

THERMAL INSULATION, MATERIALS, AND SYSTEMS FOR ENERGY CONSERVATION IN THE '80s

Govan/Greaseon/McAllister, *editors*



STP 789

THERMAL INSULATION, MATERIALS, AND SYSTEMS FOR ENERGY CONSERVATION IN THE '80s

A conference
sponsored by ASTM
Committee C-16 on
Thermal Insulation
and DOE-ORNL
Clearwater Beach, Fla., 8-11 Dec. 1981

ASTM SPECIAL TECHNICAL PUBLICATION 789
F. A. Govan, Ziel-Blossom & Associates,
D. M. Greason, Dow Chemical USA, and
J. D. McAllister, American Electric Power
Service Corporation, editors

ASTM Publication Code Number (PCN)
04-789000-10



1916 Race Street, Philadelphia, Pa. 19103

Copyright © by AMERICAN SOCIETY FOR TESTING AND MATERIALS 1983
Library of Congress Catalog Card Number: 82-70616

NOTE

The Society is not responsible, as a body,
for the statements and opinions
advanced in this publication.

Foreword

The Conference on Thermal Insulation, Materials, and Systems for Energy Conservation in the '80s was held 8–11 December 1981 in Clearwater Beach, Florida. ASTM Committee C-16 on Thermal Insulation sponsored the conference in cooperation with the Department of Energy and Oak Ridge National Laboratory. A list of the Conference Steering Committee and the Session Chairmen will be found in the Introduction. F. A. Govan, Ziel-Blossom & Associates, was Conference Chairman; J. D. McAllister, American Electric Power Service Corporation, Conference Co-Chairman; D. M. Greason, Dow Chemical USA, Conference Vice Chairman—Technical Program; and T. S. Lundy, Oak Ridge National Laboratory, Conference Vice Chairman—Arrangements. Messrs. Govan, Greason, and McAllister have edited this publication.

Related ASTM Publications

Thermal Insulation Performance, STP 718 (1980), 04-718000-10

Thermal Transmission Measurements of Insulation, STP 660 (1979),
04-660000-10

Thermal Insulations in the Petrochemical Industry, STP 581 (1975),
04-581000-10

Heat Transmission Measurements in Thermal Insulations, STP 544 (1974),
04-544000-10

Part 18 of the ASTM Book of Standards—Thermal Insulation; Building
Seals and Sealants; Fire Standards; Building Constructions; Environ-
mental Acoustics, 01-018082-10

A Note of Appreciation to Reviewers

This publication is made possible by the authors and, also, the unheralded efforts of the reviewers. This body of technical experts whose dedication, sacrifice of time and effort, and collective wisdom in reviewing the papers must be acknowledged. The quality level of ASTM publications is a direct function of their respected opinions. On behalf of ASTM we acknowledge with appreciation their contribution.

ASTM Committee on Publications

ASTM Editorial Staff

Janet R. Schroeder
Kathleen A. Greene
Rosemary Horstman
Helen M. Hoersch
Helen P. Mahy
Allan S. Kleinberg
Virginia M. Barishek

Contents

Introduction	1
Welcoming Remarks	
F. A. GOVAN	7
MAXINE SAVITZ	7
J. G. O'GRADY	10
 FEDERAL AND STATE ENERGY PROGRAMS	
The National Program Plan for the Thermal Performance of Building Envelope Systems and Materials—	
P. R. ACHENBACH AND E. C. FREEMAN, JR.	19
Innovative Building Insulation Systems: Code Acceptance, Standards, and Laboratory Accreditation Practices in Massachusetts—	
L. C. TARTAGLIONE AND D. C. MACARTNEY	35
Implementation and Enforcement of Residential Energy Conservation Standards—The California Experience—	
ROBERT FEINBAUM AND EARL RUBY	52
Home Insulation: The User's View—	
WILLETT KEMPTON, PETER GLADHART, AND DENNIS KEEFE	69
Session Summary: Federal and State Energy Programs—	
E. C. FREEMAN, JR.	81
 INSULATION SAFETY AND HEALTH ISSUES	
Tackling Safety and Health Issues in the Use of Thermal Insulation—	
P. M. LANCER	85
Efficient Application of Boron Fire Retardant to Cellulosic Loose-Fill Insulation—	
T. H. WEGNER AND C. A. HOLMES	100
Aspects of Corrosion Testing of Thermal-Insulating Materials—	
K. G. SHEPPARD AND R. WEIL	114
Health Aspects of Man-Made Vitreous Fiber Insulations—	
C. L. SHECKLER	133
Indoor Air Pollution, Energy Conservation, and the Use of Building Materials—	
DAVID LORD	138
Session Summary: Insulation Safety and Health Issues—	
J. M. BARNHART	146

ECONOMIC EVALUATION

Total Energy Costs of Building Construction and Operation— Y. C. WONG AND H. J. SAUER, JR.	149
Study Periods and Energy Price Escalation Rates—Important Factors in the Economic Evaluation of Insulation Systems— R. J. ALBRECHT	161
Life-Cycle Cost Economic Optimization of Insulation, Infiltration, and Solar Aperture in Energy-Efficient Houses— D. A. ROBINSON	176
Engineering and Economic Evaluation of a Commercial Roof/Insulation Retrofit— B. E. WOLLER	189
Session Summary: Economic Evaluation— R. L. BAUMGARDNER	202

THERMAL TESTING APPARATUS

Development of a Testing Procedure for a Guarded Hot Box Facility— R. D. ORLANDI, J. W. HOWANSKI, G. D. DERDERIAN, AND L. S. SHU	205
Design and Calibration of a Rotatable Thermal Test Facility— W. P. GOSS AND AHMET OLPAC	215
Flanking Loss Calibration for a Calibrated Hot Box— A. G. LAVINE, J. L. RUCKER, AND K. E. WILKES	234
Design of Round-Robin Tests with Guarded/Calibrated Hot Boxes, Guarded Hot Plates, and Heat Flow Meters— F. J. POWELL AND E. L. BALES	248
Design and Construction of a Full-Thickness Guarded Hot Plate Test System— D. A. MESSMER	265
Comments on Calibration and Design of a Heat Flow Meter— M. BOMBERG AND K. R. SOLVASON	277
Effect of Mounting on the Performance of Surface Heat Flow Meters Used to Evaluate Building Heat Losses— R. E. WRIGHT, JR., A. G. KANTSIOS, AND W. C. HENLEY	293
Session Summary: Thermal Testing Apparatus— C. M. PELANNE	318

FIELD AND LABORATORY TESTING OF BUILDING COMPONENTS

Thermographic Inspection of Cavity-Wall Insulation Retrofits— R. A. GROT AND YUI-MAY L. CHANG	321
Residential Sidewall Insulation Case Histories, Including Experiences and Problems in the Field Application of Loose Fill— L. J. INFANTE, P. F. ALLER, AND R. E. FAY	337
Simplified Thermal Parameters: A Model of the Dynamic Performance of Walls— M. H. SHERMAN, J. W. ADAMS, AND R. C. SONDEREGGER	355

Thermal Resistances of Insulated Brick Veneer Walls with Reflective and Nonreflective Air Spaces—A. G. CONTRERAS AND A. J. PALFEY	373
Thermal Performance of Insulated Metal Building Roof Deck Constructions—R. G. MILLER AND M. SHERMAN	384
Thermal Testing of Roof Systems—D. C. LARSON AND R. D. CORNELIUSSEN	400
Glass Fiber as a Draining Insulation System for the Exterior of Basement Walls—P. C. DEACON	413
Thermal Performance of Various Insulations in Below-Earth-Grade Perimeter Application—G. OVSTAAS, S. SMITH, W. STRZEPEK, AND G. TITLEY	435
Comparison of Annual Heating Loads for Various Basement Wall Insulation Strategies by Using Transient and Steady-State Models—P. H. SHIPP AND T. B. BRODERICK	455
Session Summary: Field and Laboratory Testing of Building Components—E. L. BALES	474

CONVECTION AND AIR INFILTRATION EFFECTS

Thermal Transmittance and Conductance of Roof Constructions Incorporating Fibrous Insulation—B. E. TAYLOR AND A. J. PHILLIPS	479
Investigation of Attic Insulation Effectiveness by Using Actual Energy Consumption Data—T. F. SCANLAN, C. K. BAYNE, AND D. R. JOHNSON	502
New and Retrofit Insulation of Single-Member Cathedral Ceiling, A-Frame, and Flat Residential Roofs—HENRI DE MARNE	516
Effect of Air Movement on Thermal Resistance of Loose-Fill Thermal Insulations—D. W. YARBROUGH AND I. A. TOOR	529
Effectiveness of Wall Insulation—G. D. SCHUYLER AND K. R. SOLVASON	542
Energy Conservation with Air Infiltration Barriers—G. N. HENNING	551
Session Summary: Convection and Air Infiltration Effects—F. J. POWELL	559

MOISTURE EFFECTS

Influence of Moisture on Heat Transfer Through Fibrous-Insulating Materials—C. LANGLAIS, M. HYRIEN, AND S. KLARSFELD	563
Heat and Moisture Transfer in a Glass Fiber Roof-Insulating Material—W. C. THOMAS, G. P. BAL, AND R. J. ONEGA	582

Effect of Moisture on Thermal Resistance of Some Insulations in a Flat Roof under Field-Type Conditions—C. P. HEDLIN	602
Can Wet Roof Insulation Be Dried Out?—WAYNE TOBIASSON, CHARLES KORHONEN, BARRY COUTERMARSH, AND ALAN GREATOREX	626
Moisture Control in Retrofit Commercial Roof Insulations—M. B. STEWART	640
Water Vapor Flow and High Thermal Resistance Insulation Systems for Metal Buildings—R. M. KELSO	651
Session Summary: Moisture Effects—M. HOLLINGSWORTH, JR.	661

MATERIALS BEHAVIOR

Elevated Temperature and Humidity Effects on Urea-Formaldehyde Foam Insulations Observed by Scanning Electron Microscopy—W. J. ROSSITER, JR., D. B. BALLARD, AND G. A. SLEATER	665
Thermal Resistance and Aging of Rigid Urethane Foam Insulation—J. A. VALENZUELA AND L. R. GLICKSMAN	688
Settling of Loose-Fill Insulations Due to Vibration—D. W. YARBROUGH, J. H. WRIGHT, D. L. MCELROY, AND T. F. SCANLAN	703
Glass-Mica Composite: A New Structural Thermal-Insulating Material for Building Applications—N. M. P. LOW	715
Session Summary: Materials Behavior—D. L. MCELROY	730

MECHANICAL, POWER, AND PROCESS SYSTEMS INSULATION

Factors Influencing the Thermal Performance of Thermal Insulations for Industrial Applications—R. P. TYE AND A. O. DESJARLAIS	733
Protection of Thermal and Cryogenic Insulating Materials by the Use of Metal Jacketing and Mastic Coatings—J. B. MARKS	749
Effects of Binder Decomposition on High-Temperature Performance of Mineral Wool Insulation—E. SAATDJIAN, Y. DEMARS, S. KLARSFELD, AND Y. BÜCK	757
Thermal Performance of Insulated Pipe Systems—J. M. SULLIVAN, JR.	778
A Lump Sum, Unit-Price Bid Proposal Evaluation Method—J. D. MCALLISTER AND R. K. BIGGERS	796
Boiling Tests of Thermal Insulation in Conduit-Type Underground Heat Distribution Systems—TAMAMI KUSUDA AND W. M. ELLIS	802

Reduction of Heat Stress on Naval Ships Through Improved Insulation Installations—B. J. ROGUS	819
Total System Heat Loss Measurements—B. A. ALLMON, D. A. RAUSCH, AND H. W. WAHLE	839
Finite-Difference Thermal Analysis of an Insulation System on a Precipitator Building in a Power Plant—K. F. CHARTER	857
Session Summary: Mechanical, Power, and Process Systems Insulation—W. W. HEINRICH	874
 SUMMARY	
Summary	879
Index	883

Introduction

Prior to the 1973-74 oil embargo the price of oil for heating and process applications was less than 40 cents per million Btu. At the time of this conference the price of the same oil is in excess of \$5.00 per million Btu. When oil and gas were an insignificant cost factor, the purchase of energy-efficient devices, thermal insulation, and weatherproofing, as well as adequate attention to the envelope of all structures, was rarely considered seriously by either the purchaser or the contractor. In fact, when construction budgets were in excess of the estimates, the first thing to be removed was anything that related to energy conservation. The lowest possible price was the basic criterion for construction. Thus almost all development efforts by equipment and material suppliers were directed towards reducing the price of their products. There was little incentive to invest, develop, and market anything that would reduce the use of energy.

The embargo was our rude awakening to our dependence on imported oil and to the fact that liquid-fuel resources are finite. Two events occurred in the mid-1970s that, in a dramatic way, stimulated interest in energy conservation and improvements in the utilization of fuels. In the first place, the market began to develop for new or improved energy-saving products, which resulted in manufacturers increasing their research and development efforts. Secondly, the federal government began to finance research in order to obtain a better understanding of the basic mechanisms of heat, moisture transfer, energy utilization, and fuel technology. Also sponsored and encouraged were investigations into practices that might reduce the as-installed inefficiencies of materials and products. In addition, the federal government promulgated rules, regulations, and tax incentives that allowed residential, commercial, and industrial organizations to consider energy conservation a major factor in their capital investment plans.

Since 1976 there has been a great surge in the amount of research in energy conservation. The results of this work, however, will only be of value if they are made available in a practical way to those people and organizations who can stimulate the market applications. The construction sector of the economy, being highly fragmented, does not offer a broadly based forum for the exchange of these data. How, then, to develop a forum where the free exchange of the results of these multimillion dollar efforts could be presented, discussed, and debated?

Over the last few years, with funds provided by the Department of Energy

and with the assistance of the American Society for Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), ASTM Committee C-16 on Thermal Insulation has sponsored and organized a series of conferences and symposia. These were primarily highly technical and sophisticated discussions, however, with participation generally limited to scientists, researchers, and product-development people. In order to reach the audience of architects, engineers, consumers, contractors, and product manufacturers who would implement and market products, it was decided that a conference directed towards this broadly based audience would be the most effective method of disseminating the information rapidly and effectively.

A Conference Steering Committee was formed in early 1980. The representatives and their affiliations are given below.

CONFERENCE STEERING COMMITTEE

Francis A. Govan, Conference Chairman
Ziel-Blossom & Associates
Cincinnati, Ohio

John D. McAllister, Conference Co-Chairman
American Electric Power Service Corporation
New York, New York

David M. Greason, Conference Vice Chairman—Technical Program
Ted S. Lundy, Conference Vice Chairman—Arrangements
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Jack F. Corey
PPG Industries—Fiberglas Division
Shelby, North Carolina

Wayne P. Ellis
H. B. Fuller Company
Spring House, Pennsylvania

Ernest C. Freeman
Department of Energy
Washington, D.C.

Stanley L. Matthews
Rockwool Industries, Inc.
Denver, Colorado

Charles M. Pelanne
Johns-Manville Research and Engineering Center
Denver, Colorado

Frank J. Powell
National Bureau of Standards
Washington, D.C.

James A. Thomas
ASTM
Philadelphia, Pennsylvania

Oak Ridge National Laboratory Conference Staff*Bonnie S. Reesor*

Conference Coordinator

Marjorie C. Matthews

Assistant Vice Chairman—Arrangements

Registration/Finance Chairman

The Conference on Thermal Insulation, Materials, and Systems for Energy Conservation in the '80s was held 8–11 December 1981 in Clearwater Beach, Florida. ASTM Committee C-16 sponsored the conference in cooperation with the Department of Energy and Oak Ridge National Laboratory. As was hoped, architects, engineers, consumers, and contractors were among the over 300 registrants, giving the forum the desired mix. New understandings of the fundamental mechanisms of heat and moisture transfer were presented, and the application of products that improve energy conservation was discussed. The conference was the first to include substantial data on industrial applications, an area where large savings in energy use are possible.

The nine sessions of the conference and their chairmen are listed below.

SESSION I—Federal and State Energy Programs*Ernest C. Freeman*

Department of Energy

Washington, D.C.

SESSION II—Insulation Safety and Health Issues*Jack M. Barnhart*

Thermal Insulation Manufacturers' Association

Mt. Kisco, New York

SESSION III—Economic Evaluation*R. L. Baumgardner*

Rollin Incorporated

Stroudsburg, Pennsylvania

SESSION IV—Thermal Testing Apparatus*C. M. Pelanne*

Johns-Manville Research and Engineering Center

Denver, Colorado

SESSION V—Field and Laboratory Testing of Building Components*E. L. Bales*

Department of Energy

Washington, D.C.

SESSION VI—Convection and Air Infiltration Effects*F. J. Powell*

National Bureau of Standards

Washington, D.C.

SESSION VII—Moisture Effects

M. Hollingsworth, Jr.
Owens-Corning Fiberglas Corporation
Granville, Ohio

SESSION VIII—Materials Behavior

D. L. McElroy
Oak Ridge National Laboratory
Oak Ridge, Tennessee

SESSION IX—Mechanical, Power, and Process Systems Insulation

W. W. Heinrich
Phillips Petroleum Company
Bartlesville, Oklahoma

Most of the papers presented at the conference are contained in this volume; in addition, the session chairmen have provided summaries of their respective sessions.

The session on Moisture Effects is an example of the fundamental, as well as practical, aspects of coping with moisture movement and migration. The paper "Can Wet Roof Insulation Be Dried Out?" presents the results of field and laboratory testing of various commercial *in situ* methods of drying roof insulations. The major conclusion of this paper is that none of the commercially available methods of drying is effective in returning the insulation to its dry values. Rather, the best solution to wet roofs seems to be to locate and repair the leak areas and to replace the wet insulation. There was some interesting work indicating that vacuuming the area would aid in the drying process, but the time required would still be lengthy. The data from this paper had an immediate effect in the marketplace: full-page ads are currently being taken out to promote certain devices and their value for *in situ* drying. Thus potential users now have information that allows them to make an objective decision.

Another purpose of presenting the results of research is to prevent the repetition of work that has already been accomplished. One paper presented work identical to that conducted in the past and published in obscure publications. If the previous work had been published widely in an ASTM publication, a thorough literature search would have identified that the fundamentals had already been examined and the researcher could have then continued to work through to the next logical step rather than repeat the basic work that had already been documented. In today's economy, and with the significant reduction in research funds available from the federal government, it is absolutely necessary that these funds be spent wisely and efficiently. It is important that the flywheel effect of this research not be stopped because of a drying-up of funds.

ASTM Committee C-16, as well as organizations such as ASHRAE, intend to continue these conferences on a biannual basis in order to assure that sig-

nificant test results and applications are made available through publication and broad dissemination. America now recognizes the importance of energy conservation. It is up to us workers in the field to provide the basic understanding, products, and tools needed for this national cause. It is time to be positive and bold in accomplishing these ends. We believe this conference is a major part of this effort.

F. A. Govan

Vice President of Professional Services, Ziel-Blossom & Associates, Inc., Cincinnati, Ohio; conference chairman and editor

D. M. Greason

Research Leader, Foam Products TS&D, Dow Chemical USA, Granville, Ohio; conference vice chairman - Technical Program and editor

J. D. McAllister

Senior Mechanical Engineer, American Electric Power Service Corporation, New York, N.Y.; conference co-chairman and editor