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Monthly Progress Report

Building Thermal Envelope Systems
and Materials (BTESM)
Progress Report for DOE Office of
Buildings Energy Research

September 1990

Compiled by Gabrielle Burn
for
Jeffrey E. Christian, Program Manager
Energy Division

Prepared by the
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
operated by
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MASTER

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HIGHLIGHT

SECOND SYMPOSIUM ON INSULATION MATERIALS-- TESTING AND APPLICATIONS

October 10-12, 1991

Gatlinburg, Tennessee

SPONSORED BY ASTM COMMITTEE C16

ON

THERMAL INSULATION

Call for Papers:	April 1, 1990
Abstracts Due:	August 1, 1990
Abstract Acceptance Notification:	September 1, 1990
Manuscripts Due:	January 2, 1991
STP Available:	October 10, 1991

<i>Session I:</i>	<i>Reflectives/Radiant Barriers/Radiation Control Coatings</i>
<i>Session II:</i>	<i>Economics and Energy Impact</i>
<i>Session III:</i>	<i>Long-Term Thermal Performance of Foams</i>
<i>Session IV:</i>	<i>Assessments and Properties of Foams</i>
<i>Session V:</i>	<i>Convection in Fibrous Insulation</i>
<i>Session VI:</i>	<i>Tests and Models</i>
<i>Session VII:</i>	<i>Performance Factors I</i>
<i>Session VIII:</i>	<i>Innovative Insulations</i>
<i>Session IX:</i>	<i>Test Methods and Comparisons</i>
<i>Session X:</i>	<i>Performance Factors II</i>

For more information, please contact Symposium Co-Chairmen:

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Building Thermal Envelope Systems and Materials (BTESM) Progress Report
for DOE Office of Buildings Energy Research

ABSTRACT

The Monthly Report of the Building Thermal Envelope Systems and Materials (BTESM) Program is a monthly update of both in-house ORNL projects and subcontract activities in the research areas of building materials, wall systems, foundations, roofs, building diagnostics, and research utilization and technology transfer. Presentations are not stand-alone paragraphs every month. Their principal values are the short-time lapse between accomplishment and reporting and their evolution over a period of several months.

I. BUILDING THERMAL ENVELOPE SYSTEMS AND MATERIALS (BTESM)

A. IMPLEMENTATION

1. Administration/Technical Support/Selected Projects

This task includes overall management for the BTESM Program with the emphasis on assuring that individual R&D projects are performed via the best available expertise whether it be at universities, private labs, professional associations, or national labs (including ORNL). Also included are: implementation of major conferences, workshops and seminars, assurance of BTESM staff participation in committee work (BTECC, NIBS, ASTM, ASHRAE, etc.), BTESM National Program planning jointly with the total building community, technical support to DOE, and oversight of selected technical projects not delegated to other tasks.

a. Management (Jeffrey E. Christian/Pat M. Love, ORNL)

All BTESM Program areas have submitted planning budgets for FY 1991 to headquarters. The budget levels are very uncertain this year. The main concern is the proposed 32% Gramm-Rudman cut imposed on all programs if Congress and the Administration do not develop an acceptable deficit-reduction agreement. Our fiscal year ended September 30, 1990.

BTESM has submitted two Cooperative Research and Development Agreements (CRADAs) for approval. CRADAs are a new provision recently adopted by DOE to permit research projects to bring in money from private industry to join with DOE money for cooperative ventures. These efforts will utilize the Roof Research Center User Facilities to test the performance of CFC alternative laminate insulation materials in roofs and attic insulation.

The BTESM Program is preparing for a visit from the Tiger Team next month. The Tiger Team consists of representatives from DOE and other national labs to evaluate the entire laboratory in the areas of health, safety, and environmental protection. The RTRA and ESRA facilities will be Quality Assurance audited on October 12, 1990.

Bibliography: ORNL/CON-292, "Buildings Energy Research: A Bibliography Update," is a free publication that contains document listings from 1985 to 1989 in the DOE sponsored buildings research area. Copies are free and are available from Ms. Clara Brown, BTESM secretary.

Thermal Performance of the Exterior Envelopes of Buildings V Conference: The third planning meeting for this conference will be held in January 1991. Tentative plans have set the conference in the Florida area in December 1992.

IEA Activities: Source books - Volumes I and II of Annex XI on Energy Auditing are available free of charge from the BTESM Program office. David Harrje is currently attending the 11th AIVC Conference on Ventilation Systems Performance in Italy and will attend the Annex 20's 6th Experts Meeting next month in France. Reports on these meetings will be forthcoming. Also attending the Annex 20 meeting will be Dr. Leslie L. Christianson of the University of Illinois.

EVENTS

- September 4 D. L. McElroy gave a presentation on foams at the University of Tennessee.
- September 6 Jeff Christian presented a summary of CFC alternatives research and provided a tour of the envelope test facilities to Anatoliy Afanasiev, USSR Academy of Sciences.
- September 8 Jeff Christian was a guest on a live radio talk show, "House Talk," with host Bill Mack, Detroit, Michigan.
- September 11 Stan Floyd, Rick Wagner, and Ron Gebhardt, Weyerhaeuser, visited ORNL and met with Ken Wilkes, Ron Graves, and Jeff Christian.
- September 12-13 Jeff Christian attended ASHRAE SPC 90.2, "Energy Efficient Design of New Low-Rise Residential Buildings," meeting in Atlanta, Georgia.
- September 17 Jeff Christian briefed Eric Hurst on BTESM research activities for future congressional testimony background information.
- September 20 John Mumaw and Chris Crall, Owens Corning Fiberglas, visited Ken Wilkes, Bob Wendt, and Jeff Christian regarding attic insulation testing utilizing the Large Scale Climate Simulator.
- September 28 Jeff Christian, George Courville, and Howard McLain met to discuss future projects for U.S. AID on housing.
- September 26-28 R. S. Graves gave a talk to the Insulation Contractors of America Association in Orlando, Florida.

b. REPORTS PUBLISHED THIS PERIOD

None.

c. CONFERENCES AND MEETINGS OF INTEREST***1990**

October 14-17: ASTM C 16 Fall Meeting, Omni Royal, New Orleans, Louisiana.

October 23-26: Leaking Underground Storage Workshop, co-sponsored by the Environmental Sciences and Technology Division of the Georgia Tech Research Institute and the United States Environmental Protection Agency. The workshop will be held on the Georgia Tech campus in the Space Science Building. For more information, contact the training programs office at (404) 894-3806.

October 25-26: ASTM Symposium on Water In Exterior Building Walls: Problems and Solutions, to be held in Dearborn, Michigan. More information is available from Symposium Chairman Thomas A. Schwartz, Simpson Gumpertz & Heger, Inc., 297 Broadway, Arlington, MA 02174, (617) 643-2000.

December 10-12: Third Brazilian Thermal Science Meeting, ENCIT-90, to be held in Itapema, SC, Brazil. For more information, contact Professor Alvaro T. Prata, Department of Mechanical Engineering, Federal University of Santa Catarina, P.O. Box 476, 88049 - Florianopolis-SC, Brazil, or call (0482) 335166, FAX (0482) 331519, or Telex 481 317 FUEG BR.

1991

January 19-23: ASHRAE 1990 Winter Meeting, to be held in New York, NY. For more information, contact Judy Marshall or Jan Young, ASHRAE Meetings, 1791 Tullie Circle, NE, Atlanta, GA 30329, or call (404) 636-8400.

April 17-19: Third International Symposium on Roofing Technology, sponsored by the National Institute of Standards and Technology; U.S. National Roofing Contractors Association; Canadian Roofing Contractors Association; National Research Council of Canada; International Waterproofing Association; CIB, and RILEM. The symposium will be held at the Montreal Convention Centre, Montreal, Quebec, Canada. For more information, contact Walter Rossiter, NIST, Center for Building Technology, Building 226, Room B-348, Gaithersburg, MD 20899, or call (301) 975-6719, FAX (301) 975-4032, TELEX TRT 197674 NIST WT.

*Please send notices to Gabrielle Burn.

October 10-12: Second Symposium on Insulation Materials--Testing and Applications, sponsored by ASTM Committee C 16, to be held in Gatlinburg, TN. For more information, contact Symposium Co-Chairmen: Ron S. Graves, Oak Ridge National Laboratory, P.O. Box 2008, Bldg. 4508, Oak Ridge, TN 37831-6092, (615) 574-5978; or Don C. Wysocki, Mobay Corporation, Penn Lincoln Parkway West, Pittsburgh, PA 15205, (412) 777-2574.

1992

December: Thermal Performance of the Exterior Envelope of Buildings V, to be held in the Florida area. Sponsors include DOE, ASHRAE, and BTECC. For more information, contact Pat M. Love, Co-Chairperson, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831-6070, or call (615) 574-4346.

d. CONSULTANTS

ACEC RESEARCH AND MANAGEMENT FOUNDATION

Jack R. Warner
President
Washington, D.C. 20005
Subcontract ORNL/Sub-SE077/3
Deliver by: 05-31-90

A new contract is pending.

**BTECC WORKSHOPS AND FEASIBILITY STUDY
BUILDING THERMAL ENVELOPE COORDINATING COUNCIL
NATIONAL INSTITUTE OF BUILDING SCIENCES**

**Bruce E. Vogelsinger
National Institute of Building Sciences
Washington, D.C. 20005
Subcontract ORNL/Sub-SC111/7
Deliver by: 12-31-90**

This contract has three tasks:

1. Feasibility of a Tracking System on Current Research and Publications on Building Thermal Envelopes.

A detailed scope of work was developed and distributed to potential subcontractors. Three proposals were reviewed and a subcontract was awarded to Energy Design Associates, Inc., Ansonia, New York. Work is under way, and the Materials RCC Committee of BTECC met on June 4 and reviewed the work of the subcontractor. A three-person review committee has been appointed and an interim report will be submitted to the committee for review and comment on November 1. The report will be reviewed by the Materials RCC Committee, scheduled to meet on November 6, 1990. The final report is scheduled to be completed on December 28.

2. Workshop on Building Heat Flow Measurements.

The workshop was held at the Cold Regions Research and Engineering Laboratory, Hanover, NH on May 22-23, 1990. Twenty-three people attended the workshop. Papers from the authors were due September 1, 1990, and all but one paper has been received. Style editing and final preparation of the proceedings will be initiated in September.

3. Workshop on Preventing and Repair of Condensation Damage in New and Existing Housing.

The planning and conduct of this workshop has been assigned to BTECC's Research Coordinating Committee on Moisture Control. The Committee has had some difficulty in focusing on the necessary planning for the workshop. At the June 4 meeting, Erv Bales, New Jersey Institute of Technology, and Bill Rose, University of Illinois, volunteered to co-chair the workshop. The co-chairs are currently working on a preliminary program, date, and site selection.

TASK B. BUILDING MATERIALS PROGRAM

The Building Materials Program includes work done at ORNL and work done by others on DOE-funded projects. The following pages include project reports for three areas:

B1. ADVANCED MATERIALS RESEARCH

Cooperative Government/Industry Project on Alternatives for
CFC-Based Foam Insulation
High-Resistance Powder-Filled Evacuated Panels

B2. PERFORMANCE OF CURRENTLY-USED MATERIALS

Determination of properties of materials
Improvement of test procedures

B3. MATERIALS PROGRAM MANAGEMENT SUPPORT

Technology transfer
Coordination of subcontracted research

**BUILDING
MATERIALS
PROGRAM****TASK B1. ADVANCED MATERIALS RESEARCH****1. ALTERNATIVE MATERIALS FOR CFC-BASED FOAM INSULATIONS**

D. L. McElroy, R. S. Graves, T. G. Kollie, and D. W. Yarbrough
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6092

This task is currently focused on two topics:

(1.1) The Cooperative Government/Industry Research Project for CFC Alternatives, and

(1.2) High-Resistance Powder-filled Evacuated Panels (PEPs)

- 1.1 Cooperative Project. The second draft of ORNL/TM-11645, entitled, "Thermal Resistance of Polyisocyanurate Foam Board Insulation Blown with CFC-11 Substitutes - A Cooperative Industry/Government Project," was sent to DOE/HQ and a group of reviewers as a FY 1990 deliverable due in September 1990. The draft summarizes calibration and aging tests for panels exposed on the Roof Thermal Research Apparatus and tests of thin specimens that accelerate the foam aging process. Both topics were covered in talks entitled, "Alternative Blowing Agents for Foams," at the University of Tennessee and at a meeting of the Insulation Contractors of America Association. The thin specimen aging procedure is part of a draft of a proposed ASTM test procedure (C X3.7) that will be discussed at the meeting of ASTM C 16, New Orleans, Louisiana.

We completed the second draft of an ORNL/TM entitled, "Interlaboratory Comparison of Four Heat Flow Meter Apparatuses on Planed Polyisocyanurate Boards Foamed with CFC-11." The participants obtained a total of 15 apparent thermal conductivity values that have a precision of 2.4% (two standard deviations). Future tests may include thicker planed and unplaned specimens. The precision obtained is very supportive of the test results on planed thin specimens.

We completed preparations for presentations on the foam project at the Polyurethanes '90 conference (a FY 1990 milestone) and at the Project Steering Committee meeting on October 4, 1990. Copies of these presentations were sent to DOE/HQ and include calculations for foam aging using ORNL-MITB, a modified version of an MIT computer program. The program calculations predict effective diffusion coefficients (D) that are within an order-of-magnitude of the thermal test D values. This positive result shows determination of D values could guide future product evaluation and development.

- 1.2 Panels. Because the pressure measurements performed at Global Thermionics, Inc., on our Powder Evacuated Panels (PEPs) were grossly in error, we have repeated our measurements of the permeance (p) for helium of the bag material with which our PEPs were fabricated. These p measurements were about a factor of five higher than those we obtained previously, but still were about a factor of two below those made by the Oak Ridge Gaseous Diffusion Plant (ORGDP). They have recently discovered that their measurements were too high because of leaks between the laminations of the bag material that occurred during their measurements. These leaks caused about a factor of two increase in their background leak rate. They are presently remeasuring p with the edges of the specimen sealed with an epoxy cement. In addition, we have contracted Mocon Controls, Inc., to measure p of the bag material. All specimens will be measured after conditioning to remove absorbed water in the bag material. Water raises the p of this material considerably. In addition, samples of SRM 1470 have been obtained from the National Institute of Standards and Technology (NIST) for comparison measurements by Mocon Controls, Inc., and ORGDP.

We have recently completed a survey of the available bag materials for PEPs. Several candidate materials are being evaluated by Mocon Controls, Inc., and ORGDP.

We are presently preparing a summary report that reviews the ORNL efforts in PEP technology development, with emphasis on the work performed in the last two years. The first draft of this report should be completed by early November.

2. THERMAL RESISTANCE MEASUREMENTS AND DATA BASE OF CFC-REPLACEMENT THERMAL PROPERTIES FOR FOAM INSULATION PRODUCTS

R. Zarr
National Institute of Standards and Technology
Gaithersburg, Maryland 20899

ORNL/IA-21513/26

Progress Report for August 1990:

Task A, Milestone 5 (Measure Materials on GHP and HFM): Measurements of apparent thermal conductivity for specimens of foam insulation have been completed. A progress report entitled, "Thermal Resistance Measurements of Foam Insulation Products Using the Guarded Hot Plate and the Heat Flow Meter," was prepared for the Department of Energy. One copy was sent to ORNL. An abstract describing these measurements was accepted for the ASTM C 16 Symposium in Gatlinburg, Tennessee.

For the remainder of the month, work was diverted to the 1990 ASTM C 687 Loose-Fill Round Robin.

1. Four specimens of rockwool loose-fill insulation were prepared with assistance from the National Association of Home Builders (NAHB). Specimens were prepared on-site at the NAHB Research Center in Upper Marlboro, Maryland and transported by NIST to Gaithersburg. Specimens were stored in the laboratory along with specimens of unbonded glass-fiber and cellulose.
2. Measurements of apparent thermal conductivity were conducted using the NIST one-meter guarded hot plate (GHP). One specimen of low-density glass-fiber batt was measured at a thickness of 152.4 millimeters at a mean specimen temperature of 23.8°C. The specimen was measured three times. At the conclusion of the GHP tests, the apparent thermal conductivity of the specimen was determined in the large heat flow meter apparatus under the same test conditions.

Task B, Milestone 3 (Measure New Foam Products): Draft One of, "Interlaboratory Comparison of ASTM C 518 Apparatus on Prototypical Polyisocyanurate Boards Foamed with CFC-11," was received from ORNL. Comments were reported to ORNL.

Miscellaneous:

1. Acceptance tests for the large environmental chamber were completed.

**3. INVESTIGATION OF THE SUBSTITUTION OF ENVIRONMENTALLY ACCEPTABLE
BLOWING AGENTS IN FOAM INSULATION: MEANS TO ACHIEVE EQUIVALENT
OR APPROVED ENERGY EFFICIENCY**

Glicksman, Burke, Lanciani, Mozgowiec, Page
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

ORNL/SUB-09099/16

Sizes of potential core powder materials were observed by calibrating an optical microscope. PMMA, PPO, and Teflon Fluoradditive powders were studied. Ground PU foam powder was also analyzed using TEM techniques. Sizes of particles observed and quoted by supplying companies are in discrepancy with what Micron Powder Systems measured using their Granulmetre. Various methods of analyzing particle size of powders are currently being surveyed.

Samples composed of cores such as PMMA and PPO and coatings of graphite were processed using the mechanofusion technique at Micron Powder Systems. Similar technology exists at Bepex Co. Analysis on the FTLIR spectrometer of samples is under way. These samples will then be added to PU foam production, and the resulting foam insulation will be analyzed.

In the area of compact vacuum insulation panels, work is continuing on the implementation of glass as the encapsulant. However, during the production of these panels, problems arose due to continued out-gassing of the powder and/or glass at high temperatures once the glass seal had been achieved. Current attention is being focused on testing the integrity of the seal and determining the pressure within the panel. Experiments are being done to obtain a quantitative understanding of the factors (such as the density of the compressed powder) influencing the out-gassing of the powder.

New methods for encapsulating the powder in glass are also being explored.

Work is currently being done at MIT to produce microcellular, thermoplastic foams. A sample of the thermoplastic foam has been attained and it shall be tested for its radiative transmission. Data is being collected in order to relate a materials characteristic cell diameter to its extinction coefficient(s).

**BUILDING
MATERIALS
PROGRAM****TASK B2. PERFORMANCE OF CURRENTLY-USED MATERIALS****1. MODELS, METHODS, MEASUREMENTS - ORNL**

This task is currently focused on three topics:

1. Development and use of analytical models for heat transfer.
2. Development and use of flat insulation testers: the Unguarded Thin Heater Apparatus (UTHA) and the Advanced R-Matic Apparatus.
3. Measurement of the behavior of loose-fill attic insulation.

1.1 Models-ORNL

We are planning transient heat flow tests using the Unguarded Thin Heater technique with a 0.0046-inch-thick stainless steel screen wire heater as a substitute for the 0.026-inch-thick nichrome heater. Doing so for a polystyrene specimen will reduce the heater thermal mass from 300 to near 70 J/m³K and decrease the thermal mass ratio from 0.170 to 0.040. This test should confirm the predictions of a finite difference model of the transient test.

1.2 Methods-ORNL

The second draft of ORNL/TM-11629 entitled, "Steady-State and Transient Tests Using the Unguarded Thin-Heater Apparatus (Thermophysical Properties of Building Materials)," was sent to DOE/HQ and a group of reviewers as a FY 1990 deliverable due in September 1990. A high-capacity, temperature controlled, circulating bath was used to successfully control the top plate of the Unguarded Thin-Heater Apparatus at 55°F. This allowed one-sided measurements at a specimen mean temperature of 75°F. The results at 75°F were within 1% of the expected result obtained by extrapolating data in the range 80 to 120°F.

A second letter report was sent to Lawrence Berkeley Laboratory on results on their specimens obtained using the Advanced R-Matic Apparatus. The results showed that k-values increased with time for specimens containing argon or krypton and this is believed to be due to an increase in air components in the insulations.

1.3 Loose-Fill Attic Insulation-ORNL

In September all thermal tests were completed for the 1990 ASTM C 687 Interlaboratory Comparison on the Thermal Resistance of

Loose-Fill Insulations. The ORNL data set was sent to Dr. D. R. Smith, NIST, who will analyze and report the results. An ORNL Central Files Memo, ORNL/CF-90/292, entitled "1990 Loose-Fill Insulation Interlaboratory Comparison Test Plan," is being prepared by the Records Office.

2. THERMAL INSULATION STUDIES

D. W. Yarbrough, S. Wudhapitak, and M. Said
Department of Chemical Engineering
Tennessee Technological University
Cookeville, Tennessee 38505

ORNL/Sub-7715/90

No progress to report for the month of September.

3. STANDARD REFERENCE MATERIAL DEVELOPMENT

D. R. Smith
Chemical Engineering Science Division
National Institute of Standards and Technology
Boulder, Colorado 80303-3328

ORNL/IAA-21428/63

No progress to report for the month of September.

4. RESIDENTIAL INSULATION CORROSIVENESS

**E. E. Stansbury
Consultant
5800 Woodburn Drive
Knoxville, Tennessee 37919**

ORNL/Sub-B8240/28

No report for the month of September.

5. RESIDENTIAL INSULATION CORROSIVENESS

**E. E. Stansbury
Materials Science and Engineering Department
University of Tennessee
Knoxville, Tennessee 37919**

**Martin Marietta Energy Systems, Inc.
99732PAX/12
Consultant's Report**

No report for the month of September.

**6. RESEARCH AND DEVELOPMENT DATA TO DEFINE THE THERMAL
PERFORMANCE OF REFLECTIVE MATERIALS USED TO
CONSERVE ENERGY IN BUILDINGS**

**A. O. Desjarlais
Thermatest Division of Holometrix, Inc.
Cambridge, Massachusetts 02139**

ORNL/Sub-SA835/23

We continue to receive requests for ORNL/Sub/88-SA835/1, but our supply is exhausted. We are trying to obtain the photomasters from Bonneville Power Administration to allow 125 additional copies to be prepared.

7. RADIATION CONTROL COATINGS

**Robert W. Anderson
Robert W. Anderson and Associates, Inc.
Boulder City, Nevada 89005**

ORNL/Sub-SE791/5

Radiation Control Coatings (RCCs) applied to the external surfaces of roofs and walls can reflect up to 85% of solar radiation heating from the surfaces of buildings. In warm climates, solar heating is the primary source of heat gain through walls and roofs. RCC technology represents an alternative or adjunct to conventional thermal control methods (e.g. thermal insulation) for opaque building components.

A RCC product was tested during summer conditions in the ORNL RTRA facility. The test compared the thermal performance of a commercial black rubber (EPDM) roofing membrane with a similar roofing section coated with a RCC. The test data are being analyzed and the results will be incorporated in the project report.

Computerized simulations of the annual thermal performances of roofs with and without RCCs were made for five climatic areas using the BLAST program. Values for solar reflectance and long wavelength emittance of the RCCs were those obtained from previous laboratory testing; 85% solar reflectance and 90% emittance. Similar simulations will be made for wall sections. The data will be analyzed to identify potential areas for RCC applications.

**BUILDING
MATERIALS
PROGRAM****Task B3. BUILDING MATERIALS PROGRAM MANAGEMENT SUPPORT****1. SUPPORT ACTIVITY - ORNL**

This task is focused on two topics:

- (1.1) Exchange of technical results with the building materials community.
- (1.2) Coordination of subcontracted research at other facilities.

1.1 Exchange - ORNL

R. S. Graves, ORNL, and D. Wysocki, Mobay, are Co-Chairmen of the ASTM C 16 Second Symposium on Insulation Materials. They have organized the program and distributed acceptance letters to the authors and instruction letters to the Session Chairmen. Manuscripts are due January 2, 1991, to allow the Symposium proceedings to be available by October 10, 1991. ORNL will prepare two manuscripts based on ORNL/TM-11645 and ORNL/TM-11629 for the symposium.

R. S. Graves made a presentation on powder-filled evacuated panels at the ICAA meeting.

1.2 Coordination - ORNL

We are continuing to try to place a subcontract on research on advanced foams. We obtained a proposal to continue the Radiation Control Coating Project in FY 1991. We provided DOE/HQ with a draft Statement of Work for FY 1991. We initiated preparations for the Fall Meeting of ASTM C 16 in New Orleans, Louisiana. We provided E. Vineyard, ORNL, with a research proposal to evaluate use of powder-filled evacuated panels in refrigerator/freezers.

C. BUILDING ENVELOPE SYSTEMS

ORNL Staff:

J. E. Christian, K. E. Wilkes, R. L. Wendt,
G. E. Courville, P. W. Childs, and K. W. Childs

This task includes work done at ORNL and work by others on DOE-funded projects on Building Envelope Systems and is divided into Wall Performance, Advanced Wall Systems, Foundation Systems, Roof Systems, and Building Diagnostics. Each of these project areas is treated separately on the following pages.

WALL PERFORMANCE**1. THERMAL MASS SIMPLIFIED DESIGN TOOL ASSESSMENT**

**J. E. Christian
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6070**

No significant progress this month. A preliminary scoping statement was developed for a U.S. AID project proposal leading toward more effective use of thermal mass in developing countries. The Thermal Mass Credit Tables in the Model Energy Code are now applied to the base energy code in Iowa and Utah.

2. DYNAMIC EVALUATION OF THERMAL BRIDGES

D. Burch
National Institute of Standards and Technology
Gaithersburg, MD

ORNL/IA-21513/26

In this study, a finite-difference model is used to predict the steady-state and dynamic (time-dependent) performance of thermal bridges in a typical office building. The thermal bridges included in the analysis are a BUR roof with ceiling fasteners, a roof/wall interface, an insulated masonry cavity wall with steel studs, a slab floor penetrating an insulated masonry cavity wall, and a window frame/wall interface. The goal of this project is to analyze the effect of these thermal bridges on the predicted space heating and cooling loads of the typical office building.

Progress Report for August 1990:

Milestone 3 (Prepare Final Report): The final report for this project, entitled, "Dynamic Evaluation of Thermal Bridges in a Typical Office Building," is undergoing review at the National Institute of Standards and Technology. All other milestones for this project have been completed.

In this report, a finite-difference model is used to predict the steady-state and dynamic thermal performance of thermal bridges in a typical office building. The thermal bridges evaluated include: a built-up roof system with ceiling fasteners, a roof/wall interface, an insulated masonry cavity wall with metal studs, a floor slab that penetrates wall insulation, and a window frame/wall interface.

The steady-state analysis reveals that the thermal bridges increased the overall envelope heat transfer coefficient for the office building by 33%. A thermal bridge is found to have a large effect when it has a large cross sectional area that short circuits the thermal insulation of the building envelope.

In the dynamic analysis, a finite-difference model is used to numerically determine a complete set of conduction transfer function (CTF) coefficients for each of the thermal bridges. The mathematical procedure is to predict the heat transfer response of a thermal bridge excited by a ramp excitation function. The heat transfer response for a triangular pulse is subsequently obtained by superimposing the responses for three ramp excitation functions to form a triangular pulse. A recursive relation employing the common ratio is applied to the triangular-pulse response to determine first-order CTF coefficients. The validity of the CTF coefficients is demonstrated by accurately predicting the heat transfer response of each of the thermal bridges to a diurnal excitation function.

3. VALIDATION OF MOISTURE-TRANSFER MODEL

D. Burch
National Institute of Standards and Technology
Gaithersburg, Maryland 20899

ORNL/IA-21513/26

Progress Report for August 1990:

Milestone 3 (Complete Final Report on Sensitivity Analysis): A final report entitled, "An Analysis of Moisture Accumulation in a Wood-Frame Cavity Wall Subjected to Winter Climate," is undergoing review at the National Institute of Standards and Technology.

In this report, a distributed-capacity, one-dimensional, finite-difference model is presented that predicts the coupled transfer of heat and moisture through a multi-layer plane wall under non-steady-state conditions. The driving forces for moisture transfer are the gradient in the moisture content and the gradient in temperature. The formulation has the advantage that it can predict both vapor diffusion and capillary transfer. The model has provision for including embedded cavities which may be convectively coupled to either the indoor and/or outdoor air.

This model is subsequently used to predict the average moisture content in the sheathing and siding of wood-frame cavity wall as a function of time of year. In the analysis, hourly WYEC weather data are used for a mild winter climate (Atlanta, GA), an intermediate winter climate (Boston, MA), and a cold winter climate (Madison, WI). For the analysis, the indoor temperature is maintained at 70°F, and separate computer runs are carried out for indoor relative humidities of 35% and 50%.

The effect of several construction parameters on the winter moisture accumulation are investigated. The parameters include the interior vapor retarder permeance, sheathing permeance, exterior paint permeance, indoor air leakage, and the amount of cavity insulation. In addition, a controversial moisture management technique, outdoor ventilation of a cavity between the sheathing and siding, is investigated.

The traditional moisture management techniques of providing a vapor retarder and sealing interior air leakage paths were found to be effective in controlling winter moisture accumulation. However, the technique of outdoor ventilation of a cavity between the sheathing and siding was found to be ineffective.

ADVANCED WALL SYSTEMS

1. MOISTURE CONTROL HANDBOOK

**Joseph Lstiburek
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Park Ridge, Illinois 60068
ORNL/Sub-SD350/6**

No report.

FOUNDATION SYSTEMS**1. BUILDING FOUNDATIONS RESEARCH AGENDA**

J. E. Christian
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6070

Materials are beginning to arrive for assembling heat flux transducer guard plates to be used on the north wall of the ESRA to test several basement insulation systems. A cost for machine shop work has been received, and the work order prepared for having the basement insulation systems and instrumented panels installed in late October.

2. SLAB FOUNDATION BENCHMARK MODEL

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An operations manual for the RTRA has been written that includes a description of the data condensation conducted on the slab experiment. No significant progress on the model this month.

3. FOUNDATION THERMAL PERFORMANCE SIMPLIFIED PREDICTION TOOL

Jeff Christian
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6070

Additional comments from the DOE review of the Builders Foundation Handbook are being worked into the final mattes. The subcontract with John Carmody has been extended to accommodate some of the suggested additions.

ROOF SYSTEMS**1. ROOFING RESEARCH CENTER**

**R. L. Wendt
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6070**

A Cooperative Research and Development Agreement (CRADA) was initiated for two projects at the Center. One covers additional work on polyisocyanurate insulations developed under the joint government/industry research project. The other was to test the performance of cellulose insulation in the Attic Test Module and LSCS under severe winter conditions.

Additional work at the Center is reported in other sections under Roof Systems.

2. LARGE SCALE CLIMATE SIMULATOR

P. W. Childs, K. E. Wilkes, and J. E. Christian
Oak Ridge National Laboratory
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The Attic Test Apparatus testing was completed on the current loose-fill insulation. Plans to change this configuration to another are currently being discussed.

During this changeover period, the LSCS underwent its scheduled maintenance and modification work as follows:

1. The new pneumatic control valve for the metering chamber was installed.
2. Two replacement expansion valves were installed in the climate chamber refrigeration circuit.
3. The oil and all filters, etc., were replaced in the climate chamber refrigeration circuit.
4. The inspection plate on the climate chamber compressor was removed for observation of piston and bearing wear. Metal fragments were found in the crankcase suggesting possible abnormal wear. Some of the compressor pistons were removed for further inspection. Several pistons/rings revealed unusual wear. The inspection is continuing and oil samples were taken for analysis.

Jacques Boudin, Vista Scientific Corporation, will be visiting the Large Scale Climate Simulator on October 18, 1990. He is the original designer of this system. He will be here to discuss design modifications to the refrigeration loop to alleviate the accelerated deterioration of the main compressor. He initially proposed a smaller compressor coupled into the main refrigerant loop. He will also present an option of a completely separate, small compressor (1-5 ton) evaporator, condenser, and compressor tied into the cooling system by the control system only, to meet the low load capacity needs when the box is run at steady-state conditions.

3. IEA ANNEX 19 ON LOW SLOPE ROOF SYSTEMS

George E. Courville
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6070

No progress to report for the month of September.

4. ATTIC TESTING IN THE LSCS

Kenneth E. Wilkes and Agnes Delmas
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6070

After tests with the expanded polystyrene foam calibration panel, the attic was reinstalled in the LSCS. Tests under summer and winter conditions gave results within about five percent of those measured previously. No evidence was seen for warping of the ceiling, and additional sealing of the joint between the metering chamber walls and the ceiling had little effect. It was concluded that the previous results with the attic were not affected by warping of the ceiling and opening of gaps between the metering chamber and the ceiling as was seen with the calibration panel.

Finite difference analyses were continued to develop a theoretical understanding of convection in loose-fill attic insulation. Results thus far have shown that the wood joists have a significant influence on the initiation of convection. With joists present, convection starts at a smaller temperature difference than if joists are not present.

5. FIELD TESTING OF ISOCYANURATE FOAMS WITH ALTERNATE BLOWING AGENTS

J. E. Christian and G. E. Courville
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6070

An article was written for Construction Specifier News on the CFC alternatives. This will be a feature story in the November 1990 issue. A technical paper was presented at the Polyurethanes '90 Conference. This paper is available in the conference proceedings and in an SPI publication entitled, "CFCs & the Polyurethane Industry: Volume 3, 1990". There were 36 other technical papers on the latest findings from industry research programs to eliminate chlorofluorocarbons (CFCs) from polyurethane foams. A status report was presented to the Cooperative Industry/Government Project Steering Committee. Field data up to September 24 was presented. After 460 days since production aging has clearly slowed on all test specimens. The HCFC-141b specimens under the white membrane aged more slowly than the black throughout the winter, but experienced a period of accelerated aging in the spring such that, throughout the summer of 1990, there is no apparent difference between the k-factor of the 141b under the black membrane compared to the 141b board under the white membrane. It appears that the field specimen aging caused by the air component diffusion has run its course in these 1.5 inch thick-faced boards after 9 to 10 months. This is much more apparent in the HCFC-123 than in the CFC-11 and HCFC-141b specimens. For the last two months there has been no significant difference in the k-factors of the two blends (50/50 or 65/35 HCFC-123/HCFC-141b).

The Cooperative Industry/Government Project Steering Committee formed a Task Force to (1) evaluate the data collected thus far on the existing set of experiments; (2) examine whether or not to modify any of the remaining work in light of findings to date; and (3) prepare a list of recommendations for Phase II. This task force will be headed by Bob Blanpied of Atlas Roofing.

The Memorandum of Understanding on Roofing Research at ORNL is now available for review. ORNL has reviewed it and has urged DOE to sign it. This is an umbrella agreement that states why we are cooperating but that all working contracts between parties are separate. Another important feature of this agreement is that any of the signers can veto any individual agreement made under this Memorandum of Understanding. In other words, all principals must accept each individual contract that is part of this overall research.

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6. ROOF MECHANICAL PROPERTIES RESEARCH APPARATUS

**Robert L. Wendt
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6070**

The roof containing the five different polyisocyanurate insulation formulations was installed June 26-27, 1990. Three blisters have been noted on the roof platform. They range in size from about 18 inches in diameter to about 4 ft x 2 ft in size. The blisters are located on separate insulation boards made of the 50/50 and 65/35 blends and located in the perforated facer, plys direct to insulation, portion of the BUR section. The cause of these blisters (workmanship and/or material) is unknown at this time and will not be determined until samples are taken and analyzed at the conclusion of the test period.

A number of "fish mouths" on the BUR portion of the roof platform have been previously mentioned. One of these was in close proximity to the second blister and was weeping water. This "fish mouth" was cut open and repaired. A small amount of water had penetrated to the asphalt atop the insulation facer but the insulation itself remained dry. The under surface of the deck has been inspected and no evidence of leaking was found.

Work remaining to be accomplished includes site grading, and the installation of the initial series of foundation experiments.

7. ROOFING INDUSTRY COMMITTEE ON WIND ISSUES

**George E. Courville
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830-6070**

No progress to report for the month of September.

D. COOPERATIVE PROJECTS

1. COOPERATIVE INDUSTRY/GOVERNMENT RESEARCH PROJECT ON ALTERNATIVE BLOWING AGENTS

G. E. Courville, D. L. McElroy, J. E. Christian, and R. L. Wendt
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

This project is jointly supported by the Department of Energy, the Environmental Protection Agency, The Society of the Plastics Industry, the Polyisocyanurate Insulation Manufacturers Association, and the National Roofing Contractors Association. The objective of the project is to conduct comparative laboratory and field studies of isocyanurate foam roofing boards blown with conventional CFC-11 and with alternative blowing agents. The purpose is to identify performance differences, if any, between foams with alternative blowing agents and foam blown with CFC-11.

1. MEETINGS AND PRESENTATIONS

- September 4 D. L. McElroy gave a presentation on foams at the University of Tennessee.
- September 6 Jeff Christian presented a summary of CFC alternatives research and provided a tour of the envelope test facilities to Anatoliy Afanasiev, USSR Academy of Sciences.
- September 26-28 R. S. Graves gave a talk to the Insulation Contractors of America Association in Orlando, Florida.

2. LABORATORY TESTING

The second draft of ORNL/TM-11645, entitled, "Thermal Resistance of Polyisocyanurate Foam Board Insulation Blown with CFC-11 Substitutes - A Cooperative Industry/Government Project," was sent to DOE/HQ and a group of reviewers as a FY 1990 deliverable due in September 1990. The draft summarizes calibration and aging tests for panels exposed on the Roof Thermal Research Apparatus and tests of thin specimens that accelerate the foam aging process. Both topics were covered in talks entitled, "Alternative Blowing Agents for Foams," at the University of Tennessee and at a meeting of the Insulation Contractors of America Association. The thin specimen aging procedure is part of a draft of a proposed ASTM test procedure (C X3.7) that will be discussed at the meeting of ASTM C 16, New Orleans, Louisiana.

We completed the second draft of an ORNL/TM entitled, "Interlaboratory Comparison of Four Heat Flow Meter Apparatuses on Planed Polyisocyanurate Boards Foamed with CFC-11." The participants obtained a total of 15 apparent thermal conductivity values that have a precision of 2.4% (two standard deviations). Future tests may include thicker planed and unplanned specimens. The precision obtained is very supportive of the test results on planed thin specimens.

We completed preparations for presentations on the foam project at the Polyurethanes '90 conference (a FY 1990 milestone) and at the Project Steering Committee meeting on October 4, 1990. Copies of these presentations were sent to DOE/HQ and include calculations for foam aging using ORNL-MITB, a modified version of an MIT computer program. The program calculations predict effective diffusion coefficients (D) that are within an order-of-magnitude of the thermal test D values. This positive result shows determination of D values could guide future product evaluation and development.

3. FIELD TESTING

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