IEA-SHC TASK 27: Performance, Durability and Sustainability of Advanced Windows and Solar Components For Building Envelopes

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Introduction

The objectives of this Task 27, which has been started 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. The work-programme and the first results will be presented.

1. 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 (www.iea.org/). The European Commission also participates in the work of the Agency.

The IEA's goals of energy security, diversity, and environmental sustainability are addressed 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 (http://www.iea-shc.org/) 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.

1.1 Current Tasks

The current tasks of IEA-SHC programme are the following:

- Task 22, “Building energy analysis tools”;

- Task 23, “Optimisation 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 31, “Daylighting buildings in the 21st century.

1.2 Task27

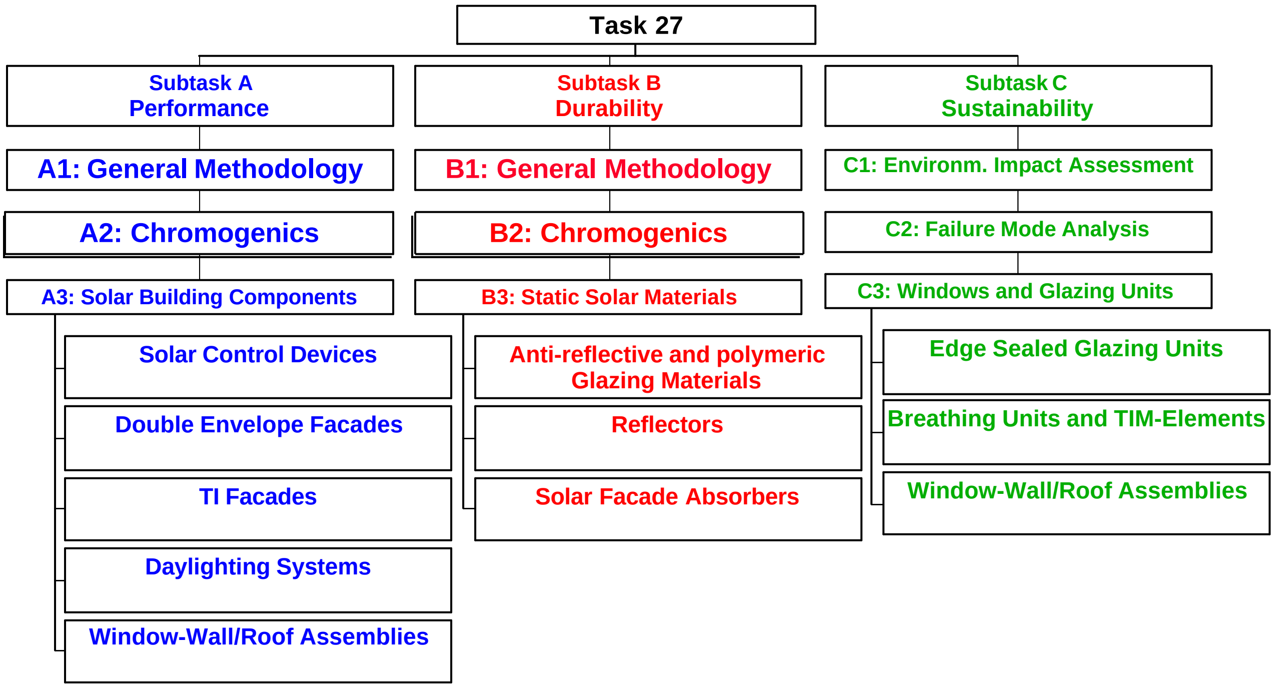
Task 27, “Performance of solar façade components - Performance, durability and sustainability of advanced windows and solar components for building envelopes” (http://www.iea-shc-task27.org/)started at the beginning of the year 2000 and is scheduled to be terminated at the end of the year 2003. Therefore no final scientific results can be presented yet, but the results of a long task definition process which finally merged the activities in performance assessment of Task18, “Advanced glazing materials” and the experience of the IEA-SHC-Working group on materials in solar-thermal collectors (MSTC). Experts representing 32 companies and institutes from 14 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 (see diagram below).

The objectives of the 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.



Structure of IEA-SHC Task27

2. Subtask A: "Performance"

2.1 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, photovoltaic windows, solar shading devices and other daylight components. Data obtained by this 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.

2.2 Activities

The planned activities of Subtask A are the following:

- "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 projects A1, A2 and A3.

2.2.1 Project A1: “Generic energy performance assessment methodology”

Objectives:

- comparison and further development of energy performance assessment methodologies on windows and other solar façade components, their assembly and integration into building envelope elements;

- set up a data structure of components and façade 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.

2.2.2 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.

Case studies:

  - electrochromics;

  - gasochromics;

Deliverables:

- performance data of chromogenic glazing systems;

- recommendations for building integration and control;

- standardised performance declaration procedure.

2.2.3 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 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).

Case studies:

  - high performance glazing/window/wall assemblies;

  - double envelope systems;

  - ti-facades;

  - light redirecting devices;

  - solar control devices.

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.

3. Subtask B: “Durability”

3.1 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 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.

3.2 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)”. 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 and B3 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.

3.3 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, operation and maintenance 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.

3.3.1 Project B1: "Durability assessment methodology development"

Objectives:

The objective of project B1 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) by providing a congruent methodology of standardised test protocols and data analysis procedures ;

- standard test procedures and recommended methods for international standardisation.

3.3.2 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.

Case studies:

- electrochromics;

- gasochromics;

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.

3.3.3 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 items will be performed in form of case studies.

Case studies:

- anti-reflective (AR) glazing;
- reflectors;
- solar facades.

Deliverables:

- durability of case study materials;
- defined failure modes;
- degradation analysis model for service life prediction;
- drafted test procedures for proposal of international standards.

4. Subtask C: "Sustainability"

4.1 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 prediction.

4.2 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 three separate projects: C1, C2 and C3.

4.2.1 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.

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 Life Cycle Analysis to the most simplified tools), studies already performed, national actions and priorities, needs expressed by the industry and the specifyiers. 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).

4.2.2 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 C3 projects) and 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 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 C3, the possible case studies could deal with a whole window, a transparent insulation element, and a double facade unit.

4.2.3 Project C3: "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.

Case studies:

- Edge-sealed glazing units (large samples);
- breathing glazing units and TIM-elements;
- assembly of window and wall/roof (complete windows).

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 Project C2 on failure modes and effect analysis.

5. Conclusions

The attendance of such a number of distinguished companies and institutes working in the field of solar facade components shows on one hand the great interest in this field and rises big expectations in the impact of this task for standardization of test methodologies for the perforamance and the durability of innovative materials and components für solar building envelopes. Everybody who is interested in the work of this group is encouraged to contact the secretary (bgrei@ise.fhg.de) or his national contact persons.

Appendix: List of participants of Task27

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