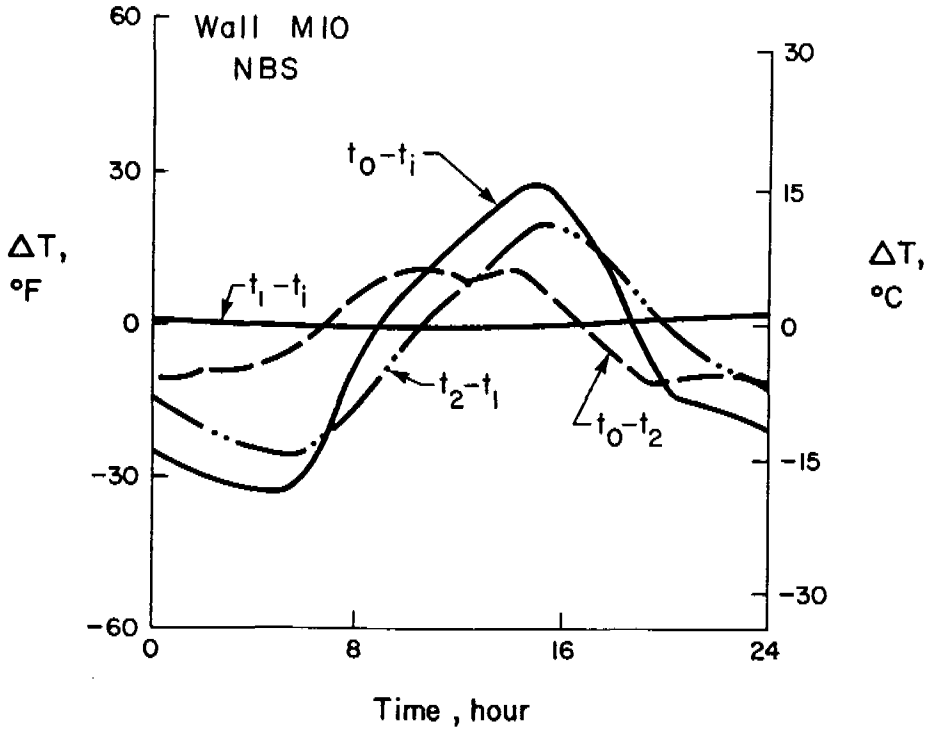
Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	22.9	23.1	22.8	22.5	22.4	22.2	2.1	0.3	0.4	0.4
1	6.0	15.7	22.1	22.4	22.4	22.2	3.3	0.0	-129.8	-4.4
2	-9.6	5.5	18.1	22.3	22.4	22.2	3.9	0.1	-240.4	-11.2
3	-16.0	-1.1	12.3	22.0	22.4	22.2	3.2	0.1	-254.7	-15.6
4	-18.8	-5.4	6.6	21.5	22.3	22.2	1.6	-0.4	-234.1	-18.5
5	-20.4	-8.7	1.6	20.9	22.2	22.1	-0.3	-1.0	-208.7	-20.5
6	-21.4	-11.2	-2.5	20.3	22.1	22.1	-1.8	-2.1	-181.9	-22.1
7	-22.1	-13.3	-5.8	19.7	22.0	22.0	-4.0	-3.4	-156.5	-23.4
8	-22.6	-14.8	-8.4	19.1	21.9	22.0	-5.3	-4.8	-136.7	-24.4
9	-22.9	-16.1	-10.4	18.6	21.7	22.1	-7.2	-6.6	-119.3	-25.1
10	-23.2	-17.2	-12.1	18.2	21.6	22.0	-8.2	-8.2	-103.5	-25.8
11	-23.4	-18.0	-13.6	17.7	21.5	21.9	-7.3	-10.0	-90.2	-26.2
12	-23.6	-18.7	-14.7	17.3	21.3	21.9	-12.3	-11.7	-79.8	-26.6
13	-23.7	-19.3	-15.7	17.0	21.2	21.8	-14.6	-13.4	-71.0	-26.9
14	-23.8	-19.7	-16.4	16.7	21.2	21.8	-16.9	-14.9	-62.8	-27.2
15	-23.9	-20.1	-17.1	16.5	21.1	21.8	-17.0	-16.1	-57.7	-27.3
16	-23.9	-20.4	-17.6	16.2	20.9	21.8	-18.9	-17.5	-52.1	-27.5
17	-24.0	-20.7	-18.0	16.0	20.8	21.7	-22.8	-18.7	-48.3	-27.6
18	-24.1	-20.9	-18.3	15.8	20.8	21.7	-21.4	-19.7	-44.2	-27.7
19	-24.1	-21.1	-18.6	15.7	20.8	21.7	-21.7	-20.5	-41.6	-27.8
20	-24.1	-21.2	-18.8	15.3	20.7	21.7	-21.6	-21.3	-39.5	-27.8
21	-24.1	-21.4	-19.1	15.7	20.6	21.7	-22.7	-22.0	-36.6	-27.9
22	-24.2	-21.5	-19.2	15.2	20.6	21.7	-23.0	-23.0	-35.2	-27.9
23	-24.2	-21.6	-19.3	15.2	20.6	21.7	-22.8	-23.2	-33.9	-28.0
24	-24.2	-21.7	-19.4	15.1	20.5	21.7	-24.2	-23.9	-33.0	-28.0
26	-24.2	-21.8	-19.6	14.9	20.4	21.7	-25.1	-24.7	-30.9	-28.0
28	-24.3	-21.8	-19.7	14.8	20.4	21.7	-26.1	-25.2	-29.5	-28.0
30	-24.2	-21.9	-19.7	14.8	20.4	21.7	-26.1	-25.8	-28.8	-28.1
32	-24.2	-21.9	-19.8	14.8	20.3	21.7	-26.9	-26.2	-28.4	-28.0
34	-24.2	-21.9	-19.8	14.7	20.4	21.7	-27.1	-26.5	-27.9	-28.1
36	-24.3	-21.9	-19.9	14.7	20.3	21.7	-27.4	-26.5	-27.8	-28.1
38	-24.3	-22.0	-19.9	14.7	20.3	21.7	-26.4	-26.6	-27.2	-28.1
40	-24.3	-22.0	-19.9	14.7	20.3	21.7	-27.1	-27.0	-27.1	-28.1
42	-24.3	-22.0	-19.9	14.7	20.3	21.7	-27.0	-27.0	-26.9	-28.1
44	-24.3	-22.1	-20.0	14.6	20.3	21.7	-27.4	-27.0	-27.1	-28.1
46	-24.2	-22.0	-19.9	14.6	20.2	21.7	-25.6	-27.1	-26.7	-28.0
48	-24.2	-22.0	-19.9	14.6	20.3	21.7	-25.1	-26.9	-26.7	-28.1
50	-24.2	-22.0	-19.9	14.7	20.2	21.7	-23.1	-27.1	-26.6	-28.0
52	-24.3	-22.0	-19.9	14.6	20.2	21.7	-27.1	-27.0	-26.6	-28.0
54	-24.2	-22.0	-19.9	14.7	20.3	21.7	-27.7	-27.0	-26.7	-28.1
56	-24.2	-22.0	-19.9	14.6	20.3	21.7	-27.1	-27.0	-26.6	-28.1
58	-24.2	-21.9	-19.9	14.7	20.3	21.8	-29.5	-27.1	-26.6	-28.1
60	-24.2	-21.9	-19.9	14.6	20.3	21.7	-27.6	-27.1	-26.6	-28.1
62	-24.2	-22.0	-19.9	14.7	20.3	21.8	-27.7	-27.0	-26.9	-28.1
64	-24.2	-22.0	-19.9	14.7	20.3	21.8	-27.1	-27.2	-26.6	-28.1
66	-24.3	-22.0	-19.9	14.7	20.3	21.8	-30.2	-26.9	-26.5	-28.1
68	-24.2	-22.0	-19.9	14.7	20.3	21.7	-27.0	-27.1	-26.2	-28.1
70	-24.2	-22.0	-19.9	14.6	20.3	21.7	-25.9	-26.9	-26.4	-28.1
72	-24.3	-22.0	-19.9	14.6	20.3	21.7	-26.7	-27.1	-26.5	-28.1

TABLE M10-6 - SUMMARY OF TRANSIENT TEST RESULTS

Heat Flux	Measured				Calculated	
	Calib. Hot Box		HFM @ Indoor Surf.		Steady-State	
	q_w, Btu/hr·ft^2 (W/m^2)	Time to Reach q_w, hr	q_{hfm}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{hfm}, hr	q_{ss}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{ss}, hr
99.5% of Final Heat Flux	-9.0 (-28.3)	58	-8.5 (-26.8)	40	-8.9 (-28.0)	23
95% of Final Heat Flux	-8.6 (-27.0)	33	-8.1 (-25.6)	29	-8.5 (-26.7)	13
90% of Final Heat Flux	-8.1 (-25.6)	28	-7.7 (-24.3)	26	-8.0 (-25.3)	10

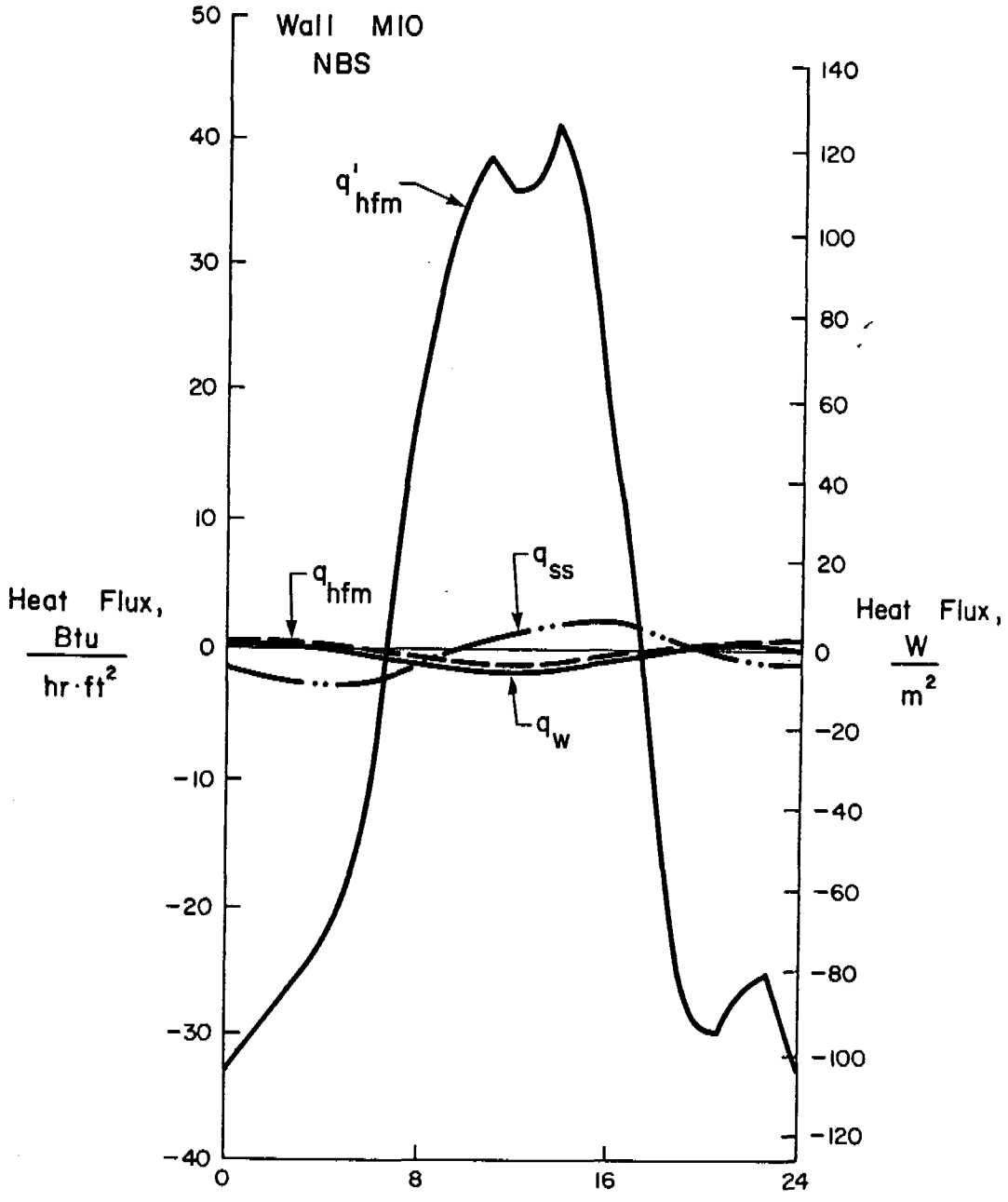


(a) Measured Temperatures



(b) Temperature Differentials

Fig. M10-2 Wall M10 Dynamic Test Results for NBS Test Cycle



(c) Heat Flux

Fig. M10-2 Wall M10 Dynamic Test Results for NBS Test Cycle

TABLE M10-7(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE

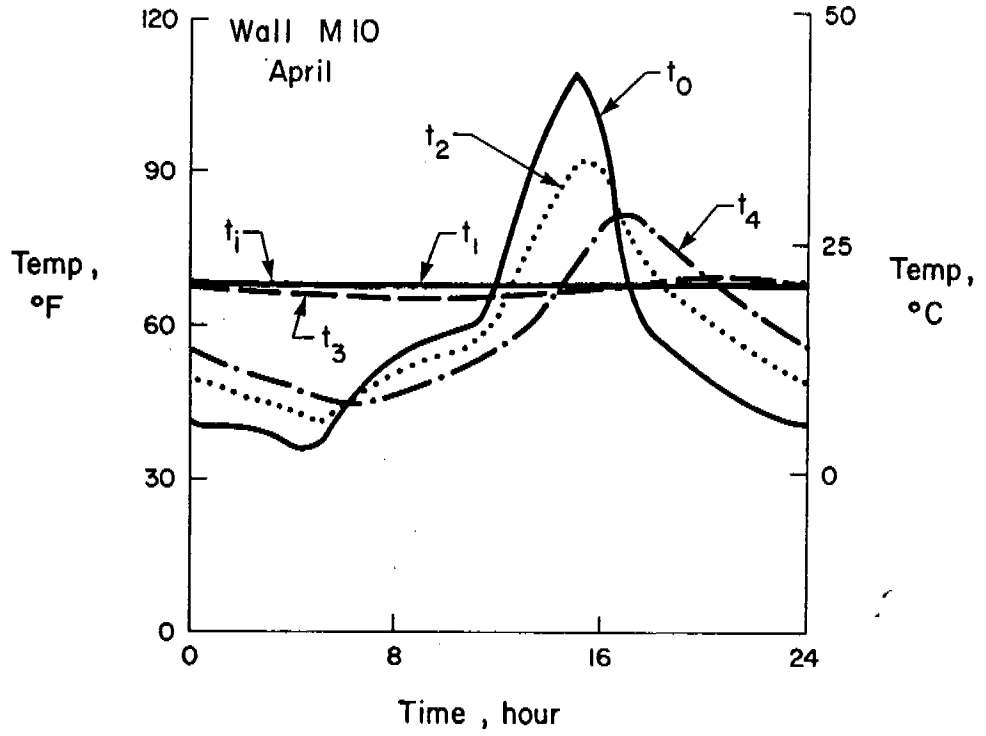
Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q'_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	44.3	54.8	63.0	72.5	72.6	72.3	0.62	0.51	-30.82	-2.09
2	42.4	52.1	59.6	72.0	72.6	72.2	0.48	0.37	-28.43	-2.40
3	40.2	49.4	56.5	71.5	72.5	72.2	0.11	0.25	-26.79	-2.70
4	39.6	47.5	53.8	71.0	72.3	72.1	-0.11	0.04	-23.59	-2.90
5	39.4	46.2	51.5	70.5	72.2	72.1	-0.31	-0.21	-20.14	-3.04
6	42.0	46.3	49.8	70.1	72.1	72.1	-0.76	-0.40	-13.90	-3.02
7	54.4	51.8	49.5	69.7	72.0	72.1	-0.75	-0.67	4.03	-2.36
8	64.5	58.0	51.6	69.4	71.9	72.0	-1.42	-0.88	17.95	-1.62
9	71.9	63.4	55.2	69.4	71.8	71.9	-1.69	-1.16	27.23	-0.99
10	79.4	69.6	60.1	69.6	71.7	71.9	-1.80	-1.31	34.64	-0.25
11	85.5	74.9	64.6	69.9	71.7	72.0	-1.90	-1.41	38.85	-0.37
12	88.6	78.8	69.2	70.3	71.7	72.0	-2.02	-1.45	36.73	0.83
13	92.9	83.0	73.3	70.8	71.8	72.0	-1.91	-1.40	37.36	1.31
14	99.5	88.3	77.6	71.3	71.9	72.0	-1.78	-1.30	41.89	1.92
15	101.1	91.8	81.9	71.9	72.0	72.1	-1.41	-1.12	36.74	2.31
16	97.4	92.0	85.3	72.5	72.1	72.1	-1.14	-0.89	22.77	2.32
17	91.7	90.1	87.1	73.1	72.3	72.2	-0.93	-0.64	9.53	2.09
18	82.4	85.9	87.2	73.5	72.4	72.2	-0.44	-0.38	-4.96	1.57
19	70.1	78.9	85.2	73.8	72.6	72.3	0.02	-0.09	-21.62	0.74
20	62.2	73.0	81.6	73.9	72.7	72.3	0.46	0.18	-29.52	0.04
21	57.9	68.6	77.3	73.7	72.7	72.3	0.60	0.37	-30.72	-0.48
22	57.1	66.1	73.3	73.6	72.8	72.2	0.31	0.51	-26.96	-0.78
23	54.9	63.6	70.1	73.3	72.8	72.3	0.63	0.58	-25.53	-1.08
24	46.8	58.2	66.7	72.9	72.7	72.3	0.56	0.56	-32.74	-1.70
Mean	66.9	68.0	68.0	71.7	72.2	72.1	-0.61	-0.41	-0.33	-0.50

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 33%
Outdoor Chamber - 24%

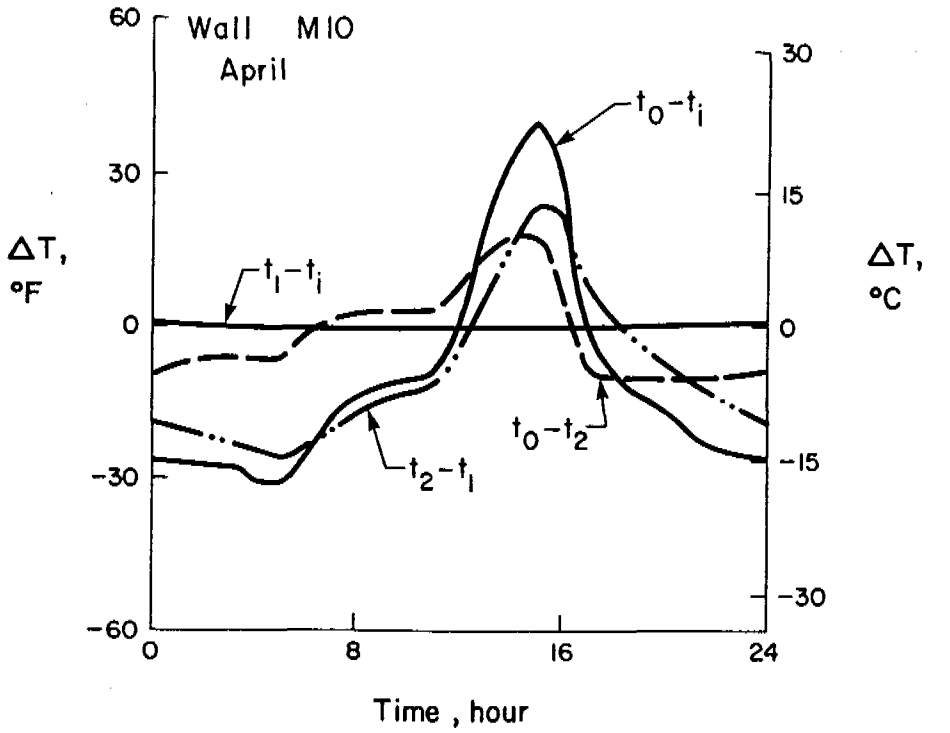
Laboratory Air Temperature:
Max. - 74°F (23°C)
Min. - 71°F (22°C)

TABLE M10-7(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	6.8	12.7	17.2	22.5	22.6	22.4	1.95	1.60	-97.24	-6.59
2	5.8	11.2	15.3	22.2	22.6	22.3	1.52	1.17	-89.70	-7.56
3	4.6	9.7	13.6	21.9	22.5	22.3	0.36	0.80	-84.52	-8.52
4	4.2	8.6	12.1	21.7	22.4	22.3	-0.36	0.12	-74.41	-9.16
5	4.1	7.9	10.8	21.4	22.3	22.3	-0.98	-0.67	-63.54	-9.58
6	5.6	7.9	9.9	21.2	22.3	22.3	-2.41	-1.27	-43.86	-9.52
7	12.4	11.0	9.7	20.9	22.2	22.3	-2.37	-2.10	12.72	-7.45
8	18.1	14.4	10.9	20.8	22.2	22.2	-4.49	-2.77	56.64	-5.12
9	22.2	17.4	12.9	20.8	22.1	22.2	-5.34	-3.66	85.92	-3.11
10	26.3	20.9	15.6	20.9	22.1	22.2	-5.69	-4.13	109.28	-0.80
11	29.7	23.8	18.1	21.1	22.1	22.2	-5.99	-4.46	122.57	1.16
12	31.4	26.0	20.7	21.3	22.1	22.2	-6.38	-4.59	115.89	2.62
13	33.8	28.3	22.9	21.6	22.1	22.2	-6.03	-4.42	117.87	4.12
14	37.5	31.3	25.3	21.8	22.2	22.2	-5.62	-4.11	132.17	6.07
15	39.4	33.2	27.7	22.2	22.2	22.3	-4.45	-3.53	115.92	7.30
16	36.3	33.3	29.6	22.5	22.3	22.3	-3.60	-2.82	71.84	7.32
17	33.2	32.3	30.6	22.8	22.4	22.3	-2.92	-2.00	30.07	6.59
18	28.0	29.9	30.7	23.1	22.4	22.3	-1.40	-1.20	-15.66	4.97
19	21.2	26.1	29.6	23.2	22.6	22.4	0.06	-0.29	-68.20	2.32
20	16.8	22.8	27.6	23.3	22.6	22.4	1.45	0.55	-93.15	0.11
21	14.4	20.3	25.2	23.2	22.6	22.4	1.90	1.17	-96.94	-1.51
22	13.9	18.9	22.9	23.1	22.7	22.3	0.99	1.61	-85.06	-2.47
23	12.7	17.6	21.2	22.9	22.7	22.4	2.00	1.82	-80.56	-3.41
24	8.2	14.6	19.3	22.7	22.6	22.4	1.77	1.75	-103.29	-5.37
Mean	19.4	20.0	20.0	22.1	22.3	22.3	-1.92	-1.31	-1.05	-1.57

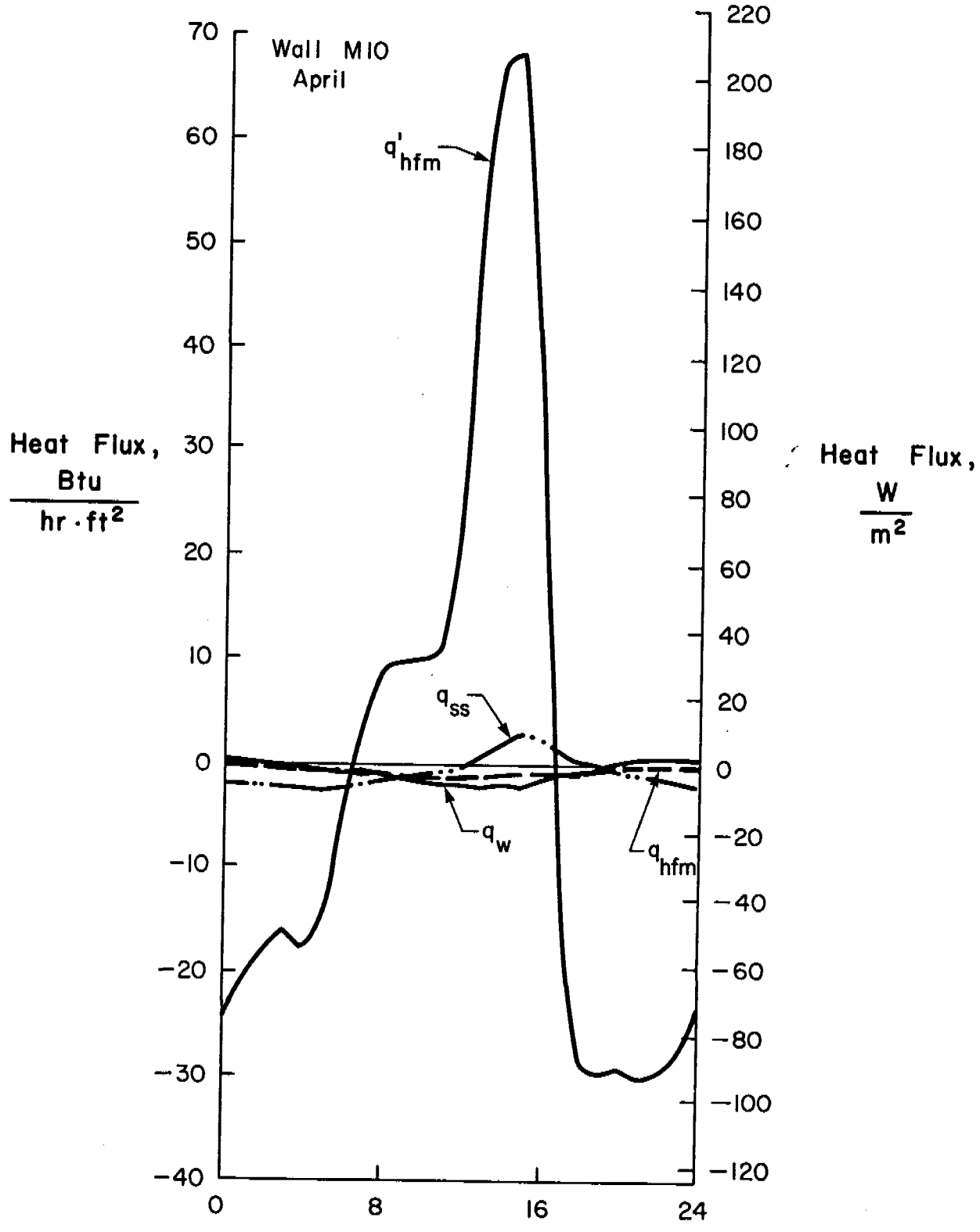


(a) Measured Temperatures



(b) Temperature Differentials

Fig. M10-3 Wall M10 Dynamic Test Results for Gaithersburg April Test Cycle



(c) Heat Flux

Fig. M10-3 Wall M10 Dynamic Test Results for Gaithersburg April Test Cycle

TABLE M10-8(a) - DYNAMIC TEST RESULTS (PERIODIC), GAITHERSBURG APRIL TEST CYCLE

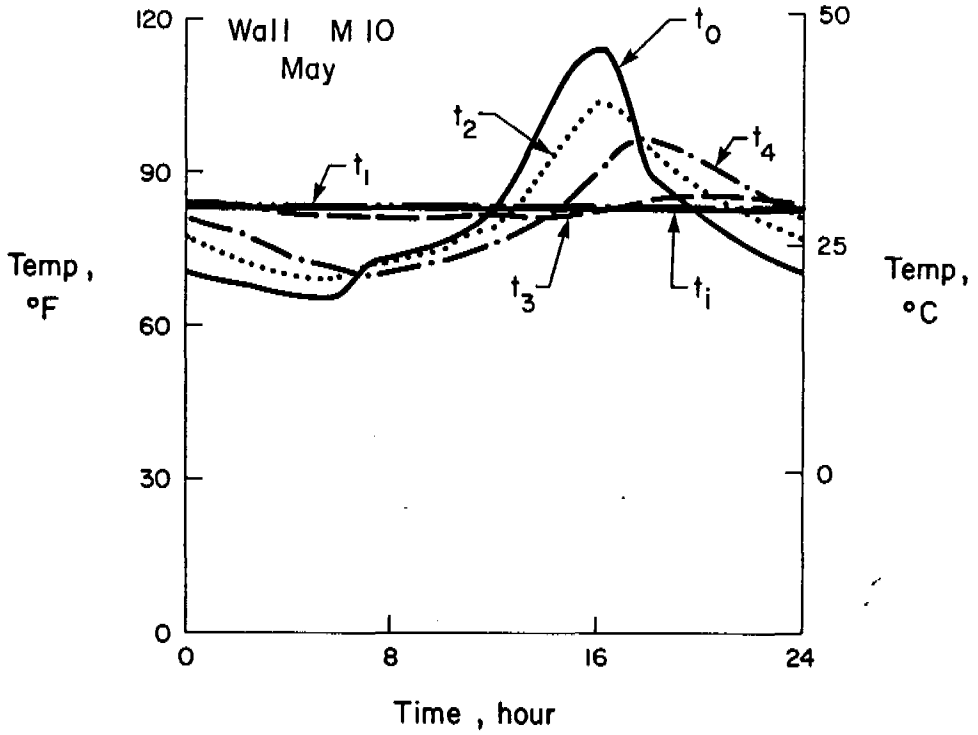
Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q'_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	40.9	47.9	53.1	67.2	68.2	68.1	0.20	-0.12	-20.56	-2.39
2	40.5	46.6	51.1	66.9	68.2	68.0	-0.04	-0.29	-17.91	-2.53
3	39.7	45.3	49.5	66.5	68.1	68.0	-0.23	-0.43	-16.27	-2.66
4	36.9	43.2	47.9	66.1	68.0	68.0	-0.44	-0.61	-17.43	-2.90
5	36.3	41.8	46.1	65.8	67.9	67.9	-0.75	-0.79	-15.77	-3.05
6	43.2	44.3	45.0	65.4	67.8	67.9	-1.06	-1.00	-5.04	-2.75
7	50.3	48.2	45.6	65.2	67.7	67.9	-1.10	-1.19	4.43	-2.29
8	54.1	51.0	47.3	65.0	67.6	67.8	-1.41	-1.38	8.51	-1.95
9	56.1	53.1	49.3	65.0	67.6	67.8	-1.73	-1.52	9.68	-1.69
10	57.6	54.7	51.2	65.1	67.6	67.8	-2.08	-1.62	9.92	-1.50
11	59.4	56.4	53.0	65.2	67.5	67.8	-2.16	-1.73	10.61	-1.31
12	68.5	61.3	55.0	65.3	67.5	67.8	-2.14	-1.80	23.63	-0.73
13	87.6	72.2	58.9	65.5	67.6	67.8	-2.47	-1.79	52.93	0.55
14	102.0	83.4	65.7	66.0	67.6	67.8	-2.09	-1.78	67.30	1.84
15	109.5	91.8	73.7	66.7	67.7	67.8	-2.46	-1.68	67.97	2.82
16	98.7	90.7	80.5	67.6	67.8	67.9	-1.89	-1.51	35.59	2.68
17	68.9	77.5	82.2	68.4	67.9	68.0	-1.18	-1.26	-15.49	1.12
18	58.1	69.3	78.6	68.9	68.1	68.0	-1.11	-0.91	-28.87	0.14
19	54.3	65.0	74.0	69.0	68.3	68.0	-0.54	-0.58	-29.81	-0.38
20	51.4	61.5	69.7	68.7	68.4	68.1	0.03	-0.33	-29.05	-0.81
21	47.0	57.5	65.8	68.7	68.4	68.1	0.40	-0.13	-30.28	-1.27
22	43.7	54.0	62.0	68.4	68.5	68.1	0.28	-0.04	-24.14	-1.69
23	42.1	51.4	58.5	68.0	68.4	68.1	0.42	0.01	-27.17	-1.99
24	41.1	49.3	55.6	67.6	68.4	68.1	0.25	-0.04	-24.14	-2.23
Mean	57.8	59.1	59.1	66.8	67.9	67.9	-0.97	-0.94	-0.71	-1.04

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 40%
Outdoor Chamber - 27%

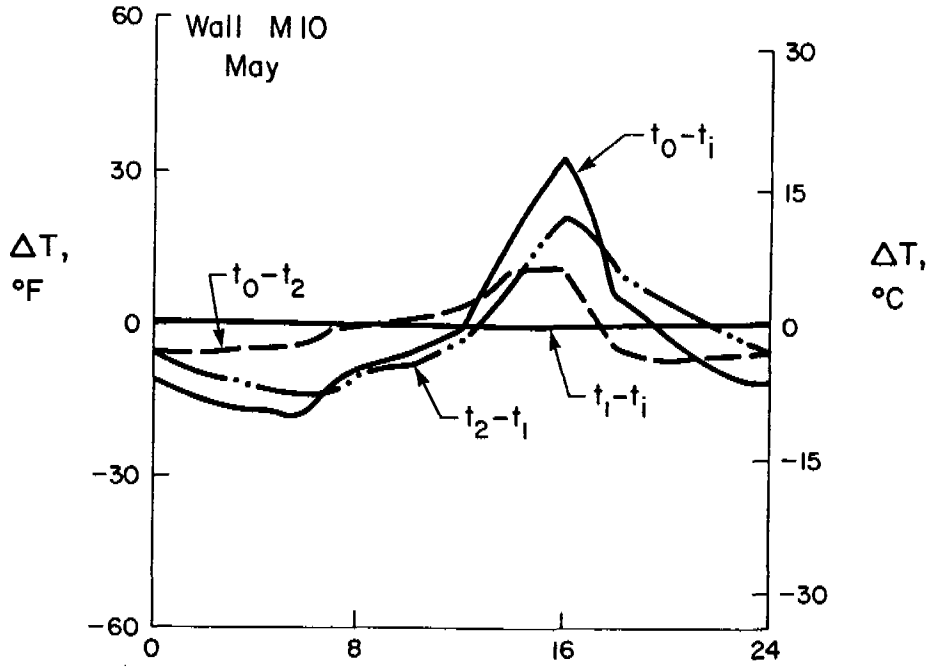
Laboratory Air Temperature:
Max. - 72°F (22°C)
Min. - 71°F (22°C)

TABLE M10-8(b) - DYNAMIC TEST RESULTS (PERIODIC), GAITHERSBURG APRIL TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	4.9	8.8	11.7	19.5	20.1	20.1	0.63	-0.38	-64.86	-7.52
2	4.7	8.1	10.6	19.4	20.1	20.0	-0.12	-0.92	-56.52	-7.97
3	4.3	7.4	9.7	19.2	20.1	20.0	-0.71	-1.36	-51.34	-8.39
4	2.7	6.2	8.8	18.9	20.0	20.0	-1.40	-1.92	-54.99	-9.15
5	2.4	5.4	7.8	18.8	19.9	19.9	-2.38	-2.50	-49.74	-9.61
6	6.2	6.8	7.2	18.6	19.9	19.9	-3.36	-3.16	-15,91	-8.69
7	10.2	9.0	7.6	18.4	19.8	19.9	-3.46	-3.76	13.96	-7.21
8	12.3	10.5	8.5	18.3	19.8	19.9	-4.44	-4.34	26.85	-6.14
9	13.4	11.7	9.6	18.3	19.8	19.9	-5.46	-4.79	30.55	-5.34
10	14.2	12.6	10.7	18.4	19.8	19.9	-6.57	-5.13	31.30	-4.73
11	15.2	13.6	11.7	18.4	19.7	19.9	-6.80	-5.47	33.48	-4.12
12	20.3	16.3	12.8	18.5	19.7	19.9	-6.74	-5.67	74.54	-2.29
13	30.9	22.3	14.9	18.6	19.8	19.9	-7.79	-5.64	166.99	1.73
14	38.9	28.6	18.7	18.9	19.8	19.9	-6.58	-5.63	212.34	5.81
15	43.1	33.2	23.2	19.3	19.8	19.9	-7.78	-5.31	214.44	8.90
16	37.1	32.6	26.9	19.8	19.9	20.0	-5.95	-4.78	112.29	8.46
17	20.5	25.3	27.9	20.2	19.9	20.0	-3.71	-3.97	-48.86	3.54
18	14.5	20.7	25.9	20.5	20.1	20.0	-3.51	-2.88	-91.08	0.44
19	12.4	18.3	23.3	20.6	20.2	20.0	-1.70	-1.83	-94.05	-1.20
20	10.8	16.4	20.9	20.4	20.2	20.1	0.09	-1.05	-91.65	-2.54
21	8.3	14.2	18.8	20.4	20.2	20.1	1.27	-0.41	-95.52	-4.02
22	6.5	12.2	16.7	20.2	20.3	20.1	0.90	-0.12	-94.22	-5.32
23	5.6	10.8	14.7	20.0	20.2	20.1	1.34	0.03	-85.72	-6.28
24	5.1	9.6	13.1	19.8	20.2	20.1	0.78	-0.13	-76.15	-7.04
Mean	14.3	15.1	15.1	19.3	19.9	19.9	-3.06	-2.96	-2.24	-3.28

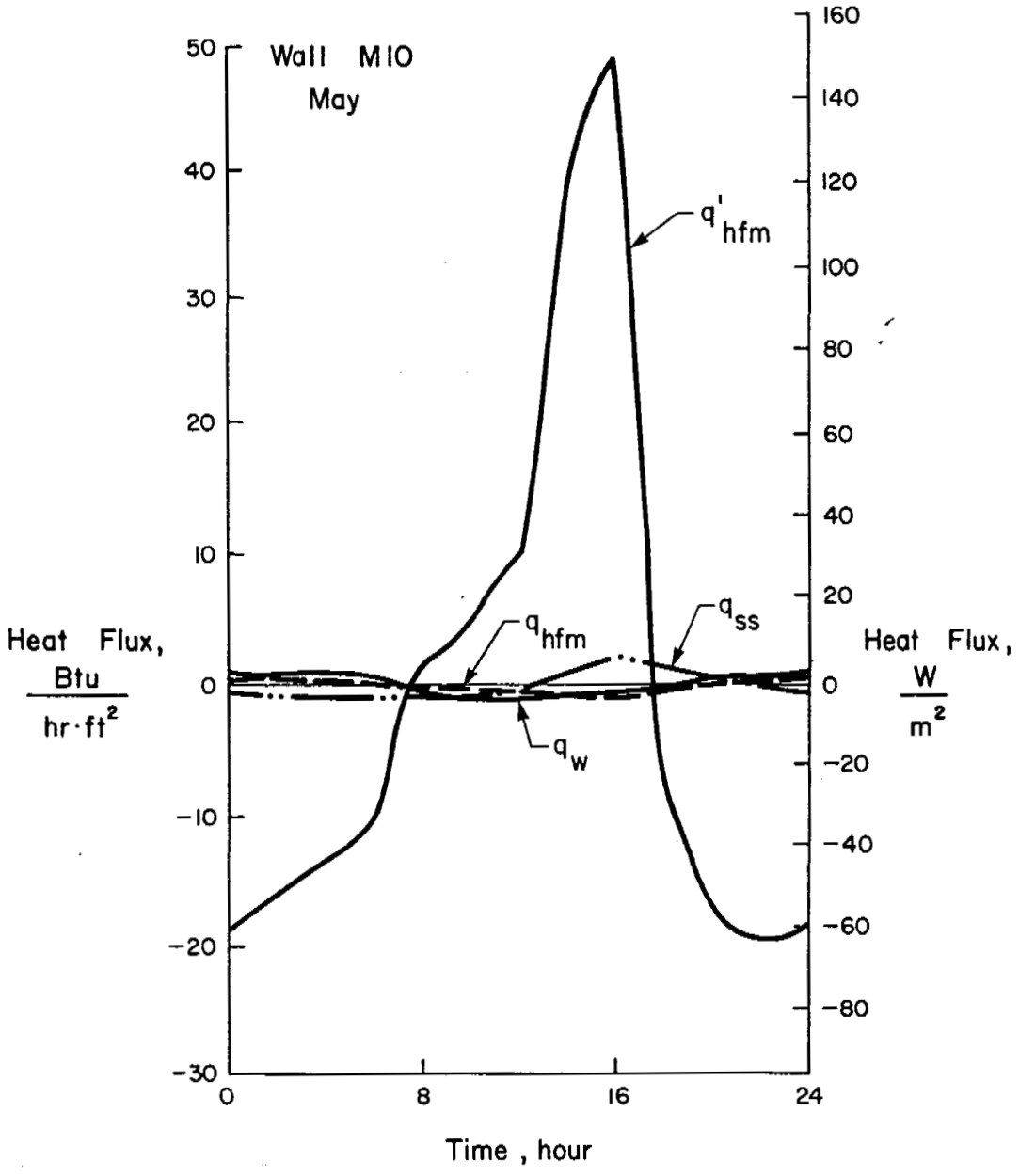


(a) Measured Temperatures



(b) Temperature Differentials

Fig. M10-4 Wall M10 Dynamic Test Results for Gaithersburg May Test Cycle



(c) Heat Flux

Fig. M10-4 Wall M10 Dynamic Test Results for Gaithersburg May Test Cycle

TABLE M10-9(a) - DYNAMIC TEST RESULTS (PERIODIC), GAITHERSBURG MAY TEST CYCLE*

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q'_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	69.5	75.5	79.9	84.1	83.8	83.2	0.56	0.53	-18.34	-0.98
2	67.9	73.6	77.9	83.8	83.8	83.3	0.63	0.44	-17.31	-1.19
3	67.0	72.2	76.0	83.4	83.6	83.3	0.47	0.41	-15.99	-1.33
4	66.5	71.2	74.4	83.1	83.6	83.1	0.60	0.30	-14.19	-1.45
5	65.3	69.9	73.0	82.8	83.4	83.2	0.16	0.16	-13.74	-1.59
6	66.6	69.9	71.8	82.5	83.4	83.2	0.04	0.02	-9.94	-1.61
7	72.1	72.1	71.3	82.3	83.4	83.2	-0.34	-0.17	-1.21	-1.32
8	74.1	73.4	71.9	82.1	83.3	83.1	-0.62	-0.30	1.69	-1.16
9	75.2	74.3	72.6	81.9	83.2	83.1	-0.78	-0.43	2.83	-1.04
10	76.9	75.5	73.4	81.9	83.2	83.1	-1.04	-0.57	4.49	-0.90
11	80.4	78.2	75.1	82.1	83.4	83.4	-1.14	-0.78	7.91	-0.61
12	82.8	79.9	76.4	82.2	83.4	83.4	-1.13	-0.87	10.02	-0.41
13	90.9	84.2	78.2	81.9	83.3	83.4	-0.98	-0.93	21.78	0.11
14	102.6	91.8	81.4	82.5	83.3	83.4	-0.92	-0.92	39.37	0.99
15	110.8	98.7	86.1	82.8	83.3	83.4	-1.15	-0.88	46.91	1.80
16	116.9	104.8	91.3	83.3	83.4	83.3	-1.07	-0.71	49.25	2.50
17	106.7	102.9	95.9	83.9	83.4	83.2	-0.77	-0.63	21.01	2.27
18	90.3	94.8	96.7	84.4	83.5	83.3	-0.53	-0.39	-7.62	1.32
19	86.3	91.5	95.0	84.8	83.6	83.3	0.11	-0.19	-11.98	0.93
20	80.9	87.6	92.6	84.9	83.7	83.3	0.19	0.08	-17.63	0.45
21	78.4	84.9	89.9	84.9	83.7	83.4	0.69	0.21	-18.45	0.13
22	75.2	82.0	87.2	84.8	83.9	83.3	0.53	0.38	-19.93	-0.22
23	72.7	79.4	84.5	84.6	83.9	83.3	0.64	0.44	-20.19	-0.52
24	71.2	77.4	82.1	84.0	83.8	83.3	0.84	0.50	-18.99	-0.74
Mean	81.1	81.9	81.5	83.3	83.5	83.3	-0.21	-0.18	-0.01	-0.19

*Data are 2-day averages, not 3-day averages, of test results.

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 34%
Outdoor Chamber - 26%

Laboratory Air Temperature:
Max. - 80°F (27°C)
Min. - 71°F (22°C)

TABLE M10-9(b) - DYNAMIC TEST RESULTS (PERIODIC), GAITHERSBURG MAY TEST CYCLE, SI UNITS*

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Internal Brick Surf.	t_3 Internal Block Surf.	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	20.8	24.2	26.6	28.9	28.8	28.4	1.76	1.66	-57.86	-3.08
2	19.9	23.1	25.5	28.8	28.8	28.5	1.98	1.38	-54.62	-3.75
3	19.4	22.3	24.4	28.6	28.7	28.5	1.47	1.29	-50.43	-4.19
4	19.2	21.8	23.6	28.4	28.7	28.4	1.91	0.95	-44.77	-4.59
5	18.5	21.1	22.8	28.2	28.6	28.4	0.51	0.49	-43.36	-5.00
6	19.2	20.9	22.1	28.1	28.6	28.4	0.12	0.05	-31.37	-5.08
7	22.3	22.3	21.8	27.9	28.6	28.4	-1.08	-0.55	-3.83	-4.17
8	23.4	23.0	22.2	27.8	28.5	28.4	-1.97	-0.96	5.32	-3.65
9	24.0	23.5	22.6	27.7	28.4	28.4	-2.45	-1.37	8.94	-3.29
10	24.9	24.2	23.0	27.7	28.4	28.4	-3.27	-1.80	14.17	-2.84
11	26.9	25.7	23.9	27.8	28.6	28.6	-3.59	-2.47	24.96	-1.92
12	28.2	26.6	24.7	27.9	28.6	28.6	-3.57	-2.74	31.62	-1.30
13	32.7	29.0	25.7	27.7	28.5	28.6	-3.08	-2.95	68.72	0.34
14	39.2	33.2	27.4	28.1	28.5	28.6	-2.90	-2.89	124.21	3.14
15	43.8	37.1	30.1	28.2	28.5	28.6	-3.64	-2.79	148.00	5.67
16	47.2	40.4	32.9	28.5	28.6	28.5	-3.39	-2.24	155.40	7.88
17	41.5	39.4	35.5	28.8	28.6	28.4	-2.44	-1.99	66.28	7.17
18	32.4	34.9	35.9	29.1	28.6	28.5	-1.66	-1.23	-24.03	4.15
19	30.2	33.1	35.0	29.3	28.7	28.5	0.33	-0.60	-37.80	2.95
20	27.2	30.9	33.7	29.4	28.7	28.5	0.59	0.26	-55.63	1.43
21	25.8	29.4	32.2	29.4	28.7	28.6	2.17	0.67	-58.19	0.42
22	24.0	27.8	30.7	29.3	28.8	28.5	1.67	1.21	-62.88	-0.68
23	22.6	26.3	29.2	29.2	28.8	28.5	2.02	1.37	-63.71	-1.65
24	21.8	25.2	27.8	28.9	28.8	28.5	2.64	1.56	-59.92	-2.34
Mean	27.3	27.7	27.5	28.5	28.6	28.5	-0.66	-0.57	-0.03	-0.60

*Data are 2-day averages, not 3-day averages, of test results.

TABLE M10-10 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), THERMAL LAG

Test Cycle	Thermal Lag, hrs								Calc. Time Constant, hrs
	Measured								
	Calibrated Hot Box					Heat Flow Meter			
	t_o vs t_1		q_{ss} vs q_w		Avg.	q_{ss} vs q_{hfm}		Avg.	
	@ Max.	@ Min.	@ Max.	@ Min.		@ Max.	@ Min.		
NBS	7.5	6	7	7	7	7	7	7	2.7
Gaith. April	7	6.5	8	9	7.5	8	7	7.5	2.7
Gaith. May	8	4.5	8	9	7.5	9	7	8	2.7

TABLE M10-11 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), REDUCTION IN AMPLITUDE

Test Cycle	Measured, %					
	Calibrated Hot Box			Heat Flow Meter		
	@ Max.	@ Min.	Avg.	@ Max.	@ Min.	Avg.
NBS	56	44	50	65	59	62
Gaith. April	64	25	45	75	57	66
Gaith. May	61	33	47	74	47	61

TABLE M10-12 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), ENERGY REQUIREMENTS

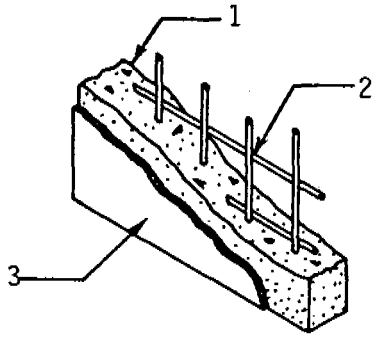
Test Cycle	Total Energy, Btu/ft^2 (W·hr/m^2)			Total Energy Comparisons, %		Net Energy, Btu/ft^2 (W·hr/m^2)			Net Energy Comparisons, %	
	Measured		Calculated			Measured		Calculated		
	q_w^T	q_{hfm}^T	q_{ss}^T	$\frac{q_w^T}{q_{ss}^T}$	$\frac{q_{hfm}^T}{q_{ss}^T}$	q_w^N	q_{hfm}^N	q_{ss}^N	$\frac{q_w^N}{q_{ss}^N}$	$\frac{q_{hfm}^N}{q_{ss}^N}$
NBS	22.2 (70.0)	16.7 (52.6)	38.9 (122.8)	57	43	-14.6 (-46.0)	-10.0 (-31.4)	-11.9 (-37.6)	122	84
Gaith. April	26.5 (83.5)	22.5 (71.1)	43.2 (136.4)	61	52	-23.3 (-73.5)	-22.5 (-71.1)	-24.9 (-78.7)	93	90
Gaith. May	15.9 (50.2)	11.2 (35.5)	25.6 (80.7)	62	44	-5.0 (-15.9)	-4.3 (-13.7)	-4.6 (-14.4)	110	95

WALL C4: 8-in. (200-mm) NORMAL WEIGHT CONCRETE WITH INSULATION ON OUTSIDE SURFACE

DESCRIPTION: Normal weight structural concrete wall with reinforcement at approximate midthickness and board insulation on outside surface.

REFERENCE: Larson, S. C. and Van Geem, M. G., "Heat Transfer Characteristics of Walls with Similar Thermal Resistance Values," Construction Technology Laboratories, Portland Cement Association, Skokie, 1985, 145 pages.

COMPOSITION:



1. Normal Weight Concrete
   Portland Cement
   Elgin Gravel and Sand
   Vinsol Resin Air-Entraining Admixture
   Exterior Finish - Off-white Concrete
   Coating and Waterproofing

2. Reinforcement
   Single layer of Grade 60 No. 5 bars
   Spaced 12 in. (300 mm)
   center-to-center

3. 5/8-in. (16-mm) Board Insulation, Painted
   Off-white

TABLE C4-1 - PHYSICAL PROPERTIES OF WALL AT TIME OF TEST

Property	Measured Value
Unit Weight, psf (kg/m^2)	98.5 (480)
Average Thickness, in. (mm)	8.90 (225)
Area, ft^2 (m^2)	73.75 (6.85)
Estimated Moisture Content, % by ovendry weight	0.8*

*Measured on concrete, after test.

TABLE C4-2(a) - MATERIAL PROPERTIES, NORMAL WEIGHT CONCRETE*

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Unit Weight, pcf (kg/m^3)	--	ovendry	--	141 (2260)
Specific Heat, Btu/lb·°F (J/kg·K)	Similar to CRD-C124-73	saturated	73 (23)	0.214 (896)
Specific Heat, Btu/lb·°F (J/kg·K)	Calculated	air dry	73 (23)	0.193 (808)
Thermal Conductivity, Btu·in/hr·ft^2·°F (W/m·K)	Hot Wire	air dry	--	20.3 (2.93)
Thermal Conductivity, Btu·in/hr·ft^2·°F (W/m·K)	ASTM C177	ovendry	70 (21)	16.1 (2.32)
Thermal Conductivity, Btu·in/hr·ft^2·°F (W/m·K)	ASTM C976	air dry	70 (21)	11.7 (1.69)
Thermal Diffusivity, ft^2/hr (mm^2/s)	CRD-C36-73	saturated	--	0.037 (0.955)
Compressive Strength, psi (MPa)	ASTM C39	air dry	--	5715 (39.4)
Splitting Tensile Strength, psi (MPa)	ASTM C496	air dry	--	514 (3.54)

*Wall C1 was used as the concrete portion of Wall C4. Properties listed in this table were measured on the material used to construct Wall C1. Wall C1 is included in the "Calibrated Hot Box Test Results Data Manual - Volume I."

TABLE C4-2(b) - MATERIAL PROPERTIES, R-5 BOARD INSULATION

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Nominal Thickness, in. (mm)	--	--	--	0.63 (16)
Thickness, as received, in. (mm)	--	--	--	0.69 (17)
Density, as received, pcf (kg/m^3)	--	--	--	2.2 (36)

TABLE C4-3 - DESIGN HEAT TRANSMISSION COEFFICIENTS

Component	R, Thermal Resistance $hr \cdot ft^2 \cdot °F/Btu$ $(m^2 \cdot K/W)$
1. Outside Air Film	0.17* (0.03)
2. 5/8-in. (16-mm) Board Insulation	5.4** (0.95)
3. 8-in. (200-mm) Normal Weight Concrete	0.69* (0.12)
3. Inside Air Film	0.68* (0.12)
Total R	6.94 (1.22)
Total U+	0.14 (0.82)

*Source: ASHRAE Handbook - 1981 Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers,Inc., Atlanta, 1981, Chapter 23.

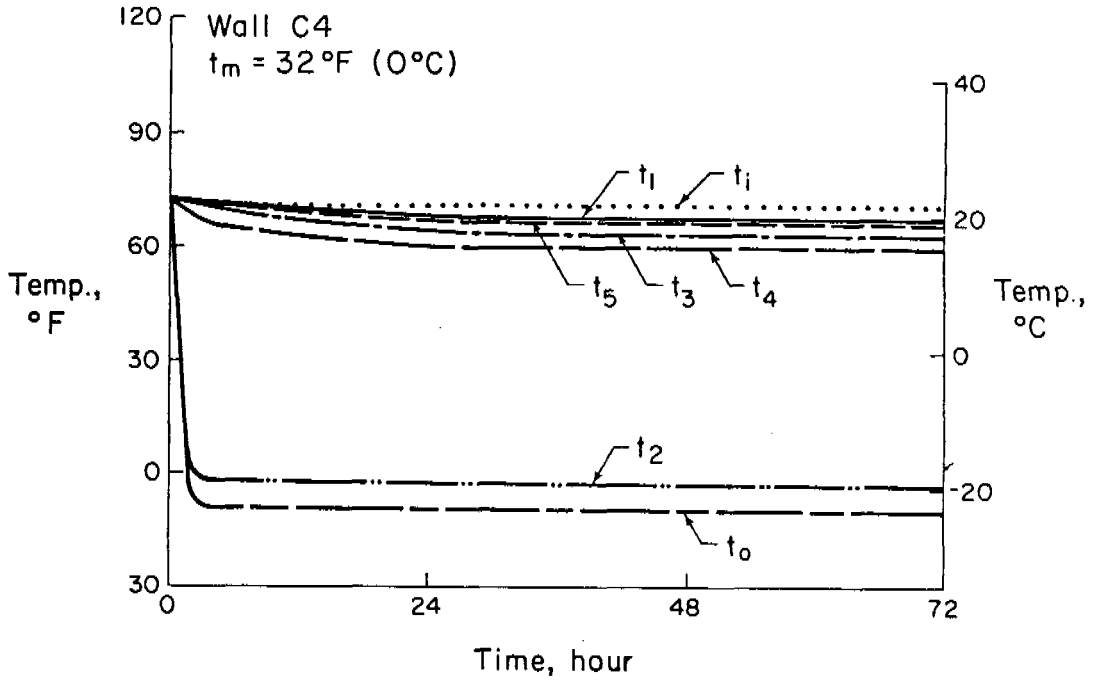
**Source: R-value at time of manufacture per manufacturer's specifications.

+Units for thermal transmittance are $Btu/hr \cdot ft^2 \cdot °F$ $(W/m^2 \cdot K)$

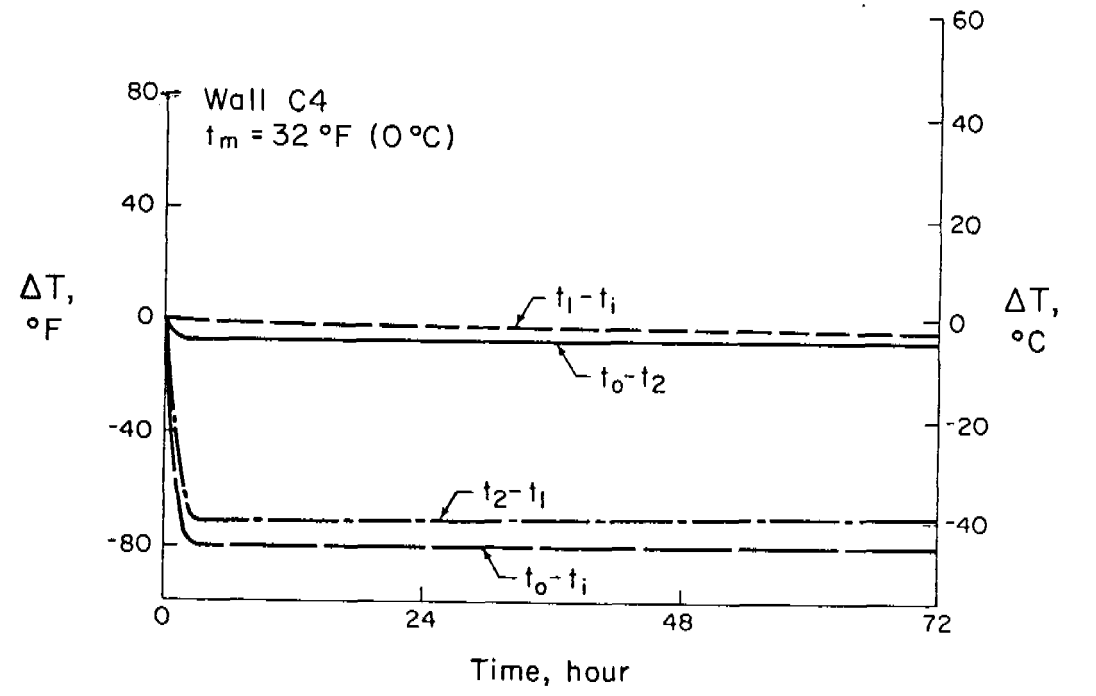
TABLE C4-4 - STEADY-STATE TEST RESULTS

Nominal Test Condition	q Heat Flux, Btu/hr·ft^2 (W/m^2)	R_T,* hr·ft^2·°F/Btu (m^2·K/W)	U,* Btu/hr·ft^2·°F (W/m^2·K)	Measured Temperatures, °F (°C)						Relative Humidity		Laboratory Air Temperature	
				t_o Outdoor Air	t_2 Outdoor Surface	t_4 Conc./ Insul.	t_5 Indoor Surface, Embed.	t_1 Indoor Surface, Taped	t_i Indoor Air	Indoor Chamber, %	Outdoor Chamber, %	Max. °F (°C)	Min. °F (°C)
t_m = 32°F (0°C)	-10.0 (-31.5)	7.85 (1.38)	0.13 (0.72)	-10 (-23)	-3 (-19)	58 (14)	66 (19)	67 (19)	71 (21)	18	19	72 (22)	71 (21)
t_m = 101°F (38°C)	7.6 (23.8)	7.49 (1.32)	0.13 (0.76)	129 (54)	126 (52)	83 (29)	77 (25)	76 (24)	73 (23)	18	13	72 (22)	71 (22)
Design Values	-	6.94 (1.22)	0.14 (0.82)	-	-	-	-	-	-	-	-	-	-

*Total thermal resistance, R_T, and transmittance, U, for steady-state tests were calculated using the design surface resistance coefficients from Table C4-3 and measured values of heat flux.

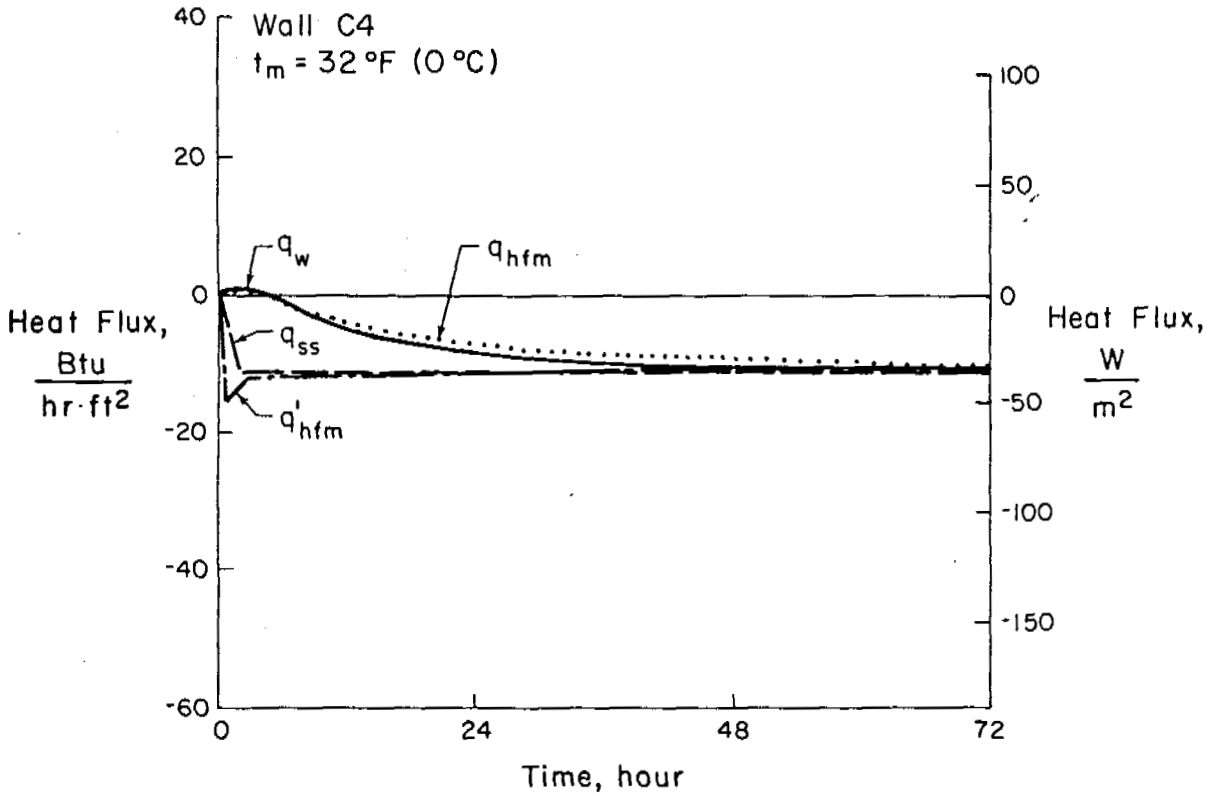


(a) Measured Temperatures



(b) Temperature Differentials

Fig. C4-1 Wall C4 Transient Test Results



(c) Heat Flux

Fig. C4-1 Wall C4 Transient Test Results

TABLE C4-5(a) - TRANSIENT TEST RESULTS

Time, hr	Measured Temperatures, °F							Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Conc./ Insul.	t_3 Internal Conc.	t_5* Indoor Surf., Embed.	t_1 Indoor Surf., Taped	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	71.8	72.1	72.3	71.7	72.2	72.0	71.7	0.16	0.09	-0.11	0.02
1	28.6	35.2	70.3	71.5	72.2	71.9	71.7	0.61	0.10	-15.32	-5.37
2	-5.4	2.1	67.7	71.1	72.2	71.9	71.7	0.87	0.04	-13.21	-10.19
3	-9.2	-1.8	66.6	70.6	71.9	71.7	71.7	0.60	-0.28	-11.06	-10.73
4	-9.4	-2.0	65.9	70.1	71.6	71.5	71.6	-0.26	-0.72	-10.86	-10.73
5	-9.5	-2.1	65.4	69.6	71.3	71.2	71.6	-0.82	-1.24	-10.78	-10.71
6	-9.4	-2.2	64.9	69.2	70.9	70.9	71.5	-1.59	-1.68	-10.68	-10.67
7	-9.4	-2.2	64.5	68.8	70.6	70.5	71.5	-2.15	-2.16	-10.64	-10.62
8	-9.5	-2.3	64.0	68.3	70.3	70.4	71.4	-2.97	-2.60	-10.60	-10.62
9	-9.6	-2.4	63.7	67.9	70.0	70.2	71.3	-3.49	-3.10	-10.53	-10.60
10	-9.6	-2.4	63.3	67.5	69.8	70.0	71.3	-4.18	-3.49	-10.42	-10.57
11	-9.5	-2.4	62.9	67.2	69.5	69.8	71.2	-4.57	-3.89	-10.43	-10.55
12	-9.6	-2.5	62.6	66.9	69.3	69.6	71.2	-4.75	-4.20	-10.38	-10.53
13	-9.6	-2.5	62.3	66.6	69.1	69.5	71.1	-5.20	-4.57	-10.31	-10.51
14	-9.6	-2.6	62.0	66.3	68.8	69.3	71.1	-5.53	-4.91	-10.25	-10.49
15	-9.6	-2.6	61.7	66.1	68.6	69.1	71.0	-5.81	-5.18	-10.16	-10.47
16	-9.6	-2.7	61.5	65.8	68.4	69.0	71.0	-6.19	-5.44	-10.24	-10.46
17	-9.6	-2.7	61.2	65.6	68.3	68.8	71.0	-6.03	-5.76	-10.17	-10.44
18	-9.6	-2.7	61.0	65.4	68.1	68.7	70.9	-6.27	-5.96	-10.05	-10.42
19	-9.6	-2.7	60.8	65.2	68.0	68.6	70.9	-6.60	-6.27	-10.04	-10.40
20	-9.6	-2.7	60.6	65.0	67.8	68.5	70.9	-6.81	-6.47	-10.03	-10.39
21	-9.7	-2.8	60.4	64.9	67.7	68.4	70.9	-7.14	-6.71	-9.99	-10.38
22	-9.7	-2.8	60.3	64.7	67.6	68.2	70.8	-7.28	-6.87	-9.96	-10.37
23	-9.7	-2.8	60.1	64.5	67.4	68.2	70.8	-7.82	-7.04	-9.95	-10.36
24	-9.7	-2.8	60.0	64.4	67.4	68.1	70.8	-7.79	-7.16	-9.93	-10.35
26	-9.6	-2.8	59.7	64.1	67.2	67.9	70.7	-8.20	-7.50	-9.83	-10.32
28	-9.7	-2.8	59.5	63.9	67.0	67.8	70.7	-8.66	-7.71	-9.84	-10.31
30	-9.7	-2.9	59.3	63.8	66.8	67.7	70.7	-8.70	-8.06	-9.78	-10.29
32	-9.7	-2.9	59.1	63.6	66.7	67.5	70.6	-8.99	-8.22	-9.79	-10.28
34	-9.7	-2.9	59.0	63.4	66.6	67.4	70.6	-9.12	-8.46	-9.73	-10.27
36	-9.8	-2.9	58.8	63.2	66.4	67.4	70.6	-9.40	-8.62	-9.81	-10.26
38	-9.7	-2.9	58.7	63.1	66.4	67.3	70.6	-9.53	-8.74	-9.69	-10.24
40	-9.8	-2.9	58.7	63.1	66.3	67.2	70.5	-9.55	-8.92	-9.74	-10.24
42	-9.8	-2.9	58.5	62.9	66.2	67.1	70.5	-9.60	-8.89	-9.71	-10.23
44	-9.8	-2.9	58.5	62.9	66.1	67.1	70.5	-9.53	-9.04	-9.62	-10.22
46	-9.8	-2.9	58.4	62.8	66.1	67.1	70.5	-9.71	-9.14	-9.69	-10.22
48	-9.8	-3.0	58.3	62.8	66.1	67.0	70.5	-9.88	-9.22	-9.67	-10.22
50	-9.7	-3.0	58.3	62.7	66.0	67.0	70.5	-9.78	-9.22	-9.69	-10.21
52	-9.9	-3.0	58.2	62.6	66.0	67.0	70.5	-9.69	-9.31	-9.70	-10.22
54	-10.0	-3.3	58.0	62.5	65.6	66.6	70.4	-9.28	-9.29	-9.61	-10.21
56	-10.0	-3.2	58.1	62.5	65.7	66.7	70.4	-9.44	-9.39	-9.64	-10.21
58	-9.9	-3.0	58.1	62.6	65.5	66.8	70.5	-9.55	-9.40	-9.63	-10.20
60	-9.8	-3.0	58.1	62.5	65.9	66.9	70.5	-9.84	-9.49	-9.59	-10.20
62	-9.8	-3.0	58.1	62.5	65.8	66.9	70.5	-9.92	-9.59	-9.57	-10.20
64	-9.8	-3.0	58.0	62.5	65.8	66.9	70.5	-10.03	-9.58	-9.64	-10.20
66	-9.9	-3.0	58.1	62.5	65.9	66.9	70.5	-9.99	-9.56	-9.62	-10.20
68	-9.8	-3.0	58.1	62.4	65.9	66.9	70.5	-9.99	-9.71	-9.62	-10.21
70	-9.7	-3.0	58.0	62.4	65.8	66.8	70.5	-9.69	-9.68	-9.68	-10.20
72	-9.9	-3.2	58.0	62.4	65.8	66.8	70.5	-9.56	-9.70	-9.66	-10.22

*Data are averages of 8 thermocouples, not 16.

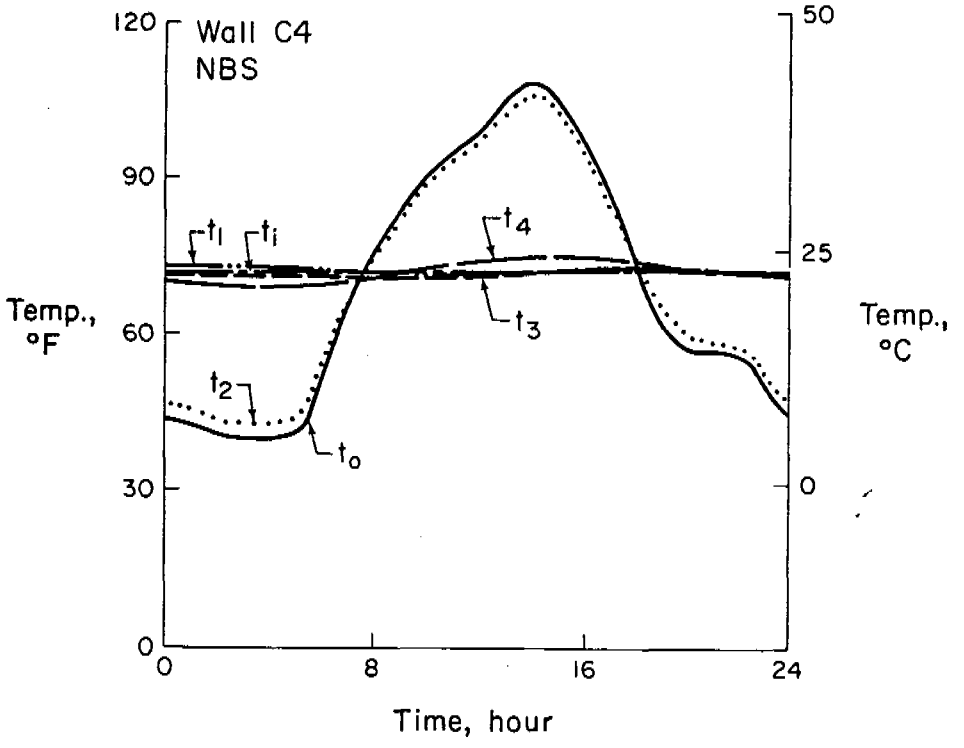
TABLE C4-5(b) - TRANSIENT TEST RESULTS, SI UNITS

Time, hr	Measured Temperatures, °C							Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Conc./ Insul.	t_3 Internal Conc.	t_5* Indoor Surf., Embed.	t_1 Indoor Surf., Taped	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	22.1	22.3	22.4	22.1	22.4	22.2	22.1	0.5	0.3	-0.3	0.1
1	-1.9	1.8	21.3	21.9	22.3	22.2	22.1	1.9	0.3	-48.3	-16.9
2	-20.8	-16.6	19.8	21.7	22.3	22.2	22.1	2.8	0.1	-41.7	-32.2
3	-22.9	-18.8	19.2	21.5	22.2	22.1	22.1	1.9	-0.9	-34.9	-33.9
4	-23.0	-18.9	18.8	21.2	22.0	21.9	22.0	-0.8	-2.3	-34.3	-33.9
5	-23.0	-19.0	18.6	20.9	21.8	21.8	22.0	-2.6	-3.9	-34.0	-33.8
6	-23.0	-19.0	18.3	20.7	21.6	21.6	22.0	-5.0	-5.3	-33.7	-33.7
7	-23.0	-19.0	18.1	20.4	21.4	21.4	21.9	-6.8	-6.8	-33.6	-33.5
8	-23.0	-19.1	17.8	20.2	21.3	21.3	21.9	-9.4	-8.2	-33.4	-33.5
9	-23.1	-19.1	17.6	20.0	21.1	21.2	21.8	-11.0	-9.8	-33.2	-33.4
10	-23.1	-19.1	17.4	19.7	21.0	21.1	21.8	-13.2	-11.0	-32.9	-33.4
11	-23.1	-19.1	17.2	19.6	20.8	21.0	21.8	-14.4	-12.3	-32.9	-33.3
12	-23.1	-19.2	17.0	19.4	20.7	20.9	21.8	-15.0	-13.3	-32.8	-33.2
13	-23.1	-19.2	16.9	19.2	20.6	20.8	21.7	-16.4	-14.4	-32.5	-33.2
14	-23.1	-19.2	16.7	19.1	20.5	20.7	21.7	-17.4	-15.5	-32.4	-33.1
15	-23.1	-19.2	16.5	18.9	20.3	20.6	21.7	-18.3	-16.4	-32.0	-33.0
16	-23.1	-19.3	16.4	18.8	20.2	20.5	21.7	-19.5	-17.2	-32.3	-33.0
17	-23.1	-19.3	16.2	18.7	20.2	20.5	21.7	-19.0	-18.2	-32.1	-32.9
18	-23.1	-19.3	16.1	18.6	20.0	20.4	21.6	-19.8	-18.8	-31.7	-32.9
19	-23.1	-19.3	16.0	18.4	20.0	20.3	21.6	-20.8	-19.8	-31.7	-32.8
20	-23.1	-19.3	15.9	18.4	19.9	20.3	21.6	-21.5	-20.4	-31.6	-32.8
21	-23.1	-19.3	15.8	18.3	19.8	20.2	21.6	-22.5	-21.2	-31.5	-32.8
22	-23.2	-19.3	15.7	18.2	19.8	20.1	21.6	-23.0	-21.7	-31.4	-32.7
23	-23.2	-19.3	15.6	18.1	19.7	20.1	21.5	-24.7	-22.2	-31.4	-32.7
24	-23.1	-19.3	15.6	18.0	19.7	20.1	21.5	-24.6	-22.6	-31.3	-32.6
26	-23.1	-19.3	15.4	17.9	19.5	20.0	21.5	-25.9	-23.7	-31.0	-32.6
28	-23.1	-19.4	15.3	17.7	19.4	19.9	21.5	-27.3	-24.3	-31.0	-32.5
30	-23.1	-19.4	15.2	17.6	19.4	19.8	21.5	-27.5	-25.4	-30.9	-32.5
32	-23.2	-19.4	15.1	17.5	19.3	19.7	21.5	-28.4	-25.9	-30.9	-32.4
34	-23.2	-19.4	15.0	17.4	19.2	19.7	21.4	-28.8	-26.7	-30.7	-32.4
36	-23.2	-19.4	14.9	17.4	19.1	19.6	21.4	-29.7	-27.2	-30.9	-32.4
38	-23.2	-19.4	14.9	17.3	19.1	19.6	21.4	-30.1	-27.6	-30.6	-32.3
40	-23.2	-19.4	14.8	17.3	19.1	19.6	21.4	-30.1	-28.1	-30.7	-32.3
42	-23.2	-19.4	14.7	17.2	19.0	19.5	21.4	-30.3	-28.0	-30.6	-32.3
44	-23.2	-19.4	14.7	17.2	19.0	19.5	21.4	-30.1	-28.5	-30.3	-32.2
46	-23.2	-19.4	14.7	17.1	18.9	19.5	21.4	-30.6	-28.8	-30.6	-32.2
48	-23.2	-19.4	14.6	17.1	18.9	19.5	21.4	-31.2	-29.1	-30.5	-32.3
50	-23.2	-19.4	14.6	17.1	18.9	19.4	21.4	-30.8	-29.1	-30.6	-32.2
52	-23.3	-19.5	14.6	17.0	18.9	19.4	21.4	-30.6	-29.4	-30.6	-32.2
54	-23.3	-19.6	14.5	16.9	18.7	19.2	21.3	-29.3	-29.3	-30.3	-32.2
56	-23.4	-19.6	14.5	17.0	18.7	19.3	21.3	-29.8	-29.6	-30.4	-32.2
58	-23.3	-19.5	14.5	17.0	18.6	19.4	21.4	-30.1	-29.7	-30.4	-32.2
60	-23.2	-19.4	14.5	17.0	18.8	19.4	21.4	-31.0	-29.9	-30.3	-32.2
62	-23.2	-19.4	14.5	17.0	18.8	19.4	21.4	-31.3	-30.2	-30.2	-32.2
64	-23.2	-19.5	14.5	17.0	18.8	19.4	21.4	-31.7	-30.2	-30.4	-32.2
66	-23.3	-19.4	14.5	16.9	18.8	19.4	21.4	-31.5	-30.2	-30.3	-32.2
68	-23.2	-19.5	14.5	16.9	18.8	19.4	21.4	-31.5	-30.6	-30.4	-32.2
70	-23.2	-19.5	14.4	16.9	18.8	19.4	21.4	-30.6	-30.5	-30.6	-32.2
72	-23.3	-19.5	14.4	16.9	18.8	19.3	21.4	-30.2	-30.6	-30.5	-32.2

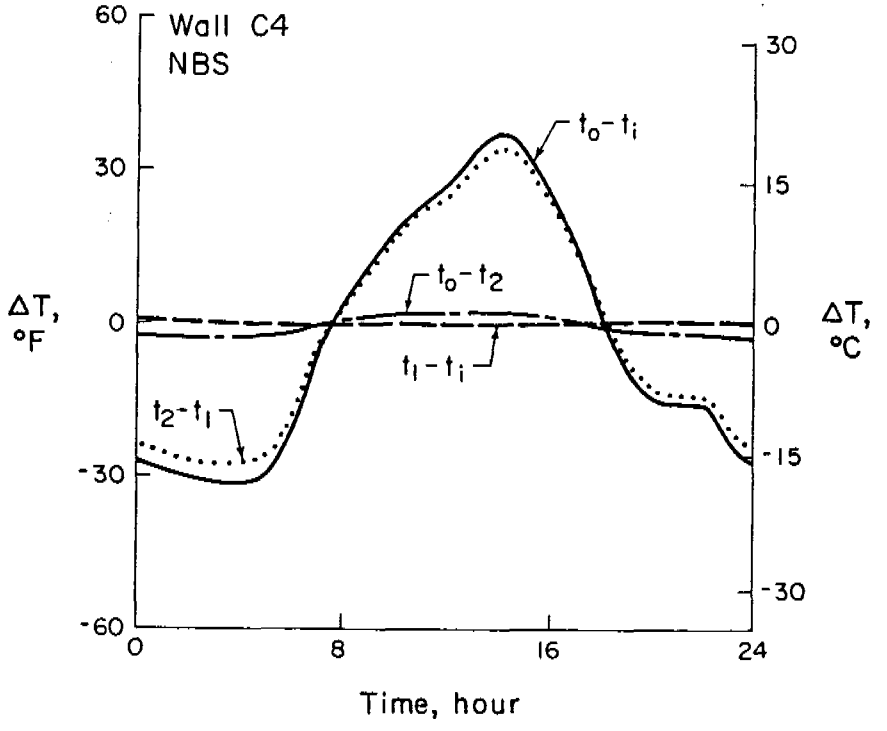
*Data are averages of 8 thermocouples, not 16.

TABLE C4-6 - SUMMARY OF TRANSIENT TEST RESULTS

Heat Flux	Measured				Calculated	
	Calib. Hot Box		HFM @ Indoor Surf.		Steady-State	
	q_w, Btu/hr·ft^2 (W/m^2)	Time to Reach q_w, hr	q_{hfm}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{hfm}, hr	q_{ss}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{ss}, hr
99.5% of Final Heat Flux	-9.9 (-31.4)	64	-9.7 (-30.6)	68	-10.2 (-32.1)	2
95% of Final Heat Flux	-9.5 (-30.0)	38	-9.3 (-29.2)	52	-9.7 (-30.6)	2
90% of Final Heat Flux	-9.0 (-28.4)	32	-8.8 (-27.6)	38	-9.2 (-29.0)	2

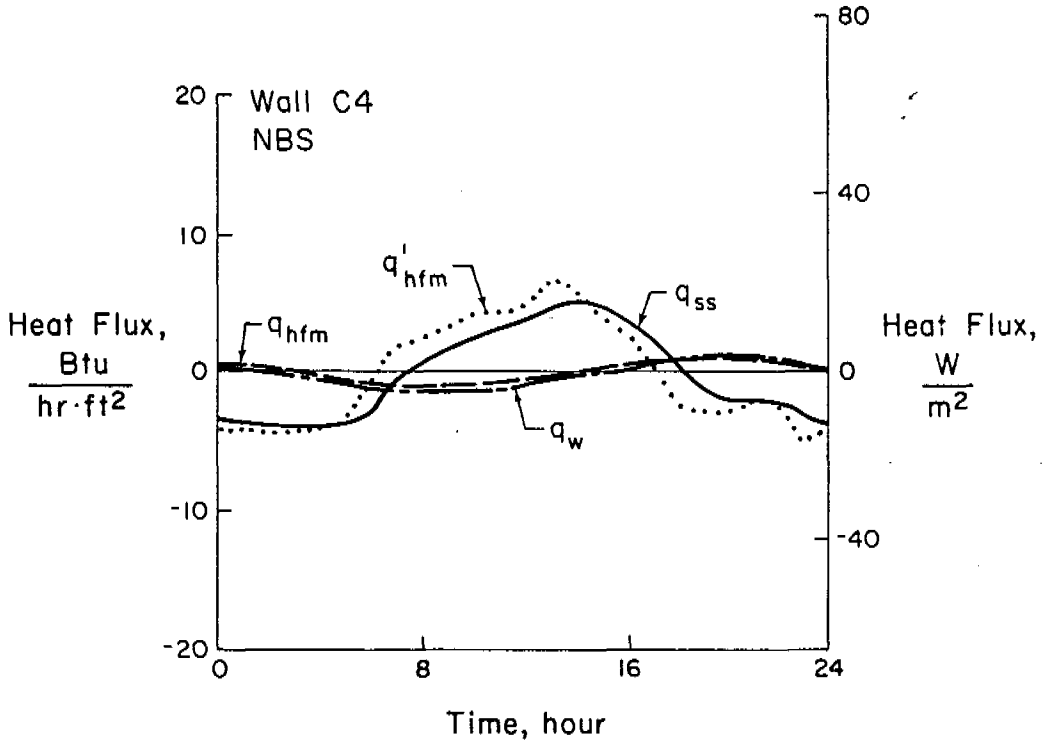


(a) Measured Temperatures



(b) Temperature Differentials

Fig. C4-2 Wall C4 Dynamic Test Results for NBS Test Cycle



(c) Heat Flux

Fig. C4-2 Wall C4 Dynamic Test Results for NBS Test Cycle

TABLE C4-7(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE

Time, hr	Measured Temperatures, °F							Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Conc./ Insul.	t_3 Internal Conc.	t_5* Indoor Surf., Embed.	t_1 Indoor Surf., Taped	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	42.8	45.7	70.2	71.4	72.1	71.9	71.7	0.14	0.14	-4.30	-3.82
2	40.7	43.7	69.8	71.2	72.0	71.8	71.7	-0.25	-0.02	-4.64	-4.09
3	40.3	43.2	69.6	71.0	71.8	71.6	71.6	-0.45	-0.23	-4.32	-4.15
4	40.1	43.1	69.3	70.8	71.7	71.5	71.6	-0.84	-0.44	-4.32	-4.15
5	41.2	44.0	69.2	70.6	71.6	71.4	71.5	-1.10	-0.64	-3.87	-4.01
6	50.4	51.9	69.4	70.5	71.4	71.3	71.5	-1.28	-0.84	-0.72	-2.83
7	66.3	66.4	70.3	70.5	71.3	71.3	71.5	-1.49	-1.02	1.66	-0.71
8	75.9	75.3	71.1	70.6	71.3	71.2	71.5	-1.45	-1.11	2.20	0.59
9	83.4	82.5	71.7	70.7	71.3	71.3	71.5	-1.42	-1.09	3.09	1.64
10	90.4	89.0	72.4	70.9	71.4	71.3	71.6	-1.44	-1.01	4.07	2.58
11	94.6	93.1	72.9	71.1	71.5	71.4	71.6	-1.33	-0.85	4.00	3.16
12	98.3	96.5	73.4	71.4	71.6	71.6	71.6	-0.91	-0.62	4.73	3.64
13	105.3	102.8	74.1	71.7	71.8	71.7	71.7	-0.84	-0.41	6.50	4.54
14	109.0	106.6	74.7	72.0	72.0	71.8	71.7	-0.46	-0.16	5.89	5.09
15	104.7	103.0	74.8	72.3	72.1	72.0	71.8	-0.33	0.09	3.81	4.53
16	97.7	96.5	74.6	72.5	72.3	72.1	71.8	-0.08	0.33	2.48	3.57
17	87.9	87.7	74.2	72.6	72.5	72.2	71.9	0.64	0.59	0.29	2.26
18	73.5	74.5	73.4	72.6	72.6	72.3	71.8	0.89	0.76	-2.49	0.32
19	62.8	64.4	72.6	72.5	72.6	72.3	71.9	1.15	0.85	-2.95	-1.15
20	57.4	59.2	72.1	72.4	72.6	72.3	71.8	1.18	0.83	-2.95	-1.91
21	56.4	58.1	71.8	72.2	72.6	72.2	71.8	1.06	0.74	-2.34	-2.06
22	56.2	58.0	71.6	72.0	72.5	72.2	71.8	0.88	0.60	-2.49	-2.07
23	48.5	51.3	71.1	71.9	72.4	72.1	71.8	0.54	0.46	-4.99	-3.02
24	44.0	46.8	70.5	71.6	72.3	72.0	71.7	0.40	0.31	-4.24	-3.68
Mean	69.5	70.1	71.9	71.5	72.0	71.8	71.7	-0.28	-0.11	-0.25	-0.24

*Data are averages of 8 thermocouples, not 16.

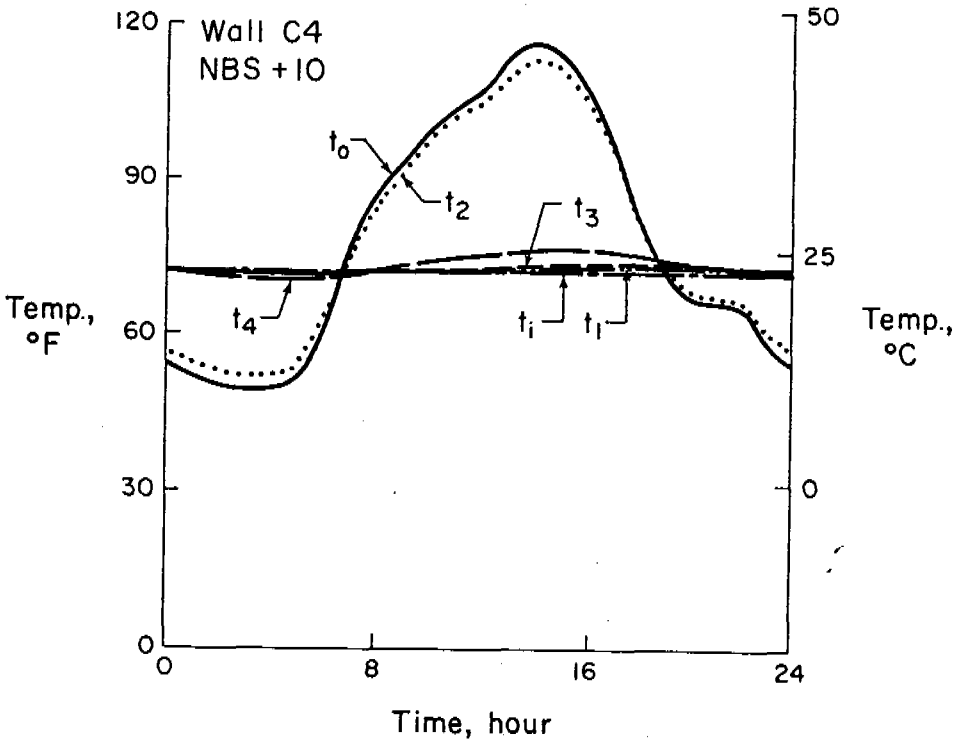
Calibrated Hot Box Relative Humidity:
Indoor Chamber - 19%
Outdoor Chamber - 15%

Laboratory Air Temperature:
Max. - 71°F - (22°C)
Min. - 70°F - (21°C)

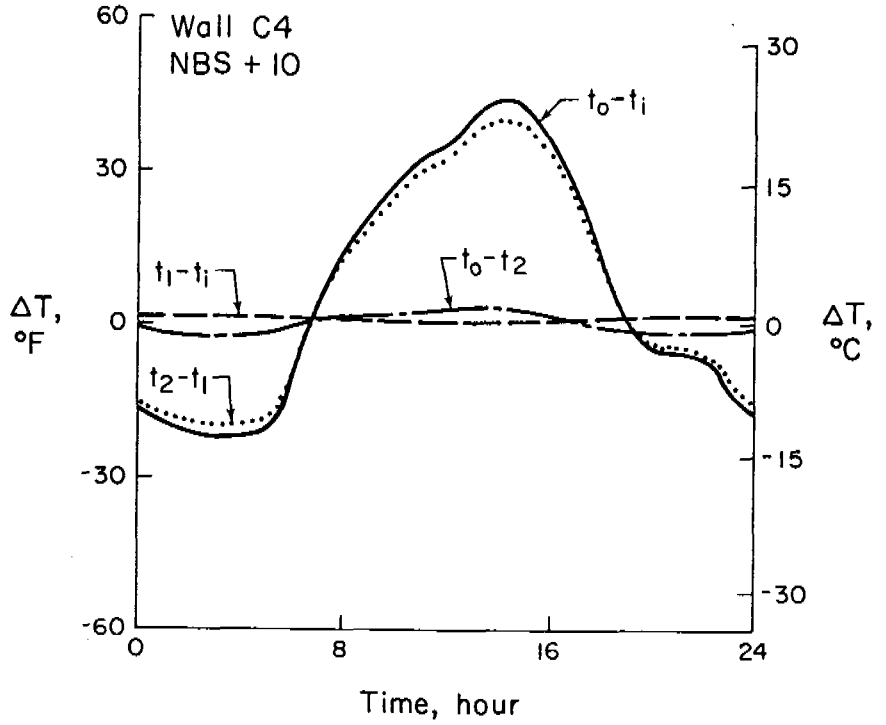
TABLE C4-7(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C							Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Conc./ Insul.	t_3 Internal Conc.	t_5* Indoor Surf., Embed.	t_1 Indoor Surf., Taped	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	6.0	7.6	21.2	21.9	22.3	22.2	22.1	0.45	0.45	-13.57	-12.05
2	4.8	6.5	21.0	21.8	22.2	22.1	22.0	-0.77	-0.07	-14.63	-12.91
3	4.6	6.2	20.9	21.7	22.1	22.0	22.0	-1.41	-0.73	-13.62	-13.08
4	4.5	6.2	20.7	21.6	22.0	22.0	22.0	-2.65	-1.40	-13.61	-13.09
5	5.1	6.6	20.7	21.5	22.0	21.9	22.0	-3.46	-2.01	-12.21	-12.64
6	10.2	11.1	20.8	21.4	21.9	21.9	22.0	-4.04	-2.67	-2.26	-8.93
7	19.1	19.1	21.3	21.4	21.8	21.8	21.9	-4.71	-3.21	5.22	-2.23
8	24.4	24.1	21.7	21.4	21.8	21.8	22.0	-4.57	-3.49	6.96	1.87
9	28.6	28.0	22.1	21.5	21.8	21.8	22.0	-4.47	-3.43	9.74	5.17
10	32.5	31.7	22.4	21.6	21.9	21.9	22.0	-4.56	-3.19	12.84	8.15
11	34.8	33.9	22.7	21.7	21.9	21.9	22.0	-4.18	-2.69	12.62	9.97
12	36.8	35.8	23.0	21.9	22.0	22.0	22.0	-2.86	-1.94	14.93	11.47
13	40.7	39.3	23.4	22.0	22.1	22.0	22.0	-2.65	-1.29	20.50	14.34
14	42.8	41.5	23.7	22.2	22.2	22.1	22.1	-1.46	-0.50	18.58	16.05
15	40.4	39.4	23.8	22.4	22.3	22.2	22.1	-1.05	0.29	12.02	14.30
16	36.5	35.8	23.7	22.5	22.4	22.3	22.1	-0.26	1.04	7.82	11.26
17	31.0	30.9	23.5	22.6	22.5	22.3	22.1	2.02	1.86	0.92	7.13
18	23.1	23.6	23.0	22.5	22.6	22.4	22.1	2.81	2.40	-7.86	1.01
19	17.1	18.0	22.6	22.5	22.6	22.4	22.1	3.63	2.68	-9.31	-3.63
20	14.1	15.1	22.3	22.4	22.6	22.4	22.1	3.71	2.61	-9.30	-6.03
21	13.6	14.5	22.1	22.3	22.5	22.4	22.1	3.34	2.33	-7.39	-6.51
22	13.5	14.4	22.0	22.2	22.5	22.3	22.1	2.77	1.90	-7.85	-6.53
23	9.2	10.7	21.7	22.1	22.4	22.3	22.1	1.72	1.47	-15.75	-9.54
24	6.6	8.2	21.4	22.0	22.4	22.2	22.1	1.26	0.97	-13.38	-11.61
Mean	20.8	21.2	22.2	22.0	22.2	22.1	22.0	-0.89	-0.36	-0.78	-0.75

*Data are averages of 8 thermocouples, not 16.

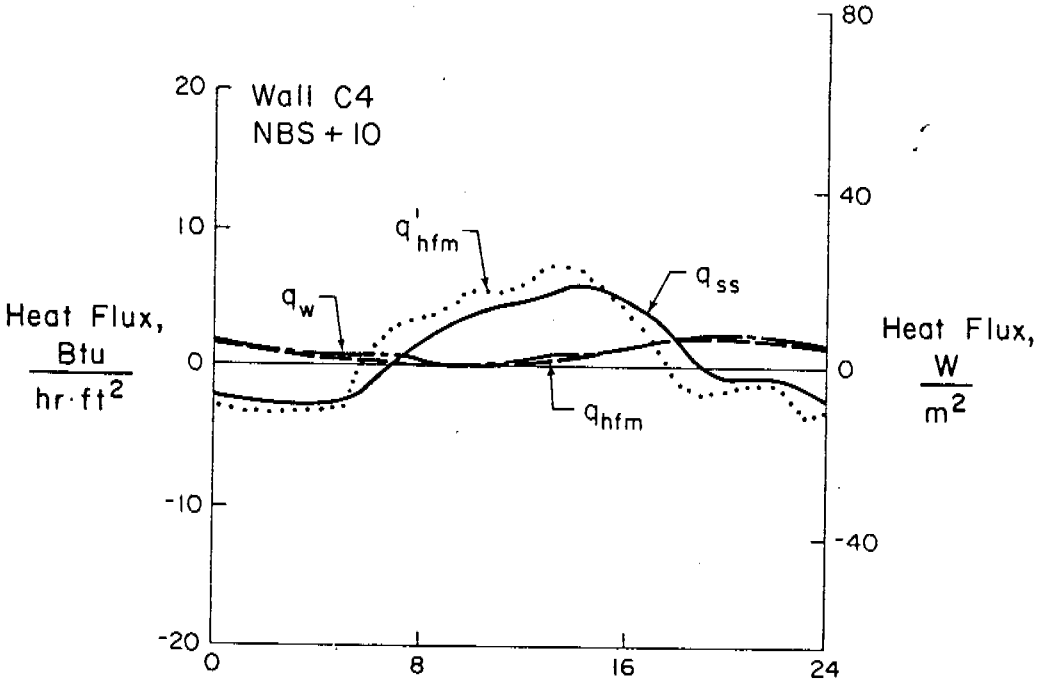


(a) Measured Temperatures



(b) Temperature Differentials

Fig. C4-3 Wall C4 Dynamic Test Results for NBS+10 Test Cycle



(c) Heat Flux

Fig. C4-3 Wall C4 Dynamic Test Results for NBS+10 Test Cycle

TABLE C4-8(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS+10 TEST CYCLE

Time, hr	Measured Temperatures, °F							Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Conc./ Insul.	t_3 Internal Conc.	t_5* Indoor Surf., Embed.	t_1 Indoor Surf., Taped	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	52.7	55.0	72.2	72.7	73.2	72.8	72.1	1.57	1.36	-3.41	-2.60
2	50.8	53.2	71.9	72.5	73.1	72.7	72.1	1.43	1.15	-3.47	-2.84
3	49.9	52.4	71.6	72.3	72.9	72.6	72.0	1.21	0.93	-3.43	-2.95
4	50.3	52.6	71.4	72.1	72.7	72.4	71.9	0.92	0.72	-3.00	-2.89
5	51.3	53.5	71.2	71.9	72.6	72.3	71.9	0.78	0.52	-2.94	-2.74
6	60.9	61.6	71.5	71.7	72.4	72.2	71.8	0.88	0.33	0.79	-1.54
7	76.1	75.5	72.3	71.7	72.3	72.0	71.8	0.75	0.17	2.80	0.50
8	85.4	84.3	72.9	71.8	72.2	72.0	71.8	0.32	0.10	3.45	1.80
9	91.9	90.5	73.5	71.9	72.2	72.0	71.8	0.19	0.10	4.07	2.70
10	99.3	97.2	74.1	72.0	72.2	72.0	71.8	0.15	0.15	5.50	3.68
11	104.0	101.9	74.8	72.3	72.4	72.1	71.8	0.37	0.30	5.34	4.34
12	106.5	104.2	75.2	72.6	72.5	72.3	71.9	0.48	0.48	5.80	4.67
13	112.2	109.3	75.8	72.8	72.6	72.3	71.9	0.98	0.76	7.42	5.41
14	115.9	113.0	76.4	73.1	72.8	72.5	71.9	0.91	0.98	7.11	5.92
15	114.0	111.6	76.7	73.4	73.0	72.7	72.0	1.14	1.25	5.69	5.69
16**	108.0	106.2	76.6	73.6	73.2	72.9	72.0	1.45	1.53	4.21	4.87
17	99.2	98.3	76.3	73.8	73.4	73.0	72.2	1.67	1.77	1.91	3.68
18	84.5	84.9	75.4	73.9	73.6	73.2	72.2	1.96	1.96	-1.26	1.71
19	72.5	73.5	74.5	73.8	73.7	73.2	72.2	2.29	2.05	-1.94	0.04
20	67.4	68.6	74.1	73.6	73.7	73.2	72.2	2.47	2.06	-1.62	-0.68
21	66.3	67.4	73.8	73.5	73.7	73.2	72.2	2.35	1.98	-1.26	-0.84
22	65.8	67.0	73.6	73.3	73.6	73.1	72.2	2.13	1.83	-1.31	-0.89
23	58.9	61.0	73.1	73.2	73.4	73.0	72.1	1.96	1.69	-3.71	-1.76
24	54.8	56.9	72.6	72.9	73.4	72.9	72.1	1.70	1.54	-3.03	-2.34
Mean	79.1	79.2	73.8	72.8	72.9	72.6	72.0	1.25	1.07	0.99	0.96

*Data are averages of 8 thermocouples, not 16.
**Data for this hour are two-day, not three-day averages.

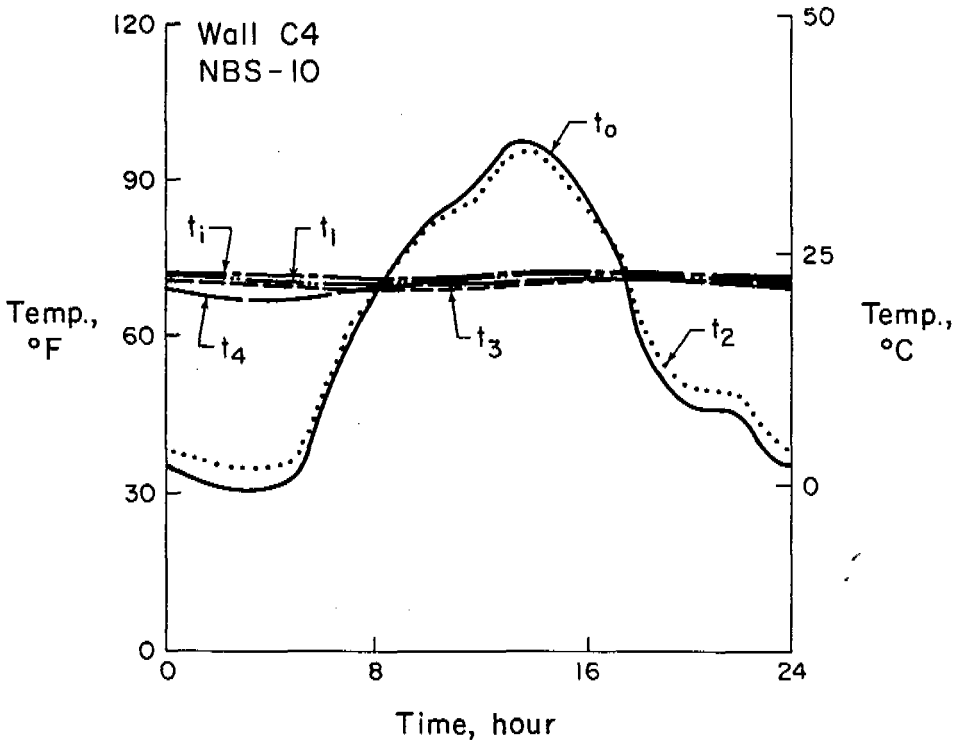
Calibrated Hot Box Relative Humidity:
Indoor Chamber - 23%
Outdoor Chamber - 15%

Laboratory Air Temperature:
Max. - 73°F - (23°C)
Min. - 69°F - (20°C)

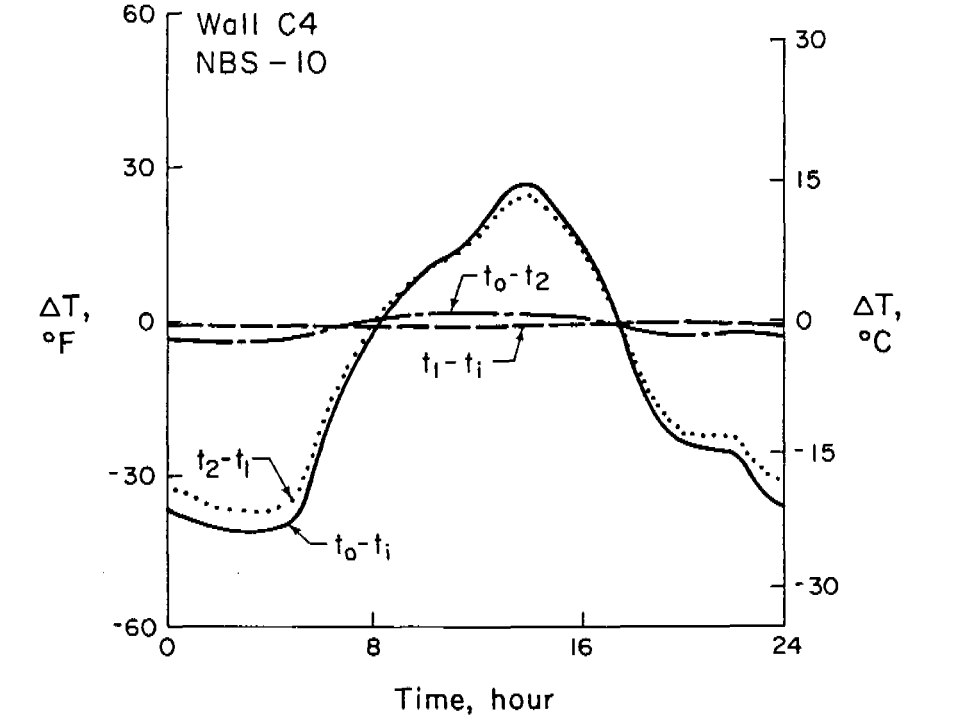
TABLE C4-8(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS+10 TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C							Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Conc./ Insul.	t_3 Internal Conc.	t_5* Indoor Surf., Embed.	t_1 Indoor Surf., Taped	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	11.5	12.8	22.4	22.6	22.9	22.7	22.3	4.96	4.28	-10.77	-8.19
2	10.4	11.8	22.1	22.5	22.8	22.6	22.3	4.52	3.62	-10.94	-8.96
3	9.9	11.3	22.0	22.4	22.7	22.5	22.2	3.81	2.93	10.81	-9.29
4	10.2	11.5	21.9	22.3	22.6	22.5	22.2	2.90	2.28	-9.47	-9.11
5	10.7	12.0	21.8	22.2	22.5	22.4	22.2	2.45	1.63	-9.28	-8.63
6	16.1	16.5	21.9	22.1	22.5	22.3	22.1	2.77	1.03	2.50	-4.85
7	24.5	24.2	22.4	22.1	22.4	22.2	22.1	2.37	0.54	8.84	1.59
8	29.6	29.1	22.7	22.1	22.3	22.2	22.1	1.00	0.30	10.88	5.66
9	33.3	32.5	23.0	22.2	22.3	22.2	22.1	0.60	0.30	12.83	8.51
10	37.4	36.2	23.4	22.2	22.4	22.2	22.1	0.47	0.47	17.35	11.60
11	40.0	38.8	23.8	22.4	22.4	22.3	22.1	1.15	0.93	16.83	13.69
12	41.4	40.1	24.0	22.5	22.5	22.4	22.2	1.53	1.51	18.29	14.72
13	44.5	43.0	24.3	22.7	22.5	22.4	22.1	3.09	2.40	23.39	17.06
14	46.6	45.0	24.7	22.8	22.6	22.5	22.2	2.86	3.10	22.42	18.68
15	45.6	44.2	24.8	23.0	22.8	22.6	22.2	3.61	3.95	17.96	17.93
16**	42.2	41.2	24.8	23.1	22.9	22.7	22.2	4.57	4.83	13.29	15.36
17	37.3	36.8	24.6	23.2	23.0	22.8	22.3	5.28	5.57	6.03	11.62
18	29.2	29.4	24.1	23.3	23.1	22.9	22.4	6.18	6.18	-3.96	5.39
19	22.5	23.0	23.6	23.2	23.2	22.9	22.3	7.22	6.48	-6.12	0.11
20	19.6	20.3	23.4	23.1	23.2	22.9	22.3	7.80	6.51	-5.11	-2.16
21	19.0	19.7	23.2	23.0	23.2	22.9	22.3	7.41	6.25	-3.96	-2.65
22	18.8	19.5	23.1	23.0	23.1	22.8	22.3	6.72	5.78	-4.14	-2.81
23	14.9	16.1	22.9	22.9	23.0	22.8	22.3	6.17	5.34	-11.70	-5.55
24	12.7	13.8	22.6	22.7	23.0	22.7	22.3	5.36	4.86	-9.55	-7.38
Mean	26.2	26.2	23.2	22.7	22.7	22.6	22.2	3.95	3.38	3.12	3.01

*Data are averages of 8 thermocouples, not 16.
**Data for this hour are two-day, not three-day averages.

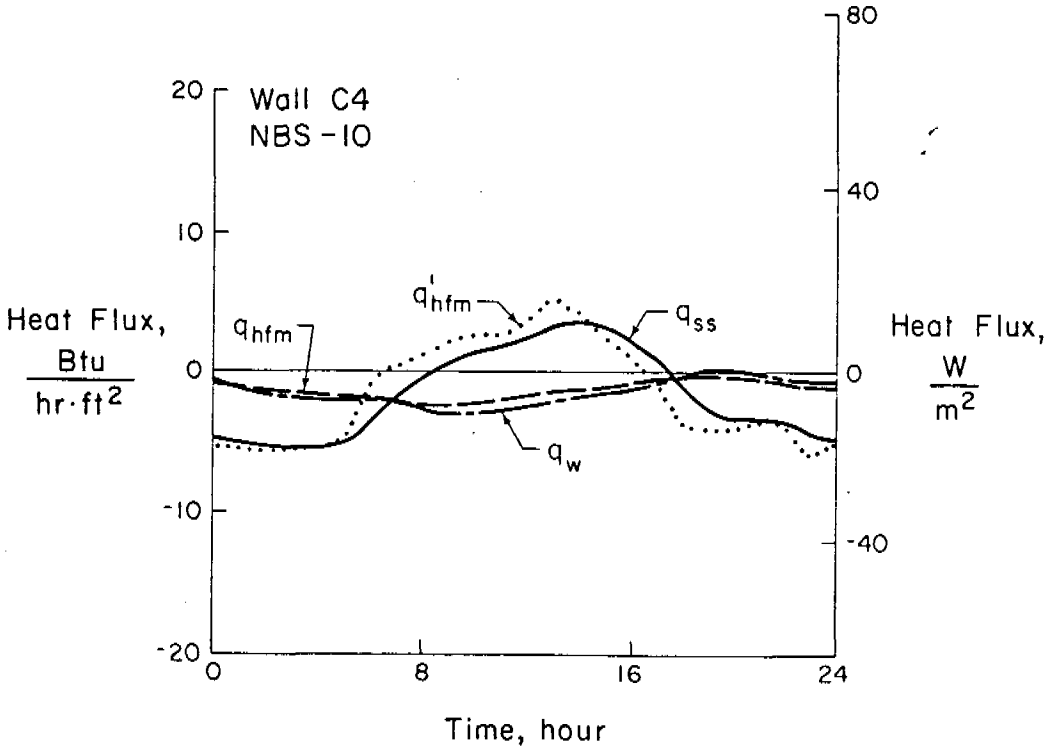


(a) Measured Temperatures



(b) Temperature Differentials

Fig. C4-4 Wall C4 Dynamic Test Results for NBS-10 Test Cycle



(c) Heat Flux

Fig. C4-4 Wall C4 Dynamic Test Results for NBS-10 Test Cycle

TABLE C4-9(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS-10 TEST CYCLE

Time, hr	Measured Temperatures, °F							Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_4 Conc./ Insul.	t_3 Internal Conc.	t_5* Indoor Surf., Embed.	t_1 Indoor Surf., Taped	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	33.5	37.1	68.7	70.4	71.5	71.4	71.6	-1.04	-0.96	-5.56	-5.01
2	31.4	35.1	68.4	70.2	71.3	71.3	71.6	-1.30	-1.17	-5.66	-5.28
3	31.1	34.7	68.1	70.0	71.2	71.2	71.5	-1.63	-1.36	-5.38	-5.32
4	31.4	34.9	67.9	69.8	71.0	71.0	71.5	-1.79	-1.59	-5.16	-5.27
5	33.3	36.6	67.9	69.6	70.9	70.9	71.5	-2.04	-1.79	-4.55	-5.01
6	46.1	47.8	68.3	69.5	70.8	70.8	71.4	-1.80	-1.97	-0.79	-3.36
7	59.9	60.5	69.0	69.5	70.6	70.7	71.3	-2.26	-2.10	0.47	-1.48
8	69.2	69.1	69.7	69.6	70.6	70.7	71.3	-2.82	-2.17	1.37	-0.23
9	76.2	75.6	70.3	69.7	70.6	70.7	71.3	-2.95	-2.13	2.01	0.71
10	82.5	81.6	70.9	69.9	70.7	70.8	71.4	-2.89	-2.05	2.90	1.57
11	85.2	84.4	71.4	70.2	70.8	70.9	71.5	-2.58	-1.89	2.59	1.97
12	89.0	87.7	71.8	70.4	71.0	71.0	71.5	-2.19	-1.71	3.53	2.44
13	96.4	94.4	72.5	70.7	71.1	71.2	71.5	-2.05	-1.51	5.29	3.40
14	98.7	97.0	73.0	70.9	71.3	71.3	71.6	-1.82	-1.25	4.17	3.75
15	94.6	93.4	73.1	71.2	71.5	71.5	71.6	-1.73	-0.99	2.50	3.21
16	88.1	87.5	73.0	71.4	71.7	71.6	71.7	-1.19	-0.75	1.34	2.33
17	79.3	79.5	72.6	71.5	71.8	71.7	71.7	-0.73	-0.51	-0.80	1.15
18	63.9	65.6	71.8	71.5	72.0	71.8	71.7	-0.24	-0.34	-3.82	-0.90
19	53.6	55.9	71.1	71.5	72.0	71.8	71.8	0.12	-0.24	-4.04	-2.32
20	47.8	50.5	70.6	71.3	72.0	71.8	71.8	0.21	-0.27	-4.04	-3.11
21	47.1	49.6	70.3	71.2	71.9	71.8	71.8	-0.01	-0.37	-3.49	-3.23
22	46.5	49.2	70.1	71.0	71.9	71.7	71.8	-0.17	-0.50	-3.74	-3.29
23	38.5	42.1	69.6	70.9	71.7	71.6	71.7	-0.33	-0.63	-6.01	-4.31
24	35.2	38.6	69.1	70.7	71.6	71.5	71.7	-0.69	-0.78	-5.07	-4.81
Mean	60.8	62.0	70.4	70.5	71.3	71.3	71.6	-1.41	-1.21	-1.33	-1.35

*Data are averages of 8 thermocouples, not 16.

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 23%
Outdoor Chamber - 16%

Laboratory Air Temperature:
Max. - 71°F - (22°C)
Min. - 66°F - (19°C)

TABLE C4-9(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS-10 TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C							Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_0 Outdoor Air	t_2 Outdoor Surf.	t_4 Conc./ Insul.	t_3 Internal Conc.	t_5* Indoor Surf., Embed.	t_1 Indoor Surf., Taped	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	0.8	2.8	21.3	20.4	21.9	21.9	22.0	-3.27	-3.04	-17.54	-15.82
2	-0.3	1.7	21.2	20.2	21.8	21.8	22.0	-4.10	-3.70	-17.87	-16.66
3	-0.5	1.5	21.1	20.1	21.8	21.8	22.0	-5.13	-4.29	-16.97	-16.77
4	-0.4	1.6	21.0	20.0	21.7	21.7	21.9	-5.65	-5.00	-16.29	-16.64
5	0.7	2.6	20.9	19.9	21.6	21.6	21.9	-6.42	-5.64	-14.37	-15.79
6	7.8	8.8	20.8	20.2	21.5	21.6	21.9	-5.68	-6.21	-2.48	-10.60
7	15.5	15.9	20.8	20.6	21.5	21.5	21.9	-7.14	-6.64	1.48	-4.68
8	20.7	20.6	20.9	20.9	21.4	21.5	21.8	-8.89	-6.85	4.31	-0.73
9	24.6	24.2	21.0	21.3	21.5	21.5	21.9	-9.31	-6.73	6.34	2.25
10	28.1	27.5	21.1	21.6	21.5	21.6	21.9	-9.12	-6.45	9.15	4.96
11	29.6	29.1	21.2	21.9	21.6	21.6	21.9	-8.13	-5.96	8.17	6.20
12	31.7	31.0	21.3	22.1	21.7	21.7	22.0	-6.90	-5.39	11.14	7.69
13	35.8	34.7	21.5	22.5	21.7	21.8	22.0	-6.46	-4.76	16.68	10.72
14	37.1	36.1	21.6	22.8	21.8	21.8	22.0	-5.73	-3.95	13.16	11.82
15	34.8	34.1	21.8	22.9	21.9	21.9	22.0	-5.47	-3.13	7.89	10.11
16	31.2	30.8	21.9	22.8	22.0	22.0	22.0	-3.76	-2.35	4.24	7.34
17	26.3	26.4	22.0	22.6	22.1	22.1	22.1	-2.30	-1.61	-2.53	3.61
18	17.7	18.7	22.0	22.1	22.2	22.1	22.1	-0.77	-1.08	-12.05	-2.84
19	12.0	13.3	21.9	21.7	22.2	22.1	22.1	0.39	-0.77	-12.74	-7.32
20	8.8	10.3	21.9	21.4	22.2	22.1	22.1	0.65	-0.87	-12.74	-9.81
21	8.4	9.8	21.8	21.3	22.2	22.1	22.1	-0.02	-1.18	-11.00	-10.20
22	8.1	9.5	21.7	21.2	22.1	22.1	22.1	-0.53	-1.59	-11.81	-10.38
23	3.6	5.6	21.6	20.9	22.1	22.0	22.1	-1.05	-1.99	-18.96	-13.58
24	1.8	3.7	21.5	20.6	22.0	22.0	22.0	-2.19	-2.47	-16.01	-15.18
Mean	16.0	16.7	21.4	21.3	21.8	21.8	22.0	-4.46	-3.82	-4.20	-4.26

*Data are averages of 8 thermocouples, not 16.

TABLE C4-10 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), THERMAL LAG

Test Cycle	Thermal Lag, hrs								Calc. Time Constant, hrs
	Measured								
	Calibrated Hot Box					Heat Flow Meter			
	t_o vs t_1		q_{ss} vs q_w		Avg.	q_{ss} vs q_{hfm}		Avg.	
	@ Max.	@ Min.	@ Max.	@ Min.		@ Max.	@ Min.		
NBS	5	4	6	4	5	5	5	5	1.6
NBS+10	5.5	5.5	6	7	6	5.5	5.5	5.5	1.6
NBS-10	5.5	5	6	6	5.5	5	5	5	1.6

TABLE C4-11 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), REDUCTION IN AMPLITUDE

Test Cycle	Measured, %					
	Calibrated Hot Box			Heat Flow Meter		
	@ Max.	@ Min.	Avg.	@ Max.	@ Min.	Avg.
NBS	73	69	71	82	75	79
NBS+10	75	72	74	80	75	78
NBS-10	68	61	65	81	76	79

TABLE C4-12 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), ENERGY REQUIREMENTS

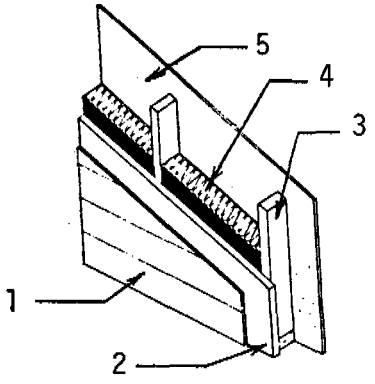
Test Cycle	Total Energy, Btu/ft^2 (W·hr/m^2)			Total Energy Comparisons %		Net Energy, Btu/ft^2 (W·hr/m^2)			Net Energy Comparisons, %	
	Measured		Calculated	$\frac{q^T_w}{q^T_{ss}}$	$\frac{q^T_{hfm}}{q^T_{ss}}$	Measured		Calculated	$\frac{q^N_w}{q^N_{ss}}$	$\frac{q^N_{hfm}}{q^N_{ss}}$
	q^T_w	q^T_{hfm}	q^T_{ss}			q^N_w	q^N_{hfm}	q^N_{ss}		
NBS	20.5 (64.8)	14.1 (44.6)	69.6 (219.5)	30	20	-6.8 (-21.4)	-2.7 (-8.6)	-5.7 (-18.1)	118	48
NBS+10	30.1 (94.8)	25.7 (81.1)	67.0 (211.5)	45	38	30.1 (94.8)	25.7 (81.1)	22.9 (72.3)	131	112
NBS-10	34.6 (109.0)	29.1 (91.7)	73.4 (231.7)	47	40	-33.9 (-107.0)	-29.1 (-91.7)	-32.4 (-102.3)	105	90

WALL F1: 2x4-in. (50x100-mm) WOOD FRAME WITH R-13 FIBERGLASS INSULATION, R-5 INSULATION BOARD, AND ALUMINUM SIDING

DESCRIPTION: Wood frame wall with R-13 fiberglass blanket insulation between studs, gypsum wallboard on interior surface, and rigid expanded polystyrene board insulation and aluminum siding with insulating board backing on exterior surface.

REFERENCE: None

COMPOSITION:



1. Off-white Aluminum Siding, with 3/8-in. (10-mm) Insulating Board Backing
2. 1-in. (25-mm) R-5 Rigid Expanded Polystyrene Board Insulation
3. 2x4-in. (50x100-mm) Wood Studs Spaced 16 in. (400 mm) on Center
4. 3-5/8-in. (90-mm) R-13 Fiberglass Blanket Insulation Faced with Kraft Paper
5. 1/2-in. (13-mm) Gypsum Wallboard, Painted Off-white

TABLE F1-1 - PHYSICAL PROPERTIES OF WALL AT TIME OF TEST

Property	Measured Value
Weight, psf (kg/m^2)	4.0 (19.6)
Average Thickness, in. (mm)	5.6 (141)
Area, ft^2 (m^2)	73.61 (6.84)

TABLE F1-2 - MATERIAL PROPERTIES, R-13 FIBERGLASS INSULATION

Property	Test Method	Specimen Condition	Mean Temperature, °F (°C)	Measured Value
Nominal Installed Thickness, in. (mm)	--	--	--	3.625 (92)
Thickness, as received, in. (mm)	ASTM C167*	--	--	3.60 (91)
Density, as received, pcf (kg/m^3)	ASTM C167	--	--	0.87 (14)

*Measured at four points along centerline of blanket

TABLE F1-3 - DESIGN HEAT TRANSMISSION COEFFICIENTS

Component	R, Thermal Resistance	
	Between Framing $hr \cdot ft^2 \cdot °F/Btu$ ($m^2 \cdot K/W$)	At Framing $hr \cdot ft^2 \cdot °F/Btu$ ($m^2 \cdot K/W$)
1. Outside Air Film	0.17* (0.03)	0.17 (0.03)
2. Aluminum Siding with 3/8-in. (10-mm) Insulating Board Backing	1.82* (0.32)	1.82 (0.32)
3. 1-in. (25-mm) Rigid Expanded Polystyrene Board Sheathing	5.00* (0.88)	5.00 (0.88)
4. 3-5/8-in. (90-mm) Fiberglass Insulation	13.00** (2.29)	--
5. 2x4-in. (50x100-mm) Wood Stud	--	4.38* (0.77)
6. 1/2-in. (13-mm) Gypsum Wallboard	0.45* (0.08)	0.45 (0.08)
7. Inside Air Film	0.68* (0.12)	0.68 (0.12)
Total R	21.12 (3.72)	12.50 (2.20)
Total U+	0.05 (0.27)	0.08 (0.45)

*Source: ASHRAE Handbook - 1981 Fundamentals, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, 1981, Chapter 23.

**Source: Manufacturer's Rating

Adjust for Framing (15.5%):

$U = (0.845)(0.05) + (0.155)(0.08) = 0.05$ Btu/hr·ft^2·°F (0.30 W/m^2·K)

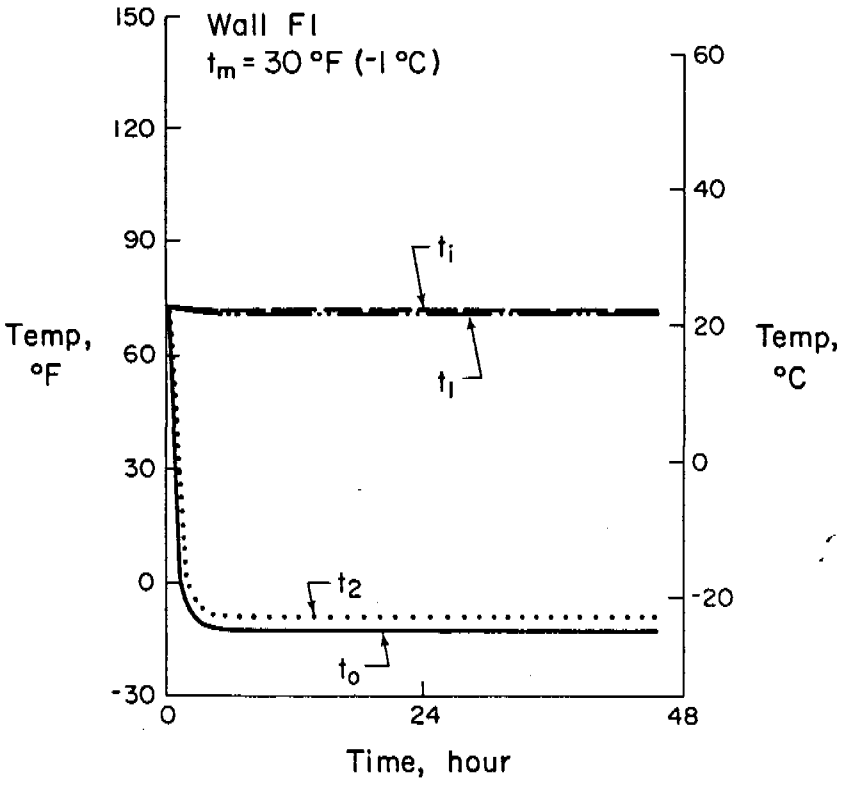
$R_T = 1/U = 19.08$ hr·ft^2·°F/Btu (3.36 m^2·K/W)

+Unit for thermal transmittance are Btu/hr·ft^2·°F (W/m^2·K)

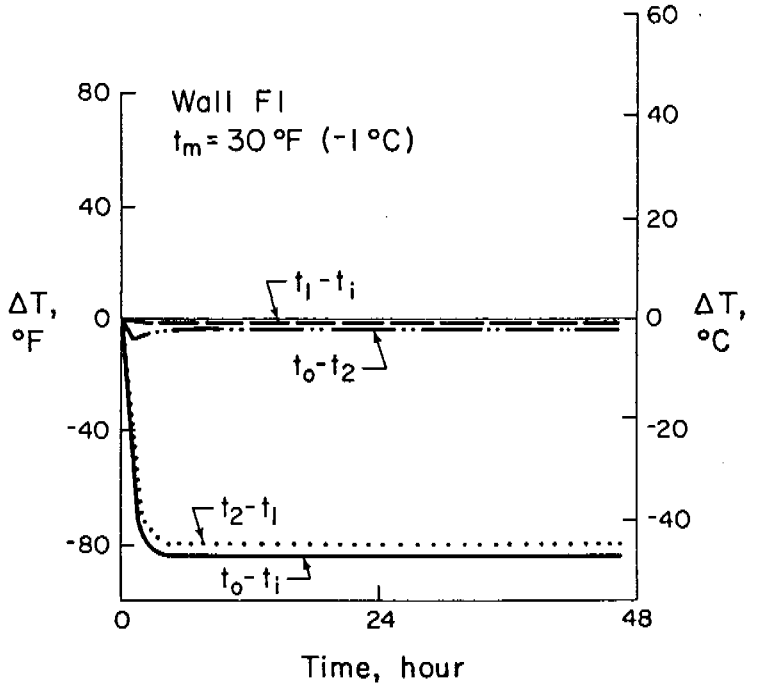
TABLE F1-4 - STEADY-STATE TEST RESULTS

Nominal Test Condition	q Heat Flux, Btu/hr·ft^2 (W/m^2)	R_T,* hr·ft^2·°F/Btu (m^2·K/W)	U,* Btu/hr·ft^2·°F (W/m^2·K)	Measured Temperatures, °F (°C)						Relative Humidity		Laboratory Air Temperature	
				t_o Outdoor Air	t_2 Outdoor Surface	t_3** Inter-nal	t_4** Inter-nal	t_1 Indoor Surface	t_i Indoor Air	Indoor Chamber, %	Outdoor Chamber, %	Max. °F (°C)	Min. °F (°C)
t_m = 101°F (39°C)	3.49 (11.0)	16.42 (2.89)	0.061 (0.35)	129 (54)	129 (54)	-	-	74 (24)	73 (23)	21	23	72 (22)	70 (21)
t_m = 30°F (-1°C)	-4.41 (-13.9)	19.17 (3.38)	0.052 (0.30)	-13 (-25)	-10 (-23)	-	-	71 (22)	72 (22)	21	20	72 (22)	70 (21)
Design Values	-	19.08 (3.36)	0.050 (0.30)	-	-	-	-	-	-	-	-	-	-

*Overall thermal resistance, R_T, and transmittance, U, for steady-state tests were calculated using the design surface resistance coefficients from Table F1-3 and measured values of heat flux.
**Internal thermocouples were not used on this wall assembly.

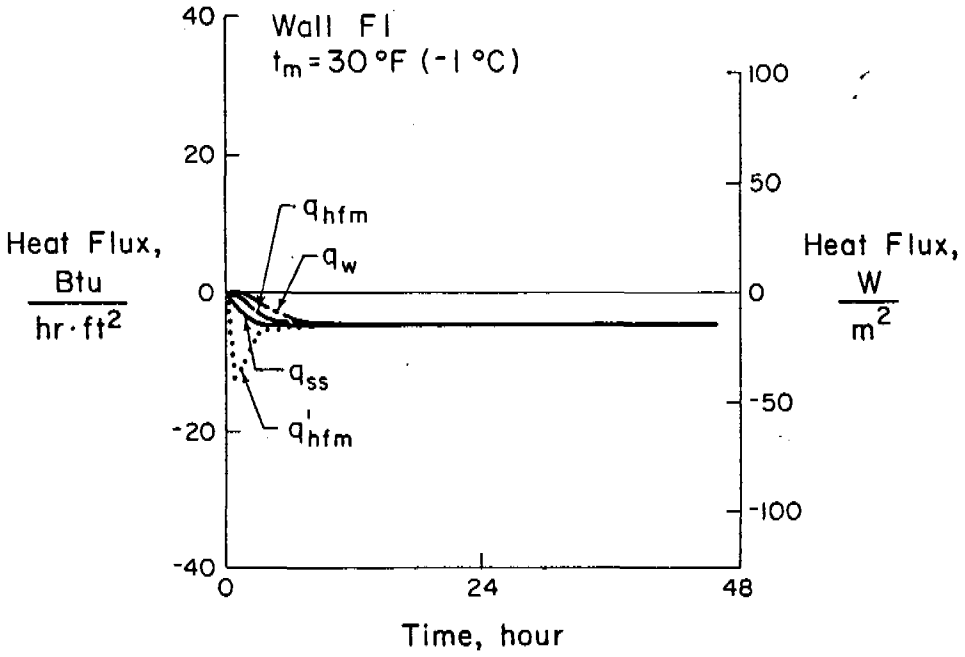


(a) Measured Temperatures



(b) Temperature Differentials

Fig. F1-1 Wall F1 Transient Test Results



(c) Heat Flux

Fig. F1-1 Wall F1 Transient Test Results

TABLE F1-5(a) - TRANSIENT TEST RESULTS

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	73.1	73.8			72.8	72.6	0.0	0.0	0.0	0.1
1	34.8	43.0			72.8	72.6	0.3	-0.1	-12.6	-1.7
2	-4.3	1.6			72.2	72.5	-0.2	-1.7	-9.4	-3.9
3	-10.0	-6.0			71.6	72.4	-1.8	-3.4	-5.6	-4.3
4	-11.4	-7.9			71.4	72.4	-2.6	-4.0	-5.0	-4.3
5	-11.9	-8.6			71.2	72.4	-2.8	-4.2	-4.7	-4.4
6	-12.3	-9.1			71.1	72.3	-3.6	-4.3	-4.6	-4.4
7	-12.3	-9.1			71.1	72.3	-3.8	-4.3	-4.4	-4.4
8	-12.4	-9.2			71.0	72.3	-3.8	-4.4	-4.4	-4.4
9	-12.6	-9.4			71.0	72.4	-4.1	-4.4	-4.4	-4.4
10	-12.7	-9.5			70.9	72.3	-4.1	-4.4	-4.4	-4.4
11	-12.7	-9.6			70.9	72.3	-4.2	-4.4	-4.4	-4.4
12	-12.7	-9.6			70.9	72.3	-4.2	-4.5	-4.4	-4.4
13	-12.8	-9.7			70.8	72.3	-4.3	-4.4	-4.4	-4.4
14	-12.8	-9.7			70.9	72.2	-4.3	-4.4	-4.4	-4.4
15	-12.8	-9.8			70.9	72.3	-4.3	-4.4	-4.4	-4.4
16	-12.8	-9.8			70.9	72.3	-4.3	-4.4	-4.4	-4.4
17	-12.8	-9.8			70.9	72.3	-4.3	-4.4	-4.4	-4.4
18	-12.9	-9.8			70.9	72.3	-4.4	-4.5	-4.4	-4.4
19	-12.9	-9.9			70.9	72.2	-4.3	-4.4	-4.4	-4.4
20	-12.9	-9.9			70.8	72.3	-4.4	-4.4	-4.4	-4.4
21	-12.9	-9.9			70.9	72.2	-4.2	-4.5	-4.4	-4.4
22	-12.9	-9.9			70.8	72.2	-4.2**	-4.5	-4.4	-4.4
23	-12.9	-9.9			70.7	72.3	-4.2	-4.5	-4.4	-4.4
24	-12.9	-9.9			70.9	72.3	-4.5	-4.4	-4.4	-4.4
26	-13.0	-9.9			70.8	72.2	-4.0	-4.5	-4.4	-4.4
28	-13.0	-9.9			70.9	72.3	-4.1	-4.4	-4.4	-4.4
30	-13.0	-10.0			70.9	72.3	-4.1	-4.5	-4.4	-4.4
32	-13.0	-9.9			70.9	72.4	-4.0	-4.4	-4.4	-4.4
34	-13.1	-10.0			70.9	72.3	-4.4	-4.4	-4.4	-4.4
36	-13.0	-10.0			70.9	72.3	-4.3	-4.5	-4.4	-4.4
38	-13.0	-10.0			70.9	72.3	-4.5	-4.5	-4.4	-4.4
40	-12.9	-9.9			70.9	72.3	-4.3	-4.4	-4.4	-4.4
42	-13.0	-9.9			70.9	72.3	-4.6	-4.4	-4.4	-4.4
44	-12.9	-10.0			70.8	72.2	-4.5	-4.5	-4.4	-4.4
46	-13.0	-10.0			70.8	72.2	-4.4	-4.5	-4.4	-4.4
48										

*Internal thermocouples were not used for this wall assembly.
**Calibrated hot box heat flux for hour 22 was derived from linear interpolation of data from hours 21 to 23.

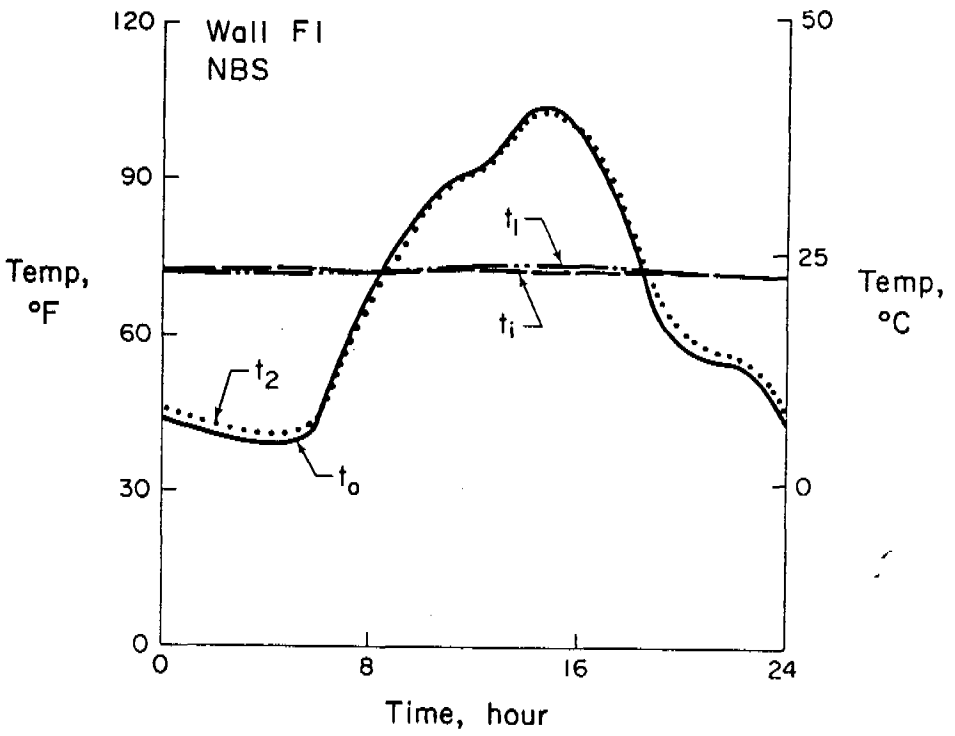
TABLE F1-5(b) - TRANSIENT TEST RESULTS, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
0	22.8	23.2			22.7	22.5	-0.1	0.1	0.0	0.2
1	1.6	6.1			22.6	22.6	0.8	-0.3	-39.8	-5.5
2	-20.2	-16.9			22.3	22.5	-0.6	-5.4	-29.6	-12.3
3	-23.3	-21.1			22.0	22.4	-5.6	-10.3	-17.6	-13.5
4	-24.1	-22.2			21.9	22.4	-8.0	-12.7	-15.9	-13.7
5	-24.4	-22.5			21.8	22.4	-9.4	-13.2	-14.9	-13.8
6	-24.6	-22.8			21.7	22.4	-11.2	-13.5	-14.6	-13.8
7	-24.6	-22.8			21.7	22.4	-11.9	-13.7	-14.0	-13.8
8	-24.6	-22.9			21.7	22.4	-11.9	-13.7	-14.0	-13.8
9	-24.8	-23.0			21.6	22.4	-13.1	-13.9	-14.0	-13.9
10	-24.8	-23.1			21.6	22.4	-13.0	-14.0	-14.0	-13.9
11	-24.8	-23.1			21.6	22.4	-13.2	-13.8	-14.0	-13.9
12	-24.8	-23.1			21.6	22.4	-13.4	-14.0	-13.8	-13.9
13	-24.9	-23.2			21.5	22.4	-13.6	-13.9	-14.0	-13.9
14	-24.9	-23.2			21.6	22.3	-13.6	-14.0	-13.9	-13.9
15	-24.9	-23.2			21.6	22.4	-13.6	-14.0	-13.8	-13.9
16	-24.9	-23.2			21.6	22.4	-13.4	-14.0	-13.9	-13.9
17	-24.9	-23.2			21.6	22.4	-13.4	-14.0	-13.8	-13.9
18	-24.9	-23.2			21.6	22.4	-14.0	-14.1	-13.9	-13.9
19	-24.9	-23.3			21.6	22.4	-13.6	-14.0	-13.8	-13.9
20	-24.9	-23.3			21.6	22.4	-13.8	-14.0	-14.0	-13.9
21	-25.0	-23.3			21.6	22.4	-13.3	-14.0	-13.9	-13.9
22	-24.9	-23.3			21.6	22.3	-13.3**	-14.1	-13.9	-13.9
23	-24.9	-23.3			21.5	22.4	-13.4	-14.1	-13.7	-13.9
24	-25.0	-23.3			21.6	22.4	-14.2	-13.9	-13.8	-13.9
26	-25.0	-23.3			21.6	22.3	-12.6	-14.1	-13.8	-13.9
28	-25.0	-23.3			21.6	22.4	-12.9	-14.0	-13.8	-13.9
30	-25.0	-23.3			21.6	22.4	-13.0	-14.1	-13.8	-13.9
32	-25.0	-23.3			21.6	22.4	-12.7	-13.9	-13.9	-13.9
34	-25.0	-23.3			21.6	22.4	-13.9	-14.0	-13.8	-13.9
36	-25.0	-23.3			21.6	22.4	-13.7	-14.1	-13.8	-13.9
38	-25.0	-23.3			21.6	22.4	-14.2	-14.1	-14.0	-13.9
40	-25.0	-23.3			21.6	22.4	-13.4	-14.0	-13.8	-13.9
42	-25.0	-23.3			21.6	22.4	-14.3	-13.9	-13.9	-13.9
44	-24.9	-23.3			21.6	22.3	-14.1	-14.1	-13.8	-13.9
46	-25.0	-23.3			21.6	22.3	-13.9	-14.1	-13.8	-13.9
48										

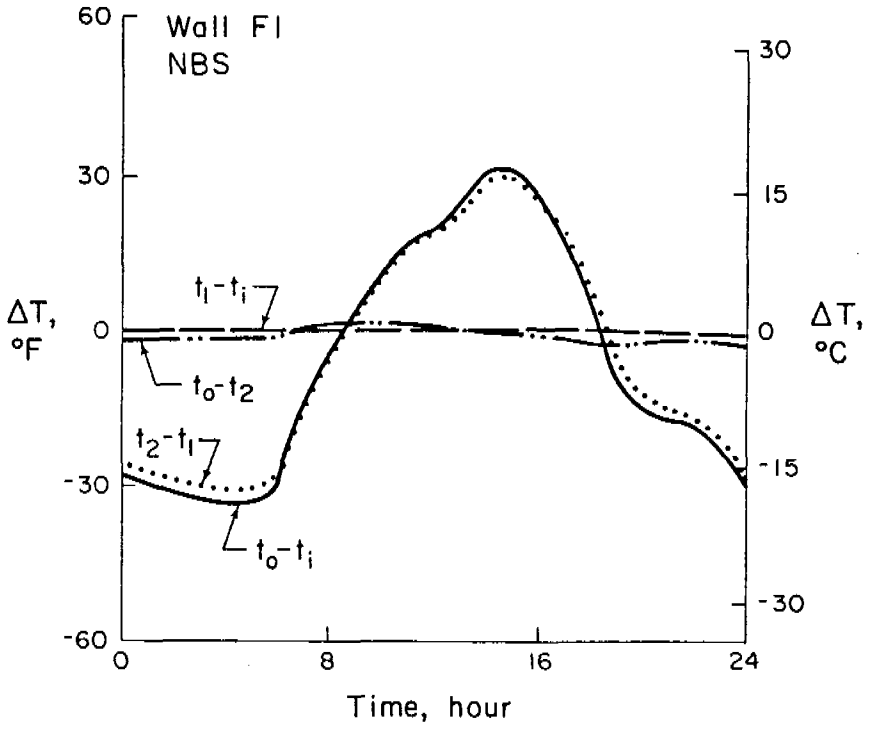
*Internal thermocouples were not used for this wall assembly.
**Calibrated hot box heat flux for hour 22 was derived from linear interpolation of data from hours 21 to 23.

TABLE F1-6 - SUMMARY OF TRANSIENT TEST RESULTS

Heat Flux	Measured				Calculated	
	Calib. Hot Box		HFM @ Indoor Surf.		Steady-State	
	q_w, Btu/hr·ft^2 (W/m^2)	Time to Reach q_w, hr	q_{hfm}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{hfm}, hr	q_{ss}, Btu/hr·ft^2 (W/m^2)	Time to Reach q_{ss}, hr
99.5% of Final Heat Flux	-4.4 (-13.8)	18	-4.4 (-14.0)	9	-4.4 (-13.8)	5
95% of Final Heat Flux	-4.2 (-13.2)	11	-4.2 (-13.3)	5	-4.2 (-13.2)	3
90% of Final Heat Flux	-4.0 (-12.5)	9	-4.0 (-12.6)	4	-4.0 (-12.5)	2

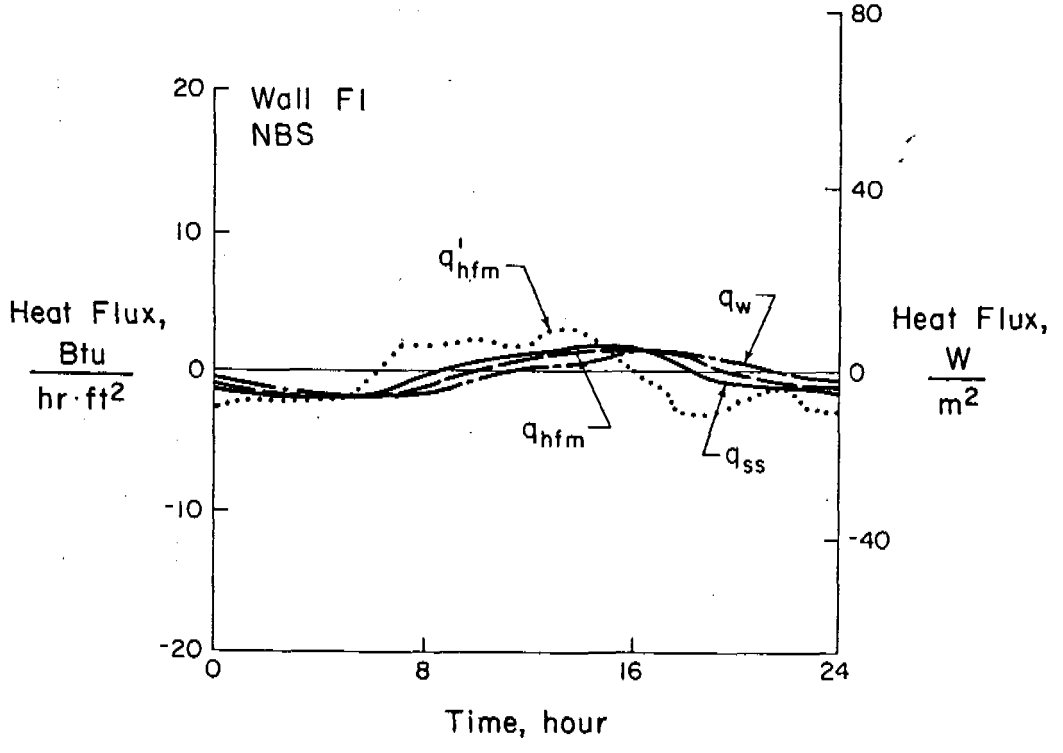


(a) Measured Temperatures



(b) Temperature Differentials

Fig. F1-2 Wall F1 Dynamic Test Results for NBS Test Cycle



(c) Heat Flux

Fig. F1-2 Wall F1 Dynamic Test Results for NBS Test Cycle

TABLE F1-7(a) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE

Time, hr	Measured Temperatures, °F						Measured Heat Flux, Btu/hr·ft^2			Calculated Heat Flux, Btu/hr·ft^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	42.2	44.0			72.1	72.3	-0.85	-1.47	-2.01	-1.64
2	40.5	42.4			72.0	72.3	-1.05	-1.61	-2.24	-1.73
3	39.1	40.8			72.0	72.2	-1.17	-1.69	-2.03	-1.81
4	39.0	40.6			71.9	72.2	-1.43	-1.79	-1.90	-1.82
5	38.9	40.5			71.9	72.2	-1.59	-1.81	-1.87	-1.82
6	43.1	43.7			71.9	72.2	-1.65	-1.81	-0.31	-1.64
7	57.6	56.9			72.0	72.2	-1.70	-1.61	1.92	-0.89
8	67.9	67.4			72.1	72.3	-1.48	-1.02	1.94	-0.29
9	76.2	75.7			72.4	72.4	-1.16	-0.45	2.04	0.20
10	85.0	84.2			72.6	72.5	-0.60	0.10	2.48	0.71
11	90.0	89.7			72.8	72.5	-0.16	0.53	1.96	1.04
12	92.3	92.0			73.0	72.6	0.15	0.84	1.88	1.18
13	98.0	97.1			73.1	72.6	0.45	1.04	3.09	1.49
14	104.2	103.5			73.1	72.5	0.58	1.37	3.02	1.90
15	104.7	104.5			73.4	72.7	1.10	1.69	1.93	1.95
16	99.4	100.1			73.4	72.7	1.49	1.80	0.32	1.66
17	91.2	92.6			73.4	72.7	1.53	1.58	-0.85	1.18
18	78.2	80.6			73.2	72.6	1.59	1.20	-2.80	0.45
19	65.1	67.5			73.0	72.6	1.16	0.52	-3.01	-0.33
20	58.3	60.2			72.8	72.5	0.70	-0.16	-2.33	-0.75
21	55.6	57.0			72.6	72.5	0.28	-0.60	-1.60	-0.92
22	55.2	56.4			72.4	72.5	-0.09	-0.82	-1.20	-0.95
23	50.7	52.9			72.4	72.4	-0.41	-0.91	-2.69	-1.15
24	43.4	45.6			72.2	72.3	-0.51	-1.14	-2.70	-1.56
Mean	67.3	68.2			72.6	72.4	-0.20	-0.26	-0.29	-0.23

*Internal thermocouples were not used on this wall assembly.

Calibrated Hot Box Relative Humidity:
Indoor Chamber - 21%
Outdoor Chamber - 19%

Laboratory Air Temperature:
Max. - 71°F (22°C)
Min. - 69°F (21°C)

TABLE F1-7(b) - DYNAMIC TEST RESULTS (PERIODIC), NBS TEST CYCLE, SI UNITS

Time, hr	Measured Temperatures, °C						Measured Heat Flux, W/m^2			Calculated Heat Flux, W/m^2
	t_o Outdoor Air	t_2 Outdoor Surf.	t_3* Inter-nal	t_4* Inter-nal	t_1 Indoor Surf.	t_i Indoor Air	q_w Calib. Hot Box	q_{hfm} HFM @ Indoor Surf.	q_{hfm} HFM @ Outdoor Surf.	q_{ss} Steady-State
1	5.7	6.6			22.3	24.4	-2.70	-4.63	-6.33	-5.18
2	4.7	5.8			22.2	22.4	-3.32	-5.07	-7.06	-5.45
3	4.0	4.9			22.2	22.4	-3.70	-5.33	-6.41	-5.71
4	3.9	4.8			22.2	22.3	-4.50	-5.66	-6.00	-5.74
5	3.8	4.7			22.2	22.3	-5.02	-5.70	-5.91	-5.75
6	6.2	6.5			22.2	22.3	-5.21	-5.72	-0.99	-5.19
7	14.2	13.8			22.2	22.4	-5.36	-5.07	6.05	-2.81
8	20.0	19.7			22.3	22.4	-4.67	-3.21	6.12	-0.90
9	24.6	24.3			22.4	22.4	-3.67	-1.41	6.44	0.64
10	29.4	29.0			22.6	22.5	-1.89	0.30	7.83	2.23
11	32.2	32.0			22.7	22.5	-0.50	1.69	6.19	3.27
12	33.5	33.4			22.8	22.5	0.47	2.66	5.94	3.71
13	36.7	36.2			22.8	22.6	1.42	3.28	9.75	4.71
14	40.1	39.7			22.9	22.5	1.82	4.33	9.52	5.99
15	40.4	40.3			23.0	22.6	3.48	5.33	6.08	6.15
16	37.4	37.8			23.0	22.6	4.69	5.67	1.00	5.24
17	32.9	33.6			23.0	22.6	4.83	4.98	-2.69	3.73
18	25.6	27.0			22.9	22.6	5.02	3.78	-8.82	1.41
19	18.4	19.7			22.8	22.5	3.65	1.63	-9.50	-1.04
20	14.6	15.7			22.6	22.5	2.21	-0.49	-7.35	-2.35
21	13.1	13.9			22.5	22.5	0.88	-1.88	-5.05	-2.92
22	12.9	13.6			22.5	22.5	-0.28	-2.59	-3.78	-2.99
23	10.4	11.6			22.4	22.4	-1.31	-2.88	-8.48	-3.62
24	6.3	7.5			22.3	22.4	-1.61	-3.61	-8.52	-4.92
Mean	19.6	20.1			22.5	22.5	-0.64	-0.82	-0.92	-0.73

*Internal thermocouples were not used on this wall assembly.

TABLE F1-10 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), THERMAL LAG

Test Cycle	Thermal Lag, hrs								Calc. Time Constant, hrs
	Measured								
	Calibrated Hot Box					Heat Flow Meter			
	t_o vs t_1		q_{ss} vs q_w		Avg.	q_{ss} vs q_{hfm}		Avg.	
	@ Max.	@ Min.	@ Max.	@ Min.		@ Max.	@ Min.		
NBS	1	0	3	2.5	1.5	1	1	1	0.5

TABLE F1-11 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), REDUCTION IN AMPLITUDE

Test Cycle	Measured					
	Calibrated Hot Box			Heat Flow Meter		
	@ Max.	@ Min.	Avg.	@ Max.	@ Min.	Avg.
NBS	18	6	12	6	2	4

TABLE F1-12 - SUMMARY OF DYNAMIC TEST RESULTS (PERIODIC), ENERGY REQUIREMENTS

Test Cycle	Total Energy, Btu/ft^2 (W·hr/m^2)			Total Energy Comparisons %		Net Energy, Btu/ft^2 (W·hr/m^2)			Net Energy Comparisons, %	
	Measured		Calculated	$\frac{q_w^T}{q_{ss}^T}$	$\frac{q_{hfm}^T}{q_{ss}^T}$	Measured		Calculated	$\frac{q_w^N}{q_{ss}^N}$	$\frac{q_{hfm}^N}{q_{ss}^N}$
	q_w^T	q_{hfm}^T	q_{ss}^T			q_w^N	q_{hfm}^N	q_{ss}^N		
NBS	22.9 (72.2)	27.6 (87.0)	29.1 (91.7)	79	95	-4.8 (-15.2)	-6.2 (-19.6)	-5.5 (-17.5)	87	112