EUROPEAN RESEARCH PROJECT RE-VIS, DAYLIGHTING PRODUCTS WITH REDIRECTING VISUAL PROPERTIES

H.A.L. van Dijk[1]

Department of Sustainable Energy and Buildings, TNO Building and Construction Research,
P.O. box 49, NL 2600 AA Delft, The Netherlands
[1]See also acknowledgements for other contributors

ABSTRACT

The European RTD project REVIS, Daylighting products with redirecting visual properties (contract JOE3-CT98-0096), started in October 1998 and was completed by the end of 2000. The project was coordinated by TNO. The presentation highlights the objectives, means and some of the main results.
The main results are: Measurement data of the full angular (bi-directional) distribution of solar/light radiation transmitted through and reflected in a daylight component (glazing, sun shading), measured in goniophotometer equipment and data analysis software, applied on a number of samples representing novel daylight products. A set of indices on the daylight transmitting quality of glazing and sun shading products in terms of their potential to prevent glare, to redistribute the daylight and to view through as a basis for future European standardisation.

KEYWORDS

Daylight quality, window properties, measurement techniques, calculation methods, standardization, directional properties

INTRODUCTION

The European RTD project REVIS, Daylighting products with redirecting visual properties (contract JOE3-CT98-0096), started in October 1998 and was completed by the end of 2000. For the list of participants: see Acknowledgements.
This presentation highlights the objectives, means and some of the main results.

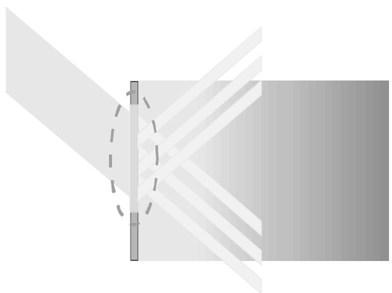


Figure 1. The REVIS logo, illustrating the topic of the research

OBJECTIVES

The overall objective of the project RE-VIS was to develop the detailed product information needed for a Europe-wide uniform comparison and selection of novel daylighting products on the basis of optimizing the daylight quantity and quality in a room (glare, distribution of daylight in the room, ..).

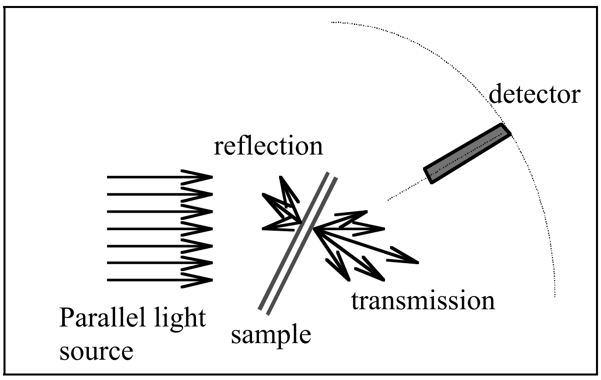
RESULTS

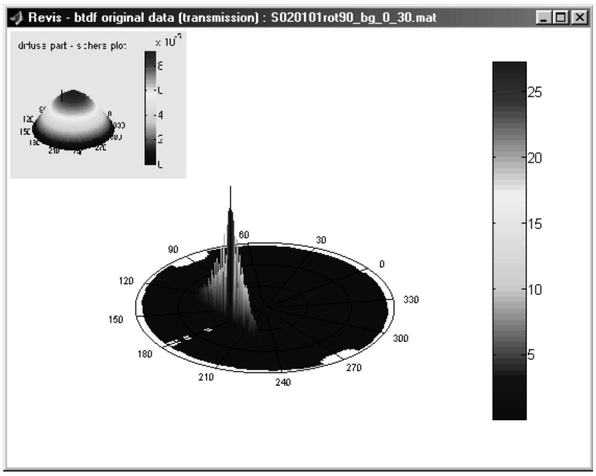
The research had a typical pre-normative character, leading to the following end products:
- Sets of measurement data of the full angular (bi-directional) distribution of solar/light radiation transmitted through and reflected in a daylight component (glazing, sun shading), measured in validated goniophotometer equipment and data analysis software, applied on a number of samples representing novel daylight products.
- A set of indices on the daylight transmitting quality of glazing and sun shading products in terms of their potential to prevent glare, to redistribute the daylight and to view through, suitable as a basis for future European standardisation.
- Calculation routines for the directional optical properties of daylighting products, and window assemblies, suited for e.g. the European software tool for the determination of thermal and solar properties of windows, WIS.

Some of the main results will be highlighted briefly below:

Goniophotometer Measurements

The full angular (bi-directional) distribution of solar/light radiation transmitted through (τ) and reflected (ρ) in daylight components (glazing, sun shading), the socalled BTDF, was determined in a goniophotometer device at TNO. Figure 2 shows the principle of the goniophotometer measurements. Figure 3 shows an example of such BTDF.





Left: Figure 2. Principle of the goniophotometer
Right: Figure 3 Light transmittance through prismatic glazing as function of angle of transmission (incidence angle [0°;30°]); the insert shows an example of filtering out different components; in this case: the (low) Lambertian diffuse component.

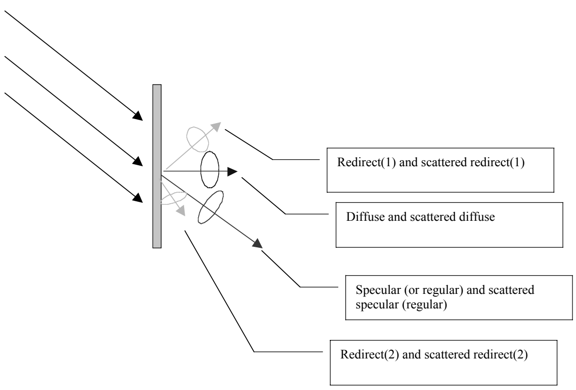
About 15 samples were selected for measurements, covering simple and complex glazings, plastics and shading fabrics. The results were compared with results obtained with (spectral) integrating sphere equipment and with results of twodimensional goniophotometer equipment.

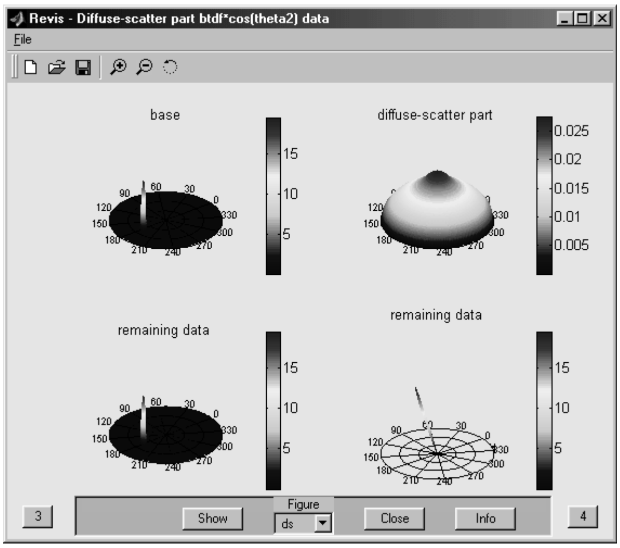
BTDF Data Reduction

Within REVIS we have developed procedures to filter out from the full BTDF the following portions of transmission (resp. reflection) (figure 4:

- Specular or regular portion (τ or ρ within cone of 1 degree in specular direction)
- Diffuse portion (in short: τ or ρ symmetrical around normal to sample), with associated angular width (maybe deviating from Lambertian, in which case we call it: diffuse-scatter)
- Specular redirect portion(s) (τ or ρ within cone of 1 degree in other direction), with associated direction angle. Note: there may be more than one redirect portion
- Scattered specular portion (τ or ρ outside cone of 1 degree in specular (regular) direction) with associated direction angle and associated angular width.
- Scattered redirect portion(s) (τ or ρ outside cone of 1 degree in redirect direction), with associated direction angle and associated angular width. Note: there may be more than one scattered redirect portion.

The angular width of diffuse and scattered portions are represented by the 'energy' weighted average angle.
A program has been written in Matlab to carry out the filtering process and show the results in an numerical and graphical way (figure 5).





left: Figure 4 REVIS breakdown of transmission into characteristic components

right: Figure 5 Example of graphical presentation of the reduction process of the BTDF data (Matlab program); spherical plots; right below: vector plot

Visual Comfort

Visual comfort is associated with disability glare, luminance ratios, view through and colour

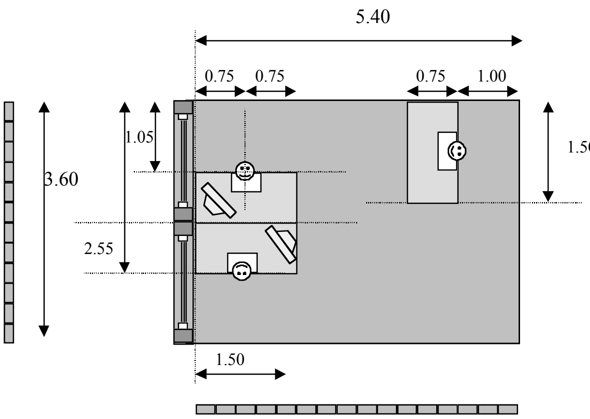
Disability glare and luminance ratios
A reference office room has been specified (figure 6), with reference occupants, a variety of electric lighting options in a given climate condition.to calculate for a specific daylight product for each situation the characteristic values for visual (dis-)comfort in the room.

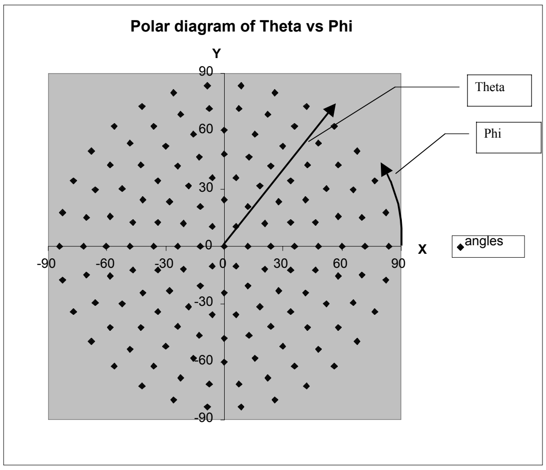
Note: in a combined effort of IEA SHC Task 27 and EU RTD project Swift the REVIS reference office room has recently been extended to a reference office building for thermal, solar and lighting calculations, giving full details on the building, climate and location, occupation, systems and controls, for inter-comparative simulations.

Selected characteristic values for visual comfort are among others:

- disability glare due to high luminance from sun or sky through the window (whether or not redirected, etc.) within the fields of view
- minimum illuminance at desk
- maximum luminance ratio desk/wall behind
- maximum illuminance at PC screen (reflections!)
- minimum luminance ratio of PC screen and wall behind
- maximum ratio illuminance at desks in front and back of room

Such a series of calculations with a program like Radiance would consume extremely long calculation run time in a Unix environment.





left: Figure 6. REVIS reference office room
right: Figure 7. Tregenza distribution of points in outside hemisphere seen through the daylighting product (sky and ground)

Pre-calculated Response Factors

To avoid that, response factors have been pre-calculated with Radiance, giving the illuminance and luminance at a high number of positions in the room, related to a unit light source from one specific point in the sky. Response factors have been pre-calculated for 145 points in the outdoor hemisphere (distribution according to Tregenza, figure 7). Although this is basicly a known technique, the specific novel features of the REVIS method are:

- the high number (few hundred) of points in the room for which the (il-)luminance responses are taken; this allows to apply various criteria for visual comfort in the room;
- the indiscriminant combination of points in the sky and the ground: this allows to apply the method also for daylighting product with strong redirecting (or diffusing/scattering) properties: the daylight product changes the direction of the source of light or the sun into the room, so the light or even the sun may come into the room from a point which seems to lay below the horizon.

With a fast PC based program, the responses for all the points in the environment can be weighted with the actual luminance distribution of sky and ground and the sun beam, modified by the daylight product (according to the different portions: specular, redirect, diffuse, scatter,..) and summed up to produce the actual (il)luminances in the room, for each skytype and lighting situation. The visual discomfort is then (hourly) calculated as an index based on the above mentioned characteristics (luminances and ratios), using a reference weather file.

In the façade of the reference room we can define different daylighting systems for the lower, large, view window and for the smaller top window. We can also model switching between two daylighting systems per window: e.g. a system with blinds up, and with blinds down. The switching between the two systems may be done on the basis of best visual comfort, resulting in the least visual discomfort per hour. The final step is to count the hours with visual discomfort and the hours with extreme visual discomfort, to give a quantitative indication of the potential of the chosen combination of daylighting systems to provide visual comfort.

View Through

Within REVIS we also developed an index for the possibility to view through the daylight product. This index uses primarily the information given by the transmission and reflection portions: specular, specular redirect (incl. The redirect angle), diffuse and specular and/or redirect scatter (incl. the width). See full details in the REVIS final report van Dijk, 2001).

Calculation of BTDF Instead of Measurement

Similarly, another part of the activities was on modelling: calculating the BTDF's with Monte Carlo statistical techniques (ray tracing), instead of measurements for products with a specific geometry like (curved) slat types of shading devices and combinations of glazings and shading devices (figure 8).

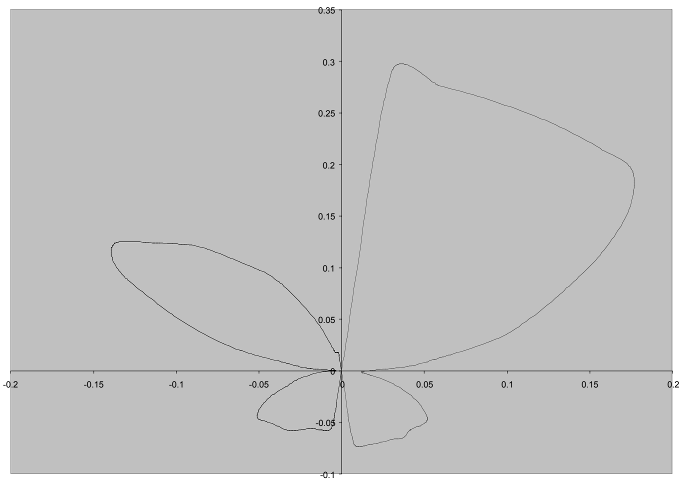


Figure 8. Example of 2D cut of Monte Carlo model calculated reflection and transmission through a daylighting product

These latter activities were carried out within the context of one of the aims of REVIS: develop calculation routines for the directional optical properties of daylighting products, and window assemblies, suited for e.g. the European software tool for the determination of thermal and solar properties of windows, WIS.

CONCLUSIONS

The EU REVIS project has resulted in a series of end products of a typical pre-normative character:
measurement data of the full angular (bi-directional) distribution of solar/light radiation transmitted through and reflected in a daylight component (glazing, sun shading), measured in goniophotometer equipment and data analysis software, applied on a number of samples representing novel daylight products;
a set of indices on the daylight transmitting quality of glazing and sun shading products in terms of their potential to prevent glare, to redistribute the daylight and to view through as a basis for future European standardisation.
Other end products are a set of calculation tools associated with the mentioned procedures.
The intention is to use, discuss and further improve the procedures developed in REVIS in current and future international research and standardisation activities.

REFERENCES

Dijk van, H.A.L. (2001). *REVIS, Daylighting Products with Redirecting Visual Properties,* Final publishable report of the EU RTD contract JOE3-CT98-0096, Delft, August 2001 (173 pages)

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