NEW IEA-SHC TASK: PERFORMANCE OF SOLAR FACADE COMPONENTS

Performance, durability and sustainability of advanced windows and solar components for building envelopes

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Abstract - The objectives of this Task 27, which have been started 1 January 00, is to determine the solar, visual and thermal performance of materials and components, such as advanced glazing, for use in more energy efficient, comfortable, sustainable buildings, on the basis of an application oriented energy performance assessment methodology; and to promote increased confidence in the use of these products by developing and applying appropriate methods for assessment of durability, reliability and environmental impact.

INTRODUCTION

The IEA Solar Heating and Cooling Programme

The International Energy Agency (IEA) was founded in November 1974 as an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD) to carry out a comprehensive program of energy cooperation among its 25 Member countries. The European Commission also participates in the work of the Agency.

The IEA's goals of energy security, diversity, and environmental sustainability are addressed in part through a program of international collaboration in the research, development and demonstration of new energy technologies, under the framework of over 40 Implementing Agreements.

The Solar Heating and Cooling Implementing Agreement was one of the first collaborative R&D programs to be established within the IEA, and its Participants have been conducting a variety of joint projects in active solar, passive solar and photovoltaic technologies, primarily for building applications. The overall program is monitored by an Executive Committee consisting of one representative from each of the member countries. The leadership and management of the individual Tasks are the responsibility of Operating Agents.

Current Tasks:

Task 21: Daylight in Buildings
Task 22: Building Energy Analysis Tools
Task 23: Optimization of Solar Energy Use in Larger Buildings
Task 24: Solar Procurement
Task 25: Solar Assisted Air Conditioning of Buildings
Task 26: Solar Combisystems
Task 27: Performance of Solar Facade Components
Task 28: Solar Sustainable Housing
Task 29: Solar Crop Drying
Task 30: Solar Cities – (Task Definition Phase)

Task 27

Task 27 Performance of Solar Facade Components started at the beginning of the year 2000 and is scheduled to be terminated at the end of the year 2003. Therefore no scientific results can be presented yet, but the results of a long task definition process which finally merged the activities in performance assessment of Advanced Glazing Materials (Task18) and the experience of the IEA-SHC-Working Group on Materials in Solar-Thermal Collectors (MSTC). Experts representing 24 companies and institutes from 14 countries were involved in this planning phase, and 27 companies and institutes from 12 countries are presently co-operating in the Task.

The workplan of this task is presented briefly in this paper in order to inform the interested colleagues about our aims and goals and the structure of Task 27.

The objectives of he Task shall be achieved in the following Subtasks:

Subtask A: Performance (Subtask Leader: Dick van Dijk, TNO, Netherlands)
Subtask B: Durability (Subtask Leader: Bo Carlsson, SP, Sweden)
Subtask C: Sustainability (Subtask Leader: Jean-Luc Chevalier, CSTB, France)

Subtask A will provide Subtask B with the definitions and characterisation methods of the performance of building envelope components and a description of their
application. Subtask B will supply Subtask C with the evaluated failure modes and expected service life times of the investigated materials and components, which will also be included in the data-bases compiled by Subtask A, as well as the information about failure modes and environmental impact achieved by Subtask C.

2. SUBTASK A: PERFORMANCE

Objectives
The objective of Subtask A is to further develop, structure and integrate the energy performance assessment methodology for windows and other solar building envelope components. Such a methodology will facilitate selection of components and enable performance comparison to be made. Particular emphasis will be given to the assembly and integration of high performance, novel and/or complex solar components into functional building envelope elements. Those assemblies may incorporate highly insulating glazing/frames, anti-reflecting or chromogenic switchable glazings, PV windows, solar shading devices and other daylight components. Data obtained by the Subtask will be provided in consistent and harmonised forms suitable for use for product comparison and selection and in building simulation tools. This work will also enable cost benefit studies to be performed and performance criteria to be defined for the work of Subtask B. The work will directly support manufacturers in improving product characterisation and specification.

Activities
Evaluation of the state-of-the-art of energy performance assessment in different participating countries and international standardisation
Solar, optical/visual and thermal performance properties of materials and building envelope components and their integration into assemblies will be defined which are relevant for the energy and daylight performance of a product or integrated assembly, and for the assessment of the impact of material degradation or component failure on the performance over time.

Assessment of performance in real use and for characterisation
Test conditions for measurement of the performance parameters of components will be determined and measurements will be made on materials and complete components. Physical models will be further developed that will allow prediction of the performance of components from material properties. The ultimate goal is to achieve coherent sets of widely applicable calculation methods supported by simple test methods. In this context, recommendations for standard calculation and test methods will be made to support work on international standards.

Development of a structured data base of components and systems
Product and component data have to be made available in consistent and harmonised forms, suitable for product comparison and selection and for simulation of performance in specific applications. The structured data base will comprise the range from certified data of established high performance products to results from research on prototypes of novel materials and products.

These activities will be carried out within 3 different projects:

Project A1: Generic energy performance assessment methodology

Objectives
- Comparison and further development of energy performance assessment methodologies on windows and other solar facade components, their assembly and integration into building envelope elements.
- Set up a data structure of components and facade elements in a form suitable for product comparison, for product selection and for simulation of performance in specific applications.
- Identification of performance criteria for durability and service lifetime prediction.

Deliverables
- Improved and coherent energy performance methodology
- Structured database of components and integrated systems in consistent and harmonised forms suitable for product comparison and selection and for simulation of performance in specific applications
- Recommended calculation and test procedures for solar and thermal performance parameters in support of international standards development.

Project A2: Chromogenic Glazing

Objectives
- Define necessary solar, optical and electrochemical properties of chromogenic glazings.
- Develop improved electrochemical and solar/optical performance characterisation procedures.
- Harmonisation of performance definition.
- Determination of chromogenic window solar/thermal performance.

Deliverables
• Performance data of chromogenic glazing systems.
• Recommendations for building integration and control.
• Standardised performance declaration procedure.

Project A3: Solar building components and integrated assemblies

Objectives
- Determine thermal performance and improve models of selected window and other solar components and their integration into building envelope assemblies or facade systems
- Develop recommendations for standardised test and calculation procedures for the integrated thermal/solar/daylighting performance of products and building envelope elements with solar components such as high performance windows (glazings/frames), light redirecting components and solar control elements (incl. blinds).

Deliverables
- Improved test and calculation methods
- Thermal/solar performance data of selected window/solar components and assemblies
- Recommendations for building application and integration
- Recommendations for standardised performance assessment procedures

SUBTASK B: DURABILITY

Objectives
There are two main objectives. The first is to develop a general framework for durability test procedures and service lifetime prediction (SLP) methods that are applicable to a wide variety of advanced optical materials and components used in Energy Efficient Solar Thermal and Buildings applications. The second is to apply the appropriate durability test tools to specific materials / components to allow prediction of service lifetime and to generate proposals for international standards.

Activities
The activities are structured within two major parts. These are "Durability Assessment Methodology Development" (B1) and "Durability Test Procedures for Materials and Components (B2, B3, B4)". Within B1, a review of existing durability test procedures and SLP methodologies will be performed. Next, a general outline of methodologies applicable to a variety of specific materials (identified by B2, B3, and B4 and leading to individual case studies) will be drafted. The general approach will be adapted to these specific materials/devices/components/systems. Through interactions with the case study projects, revisions to the general methodology will be made. In parallel with these revisions, the general methodology will be validated. This will be accomplished by applying the methodology to a material for which real-world data are available and demonstrating that the predicted time-dependent performance based on accelerated test results agrees with real-world ageing behaviour. After the general methodology has been successfully adapted to a number of specific materials and its validity has been shown, the final version will be documented. Standardised analysis and testing protocol tools will also be developed throughout this process. These will include standardised data formats, data base structures, and computer algorithms for data analysis, along with hardware instrumentation specifications for monitoring and measurement.

The list of materials and components to which the B1 methodology will be adapted will include
- glazing incorporating thermotropic coatings, electrochromic materials, and gasochromic materials (Project B2)
- anti-reflective (AR) and polymeric glazing, reflectors, and solar facade absorbers (Project B3)
- edged sealed and breathing glazing units, complete windows (Project B4)

Applications
To achieve successful and sustainable commercialisation, solar building products must meet three important criteria, namely minimum cost, maximum performance, and demonstrable durability. Durability assessment directly addresses all three segments of this triad. First, it permits analysis of life cycle costs by providing estimates of service lifetime, O&M costs, and realistic warranties. Understanding how performance parameters are affected by environmental stresses (for example by failure analysis) allows improved products to be devised. Finally, mitigation of known causes of degradation directly results in increased product longevity. Thus, accurate assessment of durability is of paramount importance to assuring the success of solar thermal and building products.

Project B1: Durability assessment methodology development

Objectives
The objective of this Project is to develop a general methodology of test procedures for the assessment of durability, reliability and service lifetime prediction (SLP) of materials and devices used in solar thermal and building applications. The methodology will be sufficiently robust that it can be adapted to a wide variety of specific materials systems that are of interest.

Deliverables
- A validated methodology for durability and lifetime assessment
- Support for the durability projects B2, B3, and B4 by providing a congruent methodology of standardised test protocols and data analysis procedures
- Standard test procedures and recommended methods for international standardisation.

Project B2: Durability and reliability assessment of switchable materials and devices (chromogenics)

Objectives
The general objective of this project is to assess the durability and reliability, under service conditions, of a variety of switchable materials and devices including those containing electrochromic, gasochromic, and/or thermotropic layers. Such materials may have application for both building facades and solar thermal collector systems.

Deliverables
- Durability assessment methodology appropriate to chromogenic components
- Validated ageing model for chromogenic components
- Service life prediction algorithm for chromogenic components
- Recommended test procedure for chromogenic components

Project B3: Durability and reliability assessment of static solar materials

Objectives
The general objective of this project is the assessment of the durability, reliability and service life of static solar materials. Materials to which the B1 methodology will be adapted will include anti-reflective (AR) and polymeric glazings, reflectors, and solar façade absorbers. Work on these will be performed in form of case studies.

Deliverables
- Durability of case study materials
- Defined failure modes.
- Degradation analysis model for service life prediction.
- Drafted test procedures for proposal of international standards.

Project B4: Durability and reliability assessment of windows and glazing units

Objectives
The general objective of the project is the assessment of the durability and reliability (fitness for use) of selected window systems (e.g. highly insulating frames, glazing units ..). This requires accumulation of long-term performance data, as well as measured and calculated results of hygro-thermal behaviour. Durability / reliability assessment procedures will be documented.

Deliverables
- Long term performance data of selected window elements
- Requirements for the reliability of advanced windows
- Improved thermal and microclimatic device models
- Durability / reliability assessment procedures
- Supporting data for Subtask C on failure modes and effect analysis

SUBTASK C: SUSTAINABILITY

Objectives
The sustainability of solar building envelope components will be addressed by investigating, identifying and applying to examples relevant methodologies and criteria in two of its main fields which are environmental impact assessment and service life anticipation.

Activities
As this subtask is dealing with relatively new concepts, which are not yet completely defined and harmonized at an international level, a lot of work will be needed on information collection. The first step will consist of a review of internationally agreed sustainability indexes, and the way they address particularly environmental impacts and service life prediction. Then the work will be split in two separate projects:

Environmental impact assessment (project C1) will be developed in three steps. The first one is a state-of-the-
art-study, in order to collect existing knowledge within the participating countries, regarding: tools available (from LCA to the most simplified tools), studies already performed, national actions and priorities, needs expressed by the industry and the specifiers. The second step will undertake methodological aspects (boundary options, data quality, effects and limitation of simplified approaches, priorities, link with performance and durability, expression and format of the results, and proceed towards an harmonized format for communication on environmental characteristics. The last step, (whose success is strongly dependent on the contributions by industry), will demonstrate the applicability of the methodology by experiencing three examples (suggestions are: comparison between an advanced and a traditional double glazing unit, sensitivity study on a solar collector, objective investigation of window frames, but the final choice will depend on industry and users expectations).

Failure mode analysis (Project C2) is a multiple-scale exercise. The durability approach developed in Subtask B contributes to the project by providing information at the material and component level. The extrapolation over time of decreasing performance after aging processes permits an assessment of estimated service lifetime, "nominal" life duration. But premature failures of the products at the component or at the system scale must be considered in addition. The suggested methodology is the application of the Failure Mode Effects and Analysis tool (FMEA). Widely used in industries, FMEA will be adapted to windows and solar devices, and recommended for checking the risks of failure at the component scale. In a second phase FMEA will be applied to several examples to allow the identification of possible premature end of the predicted service life (before the nominal value). Provided that industrial partners will participate, and in conjunction with project B4, the possible case studies could deal with a whole window, a transparent insulation element, and a double facade unit.

Project C2: Failure mode analysis

Objectives
- Investigation the durability and reliability approach at the component and system scale: terminology, data collection, methodology, experimentation.
- Information on the service life prediction (SLP) existing methodologies (both in correlation with the B1 and B4 projects)
- Survey of the Failure Mode Effects Analysis (FMEA) expertise in the group, and its adaptation to glazing, windows and solar components for identification of premature termination of the service life
- Application of the SLP and FMEA adapted methodology to selected products (nominal service life prediction and anticipation of premature termination).

Project C1: Environmental impact assessment

Objectives
- Survey of the existing knowledge in the participating countries in the field of environmental impact of building products, and particularly glazing and solar components
- Assessment of an appropriate format for communicating on environmental characteristics, adapted to the industry needs and to the users (specially specifiers) demand
- Application of the methodology to selected products