

THERMAL INSULATION

Materials and Systems

Powell/Matthews *editors*

STP 922



THERMAL INSULATION: MATERIALS AND SYSTEMS

A conference
sponsored by
ASTM Committee C-16
on Thermal Insulation
Dallas, TX, 2-6 Dec. 1984

ASTM SPECIAL TECHNICAL PUBLICATION 922
Frank J. Powell, National Bureau of Standards,
and Stanley L. Matthews, consultant, editors

ASTM Publication Code Number (PCN)
04-922000-10



1916 Race Street, Philadelphia, PA 19103

Library of Congress Cataloging-in-Publication Data

Thermal insulation: materials and systems/a conference sponsored by
ASTM Committee C-16 on Thermal Insulation, Dallas, TX, 2-6 Dec. 1984;
Frank J. Powell and Stanley L. Matthews, editors.
(ASTM special technical publication 922)
"ASTM publication code number (PCN) 04-922000-10."
Includes bibliographies and index.
ISBN 0-8031-0493-6

1. Insulating materials—Congresses. 2. Insulation (Heat)—
Congresses. I. Powell, Frank J., 1923- . II. Matthews, Stanley L.
III. ASTM Committee C-16 on Thermal Insulation. IV. Series.
TH1715.A1T47 1987
620.1'1296—dc19

87-27045
CIP

Copyright © by AMERICAN SOCIETY FOR TESTING AND MATERIALS 1987
Library of Congress Catalog Card Number: 87-27045

NOTE

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



Stanley L. Matthews

In Memoriam

This volume is dedicated to the memory of Stan Matthews, coeditor of this book, who passed away before the book was in print. Stan was for many years a tireless worker for ASTM and, particularly, for ASTM Committee C-16 on Thermal Insulation. In Committee C-16, he was constantly involved at every level, from task group commitment to serving as a leading officer. His dedication to ASTM and to professional associations, the government, and the entire thermal insulation industry was admired and respected by all who actively worked with him. Stan's whole life was one of vigor, from his days as a Harvard M.B.A. graduate student, through his career as a U.S. Army colonel, and for the past 25 years as a champion for the thermal insulation industry, including eleven terms as president of the Mineral Insulation Manufacturers Association. The honors accorded Stan have been numerous, including ASTM's highest recognition, the Award of Merit. He will be missed.

Foreword

The conference on Thermal Insulation: Materials and Systems was held in Dallas, Texas, on 2-6 Dec. 1984. ASTM Committee C-16 on Thermal Insulation was sponsor of the event. Frank J. Powell, National Bureau of Standards, and Stanley L. Matthews, consultant, presided as chairmen of the conference and also served as editors of this publication.

Related ASTM Publications

Guarded Hot Plate and Heat Flow Meter Methodology, STP 879 (1985),
04-879000-10

Building Applications of Heat Flux Transducers, STP 885 (1985),
04-885000-10

Corrosion of Metals Under Thermal Insulation, STP 880 (1985),
04-880000-27

Thermal Insulations, Materials, and Systems for Energy Conservation in the
'80s, STP 789 (1983), 04-789000-10

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

A Note of Appreciation to Reviewers

The quality of the papers that appear in this publication reflects not only the obvious efforts of the authors but also the unheralded, though essential, work of the reviewers. On behalf of ASTM we acknowledge with appreciation their dedication to high professional standards and their sacrifice of time and effort.

ASTM Committee on Publications

ASTM Editorial Staff

**Helen Mahy
Janet R. Schroeder
Kathleen A. Greene
William T. Benzing**

Contents

Introduction	1
CONTROLLING FUEL COSTS	
Thermal Envelope Case History for a School District— WILBUR T. COYLE	5
Utilization of Energy Code Compliance Procedures for the Prediction of Commercial Building Annual Fuel Consumption— HELMUTH E. WORBS	8
Recommendations for the Development of a Residential Energy Standard—T. J. CARDENAS, MERLE MCBRIDE, GEORGE BARNEY, BRUCE WILCOX, AND ARTHUR JOHNSON	21
INDUSTRIAL APPLICATIONS	
Design Criteria for Underground Insulated Piping Systems— FRANCIS A. GOVAN AND NICHOLAS M. DEMETROULIS	43
A Method for Measuring Heat Loss from Underground Heat Distribution Systems—TAMAMI KUSUDA, JIN B. FANG, AND WALTER M. ELLIS	52
Foamed-in-Place Polyurethane Foam Insulation System Design and Application for Low-Temperature Storage Tanks— MICHAEL P. DUFF	69
Prevention of Common Pitfalls Through Engineered Specifications and On-Site Review—WARTAN J. WARTAN	82
THERMAL PERFORMANCE	
<i>In Situ</i> Measurement of Wall Thermal Performance: Data Interpretation and Apparatus Design Recommendations— MARK P. MODERA, MAX H. SHERMAN, AND SANTIAGO G. DE VINUESA	91

Field Measurement of the Thermal Resistance of Office Buildings— JIN B. FANG AND RICHARD A. GROT	107
Air Movements and the Thermal Performance of the Building Envelope— CLAES G. BANKVALL	124
Design Heat Loss Factors for Basement and Slab Floors— TAMAMI KUSUDA AND JOHN W. BEAN	132
Thermal Efficiency of Counterflow Insulation Systems: Possible Applications— CATHERINE LANGLAIS AND ERIC ARQUIS	153

THERMOGRAPHIC MEASUREMENTS

Infrared Inspection Techniques for Assessing the Exterior Envelopes of Office Buildings— Y. MAY CHANG, RICHARD A. GROT, AND LAWRENCE S. GALOWIN	175
Thermographic Inspection of the Installation Quality of Retrofitted Wall Insulation— GEORGE A. TSONGAS AND TIMOTHY J. BALL	196
Measured Insulation Improvement Potential for Ten U.S. Army Buildings— STEPHEN N. FLANDERS	202

MATERIALS

Formaldehyde Emissions from Selected Fibrous Glass Insulation Products— THOMAS G. MATTHEWS AND RITA R. WESTLEY	223
The Thermal Properties of Wood—Data Base— T. J. CARDENAS AND G. THOMAS BIBLE	238
Heat Transfer Through a Still Air Layer— JEAN-LAURENT JAOUEN AND SORÏN KLARSFELD	283

HOT BOXES

A Detailed Verification Procedure for a Guarded Hot Box— ALAN G. GUY AND JEFFREY A. NIXON	297
Experiences in Identification of Thermal Bridging and Elimination of the Thermal Short— DAVID J. MCCA, EDWARD D. PENTZ, JOHN CARRE, AND LESTER J. INFANTE	310

Heat Transfer Characteristics of a Masonry Cavity Wall— MARTHA G. VAN GEEM	318
--	-----

MOISTURE

Design Considerations on Guarded and Calibrated Hot Box Apparatus— FRANCESCO DE PONTE	345
Effects of Moisture on the Thermal Performance of Spray-Applied Insulation Systems— STEVEN M. BENNER, DEBENDRA MODI, AND DONALD C. LARSON	360
Field Study on Moisture Problems in Exterior Walls of a Masonry Housing Development on the Coast of the Gulf of Mexico— HEINZ R. TRECHSEL, PAUL R. ACHENBACH, AND SPENCER CONKLIN	371
Thermal Resistance of a Wet Mineral Fiber Insulation— PER INGVAR SANDBERG	394
Condensation Potential in Wood-Frame Walls— GERALD E. SHERWOOD	405

ROOFS

Wetting of Polystyrene and Urethane Roof Insulations in the Laboratory and on a Protected Membrane Roof— WAYNE TOBIASSON, ALAN GREATOREX, AND DORIS VAN FELT	421
Risk of Blistering of Built-Up Roofing Membranes Applied to Polyurethane Foam Insulation— WALTER J. ROSSITER, JR., AND ROBERT G. MATHEY	431
An Apparatus for Thermal Performance Measurements of Insulated Roof Systems— GEORGE E. COURVILLE, KENNETH W. CHILDS, DONALD J. WALUKAS, PHILIP W. CHILDS, AND EDWIN I. GRIGGS	449

INDUSTRIAL APPLICATIONS

Anomalous Behavior of Water Vapor Retarders Applied to Spray-Applied Polyurethane Foam Insulation on Low-Temperature Outdoor Storage Tanks— VERNON BATDORF	463
---	-----

MATERIALS

- Material Degradation of Thermal Insulating Mineral Fibers—**
NORMAN M. P. LOW 477
- Thickness and Density of Loose-Fill Insulations After Installation in Residential Attics—**DAVID L. MCELROY,
DAVID W. YARBROUGH, AND RONALD S. GRAVES 493
- Thermal Testing of Reflective Insulations—**
MARION HOLLINGSWORTH, JR. 506
- Development of Experimental Data on Cellular Plastic Insulations Under Simulated Winter Exposure Conditions—**
R. P. TYE AND C. F. BAKER 518

WALLS AND WINDOWS

- Effect of Wall Mass on the Annual Heating and Cooling Loads of Single-Family Residences for Five Selected Climates—**
DOUGLAS M. BURCH, GEORGE N. WALTON, KEVIN CAVANAUGH,
AND BETTY A. LICITRA 541
- A Calorimeter for Determining Heat Transmission Characteristics of Windows—**ROBERT P. BOWEN AND K. RICHARD SOLVASON 567
- Thermal Resistances of Various Concrete Masonry Wall Constructions Incorporating Rigid Plastic Foam Insulation—**
WILLIAM R. STRZEPEK 582
- Performance of a Group of Well-Insulated Solar Houses in the United Kingdom—**JOHN V. ALDERSON, ALAN GUY,
BARRY JUSTIN, AND GERALD SHAW 599

AIR AND MOISTURE

- Case Histories of Moisture Monitoring in Residential Walls—**
ROBERT KANE AND GUY TITLEY 615
- A Method to Predict the Hour-by-Hour Humidity Ratio of Attic Air—**PETER CLEARY AND ROBERT SONDEREGGER 630
- Measurement of Air Leakage Properties of Common Residential Insulating Materials—**DAVID JACOBSON, DAVID T. HARRJE,
AND GAUTAM S. DUTT 639

RESEARCH

- Historical Development of Large Heat Flow Meter Apparatus for Measurements of Thermal Resistance of Insulations—**
RONALD P. TYE, KARL G. COUMOU, ANDRÉ O. DESJARLAIS, AND
DAVID M. HAINES 651
- Thermal Conductivity of Insulants at High Temperature: Reference Materials and Standards—**SORIN KLARFELD, JEAN BOULANT,
AND CATHERINE LANGLAIS 665

REPORTS

- Thermal Performance of the Building Envelope as Influenced by Workmanship—**CLAES G. BANKVALL 679
- Final Report of ASTM Committee C-8 Thermal Conductivity Ceramic Fiber Round Robin—**DAVID OBER 685
- Human Protection from Burns by Heated Surfaces—The Problem and Solution—**JOHN R. MUMAW 704
- Building Component Test Development Using Module Simulators—**
CHARLES C. ROBERTS, JR. 713
- Thermal Performance of Metal Furred/Foam Board Insulated Wall Systems—**R. GERRY MILLER, JAMES A. BERRY, AND
MORTON SHERMAN 720

INDEXES

- Author Index 731**
- Subject Index 733**

ISBN 0-8031-0493-6