DISCLAIMER

PREMIERE ISSUE FALL 1995

FENESTRATION R&D

LAWRENCE BERKELEY NATIONAL LABORATORY ENERGY & ENVIRONMENT DIVISION

Focusing on International Energy Agency Activities

World's Largest Coordinated Effort in Glazings Research

Glazing research is receiving increased attention around the world, thanks to cooperation among industrialized nations in the research and development of new glazing materials and systems that can contribute to a reduction of the excessive dependence on non-renewable energy sources.

The International Energy Agency (IEA) is a major vehicle for carrying out collaborative R&D on a global basis. The IEA was formed in 1974 with 23 member countries to develop a coordinated approach to the utilization of energy resources. This involves collaboration in the research, development, and demonstration of new energy technologies. The IEA Solar Heating and Cooling Program was initiated in 1977 and a total of nineteen projects or tasks have been undertaken. The U.S., primarily through work at the Lawrence Berkeley National Laboratory (LBNL), is one of 15 countries actively involved in IEA/SHC Task 18 Advanced Glazing & Associated Materials for Solar & Building Applications. This is the world's largest coordinated effort in glazings research, with more than 60 researchers participating worldwide.

INTERNATIONAL ENERGY AGENCY
Solar Heating & Cooling Programme

The goal of Task 18 is to reduce the energy consumption of buildings through improved glazing technologies. This task was initiated January 1992 as a five-year effort. In addition to developing the scientific, engineering, and architectural basis for development of new technologies, the Task 18 research will also focus on application and technology transfer issues. The emphasis is on near-term or emerging market applications.

Task 18 also intends to increase general awareness of advanced glazings, plus aid industry, universities, and standards organizations in the proper measurement, application, energy benefit, and use of these advanced materials on an international level. Task 18 is organized into two Subtask areas: Subtask A focuses primarily on analyses required to identify energy and environmental benefits and building applications of various potential glazing materials and Subtask B involves laboratory characterization of glazings and

*(See **IEA Activities,** page 2)*

IEA Task 18 Experts Meet in Toronto

The International Energy Association (IEA) Task 18 meeting was held June 5-6, 1995 in Toronto, Canada, following the Window Innovation Conference, to review research progress.

Chaired by Professor Michael Hutchins, Oxford Brookes University, UK, the plenary sessions focused on electrochromics and advanced glazing technology and assessment, with project presentations following. A report on the performance of frame and edge seal technologies was distributed, along with a review of a new phase dispersed liquid crystal (PDLC) device from 3M.

*(See **Toronto Meeting,** page 2)*

INSIDE THIS ISSUE

FALL 1995

BUILDING TECHNOLOGIES PROGRAM
WINDOWS & DAYLIGHTING GROUP

The Building Technologies Program works closely with the U.S. building industry to reduce building-sector energy use while improving the comfort, health, and productivity of building occupants.

The Program focuses on windows and lighting, two major building systems which together account for more than 30% of the energy used in buildings — more than $50 billion annually in consumer energy expenditures — and which affect the energy used by other major building systems. Program researchers also create advanced simulation and design tools that enable building professionals to fully integrate energy-efficient technologies into new and existing buildings, extending the market penetration of these technologies.

The **Windows and Daylighting Group** develops advanced optical materials, studies fenestration performance, and creates computer-based tools and applications guides for improving the energy-related performance of windows.

Stephen E. Selkowitz
Program Head

FALL 1995

LAWRENCE BERKELEY NATIONAL LABORATORY

ENERGY & ENVIRONMENT DIVISION
BUILDING TECHNOLOGIES PROGRAM
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IEA/SHC Task 18 Highlighted Publications

IEA Task 18 regularly publishes documents that might prove useful to your needs. We highlight some of these publications in each issue of the newsletter. For copies of these reports send a letter or FAX to Pat Ross, MS 90-3111, Lawrence Berkeley National Laboratory, Berkeley, CA 94720 USA; Fax: (510) 486-4089; e-mail: PLRoss@lbl.gov.

International Chromogenic Glazings Technology [LBL-36847, 1995]
C. Lampert, Lawrence Berkeley National Laboratory, Berkeley, California

This study develops a foundation of knowledge for the chromogenics field. Information about international activities on chromogenics was extracted from representatives of companies, universities, and institutes. Also included is information from papers, trade journals, product literature and patents when appropriate. For each country we have detailed the following information: Companies & Research Groups; Potential Manufacturers of Architectural Products; Designers and Users; Device Properties.

Effect of Switching Control Strategies on the Energy Performance of Electrochromic Windows [LBL-35453, 1994]
R. Sullivan, E.S. Lee, K. Papamichael, M. Rubin, and S. Selkowitz; Lawrence Berkeley National Laboratory, Berkeley, California

This document presents the results of a study investigating the energy performance of electrochromic windows in a prototypical commercial office building module under a variety of state-switching control strategies. The DOE-2.1E energy simulation program was used to analyze the annual cooling, lighting, and total electricity use and peak demand as a function of glazing type, size, and electrochromic control strategy. Control strategies analyzed were based on daylight illuminance, incident total solar radiation, and space cooling load.

State-of-the-Art of Evacuated Glazing
R.E. Collins, A.C. Fischer-Cripps, J.Z. Tang, G.M. Turner, C.J. Dey, D.A. Clugston, E. Bezzel-Hansen, T. Simko; School of Physics, University of Sydney, Australia

B. Norton, P.C. Eames, S.N.G. Lo; Centre for Performance Research on the Built Environment, University of Ulster, Northern Ireland

V. Wittwer, M. Brunotte; Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany

This document characterizes evacuated glazing research in mid-1993. It includes a brief history, technical issues of relevance, and a summary of current research. To date, an evacuated glazing area one square meter (10.8 ft^2) has been produced with a mid-plane thermal conductance below 1.1W/ m^2-°K (0.19 Btu/hr-ft^2-F) of which about 0.8 W/m^2-K (0.14 Btu/hr-ft^2-F) is due to radiative heat flow and the remainder is a result of conduction through support pillars. It appears possible that values of mid-plane conductance as low as 0.6 W/m^2-K (0.10 Btu/hr-ft^2-F) may be achievable in these devices.

Frame and Edge Seal Technology: A State-of-the-Art Survey
Ø. Aschehoug, Department of Architecture, Norwegian Institute of Technology

M. Thyholt, I. Andresen; INTEF Architecture and Building Technology

B.Hugdal, Norwegian Building Research Institute

This document gives a brief overview of the heat transfer characteristics of windows with a focus on frames and edge seals and other topics related to window perimeter performance. Thermal performance is discussed for different glazings, spacers, and sealants. The survey included a detailed annotated bibliography.

Toronto Meeting...

(continued from page 1)

An IEA World Wide Web homepage has been installed on the Internet, and will be maintained at a site in New Zealand. To connect, use the following URL: http//www-iea.vuw.ac.nz:90:/index.html.

The next IEA Task 18 meeting will take place in Zurich, Switzerland, February 27-29, 1996.

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IEA Activities...

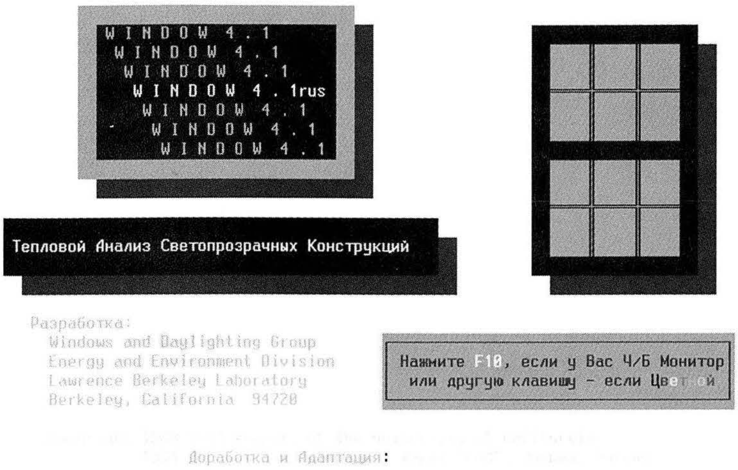
(continued from page 1)

daylighting component materials.

Task 18 activity is expected to promote trade and standardization of new glazing products, and augment activities at the national labs, in the glazing industry, and in organizations such as NFRC. In support of this, one major product of Task 18 will be a database of glazing material optical and thermal properties, essential to the development of consensus-based standards and for use in whole building energy analysis simulations.

The U.S. effort in Task 18 is supported by the Building Systems and Materials Division, Office of Building Technologies, U.S. Department of Energy, with Samuel Taylor, program manager. U.S. participants include Stephen Selkowitz (project manager), Carl Lampert, Dariush Arasteh, Mike Rubin, and Robert Sullivan at LBNL; William Goss at the University of Massachusetts; and Ross McCluney at the Florida Solar Energy Center.

The IEA Task 18 researchers meet twice a year in one of the countries represented.



This computer screen represents the Russian translation of Window 4.1.

Opening a Window to Russia

Initial Collaboration to Transfer NFRC's Window-rating Procedures Results in WINDOW 4.1 Translation

In a further move to enhance energy efficiency around the world, researchers in the Windows & Daylighting Group are helping to bring energy-performance simulation programs to the states of the former Soviet Union.

The effort began last year when Valery Tishenko, head of building standards under the Russian Construction Ministry (Gosstroy) wrote to the U.S. Department of Energy (DOE) expressing interest in collaborating closely to improve Russian certification of construction technologies, in particular, certification of window construction technologies.

Tishenko also requested assistance in transferring the National Fenestration Rating Council (NFRC) rating procedures and computer programs to Russia. LBNL has been a major developer of the simulation tools used by the NFRC in developing its window-rating procedures, which are now used widely in the United States and serve as a model for other countries.

As a first step in this collaboration, two Russian programmers, Michael Vilinsky and Vladimir Chornorutsky, came to Lawrence Berkeley National Laboratory last year to translate WINDOW 4.1, the latest version of the window thermal performance computer program used by NFRC in their rating of windows. WINDOW was developed by Windows & Daylighting Group researchers Dariush Arasteh, Elizabeth Finlayson, Charlie Huizenga, and Mike Rubin.

In addition, NRFC certification of the window test facilities at Gosstroy's Building Physics Research Institute is being explored.

LBNL researchers and Russian energy efficiency experts recently held discussions in Berkeley concerning possible transfer of other LBNL-developed computer programs for thermal and energy performance. Such programs include RESFEN (used to calculate annual energy ratings), translation of DOE 2.1E, an LBNL-developed whole-building simulation program, into Russian, and participation of Russian researchers in developing the next generation of DOE building-performance simulation programs and upgrades to the WINDOW software.

If adopted by Russia, thermal and energy performance programs such as WINDOW and DOE-2 could provide a common technical basis for standards, and trade between the United States and Russia, as well as other member nations of the Commonwealth of Independent States (CIS).

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Helping Russians Improve Window Energy Efficiency

As part of a bilateral agreement between U.S. DOE and the Russian Energy Ministry, a team of American researchers, DOE officials, and manufacturers visited Moscow and St. Petersburg in May.

Meetings were held with their counterparts and with Russian government officials to share information on window rating, testing and calculation procedures, and new energy-efficient technologies.

"A specific goal of the U.S. team," said LBNL's Steve Selkowitz, one of its ten members, "was to examine how the Russians might benefit from the U.S. experience in developing window ratings to guide selection of energy efficient products."

The visiting American team participated in a special window seminar at the Annual Russian ABOK conference (ASHRAE equivalent) and later in a three-day Window Workshop, which included tours of factories and text labs. More details will be provided in an upcoming issue.

Fenestration R&D

Published Quarterly

Volume 1, Number 1

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This newsletter also may be found on the World Wide Web at the following URL: http//eande.LBL.gov/CBS/BTP.html

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BUILDING TECHNOLOGIES PROGRAM
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Fenestration Facts

Glass windows became more common in castles in the fourteenth century, but they were still a luxury. Since many barons and nobles owned several castles, which they lived in at different times of the year, they devised a way to avoid the expense of outfitting all of them with glass windows. They had special window frames made that could be removed easily. When they traveled from one castle to another, the nobles and barons simply took their windows with them. Shutters kept out the wind and rain while they were away.

Let There Be Light
James Cross Giblin
1988

Solar light pipe daylighting system demonstration at Marklane High School, Toronto,Canada.

Window Innovations Conference Attracts 300 Participants

IEA Task 18 Expert's Meeting Follows

The Window Innovations Conference, held in Toronto, Canada June 5-6, 1995, attracted over 300 building industry professionals representing 20 countries, with over 50% coming from the window and glass industry.

Sixty-eight presentations included performance studies on many different types of window materials and components, the energy implications of the use of advanced windows in buildings, and window rating and labeling activities.

Dariush Arasteh and Carl Lampert of LBNL's Windows & Daylighting Group with Ross McCluney of the Florida Solar Energy Center, served on the program committee and as session chairs.

Brian Crook, Cardinal IG, collaborating with LBNL's Robert Sullivan, Dariush Arasteh, and Stephen Selkowitz, covered the NRFC's annual energy rating methodology. John Hogan, Seattle Department of Construction and Land Use, discussed the impact of NFRC's rating on U.S. energy codes.

Integrated Window System Exhibited at Builders Conference

Industry Contacts Made

The Windows & Daylighting Group joined over 350 exhibitors at the Pacific Coast Builders Conference's "Home Building 2001" at Moscone Center in San Francisco, June 22-24, 1995.

The integrated window system (IWS) prototype and the Residential Window Guidelines multimedia kiosk were demonstrated at this conference, which attracted over 10,000 attendees.

Paul LaBerge, Jessica Sadlier, Brent Griffith, Daniel Turler and Michael Wilde of the Windows & Daylighting Group discussed these and other U.S. DOE-funded research projects with building industry representatives that included a cross-section of the residential design and construction market in the 11 western states.

Special invitations to discuss the integrated window system prototype were extended to window and shade system manufacturers exhibiting at the conference. Representatives from Hurd, Southwall Technologies, Andersen, Marvin, Milgard, Sierra-Pacific, and Viking gave enthusiastic approval for the IWS concept and indicated their interest in collaborating in further prototype development.

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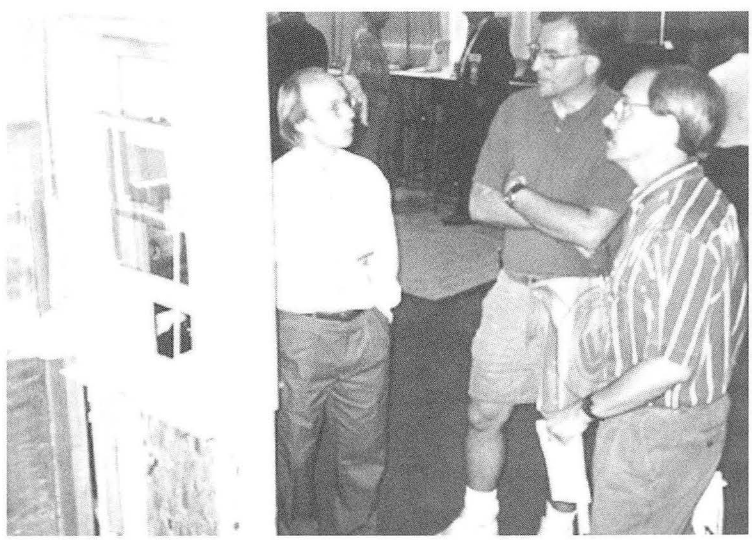
Researcher Jessica Sadlier discusses the Residential Window Guidelines, a multimedia kiosk, equipped with touchscreen access.



Photographs by Michael Wilde

Paul LaBerge, a researcher with LBNL's Windows & Daylighting Group, demonstrates the prototype integrated window system (IWS) to building industry professional attending the Pacific Coast Builders Conference.

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Infrared Thermography and the Design of Energy Efficient Windows

Research at Lawrence Berkeley National Laboratory's Windows and Daylighting Group includes collaborative efforts with industry R&D departments to develop highly insulating window systems.

Infrared thermography is a

- Powerful technique for analyzing the thermal performance of prototype windows and their components.
- Simple procedure, with results available almost instantaneously.
- Means for visually and quantitatively identifying the strengths and weaknesses of window frame and edge systems in order to achieve optimum thermal performance.

Photograph by Michael Wilde

The Infrared Thermography Laboratory is used to measure the temperature on flat surfaces, such as windows, using an IR scanner. Researchers Brent Griffith and Paul LaBerge discuss details in for an upcoming test of a super-insulated window prototype.

Infrared Heat Transfer Analysis

Heat transfer through window systems is typically characterized by one number, the U-value, or its reciprocal, the R-value. This single number does not give detailed information about the thermal performances of separate system components, nor does it give any spatial data on heat transfer through a window system

Infrared thermography is an experimental technique which produces two-dimensional heat transfer information in the form of a temperature contour map. This information is a valuable tool for improving the design of energy efficient windows, with a focus on frames and edges. Infrared thermography has long been used for qualitative field evaluations of building envelope thermal performance. Lawrence Berkeley National Laboratory is working to establish infrared thermography as a more exact and quantitative method for laboratory research. To serve this purpose, a Building Technologies Thermography Laboratory, available for use by the window industry, has been established at Lawrence Berkeley National Laboratory. To date more than a dozen manufacturers and researchers have found tests done at the laboratory to be very useful in evaluating their product lines.

The window industry is finding IR testing very useful in evaluating their product lines.

Heat Transfer Through Window Systems

Reducing heat transfer rates through windows is a topic of growing interest for window manufacturers, consumers, and public officials. Window heat transfer rates driven by a temperature difference between the indoors and outdoors are typically represented by U-values (measured in Btu/hr-ft^2-F or W/m^2-C). These U-values are currently determined by hot box testing methods, which give one U-value for the overall performance of the window. However, knowing only the window's overall U-value does not tell one anything about the relative thermal performances of the different window components (i.e., frame, spacer, dividers, and glazing) or sub-components (i.e., cladding, thermal breaks in an aluminum frame, etc.). The effects of using conventional frame, sash, and divider materials and designs with state-of-the-art glazing systems (i.e., low-E glass and low-conductivity gas fills) can be very significant: in a typical non-thermally broken aluminum framed low-E residential

Fenestration Facts

The first important building to use tinted glass in its windows was Lever House, designed by Gordon Bunshaft and erected in New York City in 1952.

Let There Be Light
James Cross Giblin
1988

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window, more heat can be lost through the frame (10%-20% of the total window area) than through the glazing. To provide us with more information about the relative thermal performances of window components and to isolate thermal bridges which may destroy the thermal performance of a specific window design, we turn to the use of infrared (IR) thermography.

The Thermography Laboratory

The physical setup of the LBNL Building Technologies Thermography Laboratory is illustrated in the photo on the previous page. A window specimen is mounted in the opening of a cold chamber. One side of the window is exposed to the interior of the cold chamber while the other side is exposed to an ambient temperature chamber held at 70° F (21° C). For each test, the cold side of the chamber is maintained at a constant temperature of 0°F (-18°C). A thermographic image, or thermogram, of the window surface exposed to ambient temperature is then captured using an imaging infrared scanner. The thermogram is a visual representation of radiated energy, which can be converted to surface temperature information. This information may be further processed using associated computer hardware and software. Windows may be tested individually, or mounted side by side on the cold chamber so that direct visual comparisons of two window specimens can be made from a single thermographic image. Black and white and/or color images of the thermograms can be printed out for future analysis, design review, and marketing presentations.

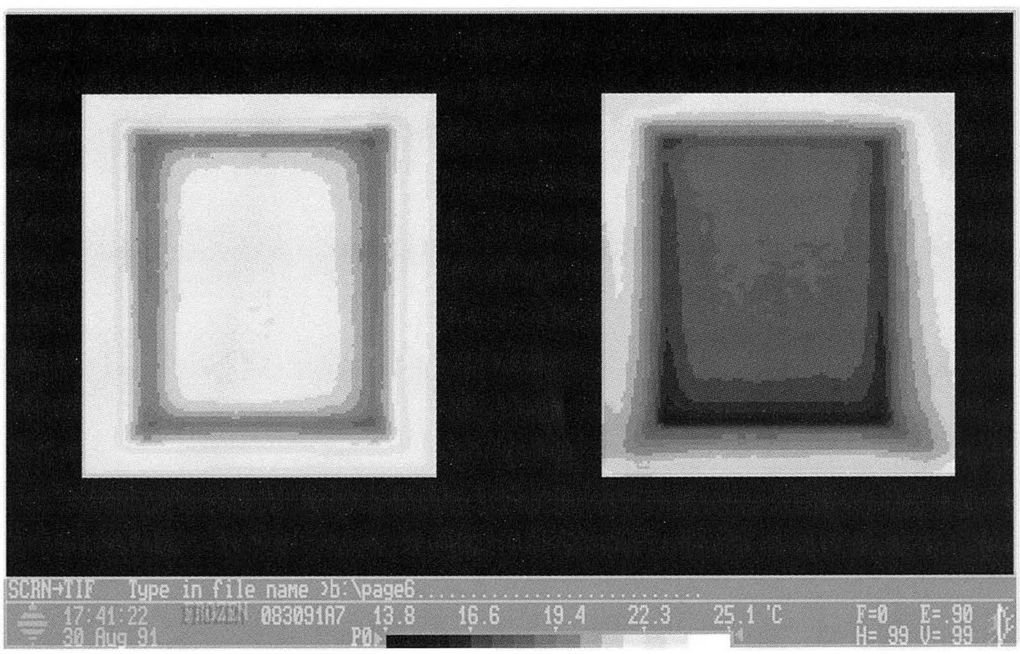
The thermogram is a visual representation of radiated energy, converted to surface temperature information.

Experimental uncertainties in relative temperature values within an image are ± 0.3° C. The absolute temperature specified for the equipment is ± 2.0° C. However, detailed laboratory procedures are being developed that enable absolute accuracy of ± 0.5° C for the temperatures involved. A knowledge of the emittance of the imaged surface is necessary to attain such accuracy. The decrease in absolute temperature uncertainty is accomplished by including a calibrated laboratory blackbody as part of each image.

The emittances of the frame and the glazing unit are not generally equal. To compensate for the varying emittances, the window and frame components are covered with a uniform layer of masking tape of known emittance. It is also possible to correct for varying emittances using computer software. The distribution of the ambient radiation in the test facility is made uniform by the use of shielding opaque to infrared radiation in the test area. The magnitude of the background thermal radiation is quantified by imaging a reflective surface positioned at the plane of the test sample. This information is fed back into the software, and the surface temperatures of the window image are automatically adjusted in order to compensate for thermal background effects.

Fenestration Facts

The world's glass producers made enough glass in 1994 to create a 2-foot wide glass walkway to the moon and back to earth.



Infrared image of two windows being tested side by side. The window on the left is a foam-filled vinyl-framed window with a super-insulating glazing system. The window on the right is a standard vinyl-framed window with a conventional insulated glazing system without a low-E coating or a low thermal conductivity gas fill.

IR Interpretation and Analysis

Each thermogram is a visual representation of that window's spatial thermal performance. Thermographic images of the windows are of the warm side surface unless otherwise noted. Different colors (or shades of grey in the case of black and white images) correspond to different surface temperatures. These temperatures can be determined from the calibrated color or grey scale at the bottom of the image. The best insulating areas of the window have the highest warm side surface temperatures (red and yellow on color plots, white and light grey on black and white plots), while the poorest insulators or thermal bridges have the lowest temperatures (blue and purple or dark grey and black).

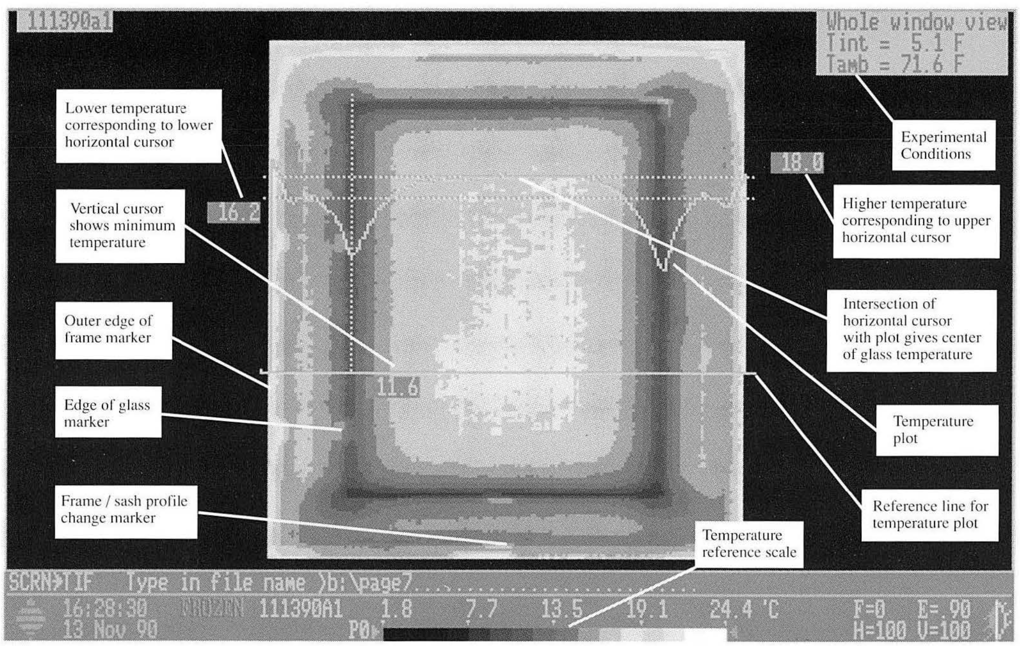
The thermographic image is post-processed on a personal computer in order to derive quantitative surface temperature data. The figure at bottom left shows a sample post-processed thermogram of the warm side of an insulating frame with a super-insulating glazing system. Strip markers (which appear as thin "hot" strips on the plots) are used to delineate profile changes along the frame and sash, the outer edge of the frame, and the sash-glass interface. The control temperatures for each test (cold box temperature and ambient temperature) are noted on each thermogram. A temperature plot gives the temperature profile along a base (lowest) line. Two dotted lines parallel to and one perpendicular to the base line are used to scale this linear plot.

Infrared thermography is being used to validate computer models resulting in frame and total window U-values.

Temperatures can also be measured within a specified region, in an outlined box with the maximum, average, and minimum values over the region displayed, respectively. The figure below shows a schematic diagram of a typical window cross-section and the locations of frame profile markers.

Temperature data from one or more thermographic images can be loaded into a spreadsheet and graphics program that produce a plot of surface temperature as a function of position across the window/frame system. This graph is useful in directly comparing the thermal performance of a standard frame to that of modified and/or prototype frames. All temperature data for the comparative graphs are normalized to a standard ambient temperature and a constant temperature differential, making direct comparisons valid.

Infrared thermography is currently being used to validate computer models that calculate window temperature profiles and resulting frame and total window U-values. At present U-values cannot be calculated directly from thermographic data, as the exterior and interior film coefficients are hard to quantify precisely. In addition, the thermographic scanning cannot yet be used to measure heat transfer in the third dimension, an important consideration in windows with deep sills. Future research will examine techniques for better understanding of interior film coefficients using IR temperature data.



Sample post-processed thermogram of the warm side of a fiberglass-framed window with a super-insulating glazing system. The center-of-glass region is a better insulator than the frame, while the edge-of-glass region has the poorest thermal performance.

Fenestration Facts

Thermally improved windows with low-E coatings will save the U.S. building owners $17 billion by 2015 and avoid the emission of 71x10[6] tons of CO_2, 157,000 tons of SO_2, and 142,000 tons of NO_x.

Additional Applications

Infrared thermography has been used in the design of thermal control devices, which increase the efficiency of compact fluorescent light fixtures. These thermal control devices can increase light output by 15% to 20%. Infrared thermography has also been used for research on gas-filled panel insulation and automobile glazing applications.

The following reports summarizing use of the IR Laboratory are available:

Arasteh, D., Beck, F., Griffith, B., Byars, N. and Acevedo-Ruiz, M. **Using Infrared Thermography to Study Building Heat Transfer**, ASHRAE Journal, October 1992. Also published as LBL-29752.

Griffith, B.; Beck, F. A.; Arasteh, D., and Turler, D. **Issues Associated with the Use of Infrared Thermography for Experimental Testing of Insulating Materials.** To be published in the Proceedings of the 1995 ASHRAE/BETEC Conference. Also published as LBL-36734.

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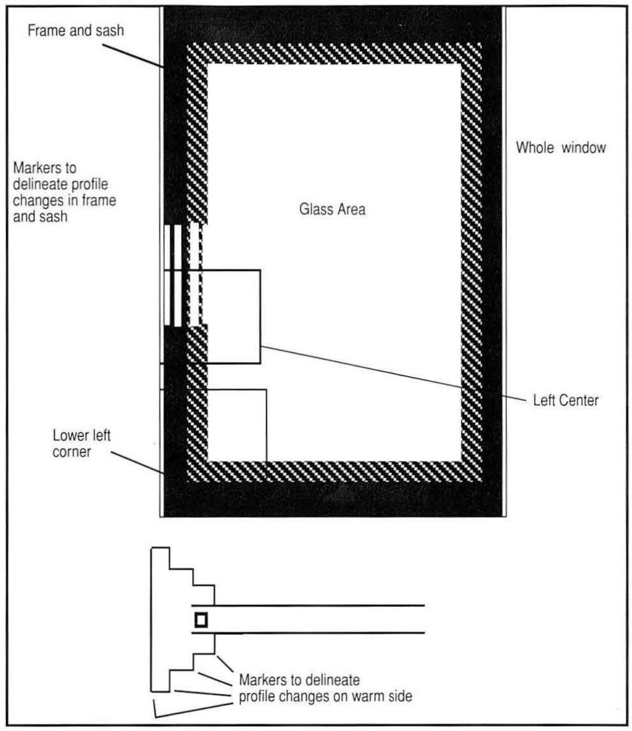
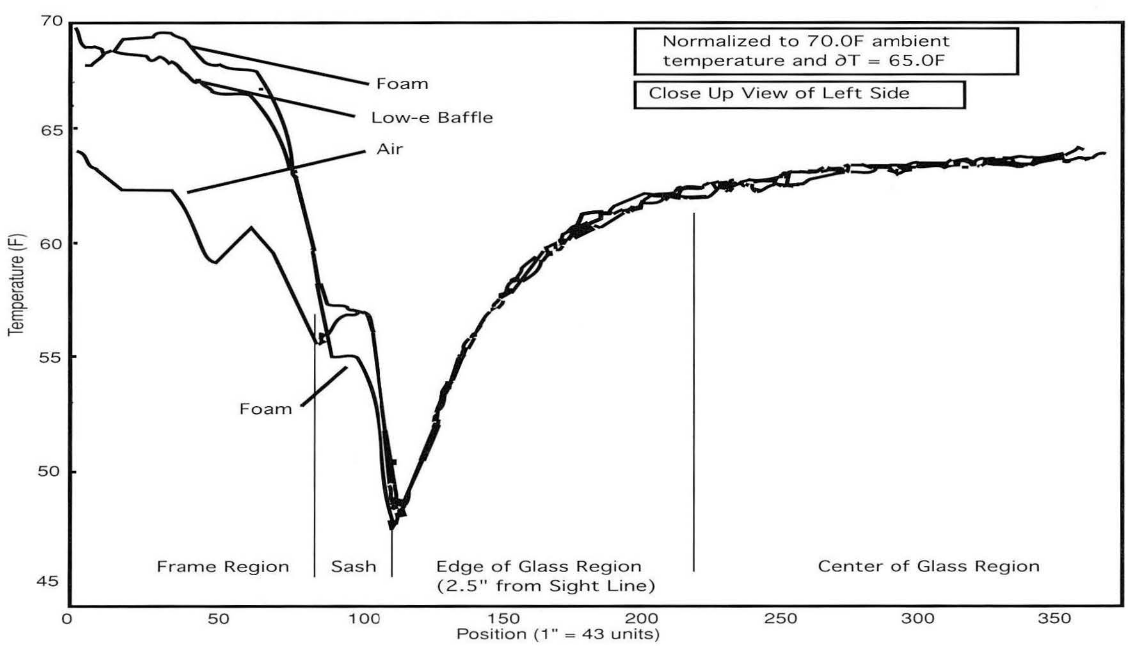


Schematic elevation and cross-section views of typical windows analyzed in the LBNL Building Technologies Thermography Laboratory. Boxes outline the three infrared images typically recorded: whole window, left center, and lower left corner.

Fenestration Facts

Low-E coatings were first introduced commercially in the early 1980's. Today they constitute about 35% of the total insulating glass sales.



Sample comparative graph of surface temperature vs. position across the window/frame system. This graph shows thermographic data taken from the close-up view of a vinyl-framed casement window. In this case, the frame geometry and the glazing unit type remained constant, while the frame fill type was varied. The standard frame (hollow, air-filled) was compared to the same frame filled with either a crumpled low-E aluminized polyester sheeting or polyurethane foam. Regions of the frame and glazing unit are delineated by labels across the bottom of the graph. Higher surface temperatures indicate better thermal performance.

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Glazing Manufacturers Cooperate to Publish Optical Properties Database

A cooperative effort among glazing manufacturers, the National Fenestration Rating Council (NFRC), and the Windows & Daylighting Group to measure and certify optical properties has resulted in the world's most complete set of glazing product data.

The optical properties of glazing materials are required in WINDOW and other software to compute the energy performance parameters of windows.

A NFRC task group, led by Jim Benney of the Primary Glass Manufacturer's Council (PGMC), has established procedures developed by LBNL and industry for determining these properties. Almost all U.S. glazing manufacturers have adopted these procedures and used them to test their products. Submission of data directly by the manufacturers is a low-cost process requiring minimum government intervention, but an independent validation was desired.

Technicians in our optical materials laboratory performed a series of checks on the data, in addition to an optional peer review. The result was a diskette containing almost 700 spectral data files, available from NFRC, LBNL, and PGMC. These files can be read directly by the WINDOW 4.1 software to determine energy performance parameters. Efforts are underway at the CEN and ISO levels to promote the adoption of these standards worldwide.

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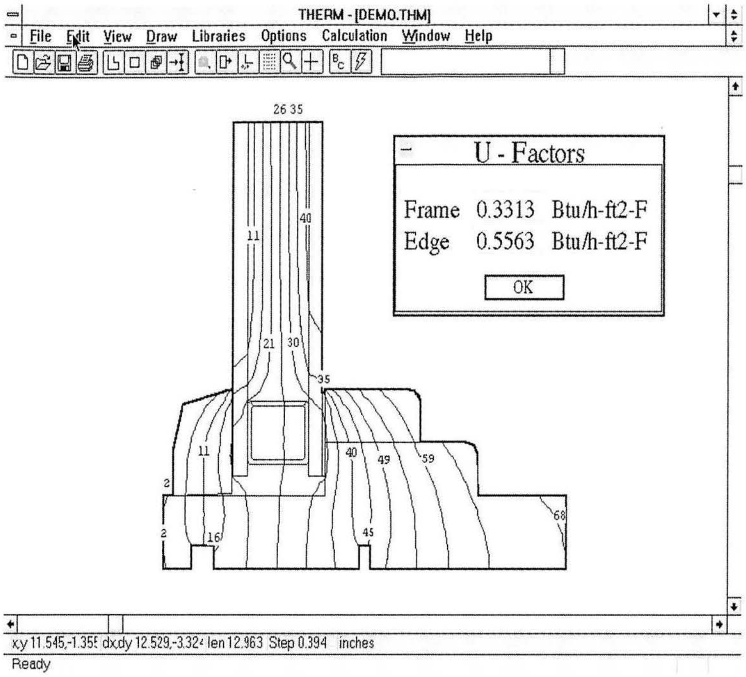

Sample THERM output showing isotherms on a window section.

WINDOW 4.1 Receiving Major Face-lift

Fall 1995 THERM Release

Based on industry user feedback, the popular WINDOW 4.1 software program developed by the Windows & Daylighting Group is receiving a major face-lift.

While WINDOW+5 will not be completed until late 1996, several modules are being released as stand-alone programs in advance of that date. This fall, THERM, a MicroSoft Windows-based 2-D heat transfer analysis tool will be available. LAMINATE, a tool to compute the properties of glazings with applied films, is currently available in beta form.

THERM is a collaborative effort involving researchers at Lawrence Berkeley National Laboratory, the University of California at Berkeley, the University of Massachusetts at Amherst, and Rensselaer Polytechnic Institute. This multipurpose software is based on finite element analysis and can model two-dimentional heat transfer with a minimum of simplifications to exact cross section geometries. THERM is currently in the Beta Test stage of its development. Ultimately, THERM will deal with fluid mechanics and complicated fenestration product geometries.

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Recent Collaborations

Evacuated Window Testing

Richard Collins, professor of Physics at Sydney University (Australia) visited in June to discuss our testing of his evacuated window system invention. We are testing the prototype unit in our Infrared Thermography Laboratory to performance of the system, particularily two-dimensional thermal bridging effects. (LBL Pub. 36958) We have also assisted in setting up meetings with U.S. glazing and window manufacturers to allow them to evaluate his technology.

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Fenestration Facts

Nation's newest oil wells? Low-E coaters! Compare the impact of energy savings from low-E coating machines to a conventional energy supply option. Assuming typical production rates and lifetimes, the energy saved by using windows using products from each low-E coater is equivalent to the energy produced by an offshore oil platform with 10 wells pumping 10,000 barrels per day.

FALL 1995

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ENERGY & ENVIRONMENT DIVISION
BUILDING TECHNOLOGIES PROGRAM
WINDOWS & DAYLIGHTING GROUP

New Research Publications

Chromogenic Switchable Glazing: Toward the Development of the Smart Window, C.M. Lampert, Lawrence Berkeley National Laboratory

Abstract

The science and technology of chromogenic materials for switchable glazings in building applications is discussed. These glazings can be used for dynamic control of solar and visible energy. Currently many researchers and engineers are involved with the development of products in this field. A summary of activities in Japan, Europe, Australia, USA and Canada is made. Both non-electrically activated and electrically activated glazings are discussed. Technologies covered in the first category are photochromics and thermochromics, and thermotropics. A discussion of electrically activated chromogenic glazings includes dispersed liquid crystals, dispersed particles, and electrochromics. A selection of device structures and performance characteristics are compared. A discussion of transparent conductors is presented. Technical issues concerning large-area development of smart windows are discussed.
LBL Pub No. 37766

NFRC Efforts to Develop a Residential Fenestration Annual Energy Rating Methodology, Brian Crooks and James Larsen, Cardinal IG, Minneapolis, MN, and Robert Sullivan, Dariush Arasteh, and Stephen Selkowitz, Lawrence Berkeley National Laboratory, Berkeley, CA.

Abstract

This paper documents efforts currently being undertaken by the National Fenestration Rating Council's Annual Energy Rating Subcommittee to develop procedures to quantify the energy impacts of fenestration products in typical residential buildings throughout the United States. Parallel paths focus on (1) the development of simplified heating and cooling indices, and (2) the development of a more detailed methodology to calculate the cost and energy impacts of specific products in a variety of housing types. These procedures are currently under discussion by NFRC's Technical Committee; future efforts will also address commercial buildings.
LBL Pub No. 36896

Edge Conduction in Vacuum Glazing, Tom Simko and Richard E. Collins, University of Sydney, and Fredric A. Beck and Dariush Arasteh, Lawrence Berkeley National Laboratory

Abstract

Vacuum glazing is a form of low-conductance double glazing, using an internal vacuum between the two glass sheets to eliminate heat transport by gas conduction and convection. An array of small support pillars separates the sheets; fused solder glass forms the edge seal. Heat transfer through the glazing occurs by radiation across the vacuum gap, conduction through the support pillars, and conduction through the bonded edge seal. Edge conduction is problematic because it affects stresses in the edge region, leading to possible failure of the device; in addition excessive heat transfer, because of thermal bridging in the edge region, can lower overall window thermal performance and decrease resistance to condensation.

Infrared thermography was used to analyze the thermal performance of prototype vacuum glazings, and for comparison, atmospheric pressure superwindows. Research focused on mitigating the edge effects of vacuum glazings through the use of insulating trim, recessed edges, and framing materials. Experimentally validated finite element and finite difference modeling tools were used for thermal analysis of prototype vacuum glazing units and complete windows. Experimental measurements of edge conduction using infrared imaging were found to be in good agreement with finite element modeling results for a given set of conditions. Finite element modeling validates an analytic model developed for edge conduction. *LBL Pub No. 36958*

Using Infrared Thermography for the Creation of a Window Surface Temperature Database to Validate Computer Heat Transfer Models, Beck, F.A., Griffith, B.T., Turler, D., and D. Arasteh, Lawrence Berkeley National Laboratory

Abstract

Infrared thermography is a useful tool for understanding the thermal performance of window components and complete window systems. While infrared thermography has long been used in the field to assess qualitative aspects of window thermal performance, it is now being used in the laboratory for quantitative assessments of window thermal performance. Infrared thermography can provide spatial resolution of system performance by generating surface temperature maps of windows under controlled and characterized environmental conditions. An external reference emitter may be used to improve the accuracy of surface temperatures measured with an imaging infrared scanning radiometer.

This paper summarizes basic theory and techniques for maximizing the accuracy and utility of infrared thermographic temperature measurements of window systems and components in a controlled laboratory setting. The physical setup of LBNL's infrared thermographic test facility is described. Temperature measurement issues and accuracy limits for quantitative laboratory infrared thermography are discussed. Quantitative infrared thermography for window thermal performance testing is used to create a database of window surface temperature profiles for use in the validation of finite-element and finite-difference heat transfer modeling tools. Analyzed results of infrared thermographic tests on a number of glazing configurations are presented. *LBL Pub No. 29752*

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Fenestration Facts

Submit your favorite *fenestration facts*, and receive instant recognition in the next issue.

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Software Available

❒ ***RESFEN 2.4*** is a WINDOWS-based PC program for calculating residential fenestration heating and cooling energy use and costs. This new program is currently being evaluated for possible use as part of a window rating system being developed by the National Fenestration Rating Council (NFRC).

❒ ***SUPERLITE 2.0*** is a PC program that calculates daylight illuminance distributions for complex room and light source geometries with tested accuracy. SUPERLITE will model daylight coming through as many as five openings and being reflected from as many as 20 opaque surfaces oriented in any direction.

❒ ***WINDOW 4.1*** is a thermal analysis PC program that is the de facto standard used by U.S. manufacturers to characterize product performance. The program is used by the National Fenestration Rating Council as the basis for development of energy rating labels for windows.

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User Facilities

Industry is invited to collaborate in the use of these facilities. In each issue of **Fenestration R&D**, we will take a closer look at one of our user facilities. Please contact the individual researcher listed under each facility to discuss potential use.

❒ ***Mobile Window Thermal Test Facility (MoWiTT)*** The MoWiTT facility contains two highly instrumented, side-by-side calorimetric test chambers that are used to test window and wall elements under actual outdoor conditions. The facility may be rotated to face in any direction and is currently located in Reno, Nevada, which experiences both summer and winter extreme climate conditions. It can directly measure solar heat gain and can be used to determine window and shading system properties for a wide variety of solar control options. With 200 data channels collecting data every few seconds, the facility can directly measure cooling load shapes on peak summer days with excellent time resolution. The facility can also be used to validate computer models and to compare various technologies in real time. Industry has used MoWiTT results to justify new product development.

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❒ ***IR Camera Test Facility*** This facility includes a high-resolution, infrared imaging camera, a computer processor/printer, and a cold/hot chamber to hold samples for testing. The camera system is portable and can measure surface temperatures that can then be correlated to various heat loss or gain parameters. The IR camera is useful for assessing heat loss from existing buildings in the field as well as from building components and appliances in the laboratory setting.

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❒ ***Thin-Film Materials Laboratory*** This laboratory includes a wide range of apparatus to deposit and analyze thin-film coatings for energy control purposes. The laboratory's thin-film deposition systems are used to make new types of selective and electrochromic coatings. The laboratory also includes spectrophotometers to measure solar, near IR, and far IR properties.

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❒ ***Sky Simulator*** The 24-foot-diameter sky simulator is a hemispherical facility used to test daylighting performance in scale-model buildings under controlled and reproducible conditions. Computerized control of light sources within the hemisphere can create luminous distributions typical of clear, uniform, or overcast skies representative of any desired location, orientation, climate, and season on Earth. It can also be used as a sun simulator to test shading strategies in scale models up to 1.5 square meters in size. Light levels within the models are measured by 60 photosensors and the measurements are used to predict daylight illuminance conditions within full-sized buildings. The facility is well-suited to test the effect of shading from overhangs, fins, awnings, shade systems, vegetation, and adjacent obstructions.

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❒ ***Solar Heat Gain Scanner*** This device is used to characterize the complex optical properties of glazings and shading systems that are geometrically complex, such as venetian blinds. The system measures transmitted and reflected energy and light at all incidence and outgoing angles. The scanner has been used to develop a new procedure to predict solar heat gain through complex shading systems. This work was cost-shared between the U.S. Department of Energy and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).

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❒ ***Multimedia Laboratory*** Design tools of the future will not only have faster and better modeling algorithms but will also have vastly improved user interfaces incorporating new multimedia software and hardware capabilities. The ability to integrate data and text with advanced graphics, animation, sound, and video will greatly enhance the value and usefulness of the next generation of design and analysis tools. The multimedia computer lab contains the equipment needed to experiment with these emerging technologies and to prototype and test promising solutions. The lab has already been used to develop an interactive computerized kiosk with videodisk for Southern California Edison.

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Fenestration Facts

Architects and homeowners used glass and windows in other ways to help overcome the effects of the energy crisis. They converted existing single-glazed windows into "twindow" units by installing second sheets of glass over the first. And they learned the importance of window management, making the best use of the sun's light and heat to save on fuel and electricity.

Let There Be Light
James Cross Giblin
1988

FALL 1995

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PUB-762 Fall 1995-5000

This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098

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Fenestration R&D is made possible with support from the U.S. Department of Energy, Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technologies.

Sponsors of research described in this issue include:
California Institute for Energy Efficiency
U.S. Department of Energy
Federal Energy Management Program
Office of Building Technologies

NFRC Update

National Fenestration Rating Council

Home Energy Rating Procedure Approved

At the NFRC Annual Fall Meeting in Minneapolis, MN, September 26-30, 1995, the technical committee accepted, and the Board of Directors has now ratified NFRC-900: *Procedure for Determining the Annual Heating and Cooling Energy Ratings for Fenestration Systems Used in Residential Dwellings*. The ratings provide a simple comparative value for heating and cooling performance that can be used throughout the country. The Certification and Labeling committees will now address the implementation issues associated with getting the new annual energy ratings into use. The Annual Energy Subcommittee will now begin work on a Users Guide and the development of NFRC 901, a computer-based procedure, which is designed to provide more accurate quantitative ratings for a specific single house.

The Simulation Workshop, held in Pella, IA, May 16-18, 1995, featured Ross McCluney (FSEC), Dan Wise (NFRC), and Dariush Arasteh and Elizabeth Finlayson (LBNL). NFRC Simulators and Independent Certification and Inspection Agencies received training on how to implement Solar Heat Gain Ratings.

NFRC Meeting Schedule

1995

November 2-3, 1995
NFRC Board of Directors Meeting
Silver Spring, Maryland
(301) 589-NFRC

November 15-17, 1995
Simulation Workshop
The Eldorado Hotel and Casino
Reno, Nevada
(800) 648-5966

1996

February 15-16, 1996
NFRC Task Group Meetings
Atlanta, GA

April 16-20, 1996
NFRC Spring Membership Meeting
Royal Sonesta Cambridge
Cambridge, MA

For more information on:

- Administrative & Membership
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