INTERNATIONAL ENERGY AGENCY

CALCULATION OF ENERGY AND ENVIRONMENTAL PERFORMANCE OF BUILDINGS

Subtask B

Appropriate use of Programs

Volume 2

ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS PROGRAM

IEA ANNEX 21 - SUBTASK B

CALCULATION OF THE ENERGY PERFORMANCE OF BUILDINGS

APPROPRIATE USE OF MODELS

FINAL REPORT

VOLUME 2

PERFORMANCE ASSESSMENT METHODS

THE SUBTASK OUTPUT

May 1994

		PAGE
CONTENTS LIST		I

INTRODUCTION TO VOLUME 2

Whereas Volume 1 describes the work carried out overall in Subtask B this Volume presents the major Subtask outputs.
Four major areas of work were completed which are considered to be of general use to users of building performance assessment programs. These may be seen as four stand alone packages:-

Section 1
A system for documenting performance assessment methods comprising a 'shell' document, guidance notes for its use,an example of its use and a glossary of terms. This should enable users to document how they use programs, and the assumptions that have to be made, in a logical and consistent manner and provide a record of office practice to improve quality control.

Section 2
A set of documented performance assessment methods, PAMDOCs, for energy audit and overheating purposes based on a number of commonly used programs.

Section 3
An interactive cross referencing system, DYNALINK, which facilitates referencing of program input file requirement against the appropriate sections of the program manual and selected PAMDOCs.

Section 4
A set of papers addressing particular problems that have arisen during the evaluation of PAMs which may be used for their further development.

IEA ANNEX 21 - SUBTASK B

CALCULATION OF THE ENERGY PERFORMANCE OF BUILDINGS

APPROPRIATE USE OF MODELS

FINAL REPORT

VOLUME 2

SECTION 1

GUIDANCE FOR

DOCUMENTATION

Part A

Notes for Guidance

NOTES FOR CARRYING OUT PAM DOCUMENTATION USING THE 'SHELL'

THESE NOTES ARE FOR THE USE OF PAM AUTHORS AND DEVELOPERS AND IT IS IMPORTANT THAT THEY ARE READ BEFORE CARRYING OUT ANY DOCUMENTATION.

GENERAL

The purpose of the 'SHELL' is to provide a framework for the documentation of performance assessment methods (PAMs).
Documentation is necessary both for the analysis and development of PAMs and to ensure as far as possible that PAM users follow consistent methodology and procedures which in turn should lead to more consistent and repeatable results.

Although a PAM may be defined as PURPOSE + PROGRAM + METHOD the documentation of a PAM is only concerned with those aspects of the PAM which enable a user to carry out the performance assessment in a consistent and unambiguous manner. In other words, it is concerned with how the PAM is used. The internal workings of the PROGRAM are only considered in terms of how they interface with the user.

It is convenient to consider the documentation as being from the point of view of an 'expert' user carrying out a specific performance assessment using a particular program and providing all the information which would enable another user to produce the same result.
The documentation, by recording the knowledge and experience of the 'expert', translates into a set of instructions for the user.
The documentation should, ideally, provide all the information necessary to enable the user to complete the program input files and set up the program.
Information is either provided directly or the user must be referred to where the information may be found. All information should, in any case, be referenced and any assumptions on which such information is based should be clearly stated.

Before describing the individual requirements of each section of the 'shell' the following general points must be made:-

1) The purpose of the'SHELL' is to provide a framework (template) for the PAM documentation to follow. It is a tool to ensure that PAM documentation, referred to as a PAMDOC, follows a consistent pattern to ensure that all the appropriate information is provided, is structured so as to facilitate subsequent information retrieval and provides comprehensive instruction for the user when carrying out a performance assessment.

2) All sections and subsections set out in the SHELL must be completed in the documentation. If, for any reason, a section cannot be completed, it is permissible to use expressions such as 'NOT APPLICABLE', 'NONE', 'UNKNOWN', etc. where appropriate. Sections must not be left blank.

3) In order to avoid too much repetition sections may be completed by referring to other completed sections within the PAM documentation OR by referring to the appropriate sections in other, existing and completed PAMDOCs. (See 11).

4) In certain cases it may be useful or necessary to provide information on a particular topic in a section or sections which do not specifically deal with that topic. When this is the case the sections must be cross referenced to each other.

5) It follows from 3) above that initially (as a first step) only PAMs having a single well-defined purpose can be documented. A PAM having several purposes can only be documented by reference to other existing and completed PAMDOCs which themselves describe PAMs with single (specific) purposes.

6) PAMDOCs dealing with multiple PURPOSES are built up from the appropriate SINGLE PURPOSE PAMDOCs.

7) As well as applying to a PAM having a single PURPOSE, the documentation should be based on a specific APPLICATION or range of APPLICATIONS e.g. housing, hotel, factory, etc. If the documentation can be used, without change, for other APPLICATIONS they should be included. For example, if a PAMDOC produced with respect to overheating in housing can also be used without change for hotels, then its APPLICABILITY would be to 'housing and hotels'.

8) Sections in the documentation (PAMDOC) must not make reference to other applications not covered by the documentation. If, for example, the application is for 'housing', only information relating to different house types, etc., may be documented. It would NOT be permissible to provide information referring to 'factories' for example even though the PROGRAM under consideration may be able to deal with factories. A subsequent PAMDOC dealing with factories, however, may only need to incorporate the specific 'factory' information and all other sections could be referred to the previously completed PAMDOC dealing with houses.

9) The PROCEDURE section of the SHELL is the only section where the order, description and possibly paragraph number of the headings may be changed. This is because PROCEDURES may vary depending on the program being used. It could, for example, follow the normally used order of the program input data tables.

10) Part of the PROCEDURE could conceivably be to carry out another PAM if a complex PAM is being documented. In this case, reference may be made to the other PAM provided that the appropriate documentation exists.

11) An exception to 3) and 9) above is allowed in the case of 'standard' calculations such as for 'U' values which can be considered as PAMs. It may be necessary, for example, to provide 'U' values as program input which may be derived from a separate

calculation program. When this is the case, the basis of the method should be stated, e.g. CIBSE Guide, as well as the program name, author, etc. where appropriate.

12) Where possible, the suggested headings under PROCEDURE should be followed in order (sequence).

13) It may be necessary, under certain circumstances, to introduce new headings not covered by the SHELL. If this is the case, then the information provided under those headings should follow the same format as for other headings and the appropriate heading levels must be maintained.

14) It has been found useful by authors of PAMDOCs to provide, as supporting information, an additional document describing the program input data requirements, in the order normally used, with cross references to the appropriate PAMDOC sections. It is suggested that this could be a standard appendix to the SHELL. It cannot be incorporated into the main body of the SHELL since its format will be determined by the program being used. From the point of view of both PAMDOC user and developer it is of considerable value.

15) The information provided in the PAMDOC for the user must obviously be, to the knowledge of the PAMDOC author, the 'best' available at the time. There may however be limitations on what a PAMDOC user is able to do depending on his/her state of knowledge of the building; whether it is at an early design stage or whether detailed information is available. If possible authors should provide default values/techniques where they are deemed appropriate.

COMPLETION OF INDIVIDUAL SECTIONS

Information is provided within the SHELL to assist in the completion of each section. In certain instances, as for example section 1.2.1, a list of items may be given from which a selection may be made.In addition a completed PAMDOC (fictional) is provided as an example of the type of information required.

Each section is described as follows:-

1) Section 0.0 - PAM IDENTIFICATION

This section identifies thePAM in terms of Purpose, Application, Program and Source.

The identifier is chosen by the document author and should identify the author, source, e.g company or institution, and each PAMDOC produced from that source in sequence.
If the PAMDOC is updated or otherwise amended its identifier should not change but the date should be amended to indicate that it is a later issue.

2) Section 1.0 - DEFINITION OF PERFORMANCE ASSESSMENT

Basically this section describes the aim (PURPOSE) of the performance assessment and the particular conditions and applications for which it may be used. It is important that this section of the PAMDOC is clear and unambiguous to ensure that users are fully aware of the application of the PAMDOC and will not use it for a purpose for which it is not intended.

It should be noted that there is a strong link between this section and Section 3.0 which describes the detail of what is needed to satisfy the requirements of this section. From the point of view of the compiler of the documentation, it could be better to leave this section until the end. The documentation can be produced for a specific set of circumstances and then checked to see whether it can be used, without change, for other applications.

3).Section 2.0 - PROCEDURE

An 'expert' when actually carrying out a performance assessment will generally follow a set sequence of operations - a Procedure. The SHELL Procedure section describes those operations which, it is anticipated, would normally be carried out and in what is assumed to be a logical order.

The documentation of the PROCEDURE effectively provides a set of instructions to the user outlining the order of steps normally taken and providing references to the sections of the PAMDOC which contain the detailed information required. The Procedure is saying "This is what you do and in this order".

The sequence of operations under PROCEDURE may in certain circumstances be defined by the actual PROGRAM being used or it could be defined by the compiler of the PAMDOC if he has found that doing things in a certain way confers advantages.

4).Section 3.0 - INFORMATION DEFINITION

Whereas Section 1.0 describes the PURPOSE of the performance assessment in qualitative terms this section details what is required to <u>achieve</u> the PURPOSE and it is important that both sections are compatible in this respect.

3.1 Information Required from Performance Assessment

From the author's/developer's point of view, this section provides a description of what is wanted from the performance assessment. In other words it is what the user wants to know. This is not necessarily the same as the program output as in many cases the program output will require some modification (post processing) to put it into the form required. A future user of the PAMDOC will of course see this as the information <u>being provided</u> by the PAM after post processing.

An important aspect of performance assessment is that of zone selection. Selecting a zone for overheating assessment for example, if not previously specified and if not all zones are run, is a part of performance assessment that is carried out by the user (assessor). The user may want to know,'What is the worst temperature?', 'What is the worst month?', 'What is the worst time of day?' and 'What is the worst zone?
To answer the last question runs may have to be performed for a selection of zones. Although a difficult problem to resolve guidance should be given, if possible, as to how the zones are identified and any criteria for identification.

3.2 Post Processing of Output

The program output may require some post processing to put it into the form desired by the user ('Information required from the performance assessment'). The processing required is described here.

3.3 Form of Presentation

Some Programs may have a facility for presenting information in a prescribed tabular or graphical form. In other cases PAM authors/developers may have found that a particular form of presentation has advantages and is recommended. Whichever is applicable should be documented here as long as it is made clear which method is used.

3.4 Information Interpretation

Any decision arising from the results of a performance assessment may depend on the way in which those results are interpreted. A description of the interpretation process is essential (for example the basis for deciding whether a zone is judged to overheat; is it a generally accepted or approved criterion?).

5) Section 4.0 - PROGRAM CONFIGURATION

This section deals with all those requirements for setting up the PROGRAM over which the user has control. It contains guidance on selection of initial conditions and computational parameters, not only in terms of what the program can accept, but also in terms of what the author of the PAMDOC has found to be most suitable. For example, a PROGRAM user may be required to specify the number of nodes to be used for each layer of construction. The PAMDOC author however may be aware that the use of a single node per layer results in a much shorter computation time with little loss of accuracy. This information should be provided.

6) Section 5.0 - CONTEXT DESCRIPTION

This section carries the information needed by the program to specify the site characteristics and climatic conditions for which the simulation is to be performed. Site Description will often contain 'real' site information, such as exposure and shading, and 'weather site' information since full weather data may not be available for the 'real' site.

7) Section 6.0 - ZONING DESCRIPTION

Many PAMs are capable of handling more than one zone and this section provides the information the user needs to determine how the building is broken down into zones for modelling purposes, i.e. the characteristics of spaces which determine whether or not they are judged to be separate zones. The requirements for zones which are not modelled but which influence the performance of adjacent modelled zones are also stated.
(NB This section is NOT concerned with how a zone is physically described to the program.This is covered in Section 7:Building Description.)

This section should clearly document what is to be done when adjacent spaces (rooms) are combined into single zones and also when single spaces (rooms) are broken down into a number of zones.

Interzonal coupling describes the exchange of energy or air or moisture mass flow across zonal boundaries. A description of how these processes are described to the program is needed.

8) Section 7.0 - BUILDING DESCRIPTION

This constitutes a description of how the building is specified to the program, both dimensionally and in terms of physical properties of the materials used and should cover any conventions used for dimensioning.
Of particular interest is the way in which windows are defined and treated by the program which may lead to certain aspects of their description being embodied in more than one sub section of the building description.
For example a window frame may be treated as part of the wall and the window defined as the glazed area only. On the other hand the program user might combine the U value of glazing and frame in which case the window area would be defined as the area of the hole in the wall. Clearly some care is needed here.

9) Section 8.0 - BUILDING OPERATION DESCRIPTION

This section provides a description of the air flow rates, incidental energy gains and environmental control conditions to which the building is assumed to be subjected. Both natural and building user-defined conditions are taken into account.

CONTENTS OF SHELL SECTIONS:

PAGE

SECTION 0.0 - PAM IDENTIFICATION

IDENTIFIER	Group Number EXAMPLE: NU 0001 [unique to document]	
PURPOSE	State in full.	
APPLICATION	State the application for which the PAM is documented.	
PROGRAM	State the name of the program used.	
DATE	Of PAMDOC.	
AUTHOR	Of PAMDOC,	EXAMPLE: John Wiltshire.
ADDRESS OF AUTHOR	EXAMPLE:	School of Architecture University of Newcastle upon Tyne Newcastle upon Tyne NE1 7RU Tel: 091 222 6012 Fax: 091 261 1182 Telex: 53654 UNINEW G

SECTION 1.0 - DEFINITION OF PERFORMANCE ASSESSMENT

1.1 PURPOSE

This should be a statement of the particular aspect of building performance that is required to be assessed, i.e. to which this PAMDOC applies.

It can either be quite simple, e.g. `assessment of overheating risk' (a single PURPOSE) or more complex, e.g. `assessment of economic energy efficiency measures for an existing building' which could involve, for example, aspects of LIGHTING, HEATING and VENTILATION.

If the purpose is complex, refer to Note 5.

1.1.1 Purpose

EXAMPLE: overheating risk
OR energy audit.

1.2 APPLICABILITY

Identification of the basic parameters in addition to PURPOSE for which this documentation is specific.

1.2.1 Building Type

Broad classification of the basic building type or types specific to this PAMDOC. At the coarsest level, it might simply distinguish between Residential and Non- Residential applications. The latter might be further sub-divided: Educational, Industrial, Transport, Commercial, etc.

Select from list below:

Residential:
- Housing
- Hotels

Non Residential:
- Transport
- Industrial
- Commercial
- Health & welfare
- Refreshment
- Entertainment
- Recreation
- Religious
- Educational

Typical entries might be:

Non-Residential:
- Transport

Industrial
or
Residential:
Housing

1.2.2 Environmental Control System

Broad classification of the system(s) used to achieve environmental control that are specifically dealt with by this PAMDOC,

<u>Choose from list below:</u>

- <u>Heating</u>
  - Passive solar
  - Active heating
- <u>Cooling</u>
  - Free (by ventilation)
  - Mechanical (by refrigeration)
- <u>Humidity</u>
  - Humidification
  - Dehumidification
- <u>Ventilation</u>
  - Natural
  - Mechanical
- <u>Lighting</u>
  - Natural
  - Artificial

1.2.3 Climatic Zone

Climatic zones to which this documentation is <u>specifically</u> applicable,
<u>Choose from list below</u>:

- Cold
- Temperate
- Hot dry
- Warm humid

1.2.4 Program

The program and version for which this PAMDOC is written.

1.2.5 Resources

Hardware platforms on which the PROGRAM can be mounted.

1.2.6 Further Information

This should identify any major limitations and/or any additional information relevant to the application of the PAMDOC.

SECTION 2.0 - PROCEDURE (Refer to Notes 9, 10, 11 attached)

2.1 PROCEDURE

In a simple performance assessment, this could consist of a procedure which simply references documented modules as defined in Section 3.0 onwards of this proforma. It is important to note that this procedure may reference modules from more than one existing PAMDOC.

For example to illustrate this [PAMDOC 3] may be built up of modules drawn from [PAMDOC 1] and [PAMDOC 2]. This is shown in the example below.

2.1.1 Define information Required

EXAMPLE
As set out in Section 3 [PAMDOC 1]

2.1.2 Configure Program

EXAMPLE
Select program version set out in Section 4.1 [PAMDOC 1]
Select program Sub Models as set out in Section 4.2 [PAMDOC 1]
Select computational parameters as set out in Section 4.3 [PAMDOC 1]
Set initial conditions as set out in Section 4.4 [PAMDOC 1]

2.1.3 Describe site and climate

EXAMPLE
Describe site as set out in Section 5.1 [PAMDOC 1]
Describe climate as set out in Section 5.2 [PAMDOC 1]

2.1.4 Describe zoning procedure to Program

EXAMPLE
As set out in Section 6 [PAMDOC 1]

2.1.5 Describe building to Program

EXAMPLE
As set out in Section 7 [PAMDOC 1]

2.1.6 Describe building operation to Program

EXAMPLE
As set out in Section 8 [PAMDOC 1]

2.1.7 Describe ventilation process

EXAMPLE
As set out in Section 8 [PAMDOC 2]

2.1.8 Describe Plant to Program

EXAMPLE
As set out in Section 9 [PAMDOC 2]

2.1.9 Describe Plant operation to Program

EXAMPLE

See Section 10

2.1.10 Process output data

EXAMPLE

See Section 3

2.1.11 Interpret information

EXAMPLE

See Section 3

2.1.12 Quality Assurance

Quality assurance checks where relevant should be built into the procedure. However, where possible checks should ideally be built into each information section, rather than the procedure, to ensure their widest use.

NOTE : COMPLEX PERFORMANCE ASSESSMENT METHODS

A more complex Performance Assessment could well make reference to a series of defined documented Performance Assessment Methods [PAMDOCS].

EXAMPLE

(1) Carry out Energy Audit of existing building using PAMDOC 3.

(2) Evaluate energy efficiency measure as defined in PAMDOC 7.

(3) Carry out Energy Audit of proposal using PAMDOC 1.

(4) Compare improvement using PAMDOC 10.

SECTION 3.0 - INFORMATION DEFINITION

3.1 INFORMATION REQUIRED FROM THE PERFORMANCE ASSESSMENT

3.1.1 Description

General description of information required.

3.1.2 Results required

For example: Annual energy use, Resultant temperature, etc. Results may be direct programme output, post processed output or a mixture of each.

Provide for each:

Name
Symbol
Units
Definition

3.1.3 Rules for Assignment of Values(rules of assignment/measurement)

May cover, for example

How individual rooms or zones are selected for assessment
Rules for generation of Parameters
How particular values are assigned.

May be complex

if (condition)
then (assign)
else
if
then, etc.

3.1.4 Rationale

Or why 3.1.3 is done this way.

3.1.5 Reference

To source(s) of information, where appropriate, listing source documents.

3.1.6 Quality Assurance

Quality Assurance checks to be carried out.

3.1.7 Further Information

3.2 POST PROCESSING OF OUTPUT

Information provision here is seen as being the identification of the relevant program outputs, post processing requirements and the form of presentation to meet the requirements set down in Section 3.1.

3.2.1 Description

A general description, where it is considered to be appropriate.

3.2.2 Program outputs

A list of outputs, provide for each:

Name
Symbol
Units
Definition

3.2.3 Process Outputs

Rules (equations?) for linking program outputs to individual results required (3.1.2).

3.2.4 Rationale

Or why it is done this way.

3.2.5 Reference

To source(s) of information, where appropriate listing source documentation.

3.2.6 Quality Assurance

Quality Assurance checks to be carried out.

3.2.7 Further Information

3.3 FORM OF PRESENTATION

3.3.1 Description

e.g. Tables, graphs, etc.

3.3.2 Presentation

e.g. If tabular, the names, etc. of rows and columns.
If graphical, the names, etc. of axes.

Name
Symbol
Units
Definition

3.3.3 Rules for Assignment of Values

e.g. Rules governing range of axes, major and minor intervals, etc.

3.3.4 Rationale

Or why is it done this way.

3.3.5 Reference

To source(s) of information, where appropriate, listing source documents.

3.3.6 Quality Assurance

Quality Assurance checks to be carried out.

3.3.7 Further Information

3.4 INFORMATION INTERPRETATION

How the meaning of the results is determined.

3.4.1 Description

Description of interpretation method, e.g. comparison with 'standard' values, field trial results, etc.

3.4.2 Interpretation

How are the results interpreted? What are they judged against? For example, for a PAM dealing with overheating, results may be compared with a selected temperature which is not exceeded for more than a given length of time in any one day.

3.4.3 Rules for Assignment of Values

The rules for determining the interpretation criteria.

EXAMPLE

A zone is said to overheat if its temperature exceeds 27°C for more than half an hour in a day.

3.4.4 Rationale

Or why it is done this way.

3.4.5 Reference

To source(s) of information, where appropriate listing source documentation.

3.4.6 Quality Assurance

Quality Assurance checks to be carried out.

3.4.7 Further Information

SECTION 4.0 - PROGRAM CONFIGURATION

4.1 PROGRAM VERSION

4.1.1 Title
Program title or acronym.

4.1.2 Program Author
Original author.

4.1.3 Vendor
Supplier of program.

4.1.4 Version Number
The version of the program used for this Performance Assessment Method.

4.1.5 Date of Release
Of this version of the program.

4.1.6 Quality Assurance
Quality Assurance checks to be carried out.

4.1.7 Further Information

4.2 USER SUB MODEL SELECTION
The selection of the method available within the program to treat particular processes or to determine particular values. All such user options must be covered.

4.2.1 Sub Model 1

4.2.1.1 Description

General description where this is considered to be apropriate.

4.2.1.2 Sub Model: Name

Definition

4.2.1.3 Select Sub Model Method

Rules for selection of Model Method

4.2.1.4 Rationale

Behind selection (why it is done this way)

4.2.1.5 Reference

To sources for rules/rationale.

4.2.1.6 Quality Assurance

4.2.1.7 Further Information

4.2.2 Sub Model 2

4.2.2.1 Description

General description where this is considered to be appropriate.

4.2.2.2 Sub Model: Name

Definition.

4.2.2.3 Select Sub Model Method

Rules for selection of Model Method.

4.2.2.4 Rationale

Behind selection.

4.2.2.5 Reference

To sources for rules/rationale.

4.2.2.6 Quality Assurance

4.2.2.7 Further Information

4.2.3 Sub Model 3

etc.

4.3 USER SELECTED COMPUTATIONAL PARAMETERS

The setting of any parameter (e.g. time step) which is internal to the workings of the Program. All computational parameters which can be set by the user must be covered.

4.3.1 Computational Parameter 1.

4.3.1.1 Description

4.3.1.2 Computational Parameter Definition List

Name)
Symbol) for each parameter
Units)
Definition)

4.3.1.3 Rules for Assignment of Values

Rules for assigning values of all parameters in parameter list.
"IF" (Condition) "THEN" (Action) "ELSE" ....

4.3.1.4 Rationale

Reasoning behind Assign Value rules.

4.3.1.5 Reference

Source of rules.

4.3.1.6 Quality Assurance

4.3.1.7 Further Information

4.3.2 Computational Parameter 2

4.3.2.1 Description

4.3.2.2 Parameter Definition List

Name	)
Symbol	) for each parameter
Units	)
Definition	)

4.3.2.3 Rules for Assignment of Values

Rules for assigning values of all parameters in parameter list.
"IF" (Condition) "THEN" (Action) "ELSE" ...

4.3.2.4 Rationale

Reasoning behind Assign Value rules.

4.3.2.5 Reference

Source of rules.

4.3.2.6 Quality Assurance

4.3.2.7 Further Information

4.3.3 Computational Parameter 3

etc.

4.4 USER SELECTED INITIAL CONDITIONS

The setting of any parameters, construction temperatures, pre- conditioning period, etc. All aspects must be covered.

4.4.1 Initial Conditions 1

4.4.1.1 Description

4.4.1.2 Parameter Definition List

Name)
Symbol) for each parameter
Units)
Definition)

4.4.1.3 Rules for Assignment of Values

Rules for assigning values of all parameters in parameter list. "IF" (Condition) "THEN" (Action) "ELSE" .....

4.4.1.4 Rationale

Reasoning behind Assign Value rules.

4.4.1.5 Reference

Source of rules.

4.4.1.6 Quality Assurance

4.4.1.7 Further Information

4.4.2 Initial Conditions 2

4.4.2.1 Description

4.4.2.2 Parameter Definition List

Name)
Symbol) for each parameter
Units)
Definition)

4.4.2.3 Rules for Assignment of Values

Rules for assigning values of all parameters in parameter list. "IF" (Condition) "THEN" (Action) "ELSE" .....

4.4.2.4 Rationale

Reasoning behind Assign Value rules.

4.4.2.5 Reference

Source of rules.

4.4.2.6 Quality Assurance

4.4.2.7 Further Information

4.4.3 Initial Conditions 3

etc.

SECTION 5 - CONTEXT DESCRIPTION

5.1 SITE DESCRIPTION

The parameters which must be specified in order to characterise the site. Each section should deal with parameter(s) values and how they should be specified.

5.1.1 Location

5.1.1.1 Description

How is site described?
e.g. Latitude and Longitude,
Altitude,
Degree day region, etc.

5.1.1.2 Parameter Definition List

Name)
Symbol) for each parameter
Units)
Definition)

5.1.1.3 Rules for Assignment of Values

5.1.1.4 Rationale

5.1.1.5 Reference

5.1.1.6 Quality Assurance

5.1.1.7 Further Information

5.1.2 Site Exposure

5.1.2.1 Description

How is exposure of site described?

5.1.2.2 Parameter Definition List

Name)
Symbol) for each parameter
Units)
Definition)

5.1.2.3 Rules for Assignment of Values

5.1.2.4 Rationale

5.1.2.5 Reference

5.1.2.6 Quality Assurance

5.1.2.7 Further Information

5.1.3 Ground Reflectivity

5.1.3.1 Description

5.1.3.2 Parameter Definition List

Name	)	
Symbol	)	for each parameter
Units	)	
Definition	)	

5.1.3.3 Rules for Assignment of Values

5.1.3.4 Rationale

5.1.3.5 Reference

5.1.3.6 Quality Assurance

5.1.3.7 Further Information

5.1.4 Ground Temperature

5.1.4.1 Description

5.1.4.2 Parameter Definition List

Name	)	
Symbol	)	for each parameter
Units	)	
Definition	)	

5.1.4.3 Rules for Assignment of Values

5.1.4.4 Rationale

5.1.4.5 Reference

5.1.4.6 Quality Assurance

5.1.4.7 Further Information

5.1.5 External Site Shading

5.1.5.1 Description

5.1.5.2 Parameter Definition List

Name)
Symbol) for each parameter
Units)
Definition)

5.1.5.3 Rules for Assignment of Values

5.1.5.4 Rationale

5.1.5.5 Reference

5.1.5.6 Quality Assurance

5.1.5.7 Further Information

5.2 CLIMATE DESCRIPTION

Sections should describe the climate data required to carry out the performance assessment.

5.2.1 Description

A general description is required of the nature of the climate data required.

EXAMPLE

A year's data representative of long-term conditions,

OR 14 days data having the highest mean air temperature over a specified period.

5.2.2 Climatic Variables List

A list of all variables, provide for each:

Name
Symbol
Units
Definition

5.2.3 Rules for Assignment of Values

Reference to the specific data sets available and/or Rules to be used to generate the weather data to meet the data requirements.

5.2.4 Rationale

Behind selection of data.

5.2.5 Reference

To source(s) of information, where appropriate listing source documents.

5.2.6 Quality Assurance

5.2.7 Further Information

SECTION 6.0 - ZONING

6.1 ZONE DESCRIPTION

A description of the rules (strategy) used for describing zones (for this building type, application. It should also cover both modelled and, where applicable, the treatment of adjacent but unmodelled zones, e.g. adjacent houses in a terrace.

6.1.1 Modelled Zones

6.1.1.1 Description

6.1.1.2 Parameter Definition List

Name: EXAMPLE: Modelled Zone
Symbol: EXAMPLE: Zi
Definition: EXAMPLE: A Zone which is explicitly modelled

6.1.1.3 Define Zone

The rules for zoning:
IF [Condition] THEN [Assign] ELSE

EXAMPLE:
IF [Space has a defined physical boundary
and NOT an ensuite bathroom]
THEN [Space = Zone]
ELSE
IF [Space is ensuite bathroom]
THEN [Zone = Ensuite + Adjacent bedroom]

6.1.1.4 Rationale

Behind Rules.

6.1.1.5 Reference

6.1.1.6 Quality Assurance

6.1.1.7 Further Information

6.1.2 Adjacent Unmodelled Zones

6.1.2.1 Description

EXAMPLE:
Adjacent unmodelled zones are treated by assigning a surface temperature dividing building element in the unmodelled zone.

6.1.2.2 Parameter Definition List

Parameter
Symbol
Units
Definition

6.1.2.3 Assign Value

EXAMPLE

Surface temperature of dividing element in unmodelled zone set to that of the modelled zone.

6.1.2.4 Rationale

EXAMPLE

No net heat flow through wall.

6.1.2.5 Reference

EXAMPLE

Practice adopted by Newcastle University.

6.1.2.6 Quality Assurance

6.1.2.7 Further Information

6.2 INTERZONAL COUPLING

A description of the strategies used for specifying interzonal coupling between modelled zones. Where appropriate there should be sections to cover conduction, air flow, longwave radiation, shortwave radiation.

6.2.1 Inter Zonal Coupling : Airflow

6.2.1.1 Description

6.2.1.2 Parameter Definition List

Parameter
Symbol
Units
Definition

6.2.1.3 Rules for Assignment of Values

6.2.1.4 Rationale

6.2.1.5 Reference

6.2.1.6 Quality Assurance

6.2.1.7 Further Information

6.2.2 Inter Zonal Coupling : Shortwave

6.2.2.1 Description

6.2.2.2 Parameter Definition List

Parameter
Symbol
Units
Definition

6.2.2.3 Rules for Assignment of Values

6.2.2.4 Rationale

6.2.2.5 Reference

6.2.2.6 Quality Assurance

6.2.2.7 Further Information

SECTION 7.0 - BUILDING DESCRIPTION

The rules used to generate the input data set from the drawings and specification of the building.

7.1 GEOMETRY

How the geometry of the building is described.

7.1.1 Description

e.g. By connecting previously defined zones
OR By using cartesian coordinates
OR By defining elements and orientations.

Also how measurements from drawings are taken
e.g from wall mid points or from internal surfaces etc.

7.1.2 Parameter Definition List

7.1.3 Rules for Assignment of Values

7.1.4 Rationale

7.1.5 Reference

7.1.6 Quality Assurance

7.1.7 Further Information

7.2 SHADING DEVICES (EXTERNAL)

If the wall construction surrounding the window provides an obstruction it may be described here and should be cross referenced with the window Section 7.8

7.2.1 Shading Device 1.

7.2.1.1 Description

7.2.1.2 Parameter Definition List

7.2.1.3 Rules for Assignment of Values

7.2.1.4 Rationale

7.2.1.5 Reference

7.2.1.6 Quality Assurance

7.2.1.7 Further Information

7.2.2 Shading Device 2.

7.2.2.1 Description

7.2.2.2 Parameter Definition List

7.2.2.3 Rules for Assignment of Values

7.2.2.4Rationale

7.2.2.5 Reference

7.2.2.6Quality Assurance

7.2.2.7Further Information

7.3 SHADING DEVICES (INTERNAL)

[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.4 CONSTRUCTION (EXTERNAL ELEMENTS)

7.4.1 Walls

If window frames are treated as walls they may be described here and cross referenced to Section 7.8.

7.4.1.1 Description

7.4.1.2 Parameter Definition List

7.4.1.3 Rules for Assignment of Values

7.4.1.4 Rationale

7.4.1.5 Reference

7.4.1.6 Quality Assurance

7.4.1.7 Further Information

7.4.2 Floors (May include carpets, see 7.4.3)

7.4.2.1 Description

7.4.2.2 Parameter Definition List

7.4.2.3 Rules for Assignment of Values

7.4.2.4 Rationale

7.4.2.5 Reference

7.4.2.6 Quality Assurance

7.4.2.7 Further Information

7.4.3 Carpets (If not part of floor)

7.4.4 Roof (May include ceiling if appropriate)

7.4.4.1 Description

7.4.4.2 Parameter Definition List

7.4.4.3 Rules for Assignment of Values

7.4.4.4 Rationale

7.4.4.5 Reference

7.4.4.6 Quality Assurance

7.4.4.7 Further Information

7.5 SURFACE PROPERTIES (EXTERNAL ELEMENTS)

7.5.1 Solar Absorbtivity
[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.5.2 Longwave Emissivity
[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.6 CONSTRUCTION (INTERNAL ELEMENTS)

7.6.1 Walls
[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.6.2 Floor (May include carpets, see 7.6.5.)
[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.6.3 Ceiling (As part of Floor above)

[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.6.4 Ceiling (Suspended, with zone above)

[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.6.5 Carpets (If not part of floor)

[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.6.6 Furniture

[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.6.7 Curtains (If not part of window properties or internal shading devices, 7.3 and 7.8)

[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.7 SURFACE PROPERTIES (INTERNAL ELEMENTS)

[Sub Paragraphs as 7.5]

7.8 WINDOW PROPERTIES

As well as physical properties provide a description of how the window is described to the program.

e.g is the frame treated separately?
are combined frame and glazing U values used?.
Cross refer to sections 7.2 and 7.4.1 if appropriate.

7.8.1 Vertical glazing

[Sub Paragraphs for Description, Parameter Definition List, etc.]

7.8.2 Horizontal glazing

[Sub Paragraphs for Description, Parameter Definition List, etc.]

SECTION 8.0 - BUILDING OPERATION DESCRIPTION

8.1 VENTILATION

The air flow description is seen as covering 2 mechanisms: adventitious ventilation (infiltration) and occupant/user defined ventilation. The latter is further broken down to cover air quality control and temperature control which may be different in terms of quantity and time schedule. The treatment may be conditioned by the Program Sub Model selected in Section 4.2. Each section should deal with the definition of the parameters to be set and the rules or conventions for selecting appropriate values for each parameter. This may apply to the whole building or to individual zones. Different Programs may use their own terminology for describing ventilation used for different purposes. Any such terms should be explained under the appropriate headings.

8.1.1 Adventitious

Air flow through the structure with closed doors and windows under influence of wind and buoyancy.
If interpretation of adventitious airflow is different from this, it should be made clear in the description.
Should refer back to any sub-models used.
Any terminology used in particular programs should be explained here.

8.1.1.1 Description:

8.1.1.2 Parameter Definition List:

8.1.1.3 Rules for Assignment of Values

8.1.1.4 Rationale

8.1.1.5 Reference

8.1.1.6 Quality Assurance

8.1.1.7 Further Information

8.1.2 Occupant Defined for Air Quality Control

Ventilation provided either naturally through window or other opening or by mechanical means.
Should refer back to any sub-models used.
Any terminology used in particular programs should be explained here.

8.1.2.1 Description

8.1.2.2 Parameter Definition List

8.1.2.3 Rules for Assignment of Values

8.1.2.4 Rationale

8.1.2.5 Reference

8.1.2.6 Quality Assurance

8.1.2.7 Further Information

8.1.3 Occupant Defined for Air Temperature Control

Ventilation provided either naturally through window or other opening or by mechanical means.
Should refer back to any sub-models used.
Any terminology used in particular programs should be explained here.

8.1.3.1 Description

8.1.3.2 Parameter Definition List

8.1.3.3 Rules for Assignment of Values

8.1.3.4 Rationale

8.1.3.5 Reference

8.1.3.6 Quality Assurance

8.1.3.7 Further Information

8.1.4 Ventilation Time Schedules

Should cover all ventilation types described in 8.1.1, 8.1.2 and 8.1.3 as appropriate.

8.1.4.1 Description

8.1.4.2 Parameter Definition List

8.1.4.3 Rules for Assignment of Values

8.1.4.4 Rationale

8.1.4.5 Reference

8.1.4.6 Quality Assurance

8.1.4.7 Further Information

8.2 ENVIRONMENTAL CONTROL (space conditions)

For each zone(s) give guidance on the internal environmental parameters and time schedules for which the space is to be controlled, e.g. Temperature set points, dead bands, humidity, etc. Primary sources (e.g. reference to National codes, etc.) should be specified where appropriate.

8.2.1 Parameters

8.2.1.1 Description

8.2.1.2 Parameter Definition List

Name
Symbol
Units
Definition

8.2.1.3 Rules for Assignment of Values

Rules for selection and conditions under which values may change, e.g. "IF" (Condition) "THEN" (Assign) "ELSE".

8.2.1.4 Rationale

8.2.1.5 Reference

8.2.1.6 Quality Assurance

8.2.1.7 Further Information

8.2.2 Time Schedules

8.2.2.1 Description

8.2.2.2 Parameter Definition List

Name
Symbol
Units
Definition

8.2.2.3 Rules for Assignment of Values

Rules for selection and conditions under which values may change, e.g. "IF" (Condition) "THEN" (Assign) "ELSE"

8.2.2.4 Rationale

8.2.2.5 Reference

8.2.2.6 Quality Assurance

8.2.2.7 Further Information

8.3 OCCUPANCY

This section defines the heat gains due to occupancy for each zone and should take into account sensible and latent gains, as a function of sex, activity, etc. allocated to zones and the appropriate occupation period information.

8.3.1 Heat Gain

8.3.1.1 Description

Description of sensible and latent gains as appropriate.

8.3.1.2 Parameter Definition List

8.3.1.3 Rules for Assignment of Values

8.3.1.4 Rationale

8.3.1.5 Reference

8.3.1.6 Quality Assurance

8.3.1.7 Further Information

8.3.2 Occupancy Profile

8.3.2.1 Description

Allocation of occupants and occupancy schedule to zones.

8.3.2.2 Parameter Definition List (Table of people)

8.3.2.3 Rules for Assignment of Values

8.3.2.4 Rationale

8.3.2.5 Reference

8.3.2.6 Quality Assurance

8.3.2.7 Further Information

8.4 EQUIPMENT

This section defines the heat gains due to all equipment for each zone, e.g. lighting, computers, etc. Both sensible and latent gains are taken into account as appropriate.

8.4.1 Heat Gain

8.4.1.1 Description

Determination of sensible and latent gains as appropriate.

8.4.1.2 Parameter Definition List

8.4.1.3 Rules for Assignment of Values

8.4.1.4 Rationale

8.4.1.5 Reference

8.4.1.6 Quality Assurance

8.4.1.7 Further Information

8.4.2 Equipment Gain Profile

8.4.2.1 Description

Allocation of equipment and operation schedule to each zone.

8.4.2.2 Parameter Definition List

8.4.2.3 Rules for Assignment of Values

8.4.2.4 Rationale

8.4.2.5 Reference

8.4.2.7 Further Information

8.5 USER OPERATED BUILDING CONTROLS

e.g. Movable solar shading devices.

8.5.1 Parameters

8.5.1.1 Description

8.5.1.2 Parameter Definition List

8.5.1.3 Rules for Assignment of Values

8.5.1.4 Rationale

8.5.1.5 Reference

8.5.1.6 Quality Assurance

8.5.1.7 Further Information

8.5.2 Time Schedules

8.5.2.1 Description

8.5.2.2 Parameter Definition List

8.5.2.3 Rules for Assignment of Values

8.5.2.4 Rationale

8.5.2.5 Reference

8.5.2.6 Quality Assurance

8.5.2.7 Further Information

Part C

Example Pamdoc

This example is to demonstrate how the Shell is used. It is a fictitious example based on a fictitious program and bears no resemblance to reality.
Its only function is to demonstrate the type of information required when using the Shell to document a performance assessment method.

SECTION 0.0 - PAM IDENTIFICATION

IDENTIFIER
NU 1023

PURPOSE
Assessment of the likelihood and extent of overheating taking place in a small office building with windows closed.
Ref Section 1.1

APPLICATION
Small commercial office buildings

PROGRAM
G-Wizz 1

DATE
April 1st 1992

AUTHOR
Professor S Claus

ADDRESS
Fun University
Play City
Toyland
Tel. 1234
Fax 12345

SECTION 1.0 - DEFINITION OF PERFORMANCE ASSESSMENT

1.1 PURPOSE

1.1.1 Purpose

To identify the room in which the maximum summertime temperature occurs in a small office building with windows closed.so that the severity of overheating may be assessed.

NB The purpose breaks down into three separate issues:

1) Identification of 'worst' room.
2) Determination of internal environmental conditions.
3) Assessment of severity of overheating .

1.2 APPLICABILITY

1.2.1 Building Type

Non residential:-
Commercial
Health and Welfare

1.2.2 Environmental Control System

Heating:-
- Passive solar
- Active heating

Ventilation:-
- Natural

1.2.3 Climatic Zone

Cold (see further information1.2.6)

1.2.4 Program

G-Wizz version Arctic 1

1.2.5 Resources

Commodore 64
Atari

1.2.6 Further Information

1) This PAMDOC is only for use in very cold climates since the program cannot handle temperatures above 0^{o}C
2) The program is suitable for initial design purposes and may be used to test compliance with Part Z of the Toyland Building Regulations.
3) Computers require joystick control.
4) The program can only handle one zone at a time and is therefore only suitable for buildings with a small number of zones so as to avoid a large number of runs with consequent extensive use of time

5) The program is only equipped to handle a fixed user specified infiltration rate.

SECTION 2.0 - PROCEDURE

2.1 PROCEDURE

The following procedure outlines the steps necessary to carry out the performance assessment and indicates the sections of this PAMDOC where detailed information may be found.The appendix to this document presents the input data tables in the order normally required by the program which have been cross referenced to the appropriate sections in this PAMDOC.

2.1.1 Define Information Required

All as set out in section 3.1

2.1.2 Configure Program

Select program version as set out in section 4.1
Select sub models as set out in section 4.2
Select computational parameters as set out in section4.3
Set initial conditions as set out in section 4.4

2.1.3 Describe site and climate to program.

Site description requirements are set out in section 5.1
Climate description requirements are set out in section 5.2

2.1.4 Describe zoning procedure to Program

As set out in section 6

2.1.5 Describe building to Program

As set out in section 7

2.1.6Describe building operation to Program

As set out in section 8

2.1.7Describe ventilation process

As set out in section 8

2.1.8 Process output data

As set out in section 3

2.1.9 Interpret information

As set out in section 3

2.1.10 Quality Assurance

All quality assurance procedures are detailed in the appropriate sections.

SECTION 3.0 - INFORMATION DEFINITION

3.1 INFORMATION REQUIRED FROM THE PERFORMANCE ASSESSMENT

3.1.1 Description

The maximum temperature likely to be reached in a single office module of the building needs to be determined.The particular module assessed should represent the worst case and the month and time of day that the max temperature occurs is also required.

3.1.2 Results required

(1) Identification of zone most likely to overheat.

(2) Name:- Zone temperature
Symbol:- Tz
Units:-degC
Definition The mean of air and surface temperatures.

(3) Name:- Worst Month
Symbol:- Mmax
Units:-N/A
Definition:-The month when the max temperature is most likely to occur

(4) Name:- Worst Hour
Symbol:- Hmax
Units:-N/A
Definition:-The time of day when the maximum temperature occurs.

3.1.3 Rules of Assignment (Determination of parameters and values used)

(1) Selection of worst zone for assessment/determination of worst zone.
a) If the number of zones in the building is less than 4 then carry out assessments for all zones.
b) If number of zones greater than 4 carry out assessments on:
S facing zone with largest glazing area on intermediate floor
and W facing zone with largest glazing area on intermediate floor
Repeat above for top floor giving 4 cases in all.
c) If glazed areas of all zones the same then proceed as in b) above but select the zones having the greatest incidental gains per m^2.

(2) N/A - Determined by program.
(3) Three cases to be run for Mmax= July , August and September
(4) N/A - Determined by program.

3.1.4 Rationale

The only foolproof way of selecting the worst zone is to carry out the assessment for all zones. It has been found however that the worst zone is usually oriented within

the SE-SW quadrant and is that zone with the greatest window area.If however a zone exists within the above quadrant having a smaller window area but with a higher incidental heat gain then this zone should also be assessed.
Previous studies have determined that Jly, Aug and Sept are the months when the maximum temperature is most likely to occur.

3.1.5 Reference

'Occurrence of High Temperatures in Buildings',BRE Digest, Toy 1, 1872.,Issue 47.

3.1.6 Quality Assurance

Check that latest issue of above reference is available.

3.1.7 Further Information

None

3.2 POST PROCESSING OF OUTPUT

3.2.1 Description

The program outputs are not in the form required and some post processing is necessary to make them compatible .For each month output is in the form of a table of air and mean surface temperatures (degF) for each minute measured from the beginning of the month. These values must be processed to determine Tz.

3.2.2 Program outputs

(1) Name:- Air temperature
Symbol:- Ta
Units:-degF
Definition The dry bulb air temperature

(2) Name:- Surface temperature
Symbol:- Ts
Units:-degF
Definition The mean surface temperature

(2) Name:- Month
Symbol:- Mth
Units:-N/A
Definition:-The month for which the assessment is carried out.

(3) Name:- Minutes
Symbol:-M
Units:-min.
Definition:-The time in minutes measured from the beginning of the month.

3.2.3 Process Outputs

(a) For each minute of tabulated output determine the value of Tz
Tz=(((Ta+Ts)/2)-32)/1.8
(b) By inspection determine the time, M, when Tz is at its maximum value. then Hmax=M/60 to the nearest whole number.
(c) Note the values of Mth,Tz and Hmax.

3.2.4 Rationale

N/A

3.2.5 Reference

N/A

3.2.6 Quality Assurance

Check that value of Tz is <= 0degC (see1.2.6)
Check that Hmax is not a night time value.

3.2.7 Further Information

If heat gains to zone are mainly convective the max value of Tz usually occurs after the time of maximum air temperature. With mainly radiative gains the converse is true.

The conversion of air temp and surface temp to Tz is best carried out using a spreadsheet to which the program output can be downloaded.

3.3 FORM OF PRESENTATION

3.3.1 Description

Since only three values are obtained from the assessment it is not strictly necessary to define their presentation.It has been found useful however to plot the hour by hour values of Tz,Ta and Ts as this provides additional Q/A when selecting the max value as well as providing a useful overall picture of the variation of temperature with time.

3.3.2 Presentation

Graphical

X-Axis	Y-Axis
Name:-Hours	Temperature
Symbol:-H	Tz
Units:-Time	degC
Definition:-The hours 0-24 for a selected day	Zone temperature

3.3.3 Rules for Assignment of Values

X-Axis range 0 to 24 with major intervals of one hour.

Y-Axis range to accomodate minimum ambient temperature and maximum zone temperature with a major interval of 1 deg C.

3.3.4 Rationale

This form of presentation is considered to provide the appropriate information in an acceptable manner.

3.3.5 Reference

Examples of this presentation , for information, may be found in 'The Arctic House Designers Handbook'.

3.3.6 Quality Assurance

N/A

3.3.7 Further Information

The 'Plot-the-Lot ' plotting package is recommended.

3.4 INFORMATION INTERPRETATION

3.4.1 Description

The max temperature information has to be interpreted in terms of whether an overheating problem exists.

3.4.2 Interpretation

If the zone temperature exceeds a given value for more than a specified period of time then an overheating problem exists.

3.4.3 Rules for Assignment of Values

The time for which the zone temperature is greater than -1.5 deg C should not be more than 2 consecutive hours in a 24 hour period.

3.4.4 Rationale

The values adopted above agree well with subjective discomfort criteria.

3.4.5 Reference

1) 'Discomfort in the Arctic',Penguin Publications,1897.
2) 'Building Regulations',Part Z3.

3.4.6 Quality Assurance

Check that results are reasonable by carrying out a check using the charts provided in'Overheating at the Design Stage' a copy of which is available on request from BRE

3.4.7 Further Information

'Building Regulations',Part Z3.are curently being updated for 1996.

SECTION 4.0 - PROGRAM CONFIGURATION

4.1 PROGRAM VERSION

4.1.1 Title
G-Wizz 1

4.1.2 Program Author
Arctic Research Association-Greenland

4.1.3 Vendor
The Department of Arctic Studies

4.1.4 Version Number
PC Version 6

4.1.5 Date of Release
November 1990

4.1.6 Quality Assurance
Check that the simulation program, presentation packages, MET data files, etc. are correctly installed on computer.

4.1.7 Further Information
None

4.2 USER SUB MODEL SELECTION

4.2.1 Sub Model 1

4.2.1.1 Description
The program incorporates a single Sub Model which is used to determine external surface heat transfer coefficients under certain conditions..

4.2.1.2 Sub Model:
EXCOFF.

4.2.1.3 Select Sub Model Method
This sub model is used when windspeed is expected to be in excess of 90 m/s.

4.2.1.4 Rationale
Heat transfer coefficients start to increase very rapidly at windspeeds above 90m/s.

4.2.1.5 Reference

'An algorithm for predicting heat transfer coefficients at high windspeeds'- Proceedings of the Institute of Wind conference,Garston,UK 1988.Vol.3

4.2.1.6 Quality Assurance

Since windspeed is critical an independent check on site conditions is desirable.

4.2.1.7 Further Information

None

4.3 USER SELECTED COMPUTATIONAL PARAMETERS

4.3.1 Computational Parameter 1.

4.3.1.1 Description

Each opaque layer of the construction may have a user specified number of nodes at which conditions are calculated.

4.3.1.2 Computational Parameter Definition List

Name: Number of nodes
Symbol: Nodes
Units : Dimensionless.

4.3.1.3 Rules for Assignment of Values

The default value is one node per layer.
For any layer one node is used unless it is thicker than 100mm in which case two nodes are used.

4.3.1.4 Rationale

More nodes per layer produce no signicant increase in accuracy but ,on the other hand, increase the computation time.

4.3.1.5 Reference

The Node Selectors Manual ,Vol 2

4.3.1.6 Quality Assurance

Check criteria in 4.3.1.3.
Check program version being used.(see 4.3.1.7)

4.3.1.7 Further Information

The version of the program used only has one user specified computational parameter.Other versions of the same program also require the maximum number of iterations to be specified.
Other programs e.g.SERI-RES, may require as many as 10 computational parameters to be specified.

4.4 USER SELECTED INITIAL CONDITIONS

4.4.1 Initial Conditions 1

The starting temperature for all construction layers must be specified.

4.4.1.1 Description

The starting (initialisation) temperature determines the rate and stability of convergence of the computation.

4.4.1.2 Parameter Definition List

Name: Starting temperature
Symbol: ST
Units: Deg C

4.4.1.3 Rules for Assignment of Values

Always use a value of -3.8 deg C

4.4.1.4 Rationale

No other temperature has been found to work satisfactorily.

4.4.1.5 Reference

The G-Wizz user manual.

4.4.1.6 Quality Assurance

Check that the year is not 1998 (see 4.4.1.7)

4.4.1.7 Further Information

The next issue of the user manual is in preparation and is expected to be issued in 1998.
No other initial conditions need to be specified with this program .

SECTION 5.0 - CONTEXT DESCRIPTION

5.1 SITE DESCRIPTION

5.1.1 Location

5.1.1.1 Description

The site is described by its co-ordinates of Latitude,Longitude and Height above mean sea level.

5.1.1.2 Parameter Definition List

Name ;Latitude
Symbol : LAT
Units : None
DefinitionThe position North or South of the equater.

Name : Longitude
Symbol : LONG
Units : None
Definition : The position East or West of Greenwich

Name : Altitude
Symbol : ALT
Units : m
Definition : Height above mean sea level.

5.1.1.3 Rules for Assignment of Values

Latitude longitude and altitude of the nearest site for which the most representative weather data is available. Values are obtainable from the Met Office Weather Tables. Program default values are those for KEW

5.1.1.4 Rationale

Actual site weather data is not always available.

5.1.1.5 Reference

Met Office Weather Tables

5.1.1.6 Quality Assurance

Check availability of Met Office sites with those held in program Weather Data files.

5.1.1.7 Further Information

None

5.1.2 Site Exposure

5.1.2.1 Description

The extent to which the site is exposed to blizzards.This will affect the external heat transfer coefficient

5.1.2.2 Parameter Definition List
Name: Driving Hail Index
Units : Dimensionless

5.1.2.3 Rules for Assignment of Values
Select appropriate value for site from Met Office Map of Driving Hail Indices

5.1.2.4.Rationale
Met Office Map of Driving Hail Indices is the most comprehensive and accurate source.

5.1.2.5 Reference
See 5.1.2.4 above

5.1.2.6 Quality Assurance
Check that value for DHI is between 0 and 10 which is the normal range.

5.1.2.7 Further Information
None.

5.1.3 Ground Reflectivity

5.1.3.1 Description
The fraction of the short wave radiation incident on the ground that is reflected onto the building.

5.1.3.2 Parameter Definition List
Name : Ground Reflectivity
Units : None

5.1.3.3 Rules for Assignment of Values
A standard value of 0.2 is used for all situations

5.1.3.4 Rationale
The effect of different values has been found to be marginal.

5.1.3.5 Reference
G-Wizz user manual.

5.1.3.6 Quality Assurance
N/A

5.1.3.7 Further Information
An investigation into the effect of Ground Reflectivity is being carried out at the University of Eskdalemuir by Professor Scheepswuhl.

5.1.4 Ground Temperature
There is no facility in G-Wizz for selecting the ground temperature.

5.1.4.1 Description
N/A

5.1.4.2 Parameter Definition List
N/A

5.1.4.3 Rules for Assignment of Values
N/A

5.1.4.4 Rationale
N/A

5.1.4.5 Reference
N/A

5.1.4.6 Quality Assurance
N/A

5.1.4.7 Further Information
N/A

5.1.5 External Site Shading

5.1.5.1 Description
The design may be shaded by nearby mountains or other objects.

5.1.5.2 Parameter Definition List
Distance ,L. The mean distance in metres between the design and the object providing shading.
Height , H. The mean height of the shading object above building ground floor level.

5.1.5.3 Rules for Assignment of Values
Values to be obtained from the site survey drawings to the nearest Metre.

5.1.5.4 Rationale
A more accurate assessment of values makes very little difference.

5.1.5.5 Reference
G-Wizz user manual.

5.1.5.6 Quality Assurance
Ensure that a recent site survey is available to obviate problems of Polar Drift.

5.1.5.7 Further Information

5.2 CLIMATE DESCRIPTION

5.2.1 Description

Hourly data values are required for a full year.The data should be from a real year that represents as closely as possible the average weather over the last twenty years.

5.2.2 Climatic Variables List

Direct normal : -kJ/m2-That part of the total solar radiation that strikes a horizontal surface directly at 90 deg to the surface.
Global horizontal : -kJ/m2-The total solar radiation thast strikes a horizontal surface.
Dry bulb temperature : -degC -The mean hourly dry bulb temperature of the air.
Dew point temperature :-deg C -The mean hourly dew point temperature of the air.
Wind speed. : - m/s -The mean hourly wind speed.

5.2.3 Rules for Assignment of Values

The data from the nearest weather station to the building should be used. This is selected from the range held in the G-WIZZ FILES.

5.2.4 Rationale

Actual site weather data is not always available

5.2.5 Reference

G-WIZZ manual of weather data.

5.2.6 Quality Assurance

N/A

5.2.7 Further Information

None.

SECTION 6.0 - ZONING

6.1 ZONE DESCRIPTION

It is necessary to state the rules which determine how spaces within the building are deemed to be zones for modelling purposes.and the parameters which describe them.i.e the parameters of zones which typify their thermal differences.

6.1.1 Modelled Zones

6.1.1.1 Description

Those zones for which an assessment of overheating risk is required ,that is, the zones which require to be explicitly modelled.

6.1.1.2 Parameter Definition List

The following parameters are those which need to be considered when dividing the building into zones.

1) Temperature control set points.
2) Occupation schedule,-numbers of people and times of occupation
3) Window type size and orientation.
4) Thermal capacity.
5) Size of space.
6) Zones are given an identifier Z1,Z2,Z3 etc.
7) Whether the space is the void above a ceiling.

6.1.1.3 Define Zone

Zones are designated according to the following criteria:-

1) Set points differ by more than 2degC.
2) Peak occupancy differs by more than 25% and/or time of peak by more than 30 minutes.
3) Window type size and orientation are different.
4) Thermal capacity. is judged to be 'high' or 'low'.
5) Size of space.is judged to be 'big' or 'small'.
6) Where the parameters in 6.1.1.2 are equal then spaces may be combined to form a single zone for modelling purposes.
7) In G-WIZZ the void above a ceiling is always modelled as a separate zone.

6.1.1.4 Rationale

The above criteria ensures that most factors are taken into account.

6.1.1.5 Reference

'Zoning for Beginners',HMSO. (50p)

6.1.1.6 Quality Assurance

Get head of department to check your work.

6.1.1.7 Further Information

None.

6.1.2 Adjacent Unmodelled Zones

6.1.2.1 Description

These are zones which may have been selected according to the criteria for modelled zones but which do not need to be explicitly modelled.They may however influence the thermal performance of the modelled zones.

6.1.2.2 Parameter Definition List

Zone Temperature :

6.1.2.3 Assign Value

Zone temperature to be the same as for the modelled zone.

6.1.2.4 Rationale

No heat flow across the boundary with the modelled zone.

6.1.2.5 Reference

See 6.1.1.5 above.

6.1.2.6 Quality Assurance

As 6.1.1.6

6.1.2.7 Further Information

None.

6.2 INTERZONAL COUPLING

6.2.1 Inter Zonal Coupling : Airflow

6.2.1.1 Description

The airflow which takes place between zones

6.2.1.2 Parameter Definition List

Name :- Vx-Vy
Units : - air changes per hour.
Where x and y are the zone numbers from and to which the air is moving respectively.

6.2.1.3 Rules for Assignment of Values

Assign value if known.
Program default value is 0.25.

6.2.1.4 Rationale

Judged to be a reasonable value.

6.2.1.5 Reference

G-WIZZ manual.

6.2.1.6 Quality Assurance
N/A

6.2.1.7 Further Information
None

6.2.2 Inter Zonal Coupling : Shortwave

6.2.2.1 Description
If there is an opening between zones some radiation transfer will take place.

6.2.2.2 Parameter Definition List
Area of opening m2
Energy transfer per m2 of window.Ew

6.2.2.3 Rules for Assignment of Values.
Use program default value for Ew. (2 W/m2)

6.2.2.4 Rationale
Found to be a suitable value

6.2.2.5 Reference
G-WIZZ manual

6.2.2.6 Quality Assurance
N/A

6.2.2.7 Further Information
None.

SECTION 7.0 - BUILDING DESCRIPTION

7.1 GEOMETRY

7.1.1 Description

The building is described in terms of the dimensions of the individual zones.i.e the length width and height of all walls, windows, floors,ceilings.Surfaces have to be defined as internal or external and their orientations specified.

7.1.2 Parameter Definition List

Name :-Length
Symbol :-L
Description :-Measured normal to external wall
Units :-m
Name :-Width
Symbol :-W
Description :-Measured parallel to external wall
Units :-m
Name :-Height
Symbol :-H
Description :-Measured from finished floor level to ceiling underside.
Units :-m
Name :-Orientation
Symbol :-O
Description :-Measured clockwise from North.
Units :-degrees.

7.1.3 Rules for Assignment of Values

Values are normally measured from drawings the measurements being taken from the mid-point of the wall thickness.(internal and external)

7.1.4 Rationale

This is the most consistent measurement since wall thickness does not have to be taken into account.

7.1.5 Reference

G-WIZZ manual.

7.1.6 Quality Assurance

Double check all measurements
Ensure that drawing scale is not smaller than 1/20

7.1.7 Further Information

The method of measurement described inevitably leads to errors in zone volumes.but these can usually be ignored.

7.2 SHADING DEVICES (EXTERNAL)

The program can only deal with one type of external shading device

7.2.1 Shading Device 1.

Overhangs.

7.2.1.1 Description

Overhangs are defined as being horizontal projections from the external surface of the building.

7.2.1.2 Parameter Definition List

Distance D(m) .The vertical dimension from the top of the surface being shaded to the underside of the shading device.

Projection J(m) The distance projected normal to the surface being shaded.

7.2.1.3 Rules for Assignment of Values

Measured from drawings.

7.2.1.4 Rationale

None

7.2.1.5 Reference

G-WIZZ manual.

7.2.1.6 Quality Assurance

As 7.1.6

7.2.1.7 Further Information

None.

7.3 SHADING DEVICES (INTERNAL)

The program can only deal with one type of internal shading device

7.3.1 Shading Device 1.

Curtains and blinds

7.3.1.1 Description

Internally positioned devices which control direct solar radiation and may also add thermal resistance.

7.3.1.2 Parameter Definition List

Name:-Shading coefficient
Symbol:-SHADCO
Units:-Dimensionless
Definition:-The fractional reduction in glazing transmission

Name:-Transmittance coefficient
Symbol:-U

Units:-W/m2K
Definition:-The total heat transfer rate through the glazing system (air to air)

7.3.1.3 Rules for Assignment of Values

All from tabulated values in 'ARCSPEC' data sheets ,Issue 3 , 1992

7.3.1.4 Rationale

These are the only recommended values.

7 3.1.5 Reference

G-WIZZ manual.

7.3.1.6 Quality Assurance

Check values for SHADCO lie between 0 and 1
Check values for U lie between 1.3 and 6.0
Check that night and day values are different

7.3.1.7 Further Information

None.

7.4 CONSTRUCTION (EXTERNAL ELEMENTS)

7.4.1 Walls

7.4.1.1 Description

Walls are described to the model in terms of the thickness and physical properties of each of the layers.

7.4.1.2 Parameter Definition List

For each layer:-
Thickness (m)
Density (kg/m3)
Specific heat (J/kgK)
Conductivity (W/mK)
Number of nodes in each layer. (see 4.3.1.3 for info on nodes)

7.4.1.3 Rules for Assignment of Values

All material properties from tabulated values in 'ARCSPEC' data sheets ,Issue 3 , 1992 Only if data is not available should it be obtained from manufacturers.
Thickness and layers from specification preferred.

7.4.1.4 Rationale

The use of ARCSPEC ensures consistency.

7.4.1.5 Reference

G-WIZZ manual.

7.4.1.6 Quality Assurance

Always use wall specification if possible to avoid measurement errors.

7.4.1.7 Further Information

None.

7.4.2 Floors (May include carpets, see 7.4.3)

All as 7.4.1 above. If full carpet information is not available the approach in 7.4.3. may be used.

7.4.3 Carpets (If not part of floor)

7.4.3.1 Description

An additional furnishing layer applied on top of the floor construction.

7.4.3.2 Parameter Definition List

Name :-Thermal resistance.
Symbol:-TRes.
Units:-Km2/W
Definition:-Reciprocal of transmittance.

7.4.3.3 Rules for Assignment of Values

TRes is 20 for thin carpets and 40 for thick carpets.

7.4.3.4 Rationale

The numbers seem to work.

7.4.3.5 Reference

`None

7.4.3.6 Quality Assurance

None

7.4.3.7 Further Information

None.

7.4.4 Roof (May include ceiling if appropriate)

All as 7.4.1

7.5 SURFACE PROPERTIES (EXTERNAL ELEMENTS)

7.5.1 Solar Absorbtivity

7.5.1.1 Description

The proportion of the total solar radiation incident on a surface that is absorbed by the surface

7.5.1.2 Parameter Definition List

Name :-.SOLAB
Symbol:-a
Units:-Dimensionless
Definition:-.The proportion of the total solar radiation incident on a surface that is absorbed by the surface.

7.5.1.3 Rules for Assignment of Values

Select appropriate value from ARCSPEC.

7.5.1.4 Rationale

Best authoritative source.

7.5.1.5 Reference

G-WIZZ manual

7.5.1.6 Quality Assurance

Check that value is between 0.7 and 1.0

7.5.1.7 Further Information

None

7.5.2 Longwave Emissivity

7.5.1.1 Description
The relative ability of a surface to emit radiation.
Radiation heat transfer is not modelled explicitly by G-WIZZ.

7.5.1.2 Parameter Definition List
N/A

7.5.1.3 Rules for Assignment of Values
N/A

7.5.1.4 Rationale
Difficult to do in a simple program such as G-WIZZ

7.5.1.5 Reference
G-WIZZ manual

7.5.1.6 Quality Assurance
N/A

7.5.1.7 Further Information
None

7.6 CONSTRUCTION (INTERNAL ELEMENTS)

7.6.1 Walls
As for external elements 7.4.1

7.6.2 Floor (May include carpets, see 7.6.5.)
As for external elements 7.4.2

7.6.3 Ceiling (As part of Floor above)
As for external elements 7.4.4

7.6.4 Ceiling (Suspended, with zone above)
As for external elements 7.4.4

7.6.5 Carpets (If not part of floor)
As for external elements 7.4.3

7.6.6 Furniture

7.6.6.1 Description
Furniture is described as any non heat producing items within a zone which will add an element of thermal capacity.

7.6.6.2 Parameter Definition List

Furniture items are designated F1 , F2 , F3 etc.
For each item:-

Name :-.Mass
Symbol:-M
Units:-kg
Definition:-.See physics book

Name :-.Specific heat.
Symbol:-c
Units:-kJ/kgdegC
Definition:-.See physics book

7.6.6.3 Rules for Assignment of Values

Average values for mass and specific heat of particular items of furniture may be obtained from 'The Furniture Manufacturers Handbook of Physical Properties'
If no furniture M and c are given the values 0 and 1 respectively.for a single item (F1)

7.6.6.4 Rationale

The only reliable source.

7.6.6.5 Reference

'The Furniture Manufacturers Handbook of Physical Properties'

7.6.6.6 Quality Assurance

N/A

7.6.6.7 Further Information

None.

7.6.7 Curtains (If not part of window properties or internal shading devices, 7.3 and 7.8)

Curtains are treated as part of the window (see 7.8)

7.7 SURFACE PROPERTIES (INTERNAL ELEMENTS)

7 7.1 Solar Absorbtivity

7.7.1.1 Description

The proportion of the total solar radiation incident on a surface that is absorbed by the surface.

7.7.1.2 Parameter Definition List

Name :-.SOLABINT
Symbol:-ai
Units:-Dimensionless
Definition:-.The proportion of the total solar radiation incident on a surface that is absorbed by the surface.

7.7.1.3 Rules for Assignment of Values

For walls.ai=0.66
For windows ai=0.8
For floors ai=0.9
For ceilings ai=0.33

7.7.1.4 Rationale

Mean values derived from a variety of sources.

7.7.1.5 Reference

G-WIZZ manual

7.7.1.6 Quality Assurance

N/A

7.7.1.7 Further Information

No other surface properties are required.

7.8 WINDOW PROPERTIES

7.8.1 Window Conduction

7.8.1.1 Description

The overal thermal conductance of the complete glazing system inclusive of frame, curtains, blinds, any applied coatings.and surface resistances.

7.8.1.2 Parameter Definition List

For each window designated W1,W2, W3 etc.
Name :-.WINCON
Symbol:-Uw
Units:-w/m2K
Definition:-.The air to air transmission coefficient of the glazing system.

7.8.1.3 Rules for Assignment of Values

From tabulated values in 'ARCSPEC' data sheets ,Issue 3

7.8.1.4 Rationale

From tests carried out by The University of East Falkland.

7.8.1.5 Reference

'ARCSPEC' (Penguin)

7.8.1.6 Quality Assurance

Double check values.

7.8.1.7 Further Information

Overheating is critically dependent on window conduction.
No other thermal properties are required.

7.8 2 Refractive Index.

7.8.2.1 Description

The refractive index is not taken into account by G-WIZZ for the purpose of this performance assessment but the program will not work unless values specified.

7.8.2.2 Parameter Definition List

For each window designated W1,W2, W3 etc.
Name :-Refractive Index.
Symbol:-RI
Units:-Dimensionless.
Definition:-.See Physics book.

7.8.2.3 Rules for Assignment of Values

For this purpose any number will do.

7.8.2.4 Rationale

N/A

7.8.2.5 Reference

G-WIZZ manual.

7.8.2.6 Quality Assurance

Double check values.to ensure they are meaningless.

7.8.2.7 Further Information

Other performance assessments will require values of RI to be specified,in which case refer to appropriate PAMDOC.

SECTION 8.0 - BUILDING OPERATION DESCRIPTION.

8.1 VENTILATION

8.1.1 Adventitious

8.1.1.1 Description:

Air exchange assumed to be into the zone from outside due to natural leakage with windows and doors closed. It is assumed to take place 24h per day.

8.1.1.2 Parameter Definition List:

Name :-.Adventitious ventilation
Symbol:-VA
Units:- air changes /h
Definition:-.see 8.1.1.1 above.

8.1.1.3 Rules for Assignment of Values

Depend on value of Driving Hail Index (DHI)(see 5.1.2)

If $0<DHI<2$ then $VA = 2$
$2<DHI<6$ then $VA = 8$
$6<DHI<10$ then $VA = 12$

8.1.1.4 Rationale

From tests carried out by The University of East Falkland.

8.1.1.5 Reference

'Hail the conquering Infiltration' UEF press 25p (10p reduction for academic use.)

8.1.1.6 Quality Assurance

None

8.1.1.7 Further Information

None

8.1.2 Occupant Defined

None for this assessment.

8.1.2.1 Description

The air exchange between the zone and ambient which takes place as a result of occupant requirements/action eg opening windows ,use of mech vent.

8.1.2.2 Parameter Definition List

Name :-.Occupant defined ventilation
Symbol:-Vocc
Units:- air changes /h
Definition:-.see 8.1.2.1 above.

8.1.2.3 Rules for Assignment of Values

VOCC =Zero

8.1.2.4 Rationale

N/A

8.1.2.5 Reference

N/A

8.1.2.6 Quality Assurance

N/A

8.1.2.7 Further Information

None

8.1.3 Ventilation Time Schedules

Not applicable in this case since no user defined vent. The program does however allow ventilation rates to be separately specified for four user defined time periods in the day if required.

8.2 ENVIRONMENTAL CONTROL

8.2.1 Parameters

8.2.1.1 Description

In G-WIZZ the zone temperature can either be set to the desired value or allowed to free float

When incidental and solar gains are insufficient to maintain the set temperature the program calculates the heating energy required.When incidental and solar gains are greater than the energy required to maintain the set temperature the zone temperature is allowed to rise accordingly. G-WIZZ is incapable of calculating cooling loads. Free floating cases are computed by setting a zone temperature below the minimum expected ambient temperature.

Set points are only specified during defined HEATING ON periods.(see8.2.2)

8.2.1.2 Parameter Definition List

Name:- Zone temperature

Symbol:- Tz

Units:-degC

Definition The mean of air and surface temperatures.

8.2.1.3 Rules for Assignment of Values

For assessment of overheating the set point is normally specified as -3degC although any value may be used.

8.2.1.4 Rationale

The optimum comfort condition for the occupants.

For this climate the heating will normally be on in the morning during July ,August and September.

8.2.1.5 Reference

Penguin Preservation Society.

8.2.1.6 Quality Assurance

N/A

8.2.1.7 Further Information

None

8.2.2Time Schedules

8.2.2.1 Description

The time periods during which heating is required to be ON or OFF.
Periods are defined by specifying the times at which the heating system is required to be ON or OFF.
G-WIZZ can only handle four ON or OFF periods.

8.2.2.2 Parameter Definition List

Name:-TIMON or TIMOFF
Symbol:-Ton or Toff
Units:-hours and minutes on 24 h clock.
Definition:-N/A

8.2.2.3 Rules for Assignment of Values

Ton = 00:01 Toff = 23:59

8.2.2.4 Rationale

For over heating risk assessment the heating system is assumed to be available for 24 hours per day.

8.2.2.5 Reference

None.

8.2.2.6 Quality Assurance

Check colon used between hours and minutes.

8.2.2.7 Further Information

None.

8.3 OCCUPANCY

8.3.1 Heat Gain

8.3.1.1 Description

The component of zone heat input due to the presence of people..The heat input has both sensible and latent components.G-WIZZ deals very simply with this by assuming three levels of activity to which heat output values are automatically assigned. Occupants are assumed to be either frantically active , asleep.or dead.

8.3.1.2 Parameter Definition List

Name:-Activity level.
Symbol:-OCCLE
Units:-.Dimensionless
Definition:-See description above.

Name :-Percent People
Symbol :-PP
Units :-%
Definition :-Percent people judged to be active.

8.3.1.3 Rules for Assignment of Values

Estimate percentages of people active ,asleep and dead.
Corresponding OCCLE values are 2(active),1(asleep) or 0 (dead).

8.3.1.4 Rationale

This simple approach has been found to give results as good as more complex methods.

8.3.1.5 Reference

(1) The Heat Gain Handbook.
(2) G-WIZZ manual.

8.3.1.6 Quality Assurance

Double check percentages.

8.3.1.7 Further Information

Actual values used for metabolic heat output (W/person) may be found By contacting The Arctic Research Association.

8.3.2Occupancy Profile

8.3.2.1 Description

The variation of number of people with time for each zone.has to be provided.
G-WIZZ has an input data table for which the number of people in the zone must be provided for each hour of the day

8.3.2.2 Parameter Definition List

For each hour :-
Name :-Number of people.
Symbol:-NP

8.3.2.3 Rules for Assignment of Values

Provide values of NP appropriate to the situation.
If values are not known G-WIZZ uses default values based on 0.25 people per m2 of floor area for the times from 09:00 to 17:00 inclusive.Other times are given the value zero.

8.3.2.4 Rationale

Typical occupation density and time.for office buildings.

8.3.2.5 Reference

(1) The Office Design Manual
(2) G-WIZZ manual.

8.3.2.6 Quality Assurance

Carefully check values as they are critical to the results.

8.3.2.7 Further Information

None.

8.4 EQUIPMENT

8.4.1 Heat Gain

8.4.1.1 Description

The heat input to the zone from electrical (or other) equipment and artificial lighting .

8.4.1.2 Parameter Definition List

Name :- Equipment Gain
Symbol :- EG.
Units :- kW/m2 of floor area.

8.4.1.3 Rules for Assignment of Values

Estimate values based on type of equipment and its mean power consumption.
If not known use 75 w/m2.

8.4.1.4 Rationale

75 w/m2 is the average figure for offices.

8.4.1.5 Reference

'Power used in offices' The Polar Electricity Authority (PEA)

8.4.1.6 Quality Assurance

Ensure that floor areas are used for lighting as they may be different from ceiling areas..

8.4.1.7 Further Information

None.

8.4.2 Equipment Gain Profile

8.4.2.1 Description

The variation of equipment heat output with time for each zone.has to be provided. G-WIZZ has an input data table for which the equipment heat output in the zone must be provided for each hour of the day

8.4.2.2 Parameter Definition List

For each hour :-
Name :-Equipment Gain..
Symbol:-EG

8.4.2.3 Rules for Assignment of Values

If not known use 75 w/m2.

8.4.2.4 Rationale

N/A

8.5 USER OPERATED BUILDING CONTROLS

8.5.1 Control type.1

8.5.1.1 Description

Automatic external sunshades.

Defined by maximum horizontal projection and width each side of window centre line.

G-WIZZ incorporates an algorithm which calculates the shading as a function of the percentage maximum sunshade projection.

8.5.1.2 Parameter Definition List

Name:-Max Projection.
Symbol:-M P
Units:-.m
Definition:-Horizontal projection

Name :-Width
Symbol :-W
Units :-m.
Definition :-Width each side of window centre line.

8.5.1.3 Rules for Assignment of Values

Dimensions from specification or drawings.

8.5.1.4 Rationale

N/A

8.5.1.5 Reference

G-WIZZ manual.

8.5.1.6 Quality Assurance

If spec. not available ensure drawings are to a large enough scale.

8.5.1.7 Further Information

None.

8.5.2 Time or other Schedules

8.5.2.1 Description

Operation of the sunshades in G-WIZZ requires that hourly values of the percentage maximum projection are provided.

8.5.2.2 Parameter Definition List

Name:-Hour
Symbol:-HP
Units:-Time
Definition:-Time of day.

Name :-Percent projection.
Symbol :-PP
Units :-%.
Definition :-.hourly values of the percentage maximum projection .

8.5.2.3 Rules for Assignment of Values

For each hour provide the percentage projection.
If values unknown the G-WIZZ default is 50% for each hour of the day.

8.5.2.4 Rationale

From observations of daily sunshade movement on a variety of buildings.

8.5.2.5 Reference

The Awning Review (issue 6, 1990)

8.5.2.6 Quality Assurance

Ensure all values between 0 and 100 %

8.5.2.7 Further Information

None.

Part D

A Glossary of Terms used in the Documentation of Performance Assessment Methods

ADVENTITIOUS VENTILATION - A mode of ventilation whereby a building exchanges air with the outside environment via cracks or other uncontrollable openings in the fabric under the influence of wind and/or buoyancy.
APPLICATION - When used in the Shell: the buildings, situations or other circumstances for which a particular PAM may be used.
ASSIGN VALUES - See Rules of Assignment
COMPUTATIONAL PARAMETER - Parameters (control settings), internal to the working of the Program, which determine the bounds of operation of a PROGRAM. These typically may determine the accuracy of computation or the time for which a program runs.
ENVIRONMENTAL CONTROL SYSTEM - Any system which controls any aspect of the internal environment of a building.
EXTERNAL SITE SHADING - The obstruction of solar radiation caused by local topography or vegetation.
INFORMATION INTERPRETATION - The translation of the program output, whether or not post processed, into an assessment of how the building performs. How the meaning of the output is determined.
INTERZONAL COUPLING - The processes which describe the energy transfer between zones.
METHOD - The description of how a PROGRAM is used for a particular APPLICATION
OCCUPANT DEFINED - Typically a mode of control of a parameter (eg ventilation) selected or influenced by the user of a building.
PAM - Performance Assessment method
PAMDOC - The document which defines a PAM
PARAMETER DEFINITION LIST - A statement of the various parameters used in the description of any particular item which needs to be considered when documenting a PAM.
PASSIVE SOLAR HEATING - The heating of a building or part thereof using solar energy with no recourse to equipment other than the normal components of the building.
POST PROCESSING OF OUTPUT - Manipulation of the output of a program which may be necessary to put it into the particular form required by the program user.
PROGRAM - Computer software which manipulates input data in a defined manner to produce a derived output. A Program may incorporate SUB - PROGRAMS.
PURPOSE - The reason why a PAM is carried out. A general statement of the particular aspect of performance to be addressed.
QUALITY ASSURANCE - A heading used in the Shell under which procedures for reducing errors, and thus increasing the validity of models and results, are described
RATIONALE - The reasoning behind the use of particular RULES OF ASSIGNMENT.
RULES OF ASSIGNMENT - See also Assign Values - The rules used to assign particular values to the parameters specified in the parameter definition list.
SHADING DEVICE - Part of a building or attachment to a building either inside or outside which obstructs direct

and/or indirect solar radiation. This definition covers the case of building self shading.

SHELL - The formalised structure used for the documentation of PAMS. It becomes the framework of the PAMDOC.

SUB-PROGRAM - Programs may incorporate Sub-Programs which enable the user to select the way in which the program approaches a task.eg the distribution of solar energy within a zone. In the context of PAM documentation a Sub-Program, to be of interest, must be capable of being invoked by the user. NB: This definition is not that used by the computing community.

USER SELECTED INITIAL CONDITIONS - Conditions or parameters set by the user to initialise the program. Typically these may be construction temperatures or the pre-conditioning period.

VENTILATION - The provision of air to a building from an external source.

ZONE - A zone may be any space, in or external to a building, to which particular attributes or conditions have been ascribed. The boundaries of the zone are the boundaries within which the ascribed attributes or conditions are assumed to exist and are not necessarily of a physical nature. In practice zones are usually discrete rooms, parts of rooms, or groups of rooms where a room is any enclosed space.

ZONING - The process of defining or selecting zones for assessment.

IEA ANNEX 21 - SUBTASK B

CALCULATION OF THE ENERGY PERFORMANCE OF BUILDINGS

APPROPRIATE USE OF MODELS

FINAL REPORT

VOLUME 2

SECTION 2

DOCUMENTED PAMS

CONTENTS

Three examples of documented PAMs (PAMDOCs) are presented. The first, using BREADMIT, is a relatively simple, single zone example. The second, based on SERI-RES is a more extensive, but single purpose, multi zone example, and the third, using DOE2, is an example of a complex PAMDOC comprising a basic document with separate extensions to deal with different purposes.

EXAMPLE PAMDOC 1

The use of the BRE admittance procedure for the assessment of overheating risk in commercial and residential buildings

The use of the BRE admittance procedure for the assessment of overheating risk in commercial and residential buildings

L.P. Roche D.P. Bloomfield

Building Research Establishment
Bucknalls Lane, Garston, Herts., WD2 7JR

8/10/1993

SECTION 0.0 - PAM IDENTIFICATION

IDENTIFIER
BRE 0001

PURPOSE
Assessment of overheating risk

APPLICATION
Evaluation at the early design stage of overheating risk in small to medium zones (less than 20m high) of all types of buildings.

PROGRAM
BREADMIT (1988 IBM version)

DATE
8/101993

AUTHOR
Liam Roche   Dave Bloomfield

ADDRESS OF AUTHOR
Building Research Establishment,
Bucknalls Lane,
Garston,
Nr. Watford,
Herts.
WD2 7JR.
Telephone: (0923) 664473

SECTION 1.0 - DEFINITION OF PERFORMANCE ASSESSMENT

1.1 PURPOSE

1.1.1 Purpose

Assessment of overheating risk

1.2 APPLICABILITY

1.2.1 Building type

Residential:	housing
	hotels
Non-residential:	commercial
	educational

1.2.2 Environmental Control system

Natural and mechanical ventilation

1.2.3 Climatic Zone

Tropical (humid and arid)
Temperate

1.2.4 Program

BREADMIT (1988 IBM version)

1.2.5 Resources

Hardware:
IBM-PC or compatible with printer
Commodore PET with disk drive and printer (earlier version)
BBC micro with disk drive and printer (earlier version)
Operating software: MS-DOS or PC-DOS and BASICA or GWBASIC

1.2.6 Further Information

Limitations - see section 4, pp34-7 of users' guide.
Note: Moisture effects are not allowed for.
An internal BRE publication by D. Bloomfield notes that "It is implicit in this method that the conditions are repeated for some days prior to that being studied (i.e. long enough for cyclic conditions to be established)."

SECTION 2.0 - PROCEDURE

2.1 PROCEDURE

Decide on overheating temperature and risk definition in days of overheating per decade. Consult CIBSE A3 or run THERMALFACTORS to determine thermal parameters of walls, floor and ceiling, then run HEATCOOL to simulate one repeated day of operation of the building for each zone of the building at risk, varying parameters as defined in sections 5, 7 and 8 where there is any uncertainty (see the relevant sections for details).

2.1.1 Define information Required

See section 3. Information required is the maximum dry resultant temperature reached in each zone at risk on the representative day using weather data selected as in 5.2.

2.1.2 Configure Program

Program version as in 4.1. Sub-programs as in 4.2.
Computational parameters as in 4.3. Set initial conditions as in 4.4.

2.1.3 Describe site and climate

Site as in 5.1, climate as in 5.2.

2.1.4 Describe zoning procedure to program

As in 6.1

2.1.5 Describe building to Program

As in section 7

2.1.6 Describe building operation to Program

As in section 8. Casual gains are specified hourly. Ventilation has two levels (day and night) and change-over times.

2.1.7 Describe ventilation process

As in section 8.1

2.1.8 Describe Plant to Program

Not modelled

2.1.9 Describe Plant operation to Program

Not applicable

2.1.10 Process output data

Select the options of dry resultant temperature and echoing of input.
Post-process results as in 3.2.

2.1.11 Interpret information

As in 3.4.

2.1.12 Quality Assurance

See QA in all other sections

SECTION 3.0 - INFORMATION DEFINITION

3.1 INFORMATION REQUIRED FROM THE PERFORMANCE ASSESSMENT

3.1.1 Description

Overheating risk is assessed by predicting the dry resultant temperature in each selected zone for a representative day.

3.1.2 Results required

Hourly dry resultant temperature T in each selected zone in degrees Centigrade. (See 3.1.7 for the definition of dry resultant temperature)

3.1.3 Assign Values (rules of assignment/measurement)

Dry resultant temperature is selected for output. Zones are selected as in section 6.
Zone selection - BREADMIT only models one zone explicitly; the user should select all zones of building most likely to overheat; these may include highly glazed zones facing S/SW and/or zones with high casual gains from equipment etc. One run should be performed for each of the zones which may be prone to overheating.

3.1.4 Rationale

BREADMIT is a single zone model and as such can only handle one zone in a run. However, individual runs are relatively quick which makes multiple runs feasible. Dry resultant temperature is the accepted CIBSE parameter for determining comfort.

3.1.5 Reference

CIBSE Guide 1986 (sections A5 and A8), paper by Danter in BSER&T Vol. 4 number 2 1983.

3.1.6 Quality Assurance

Check input data against the echoed output. Apply steady state method from CIBSE A3 to determine which zones are at risk. Alternatively (or additionally) use BRE design aids as an estimate of internal temperature to help in selecting zone to be modelled and check that the U- and Y- values are appropriate to internal/external elements in the printout of
the input data.

3.1.7 Further Information

Note that dry resultant temperature is defined in an approximate way by CIBSE as:

$$1/2 \times MST + 1/2 \times AT,$$

where MST = area-weighted mean surface temperature and AT = air temperature

3.2 POST PROCESSING OF OUTPUT

3.2.1 Description

Use predicted results to see (via a simple graph, and via tabulated values) whether overheating temperature is exceeded on the day of the run in any of the zones being modelled.

3.2.2 Program outputs

Hourly dry resultant temperature for the representative day for each selected zone.

3.2.3 Process Outputs

Examine temperature profile for the run for each zone, find the maximum temperature attained and see if it exceeds the overheating temperature.

3.2.4 Rationale

The described procedure indicates whether the overheating temperature will be exceeded for the chosen number of days per decade.

3.2.5 Reference

BREADMIT users' guide
CIBSE A2 - discussion of the use of banded climatic data

3.2.6 Quality Assurance

Check that graphical and tabular outputs give same result (but see note in 3.2.6 below)

3.2.7 Further Information

Graphical output is rounded down to the nearest degree, so some care must be taken if the overheating temperature is non-integral.

3.3. FORM OF PRESENTATION

3.3.1 Description

Table and graph

3.3.2 Presentation

Table: Hour against Temperature
Graph: Hour against Temperature in degrees Celsius (repeated for each zone simulated)

3.3.3 Assign Values

User answers "NO" to the question:- "Outputs for the case without plant as well as with?".

3.3.4 Rationale

Hourly temperatures for the representative day are conveniently read from a table or graph

3.3.5 Reference

The BREADMIT users' guide (page 33)

3.3.6 Quality Assurance

Check that all 24 hours of output have been printed out (i.e. there has been no printer fault such as a paper jam). Compare the results from the graph and table.

3.3.7 Further Information

If the overheating temperature used is an integer, either the graphical or tabular outputs are adequate for the purpose of the PAM. Choosing not to output results for the case without plant as well as with means that only one graph and table will be output for each run.

3.4 INFORMATION INTERPRETATION

3.4.1 Description

Having decided on an overheating temperature and a number of days per decade that the temperature has to be exceeded to indicate an overheating risk, section 3.2 above gives an unambiguous yes or no to the question of whether overheating occurs as defined in section 5.2. This requires no further interpretation.

3.4.2 Interpretation

If the overheating temperature is exceeded in a particular zone for the representative day then it can be expected to be exceeded for the chosen number of days per decade since banded weather data is being used. See 3.4.1

3.4.3 Assign Values

The building is considered to be subject to overheating if the chosen temperature is exceeded in any of the zones at risk using the day that represents weather occurring on 10, 30, 50 or 100 days per decade.

3.4.4 Rationale

The method used allows the overheating risk to be evaluated with a single quick run for each of the zones at risk, using a convenient source of banded weather data for SE England. See 5.2 for treatment of other climates. Using CIBSE banded data (see 5.2) ensures that the results for the representative day indicates whether the chosen overheating temperature (see 3.4) would be exceeded on more than the chosen number of days per decade.

3.4.5 Reference

(i) The CIBSE Guide A2 1986.
(ii) UK warm weather data.
(iii) Met. office references 0.617 and 0.856 (Tables of temperature, humidity and precipitation for the world)

3.4.6 Quality Assurance

No further QA necessary (see 3.4.1). It may be useful to perform runs for more than one of the sets of banded weather data and compare the results.

3.4.7 Further Information

The banded weather data in the CIBSE Guide relate only to Kew and should not be applied to buildings in areas where the climate is very different. CIBSE recommends values of appropriate climatic parameters for use in temperate and tropical climates (Tables A2.29 and A2.30). The world weather data in Table A2.22 is a possible source of temperature data although the precise nature of the data is unclear. The cloudiness value is only used for the longwave emission calculation and is of lesser importance. This parameter is not readily available for all locations.

SECTION 4.0 - PROGRAM CONFIGURATION

4.1 PROGRAM VERSION

4.1.1 Title

BREADMIT - BRE Microcomputer package for prediction of building temperatures and heating/cooling loads using the admittance method

4.1.2 Program Author

D. Bloomfield

4.1.3 Vendor

Building Research Establishment, Bucknall's Lane, Garston, Herts.
WD2 7JR

4.1.4 Version Number

1988 IBM PC version

4.1.5 Date of Release

1988

4.2 USER SUB MODEL SELECTION

THERMALFACTORS is used if it is necessary to calculate the thermal parameters for the walls, roof and floor rather than use standard CIBSE values. One run is performed for each different type of construction used in the building.

4.2.1 Sub model 1

4.2.1.1 Description

This calculates the U-value, admittance, decrement factor, internal admittance, internal decrement factor and time lags for any layer structure.

4.2.1.2 Sub Model: Name

THERMALFACTORS

4.2.1.3 Select Sub Model method

Only used if non-standard or unusual construction types or exposures are used. (see 5.1.2)

4.2.1.4 Rationale

Use is essential to avoid complex hand calculation if any non-standard construction is used

4.2.1.5 Reference

CIBSE Guide A3, appendix 5. See PAM BRE0002 for full details on the use of the THERMALFACTORS module to provide the inputs needed by HEATCOOL.

4.2.1.6 Quality assurance

Values for standard constructions in the CIBSE Guide are calculated using the same algorithm as THERMALFACTORS, using normal values for material properties and surface coefficients. It is essential that the order of the layers in a construction is correct with respect to the zone being modelled. If an asymmetric construction separates two zones being modelled, two separate runs of THERMALFACTORS must be performed.

4.2.1.7 Further information

See paper by E. Danter in the BREADMIT manual and the parts of the users' and programmers' guide that relate to THERMALFACTORS.

4.3 USER-SELECTED COMPUTATIONAL PARAMETERS

4.3.1 Computational Parameter 1

This parameter is only used in THERMALFACTORS

4.3.1.1 Description

The number of cycles per day of the driving external temperature

4.3.1.2 Computational Parameter Definition List

Name: Cycles per day
Symbol: C
Units: Day^{-1}
Definition: as in 4.3.1.1

4.3.1.3 Assign Values

Always set this parameter to 1 in this PAM.

4.3.1.4 Rationale

A 24 hour sine wave fits typical summertime external temperatures better than any other single higher frequency harmonic. Typically errors in temperature are about 10% of the swing.

4.3.1.5 Reference

"A comparison of the admittance and Fourier methods for predicting heating/cooling loads" by Sodha et al (Solar Energy Vol. 36 No. 2 p. 125-127, 1986) is a useful reference on the applicability of harmonic methods. "Summertime temperatures in buildings" by A.G. Loudon (1968) is a classic reference.

4.3.1.6 Quality Assurance

Check printout of input file to confirm that C has been set to one.

4.3.1.7 Further Information

Values of C greater than 1 are only used for determining the walls behaviour under exceptional conditions: for overheating assessment C=1 is appropriate.

4.4 USER-SELECTED INITIAL CONDITIONS

No initial conditions can be set - the program is based on the assumption/approximation that the building is subjected to repeating excitations with a period of 24 hours. This means that a steady cyclic state is established, with no initial conditions. In practice the equations resulting from the solution of such a system can be used on representative days as in this PAM. Directly measured weather data is not used, only derived data.

SECTION 5.0 - CONTEXT DESCRIPTION

5.1 SITE DESCRIPTION

5.1.1 Location

5.1.1.1 Description
The geographical position of the site (used only to calculate solar path)

5.1.1.2 Parameter Definition List
Name: Latitude
Units: degrees (non-integer part is given as a decimal fraction)
Definition: The angle subtended between a line between the site and the centre of the earth and the equatorial plane.
Range: Reals from -65 to 65

5.1.1.3 Assign Values
Use a map of the site to determine the exact latitude or use the nearest available known value if no precise data is available. Range of latitude is -65 to +65 degrees (as a decimal value) as situations where permanent day or night may occur are considered to be outside the range of interest.

5.1.1.4 Rationale
Actual location specifies this parameter unambiguously

5.1.1.5 Reference
Map of site area

5.1.1.6 Quality Assurance
Check latitude in printout of input data. Note that Ordnance Survey have far higher standards of precision for geographical locations than is significant, so data from this source is reliable for this PAM.

5.1.1.7 Further Information
Longitude is not taken into account. With a 24 hour cyclic model this is not very important although errors of up to one hour can be introduced in the timing of solar and temperature data. In the U.K. all times used should be GMT, not BST. Small errors in the latitude (less than one degree) are not of great significance.

5.1.2 Site Exposure

5.1.2.1 Description
The site exposure is not explicitly specified, but is implicit in the choice of external surface coefficients on walls and roof in THERMALFACTORS if this is used. The standard values of thermal parameters in the CIBSE Guide assume a sheltered location.

5.1.2.2 Parameter Definition List
Name: External surface resistances for each wall and roof
Symbol: R_{so}
for each wall and the roof
Units: m^2K/W
Definition: The rate of heat flow per unit area per unit temperature between the air and the wall

5.1.2.3 Assign Values

Use table A3.6 and A10.8 of the CIBSE Guide

5.1.2.4 Rationale
Table A3.6 is based on empirical data

5.1.2.5 Reference
CIBSE Guide A3

5.1.2.6 Quality Assurance
If there is uncertainty as to the site exposure, perform separate runs for different values of R_{SO} and see if it alters the overheating assessment. This will ensure that any uncertainty in the determination of the overheating risk due to the choice of R_{SO} will be apparent.

5.1.2.7 Further Information
Ventilation rates (particularly infiltration) will also be affected by exposure but data on this is not readily available so for the purpose of this PAM ventilation rates are assumed not to be dependent on exposure.

5.1.3 Ground Reflectivity

5.1.3.1 Description
Proportion of solar radiation reflected by the ground.

5.1.3.2 Parameter Definition list
Ground reflectance, a unitless constant (see 5.1.3.7 for the definition).
Range: Real from 0 to 1.

5.1.3.3 Assign Values
Consult table A2.31 in CIBSE Guide A2 (but see 5.1.3.5).

5.1.3.4 Rationale
Ground reflectances are rarely known accurately at the early design stage: the CIBSE values are an average of empirical values from given regions.

5.1.3.5 Reference
For a more complete discussion of ground reflectances and a comprehensive table of values, see Iqbal, Solar Radiation (Academic Press 1983).

5.1.3.6 Quality Assurance
Check value in printout of input data.

5.1.3.7 Further Information
The ground reflectance is an important parameter for overheating studies as it adds a significant factor to the solar gain. The value used is a weighted average w.r.t. the typical solar spectrum - reflectivity is dependent on the wavelength of the radiation; this is particularly significant if the ground is of a distinct colour such as the green of vegetation. This causes some additional errors as well as those due to the uncertainty in the value, because the spectrum of a cloudy sky and a clear sky are quite different.

Mathematically, the extra solar gain is proportional to the integral over all frequencies of the product of the solar irradiance per unit frequency and the ground reflectance, each as a function of frequency. Hence the appropriate value of ground reflectance to use is the above integral divided by the total solar irradiance. This value is therefore dependent on the distribution of the solar irradiance with respect to frequency, though not on the total irradiance, and on the distribution of the reflectivity of the ground as a function of frequency.

$$G.R. = \frac{\int_{\text{All frequencies}} d\nu \, S(\nu).R(\nu)}{\int_{\text{All frequencies}} d\nu \, S(\nu)}$$

where S is the solar irradiance per unit frequency in J/m^2 and R is the reflectance per unit frequency in s.

If the value as defined above for a typical distribution of solar radiation with respect to frequency is used under conditions where the solar radiation has a different profile, such as a change from cloudy sky to clear sky, then errors are likely to be introduced.

5.1.4 Ground Temperature

5.1.4.1 Description
The effective temperature of the material which connects to the lowest part of the construction of the building.

5.1.4.2 Parameter Definition List
None

5.1.4.3 Assign Values
None needed in this PAM

5.1.4.4 Rationale
BREADMIT treats the floor as a wall connected to a ground temperature which is the average external temperature. No input is required from the user.

5.1.4.5 Reference
"Heat loss through solid ground floors - II" by Neville S. Billington
(Journal of the institution of heating and ventilating engineers, November 1952)

5.1.4.6 Quality Assurance
The influence of the choice of ground temperature on the overheating risk assessment is only significant if the U-value of the floor is large: it does not affect the cyclic effects at all.

5.1.4.7 Further Information
Ground temperature does not vary significantly throughout the course of a day at the depth of the base of a typical floor, so is well modelled by a constant value.

5.1.5 External shading

5.1.5.1 Description
The reduction of the solar radiation incident on the building due to external objects such as trees, other buildings etc.

5.1.5.2 Parameter Definition List
(1) Solar gain factor, Se, (dimensionless), the ratio of the incident radiation on an unobstructed window to the energy that actually heats the room for constant incident radiation, range from 0.1 to 1.

$Se = Qs/ITA_g$, where Qs = mean solar gain in W, IT = mean solar irradiance on the surface in W/m^2 and A_g is the area of glazing.

(2) Alternating solar gain factor, $\tilde{S}e$, (dimensionless), the ratio of the incident radiation on an unobstructed window to the energy that actually heats the room for a sinusoidal radiation profile, range from 0.1 to 1.

$\tilde{S}_e = \tilde{Q}_s / IA_g$, where $\tilde{Q}_s$ is the first harmonic of the solar gain in W, $\tilde{I}$ is the first harmonic of the solar irradiance on the surface in W/m^2 and A_g is the area of glazing. (The values of the three alternating parameters above are the swing about the origin of the first harmonic component of the relevant function).

(3) Absorptivities of walls, As, the ratio of the solar radiation absorbed by an external wall to that incident on the wall, range from 0 to 1.

5.1.5.3 Assign values
Both the gain factors and all of the solar absorptivities should be reduced by a factor equal to the proportion of the sky that the obstructions shield from the building. If the obstruction is directional the reduction factors for the solar gain factor, alternating solar gain factor and solar absorptivities on the four walls and the roof should be chosen separately.

5.1.5.4 Rationale
A detailed analysis would involve ray path analysis of direct solar but the specified procedure gives an adequate approximation in the spirit of the admittance procedure.

5.1.5.5 Reference
No reference is available on the use of external shading factors in the admittance procedure except for a brief note in CIBSE A8-5.

5.1.5.6 Quality Assurance
If the effects of shading are unclear, different values of the correction factor are used to see how it affects the overheating assessment. This will ensure that the uncertainty in the determination of the overheating risk, due to the choice of external shading factors will be apparent. To be safe, use factors which lead to maximum risk.

5.1.5.7 Further Information
None

5.2 CLIMATE DESCRIPTION

5.2.1 Description

The calculations are performed on an hourly basis for 1 day, which is repeated through the assumption of steady cyclic conditions. The hourly values of temperature and solar radiation are constructed from the simplified inputs (mean temperature, swing in temperature and time of peak temperature) requested from the user, by adding the sinusoidal variation to the mean temperature. Hourly values of solar irradiance on all four walls and the roof can be provided by the user if preferred.

5.2.2 Climate Variables List

Daily mean outdoor temperature (° C)

Swing in outdoor temperature (max. - mean) (° C)

Time of peak outdoor temperature (integer hour)

Cloudiness (1 - actual hours of sunshine/total possible)

Direct radiation factor (k_D) - (Measured direct radiation)/(Basic direct radiation) in W/m^2

Diffuse radiation factor (k_d) - (Measured diffuse sky radiation)/(Basic diffuse sky radiation) in W/m^2. These factors are calculated for radiation on a horizontal surface.

5.2.3 Assign Values

Values appropriate for Summer overheating design for temperate localities are given in Table A2.29 of CIBSE Guide A2 and these are summarised for SE England in section 5(b) of the users' guide. Table A2.30 gives values for "tropical" localities. Table A2.22 gives World Weather temperature data. It is at the discretion of the user to choose the number of days risk per decade on which the overheating risk is defined, e.g.) 30 days per decade. As cloudiness values are not available for all sites either use C=0 for locations where clear skies are common or C=1 where overcast conditions predominate, if other data is not available.

5.2.4 Rationale

For World weather data see page A2-39 of CIBSE which in turn refers to U.K. Warm Weather Data. For temperate localities, page A2-65 states that 'parameters have been selected such that, when applied to peak summer conditions(i.e. July, SW orientation, in the case of rooms with windows in a single external wall in temperate localities), predicted temperatures are likely to be exceeded for the stated number of days in a 10 year period'. The Table allows selection of a design risk of 10, 30, 50, 100 working days in 10 years.

5.2.5 Reference

CIBSE A2

5.2.6 Quality Assurance

Check the printout of the input data.

5.2.7 Further Information

None

SECTION 6.0 - ZONING

6.1 ZONE DESCRIPTION

6.1.1 Modelled zones

Zone selection - BREADMIT only models one zone explicitly; the user should select zones of building most likely to overheat e.g. highly glazed zone facing S/SW or zone with highest casual gains from equipment etc. and perform one run for each of the zones which may be prone to overheating.

6.1.1.1 Description

The single zone that is being modelled has 4 walls a floor and a roof, all of which, except the floor, may be internal or external.

6.1.1.2 Parameter Definition List

None specific to zoning strategy, except setting the U-value of an element to zero for an internal wall or roof and using the internal admittance in this case (see 7.6.3 and 6.2).

6.1.1.3 Define Zone

BREADMIT only models one zone explicitly; the user should select rooms of building most likely to overheat e.g. highly glazed zone facing S/SW or zone with highest casual gains from equipment etc. and perform one run for each of the rooms which may be prone to overheating.

6.1.1.4 Rationale

It is better to concentrate on the zones which have an overheating risk rather than the average temperature for the whole building.

6.1.1.5 Reference

None

6.1.1.6 Quality Assurance

Use BRE design aids as an estimate of internal temperature to help in selecting zone to be modelled and check that the U- and Y- values (admittance) are appropriate to internal/external elements in the printout of the input data.

6.1.1.7 Further information

See 6.1.2

6.1.2 Adjacent Unmodelled Zones

These should be simulated by setting the U-values of any internal walls to 0 and using the value of admittance corresponding to internal admittances.

6.1.2.1 Description

Adjacent unmodelled zones are modelled by using the internal admittance for the dividing wall.

6.1.2.2 Parameter Definition List

Internal admittances and U-values for dividing walls and ceilings.
U-value, U, $W/m^2/K$ (always set to the value 0 to indicate an internal wall or ceiling)
Internal admittance , Y, (0 to 20 $W/m^2/K$), the ratio of the swing in the internal temperature to the swing in the heat flow into the internal wall or ceiling, per square metre.

6.1.2.3 Assign Values

Use internal admittances from CIBSE Guide for given construction or those generated by THERMALFACTORS. Set U-values of internal walls to zero.

6.1.2.4 Rationale
Use of the above procedure is equivalent to assuming that conditions in adjacent zones are the same as those in the modelled zone - it is important to note that there will be energy flows into and out of the internal walls so that the building's time constant will be increased. Specifically what is assumed by the method is that the temperatures in the adjacent zone vary in synchronisation with those in the explicitly modelled zone.

6.1.2.5 Reference
CIBSE Guide 1986, paper by E. Danter in BSER&T vol. 4 number 2 1983.

6.1.2.6 Quality Assurance
If THERMALFACTORS has been used compare values with CIBSE Guide for a similar construction. Check that printout of input data shows that U-value and lags are zero for all walls specified as being internal. Use BRE design aids as an estimate of internal temperature to help in selecting zone to be modelled and check that the U- and Y- values are appropriate to internal/external elements in the printout of the input data.

6.1.2.7 Further Information
None.

6.2 INTERZONAL COUPLING

6.2.1 Inter Zonal Coupling : Airflow

6.2.1.1 Description
The way in which the motion of air between zones is modelled

6.2.1.2 Parameter Definition List
None to set.

6.2.1.3 Assign Values
None to assign.

6.2.1.4 Rationale
BREADMIT does not deal with interzonal airflows. If this PAM is applied to a building with interzonal airflows the worst that can happen is that the overheating risk be exaggerated. This is because runs are performed for all zones that are determined to have possible overheating risk.

6.2.1.5 Reference
No reference is known the significance to overheating assessment of the neglect of interzonal airflows.

6.2.1.6 Quality Assurance
See 6.2.1.4

6.2.1.7 Further Information
A multi-zone version of the admittance procedure could take into account inter-zonal airflows by making an appropriate adjustment to the U-values of dividing elements, using the formula:

$$\Delta U = R / ADS$$

where ΔU = the increment to the U-value, R is the rate of exchange of air in cubic metres per second, D is the density of air and S is the specific heat capacity of air at room temperature.

6.2.2 Inter Zonal Coupling: Short-wave

6.2.2.1 Description
The transfer of energy between zones by the means of short-wave radiation

6.2.2.2 Parameter definition list
None

6.2.2.3 Assign values
None to assign

6.2.2.4 Rationale
There is no way for BREADMIT to model the short-wave coupling between the modelled zone and adjacent unmodelled zones

6.2.2.5 Reference
None appropriate

6.2.2.6 Quality assurance
The energy transfer between zones due to short-wave radiation passing through doors and other openings is likely to be of little significance to overheating studies as the energy involved would be of the order of a few per cent of that due to solar gain.

6.2.2.7 Further information
None

SECTION 7.0 - BUILDING DESCRIPTION

7.1 GEOMETRY

7.1.1 Description

BREADMIT has a very simple geometric model: the single zone modelled is assumed to be cuboidal in shape with up to one window in each wall and the roof. Constructional elements bounding the zone are described purely by their orthogonal dimensions and the orientation of the first wall. The window geometry in each construction element is described simply by the percentage of that element that is glazed.

7.1.2 Parameter Definition List

Length of zone (walls 1 and 3) m (up to 100m) [Internal dimensions are used]
Breadth of zone (walls 2 and 4) m (up to 100m) [Internal dimensions are used]
Height m (up to 20m) [Internal dimensions are used]
Azimuth of first wall degrees The angle of the perpendicular to the first wall to north in degrees, (integer 0-359 °, clockwise from North)
Percentage of wall area glazed %
Percentage of roof area glazed

7.1.3 Assign Values

Use internal dimensions so that volume used for calculating infiltration losses is correct. Glazed areas should not include frame.

7.1.4 Rationale

There is a compromise between getting the internal volume and the area of the walls for heat flow correct. The chosen approach gets the ventilation right but underestimates the heat flow through the walls.

7.1.5 Reference

Accepted thermal modelling practice

7.1.6 Quality Assurance

Check all input data with the printout

7.1.7 Further Information

HEATCOOL does not deal with the thickness of walls explicitly. This can lead to systematic errors in the results due to the conduction of heat through the corners of the building. It is unclear whether this factor causes underestimation or overestimation of the overheating risk.

7.2 SHADING DEVICES (EXTERNAL)

7.2.1 Shading device 1

7.2.1.1 Description

Any device reducing the incident radiation on one of the walls or windows.

7.2.1.2 Parameter Definition List

(1) Solar gain factor, Se, (dimensionless), the ratio of the incident radiation on an unobstructed window to the energy that actually heats the room for constant incident radiation, range from 0.1 to 1.

$Se = Qs/IT A_g$, where Qs = mean solar gain in W, IT = mean solar irradiance on the surface in W/m^2 and A_g is the area of glazing.

(2) Alternating solar gain factor, $\tilde{S}e$, (dimensionless), the ratio of the incident radiation on an unobstructed window to the energy that actually heats the room for a sinusoidal radiation profile, range from 0.1 to 1.

$\tilde{S}_e = \tilde{Q}_s / \tilde{I} A_g$, where $\tilde{Q}_s$ is the first harmonic of the solar gain in W, $\tilde{I}$ is the first harmonic of the solar irradiance on the surface in W/m^2 and A_g is the area of glazing. (The values of the three alternating parameters above are the swing about the origin of the first harmonic component of the relevant function).

(3) Absorptivities of walls, As, the ratio of the solar radiation absorbed by an external wall to that incident on the wall, range from 0 to 1.

7.2.1.3 Assign Values

All three parameters should be chosen as in sections 7.5.1 and 7.8 and then reduced by a factor corresponding to the degree of shading. It is suggested that the reduction factor used be the proportion of the visible sky that is blocked by the device.

7.2.1.4 Rationale

The main effects of an external shading device are to reduce the short-wave radiation incident on the walls and windows.

7.2.1.5 Reference

No published reference is available on the modelling of external shading devices using the admittance procedure

7.2.1.6 Quality Assurance

Check printout of input against values calculated as in 7.2.1.3. If there is uncertainty in the values to be used, doing runs with different shading factors to determine the uncertainty in the overheating risk. Using the results from the minimum shading case will ensure that the overheating risk is not under-estimated.

7.2.1.7 Further Information

At the cost of a more complex manual calculation the reduction factor chosen in 7.2.3.1 may be replaced by one that takes into account the non-isotropic nature of the distribution of the sky and solar radiation. Such a calculation should determine the average over the day of the radiation over the sky and determine how much of this mean solar sky is blocked by the shading device.

7.2.2 Shading device 2

7.2.2.1 Description

Any shading device shielding the roof from incident short-wave radiation.

7.2.2.2 Parameter definition list

7.2.2.3 Assign values

All three parameters should be chosen as in sections 7.5.1 and 7.8 and then reduced by a factor corresponding to the degree of shading.

7.2.2.4 Rationale
The main effect of an external shading device on the roof is to reduce the short-wave radiation incident on the roof and skylights.

7.2.2.5 Reference
None

7.2.2.6 Quality assurance
Check printout of input against values calculated as in 7.2.2.3. If there is uncertainty in the values to be used, doing runs with different shading factors and using results from run with minimum possible shading will ensure that the overheating risk is not under assessed.

7.2.2.7 Further information
None available.

7.3 SHADING DEVICES (INTERNAL)

7.3.1 Shading device 1

7.3.1.1 Description
Any internal shading device such as a curtain or blind shielding one of the windows from incident radiation.

7.3.1.2 Parameter Definition List
Solar gain factor of window in the wall or roof
Alternating solar gain factor of window in the wall or roof

(See 5.1.5.2 for definitions)

7.3.1.3 Assign Values
Both parameters should be chosen as in sections 7.5.1 and 7.8 and then reduced by a factor corresponding to the degree of shading. CIBSE A8.2 gives suitable values to use for single and double glazing with various types of blind.

7.3.1.4 Rationale
The main effect of an internal shading device is to reduce the short-wave radiation passing through the windows into the zone.

7.3.1.5 Reference
None available

7.3.1.6 Quality Assurance
Check printout of input against values calculated as in 7.3.1.3. If there is uncertainty in the values to be used, doing runs with different degrees of shading and using the results from the run with the minimum possible shading will ensure that the overheating risk is not under assessed.

7.3.1.7 Further Information
None available

7.4 CONSTRUCTION (EXTERNAL ELEMENTS)

7.4.1 Walls

7.4.1.1 Description

To HEATCOOL a wall is a vertical rectangular object with two dimensions, a U-value, an admittance, a decrement factor and the associated time lags. (See 7.4.1.2 for the details of the specification of these parameters). It can have an area of glazing in it.
(See 7.8 for specification of glazing).

To THERMALFACTORS a wall is made up one or more layers of homogeneous materials with specified densities, conductances, thicknesses, and internal and external combined surface coefficients. See PAM BRE0002 for the use of THERMALFACTORS to calculate the thermal parameters of constructions. See 4.2.1. for information on the use of THERMALFACTORS in this PAM).

7.4.1.2 Parameter definition list

U-value	W/m^2
Y value	W/m^2K
Decrement factor	Dimensionless
Time lag on decrement factor	hours (integer)

7.4.1.3 Assign values

Use values from CIBSE A3 or as calculated by THERMALFACTORS if non-standard construction types or exposures are required. (See 4.2.1.* for the use of THERMALFACTORS in this PAM).

7.4.1.4 Rationale

Use of CIBSE A3 gives data for floors using the standard admittance calculation. THERMALFACTORS is a validated implementation of the same method.

7.4.1.5 Reference

CIBSE A3 and A5

7.4.1.6 Quality Assurance

Check input values determined as above against those in the printout of the input file. If THERMALFACTORS is used, compare the values of U and Y produced against those for similar constructions in CIBSE A3.

7.4.1.7 Further information

BREADMIT's modelling of external walls is relatively simple: THERMALFACTORS treats a wall as a collection of homogeneous layers (See BRE0002). It is not possible to explicitly model layers of mixed materials, such as bricks and mortar, but area-weighted average properties can be used.

7.4.2 Floors

7.4.2.1 Description

To HEATCOOL a floor is a horizontal rectangular object with two dimensions, a U-value and an admittance, connected to ground. (See 7.4.1.2 for the details of the specification of these parameters). To THERMALFACTORS a floor is made up one or more layers of homogeneous materials with specified densities, conductances, thicknesses and internal and external combined surface coefficients. (See 4.2.1.* for information on the use of THERMALFACTORS in this PAM).

7.4.2.2 Parameter definition list

U-value	$W/m^2/K$
Y value	$W/m^2/K$
Decrement factor	unitless
Time lag on decrement factor	hours (integer number)

7.4.2.3 Assign values
Use values from CIBSE A3 or as calculated by THERMALFACTORS if non-standard construction types or exposures are required. (See 4.2.1.* for the use of THERMALFACTORS in this PAM).

7.4.2.4 Rationale
Use of CIBSE A3 gives data for floors using the standard admittance calculation. THERMALFACTORS is a validated implementation of the same method.

7.4.2.5 Reference
"Thermal response and the admittance procedure"- N.O. Millbank and J. Harrington-Lynn (Building Services Engineer May 1974)

7.4.2.6 Quality assurance
Check the printout for errors in the input parameters. If THERMALFACTORS has been used, compare input data with data for a similar construction in CIBSE A3.

7.4.2.7 Further information
None available

7.4.3 Carpets (If not part of the floor)

7.4.3.1 Description
For the purposes of HEATCOOL carpets are included in the description of the floor's thermal properties. In THERMALFACTORS a carpet is modelled as a layer with a density, conductance, a specific heat capacity and a thickness.

7.4.3.2 Parameter definition list
None explicit in HEATCOOL. In THERMALFACTORS, density, conductance and thickness are needed. See 4.2.1.* for details of THERMALFACTORS.

7.4.3.3 Assign Values
None in HEATCOOL. See 4.2.1.* for details of THERMALFACTORS.

7.4.3.4 Rationale
Typical carpet properties are implicit in the data about floor types in CIBSE A3. Although carpets are adequately modelled as a pure resistance, there is little overhead in the use of THERMALFACTORS to model them more accurately.

7.4.3.5 Reference
None available.

7.4.3.6 Quality Assurance
If floor has been modelled explicitly using THERMALFACTORS then the values calculated should be compared with those for a similar floor in CIBSE A3. Check values chosen against those in the printout of the input data.

7.4.3.7 Further Information
None

7.4.4 Roof

7.4.4.1 Description
To HEATCOOL a roof is a horizontal rectangular object with two dimensions, a U-value, an admittance, surface factor, decrement factor and the associated lags, and a short-wave absorptivity. It may include an area of glazing. To THERMALFACTORS a roof is made up one or more layers of homogeneous materials with certain densities, conductances, thicknesses, specific heat capacities and

internal and external combined surface coefficients. (See 4.2.1.* and BRE0002 for information on the use of THERMALFACTORS in this PAM).

7.4.4.2 Parameter definition list

U-value	$W/m^2/K$
Value	$W/m^2/K$
Decrement factor	unitless
Time lag on decrement factor	hours (integer number)

7.4.4.3 Assign values

Use values from CIBSE A3.18 or A3.19 or as calculated by THERMALFACTORS if non-standard construction types or exposures are required. (See 4.2.1.* for the use of THERMALFACTORS in this PAM).

7.4.4.4 Rationale

Use of CIBSE A3 gives reliable validated data for roofs using the standard admittance calculation. THERMALFACTORS is a validated implementation of the same method.

7.4.4.5 Reference

"Thermal response and the admittance procedure"- N.O. Millbank and J. Harrington-Lynn (BSE May 1974)

7.4.4.6 Quality assurance

Check the printout for errors in the input parameters. If THERMALFACTORS has been used, compare input data with data for a similar construction in CIBSE A3.

7.4.4.7 Further information

None

7.5 SURFACE PROPERTIES (EXTERNAL ELEMENTS)

7.5.1 Solar absorptivity

7.5.1.1 Description

The proportion of solar radiation falling on the element that is absorbed by the element.

7.5.1.2 Parameters

Solar absorptivities of the external walls and roof.

7.5.1.3 Assign values

Supply value for external surface of each wall, use default value of 0.5 for light surfaces and 0.9 for dark surfaces if no precise value is known.

7.5.1.4 Rationale

Values are not readily available for all building materials so the two standard values are taken.

7.5.1.5 Reference

CIBSE A2 (solar irradiance calculations)

7.5.1.6 Quality Assurance

Compare value chosen as above with printout of input data.

7.5.1.7 Further information

The solar absorptivity is used in the calculation of sol-air temperatures.

7.5.2 Long-wave emissivity

7.5.2.1 Description
The emission of infrared by the external surfaces of elements. This is not explicitly modelled by BREADMIT, but the value of the external surface coefficient specified in THERMALFACTORS takes this into account.

7.5.2.2 Parameter Definition List
External surface resistances for each element, as implicit in the data for standard constructions in CIBSE A3 or as used in THERMALFACTORS.

7.5.2.3 Assign Values
Use CIBSE A3 values for admittance, U-value etc. of construction or use THERMALFACTORS as described in 4.2.

7.5.2.4 Rationale
See 4.2, 7.4

7.5.2.5 Reference
See 7.4, 4.2. See PAM BRE0002 for details of the specification of surface coefficients in THERMALFACTORS.

7.5.2.6 Quality Assurance
See BRE0002

7.5.2.7 Further Information
None

7.6 CONSTRUCTION (INTERNAL ELEMENTS)

7.6.1 Walls

7.6.1.1 Description
Internal walls bounding the zone, internal walls within the zone and furniture within the zone.

7.6.1.2 Parameter Definition List

U-value	W/m^2°C
Internal Admittance	W/m^2°C

These values are specified for each of the four walls, the floor and the roof of the zone.

7.6.1.3 Assign Values
If internal walls are part of boundary to the zone being modelled by BREADMIT, they should be described as in 7.5 above, but with the U value set to 0 and the internal admittance value calculated using THERMALFACTORS or chosen from the CIBSE Guide. If the internal walls are within the zone being modelled by BREADMIT, their admittance should be calculated as:

YA = (Total 2-sided surface area) x (Internal admittance)

and this should be included in the total zone admittance e.g. by adding in an amount:

YA/(Floor area)

to the value of admittance used for the floor. This will have the effect of ensuring that the total sum of (area x admittance) for the zone is correct.

In the case of a non-symmetrical object or wall within the zone the sum of the internal admittances from each side should be added and multiplied by the single-sided area of the object or wall.

7.6.1.4 Rationale
The above method gives a good approximation to how the thermal mass of the three types of element affects the temperature in the zone. All objects in a zone certainly add to its thermal mass and affect the time constant of the zone. An internal wall within the zone is modelled as two internal walls to other zones with the same temperature profile, which justifies adding in its area-weighted internal admittance from both directions.

7.6.1.5 Reference
CIBSE Guide A3.20

7.6.1.6 Quality Assurance
Compare with CIBSE values for similar construction. Data for furniture is not readily available but may be approximated by treating an item of furniture as a layer structure, ignoring extraneous details.

7.6.1.7 Other information
Assumption of U-value being zero is valid as long as differences between zone temperature and temperature of neighbouring zones are small.

7.6.2 Floors

7.6.2.1 Description
A horizontal constructional element either within the zone being modelled or as the lower bounding element.

7.6.2.2 Parameter definition list
If the floor is within the zone, the only parameter that is affected is the admittance of the floor at the bottom of the zone (by the standard procedure for modelling any thermal mass within the zone as described in 7.6.1.3). If it is the lower boundary of the zone, the U-value and the admittance of the floor of the zone are affected.

7.6.2.3 Assign values
If the floor is within the zone determine the internal admittance of the floor from both sides using CIBSE A3.21 or THERMALFACTORS, add them together and add this sum to the admittance used for the ground floor. If the floor is the lower bounding element of the zone then set its U-value to zero and use the internal admittance as calculated by THERMALFACTORS or as in CIBSE A3.21 for standard constructions.

7.6.2.4 Rationale
For the lower boundary the approach described gives a solution which is analytically correct to the first harmonic. The method described for an internal floor within the zone models the extra thermal mass included in the zone in a way that is analytically correct to the first harmonic.

7.6.2.5 Reference
CIBSE Guide A3

7.6.2.6 Quality assurance
Check calculations of the admittances/internal admittances with the printout of the input data.

7.6.2.7 Further information
See 7.6.1

7.6.3 Ceiling

7.6.3.1 Description
The upper bounding element of the zone which is internal to the building.

7.6.3.2 Parameter definition list
U-value W/m^2
Internal admittance W/m^2

7.6.3.3 Assign values
If the ceiling is the upper boundary of the zone, set its U-value to zero and use the internal admittance either as in CIBSE A3.21 or as calculated by THERMALFACTORS. If it is within the zone determine the internal admittance of the ceiling from both sides using CIBSE A3.21 or THERMALFACTORS, add them together and add this sum to the admittance used for the ground floor.

7.6.3.4 Rationale
The described procedure ensures that the calculation will be analytically correct to the first harmonic (i.e. for an internal temperature profile which is sinusoidal), given that the temperature profile in the room bounding the other side of the ceiling is identical.

7.6.3.5 Reference
CIBSE A3.21

7.6.3.6 Quality assurance
Check printout for errors in input parameters

7.6.3.7 Further information
For ceilings connecting to an external roof, see 7.4.4.

7.6.4 Ceiling (suspended, with zone above)

7.6.4.1 Description
Case (1) Any ceiling which allows free airflow between it and the upper construction element of the room is treated as internal mass in the zone.
Case (2) A suspended ceiling around which there is partial air flow is treated as an additional layer in the description of the upper bounding construction element of the zone.

7.6.4.2 Parameter definition list
(1) Admittance of floor
(2) Admittance and U-value for roof.

7.6.4.3 Assign values
(1) Add into the admittance of the floor an amount equal to: Area of ceiling • (admittance of suspended ceiling from above + admittance of suspended ceiling from below)

(2) Include ceiling as a layer in the description of the roof to THERMALFACTORS and add an air layer with a resistance appropriate to a partially ventilated gap (0.3 m^{2}K/W).

7.6.4.4 Rationale
(1) The above procedure ensures that the thermal mass of the suspended ceiling is accounted for by the additional admittance in the floor.

(2) The method used is the most appropriate given the limitations of one-dimensional modelling using the admittance procedure. The value chosen is from CIBSE Table A3.19.

7.6.4.5 Reference

(1) CIBSE A3-8, paragraph "effect of airspace ventilation".
(2) CIBSE Table A3.19 and as in (1)

7.6.4.6 Quality assurance

Compare results of THERMALFACTORS with those from A3.21 for a similar construction.

7.6.4.7 Further information

(1) The above method gives analytically correct results for sinusoidal internal temperature profiles, given perfect mixing of the air in the zone.

(2) Little information is available on the appropriate values to use for the resistance of the ventilated air gap.

7.6.5 Carpets (if not part of the floor)

7.6.5.1 Description

Carpets are modelled as part of the floor in HEATCOOL, either as a layer in THERMALFACTORS or implicitly in the values of admittance and U-value that are given in A3.21.

7.6.5.2 Parameter definition list

Specific heat capacity, density, thermal conductivity and thickness are required by THERMALFACTORS.

7.6.5.3 Assign values

Use values in CIBSE A3.22 (page A3-22) for THERMALFACTORS or use A3.21 for HEATCOOL.

7.6.5.4 Rationale

Standard admittance procedure approach which gives result which is accurate to the first harmonic.

7.6.5.5 Reference

CIBSE A3

7.6.5.6 Quality assurance

If carpet is modelled explicitly using THERMALFACTORS, compare values of admittance and U-value used in HEATCOOL with those in CIBSE A3.21 for the most similar construction.

7.6.5.7 Further information

Carpets have a comparatively high resistance, but little thermal mass, so therefore affect the admittance quite considerably and should not be ignored.

7.6.6 Furniture

7.6.6.1 Description

Any inanimate physical objects within the zone other than internal walls, floors and ceilings. These are modelled in an approximate manner by adding an appropriate amount of admittance to the floor of the zone.

7.6.6.2 Parameter definition list

Admittance or internal admittance of floor of zone (depending on whether it is internal or external).

7.6.6.3 Assign values

View each of the items of furniture as a layer structure in the most appropriate way and calculate its admittance using THERMALFACTORS. See 4.2 of this PAM for information on the use of THERMALFACTORS. Multiply each of these values by the two-sided area of the object and divide the sum of these by the area of the floor. Add this value to the value of admittance or internal admittance used for the floor.

7.6.6.4 Rationale
The above method fits in well with the philosophy of the admittance procedure and, barring the difficulty of geometrically approximating such complicated objects as items of furniture, the method gives an analytically correct solution to the temperature profile within the zone to the first harmonic.

7.6.6.5 Reference
CIBSE Guide A3

7.6.6.6 Quality assurance
Check calculation of the artificial admittance value used for the floor and check the printout of the input data to see if any error has been made. Check consistency with correction used in 7.6.1

7.6.6.7 Further information
Data is lacking on the best values of area-weighted admittance to use for typical items of furniture. Empirical data, rather than calculated data, would be best because of the difficulties of the geometric modelling.

7.6.7 Curtains (if not part of window properties or internal shading devices)

7.6.7.1 Description
Any internal device that shades the window and/or increases the thermal resistance of the window.

7.6.7.2 Parameter definition list
Solar gain factor, alternating solar gain factor for each window. (See 5.1.5.2 for definitions)
U-value for each window in W/m^2K, the parameter determining steady state conduction of heat through the window under actual conditions in the building.

7.6.7.3 Assign values
Determine the proportion that the curtains shade solar radiation through the window during the day and reduce both the solar gain factor and the alternating solar gain factor by this amount. If the curtains are closed during the day, add 0.18 m^2K/W to the resistance of the glazing to account for the extra air-gap resistance.

7.6.7.4 Rationale
The above procedure is a modification to the standard admittance procedure that takes into account the important factors of the reduction of solar gain and the extra thermal resistance caused by the air trapped within the window space.

7.6.7.5 Reference
None available

7.6.7.6 Quality assurance
Check solar gain factor, alternating solar gain factor and glazing U-value calculated as above against the values in the printout of the input data. Check consistency with the corrections to the solar parameters used in 7.3.

7.6.7.7 Further information
Using BREADMIT, only fixed values of the parameters specified for windows are allowed, therefore curtains that are open during the day and closed at night cannot be accurately modelled. For the purposes of overheating risk assessment, the solar gain during the day is more important than the reduction in U-value caused by the curtains during the night, hence the choice of method described above.

7.7 SURFACE PROPERTIES (INTERNAL ELEMENTS)

7.7.1 Solar absorptivity

Not explicitly modelled. A value for internal solar absorptivity is built into the calculation of solar gain factors, separate values being given for light and heavy buildings.

7.7.1.1 Description
The absorption of solar radiation by the internal surfaces of the zone.

7.7.1.2 Parameter definition list
Solar gain factors for windows
Alternating solar gain factors for windows

7.7.1.3 Assign values
Use table A8.2 in the CIBSE Guide, or A5.3 and A5.4 if necessary. This takes into account typical zone geometries and an artificial value of solar absorptivity as described below. Typical proportions of the incoming radiation are assumed to fall on each of the internal surfaces.[Direct radiation - 91% on floor; Diffuse radiation - 37% on floor;
Ground reflected radiation - 0% on floor. In each case the balance is distributed among the other surfaces according to area].

7.7.1.4 Rationale
BREADMIT has no explicit way to model the solar absorptivities of internal surfaces. The assumption in the algorithm used to calculate the solar gain factors in A5 and A8 is that there is no short-wave radiation retransmitted through the window after one or more reflections. (In practice this leads to a small overestimation of the energy gained by the room - typically a few per cent of the short-wave radiation that passes through the glass will be re-emitted). Implicitly the absorptivity of the surfaces to short-wave radiation is assumed to be 1, since all the solar radiation falling on each surface is assumed to heat that surface. Although this does not correspond well to the typical values of solar absorptivities of 0.5 to 0.8., since almost all of the radiation is absorbed eventually by some surface or the air, this does not matter as much as it would at first appear.

7.7.1.5 Reference
(1) R.H.L. Jones - "Solar radiation through windows - theory and equations", B.S.E.R.T. Vol. 1 No. 2 (1980).
(2) CIBSE Guide A5, A8.

7.7.1.6 Quality assurance
As the values of solar gain and alternating solar gain factors are likely to be subject to uncertainty, do separate runs for various solar gain and alternating solar gain factors to see how much affect they have on the overheating risk assessment.

7.7.1.7 Further information
None available.

7.7.2 Long-wave emissivity

7.7.2.1 Description
The emission of infrared radiation by the internal surfaces is not explicitly modelled, but is taken into account in the choice of internal surface coefficients of the walls, floor and roof. A value of 0.9 is assumed by the program for the long-wave emissivity of each of the internal surfaces in the standard surface coefficients.

7.7.2.2 Parameter definition list

Internal surface coefficients of walls, floor and roof as input into THERMALFACTORS. If the CIBSE Guide is used instead of THERMALFACTORS then the values include the assumption of a typical long-wave emissivity of 0.5 or 0.9 of high or low emissivity respectively for each of the internal surfaces.

7.7.2.3 Assign values
See 4.2 and 7.4

7.7.2.4 Rationale
Values chosen as in 7.7.2.3 take into account typical room geometries and long-wave emissivity.

7.7.2.5 Reference
CIBSE A3.5, A3.6

7.7.2.6 Quality assurance
When using THERMALFACTORS, check that surface coefficients have been correctly entered by comparing with printout of input data.

7.7.2.7 Further information
None

7.8 WINDOW PROPERTIES

7.8.1 Vertical glazing

7.8.1.1 Description
All glazed areas in a given wall are amalgamated together to give the area that is glazed in that surface. These are all assumed to have the same (or average) properties.

7.8.1.2 Parameter definition list

Percentage of wall area glazed	%
U-value	$W/m^2/K$
Mean solar gain factor	Dimensionless
Alternating solar gain factor	Dimensionless
Lag on alternating solar gain factor	(integer hours)

7.8.1.3 Assign values
U-values for glazing can be found in Table A3.14 in CIBSE Guide A3, where above parameters are also defined. Solar gain factors can be found from Table A5.3, A5.4 in Section A5. or from A8.2.

7.8.1.4 Rationale
Properties of typical windows, such as thickness and conductance, vary little, so CIBSE values are adequate. Use of table A3.14 takes into account the conductance through the window frame and thus avoids having to account for this in the modelling of the wall.

7.8.1.5 Reference
CIBSE Guide A3 (1986)

7.8.1.6 Quality Assurance
Compare values with CIBSE tables. Range is checked for window area as a proportion of the wall area.

7.8.1.7 Further Information
Data for new types of glazing such as argon-filled double glazing are not in the CIBSE Guide. However this may be derived from manufacturer's data sheets. There is some uncertainty as to

whether the treatment of glazing area for the purposes of conduction and solar gain is completely consistent. An attempt is being made to resolve this difficulty. The CIBSE data applies to vertical glazing only (but see next section for details of how the data may be adjusted for horizontal glazing).

7.8.2 Horizontal glazing

7.8.2.1 Description

All glazed areas in the roof are amalgamated together to give the area that is glazed in that surface. These are all assumed to have the same (or average) properties.

7.8.2.2 Parameter definition list

Percentage of roof area glazed	%
U-value	$W/m^2/K$
Mean solar gain factor	Dimensionless
Alternating solar gain factor	Dimensionless
Lag on alternating solar gain factor (integer hours)	

7.8.2.3 Assign values

Use values for solar parameters from CIBSE Guide tables A5.3, A5.4 or from A8.2. Take U-values from table A3.14 of the Guide and correct the U-value from those given for a horizontal element to appropriate values for a vertical element as follows:

Replace the U-value U by the value $1/(1/U + \delta)$, where δ is defined by the following table:

	Sheltered	Normal	Exposed
High emissivity	-0.01	-0.02	-0.01
Low emissivity	0.06	0.03	0.07

7.8.2.4 Rationale

Physical properties of typical windows, such as thickness and conductance, vary little, so CIBSE values suffice. Use of table A3.14 takes into account the conductance through the window frame and thus avoids having to account for this in the modelling of the wall. The correction factors above were calculated by comparing the internal and external surface coefficients for vertical and horizontal elements from tables A3.5 and A3.6 of the CIBSE Guide for each of the six cases and combining the calculated corrections into a single adjustment.

7.8.2.5 Reference

CIBSE Guide A3 (1986). U-values for vertical glazing can be found in Table A3.14 in CIBSE Guide A3, where above parameters are also defined. Solar gain factors can be found from Table A5.3, A5.4 in Section A5, or from A8.2.

7.8.2.6 Quality Assurance

Check values for errors of calculation. Range is automatically checked for window area as a proportion of the wall area.

7.8.2.7 Further Information

Data for new types of glazing such as argon-filled double glazing are not in the CIBSE Guide. However this may be derived from manufacturer's data sheets. The CIBSE data does not distinguish between horizontal and vertical glazing which can lead to errors for conduction if the glazing is not vertical and the U-value for horizontal glazing is used. The correction suggested in 7.8.2.3 takes into account this difference.

SECTION 8.0 - BUILDING OPERATION DESCRIPTION

8.1 VENTILATION

8.1.1 Adventitious

8.1.1.1 Description

User provides 2 values of air change rate, which can be the same, together with changeover times so that there are 2 fixed values of infiltration/ventilation internal-external air exchange which are repeated every day. If any altitude correction is needed this must be done manually by the user before inputting his data. The air change rate at the internal temperature is used.

8.1.1.2 Parameter Definition List:

"Daytime" ventilation rate	air changes per hour in ac/h
"Night-time" ventilation rate	air changes per hour in ac/h
Time of change to "daytime" rate	hour (integer from 1 to 23)
Time of change to "night-time" rate	hour (integer from 1 to 23)

Note that time of change to "night" rate must be greater than time of change to "day" rate.

8.1.1.3 Assign Values

Use CIBSE A4.4 and A4.5 for openable windows. Apply Fig. A4.3. An altitude correction may be included to correct for the lower density of air at high altitudes, if greater accuracy is required. If the calculations in A4.4 and A4.5 are infeasible, apply table A8.4 of the Guide instead.

8.1.1.4 Rationale

Ventilation as a thermal process does not distinguish between adventitious and user-defined ventilation, so these can be amalgamated by the user of the program.

8.1.1.5 Reference

CIBSE Guide A4 and A5

8.1.1.6 Quality Assurance

Check values calculated as above to see if they are of the right order.

8.1.1.7 Further Information

Adventitious and occupant defined ventilation are combined in BREADMIT.
Hence 8.1.1 to 8.1.4 must be combined to derive the required parameters.

8.1.2 Occupant Defined for Air Quality Control

8.1.2.1 Description

User provides 2 values of air change rate, possibly identical, together with timing information so that there are 2 fixed values of infiltration/ventilation internal-external air exchange which is repeated every day. If any altitude correction is needed this must be done manually by the user before inputting his data. The air change rate at the internal temperature is used.

8.1.2.2 Parameter Definition List

"Daytime" ventilation rate	air changes per hour in ac/h
"Night-time" ventilation rate	air changes per hour in ac/h
Time of change to "daytime" rate	hour (integer from 1 to 23)
Time of change to "night-time" rate	hour (integer from 1 to 23)

Note that time of change to "night" rate must be greater than time of change to "day" rate.

8.1.2.3 Assign Values

Use CIBSE A4.4 and A4.5 for openable windows. Apply figure A4.3. Ensure that ventilation rates are always at least 0.2 air changes per hour so as to attain minimum ventilation requirements. An altitude correction may be included to correct for the lower density of air at high altitudes, if greater accuracy is required. If the calculations in A4.4 and A4.5 are infeasible, apply table A8.4 of the Guide instead.

8.1.2.4 Rationale
Ventilation as a thermal process does not distinguish between adventitious and user-defined ventilation, so these can be amalgamated by the user of the program.

8.1.2.5 Reference
CIBSE Guide A4 and A5

8.1.2.6 Quality Assurance
Check values calculated as above to see if they are of the right order. If there is heavy occupancy, check that minimum ventilation requirement per occupant is attained.

8.1.2.7 Further Information
Adventitious and occupant-defined ventilation are combined in BREADMIT, so sections 8.1.1 to 8.1.4 must be combined to derive the required parameters.

8.1.3 Occupant Defined for Air Temperature Control

BREADMIT has no direct way of modelling the response of the ventilation system to thermal conditions: it only allows the use of a rigidly time scheduled combined ventilation and infiltration rate. However, the user of the program can experiment with different rates to see how they affect the temperature profile for the given day.

8.1.3.1 Description
The response of the ventilation system to the air (or other) temperature within the building by a mechanical, electrical or electronic control system. This can include the response of the occupants of the building to the changing temperature conditions by the opening of windows and doors or the turning on of fans and other mechanical ventilation systems.

8.1.3.2 Parameter Definition List:

Daytime ventilation rate	air changes per hour in ac/h
Night-time ventilation rate	air changes per hour in ac/h
Time of change to "daytime" rate	hour (integer from 1 to 23)
Time of change to "night-time" rate	hour (integer from 1 to 23)

Note that time of change to "night-time" rate must be greater than time of change to "daytime" rate.

8.1.3.3 Assign Values
Set values as in 8.1.1 and 8.1.2. If it is found that overheating occurs then additional runs may be performed with longer periods of window opening to see if this reduces the overheating risk. In particular it is worth checking the case with all windows open 24 hours a day as an extreme example.

8.1.3.4 Rationale
If the occupants of the building are aware of overheating in the building, they are likely to respond by manually increasing the ventilation rate. However, on occasion such a response will only occur when a state of overheating has already bean reached.

8.1.3.5 Reference
CIBSE Guide A4 and A5

8.1.3.6 Quality Assurance

Check values calculated as above to see if they are of the right order and reach the required minimum ventilation rates for the building.

8.1.3.7 Further Information

Adventitious and occupant defined ventilation are combined in BREADMIT, so 8.1.1 to 8.1.4 must be combined to derive the required parameters.

8.1.4 Ventilation time schedules

BREADMIT uses two ventilation rates one for the day and one for the night together with their changeover times.

8.1.4.1 Description

The times of changeover between the night-time ventilation rate and the daytime ventilation rate.

8.1.4.2 Parameter Definition List:

Time of change to "day" rate	hour (integer from 1 to 23)
Time of change to "night" rate	hour (integer from 1 to 23)

Note that time of change to "night" rate must be greater than time of change to "day" rate.

8.1.4.3 Assign Values

See 8.1 and 8.2. If the case with all windows open 24 hours a day is modelled and the variation of the wind speed is not taken into account then the values above can be set to the defaults of 1 and 2 respectively.

8.1.4.4 Rationale

If the occupants of the building are aware of overheating in the building, they are likely to respond by manually increasing the ventilation rate. However, on occasion such a response will only occur when a state of overheating has already been reached.

8.1.4.5 Reference

CIBSE Guide A4 and A5

8.1.4.6 Quality Assurance

See QA in section 8.1.1 to 8.1.3

8.1.4.7 Further Information

Adventitious and occupant defined ventilation are combined in BREADMIT, so 8.1.1 to 8.1.4 must be taken into account to derive the required parameters.

8.2 ENVIRONMENTAL CONTROL (SPACE CONDITIONS)

8.2.1 Parameters

Ventilation schedule and plant control regime.

8.2.1.1 Description

The daytime and night-time ventilation rates and the times of changeover.
The set points and timing of the heating or cooling plant and its capacity.

8.2.1.2 Parameter definition list

Daytime ventilation rate	(air changes per hour)
Night-time ventilation rate	(air changes per hour)

Time of changeover to daytime rate	(integer hour form 1 to 23)
Time of changeover to night-time rate must be	(integer hour from 1 to 23, greater than the time of changeover to daytime rate)
The number of on periods of the plant	(integer hour from 1 to 12)
Times of start and finish of each period of heating/cooling	(integer hour from 1 to 23)
Internal temperature for each period of heating/cooling	(degrees centigrade)
Plant capacity (indicates if the plant is a heater or a cooling plant)	(kilowatts)

8.2.1.3 Assign Values
See Assign Values in sections 8.1.

8.2.1.4 Rationale
See Rationale in sections 8.1.

8.2.1.5 Reference
TBC

8.2.1.6 Quality Assurance
TBC

8.2.1.7 Further Information
TBC

8.2.2 Time Schedules

Time schedules in BREADMIT are represented as a set of increasing numbers each corresponding to an integer hour from 1 to 24.

8.2.2.1 Description
The times at which casual gain levels, ventilation rates and plant control information change.

8.2.2.2 Parameter Definition List

Time of changeover to night-time ventilation rate	(integer hours)
Time of changeover to daytime ventilation rate	(integer hours)
The number of on periods of the plant	(integer from 1 to 12)
Times of start and finish of each period of heating/cooling	(integer hour from 1 to 23)
The number of periods of casual gain	(integer from 1 to 24)
The start of each period of casual gain	(integer hour from 1 to 24)

8.2.2.3 Assign Values
See Assign Values in sections 8.1, 9 and 10.

8.2.2.4 Rationale
The rationale behind the choosing of ventilation, casual gain and plant control schedules is explained in sections 8.1, 9 and 10.

8.2.2.5 Reference
CIBSE guide volume A.

8.2.2.6 Quality Assurance
See QA in sections 8.1, 9 and 10.

8.2.2.7 Further information

The time of change to the night-time ventilation rate must be greater than the time of change to the daytime ventilation rate. The time of start of periods of casual gain must increase sequentially. The times of start and end of the on periods of the heating/cooling plant must also increase sequentially.

8.3 OCCUPANCY

The modelling of the heat gain due to the occupants of the building.

8.3.1 Heat gain

8.3.1.1 Description

That part of the total casual gain which is due to the occupants of the building.

8.3.1.2 Parameter Definition List

Number of periods of casual gain (1-24)
Value of total casual gain for each period in kW

8.3.1.3 Assign Values

If specific occupancy data for the building is not available then apply tables A7.1 and A7.2 of the Guide, estimating the time scheduling and density of occupants from knowledge about the projected use of the building. (e.g.- 0.125 persons/m^2., 8-5 for an open plan office)

8.3.1.4 Rationale

The prescribed method accounts well for the contribution of the occupants to the total casual gain in the zone under analysis.

8.3.1.5 Reference

Section A7 of the CIBSE Guide.

8.3.1.6 Quality Assurance

The data described is empirically based so should be reliable.

8.3.2 Occupancy Profile

8.3.2.1 Description

The number of occupants in each zone of the building as a function of time.

8.3.2.2 Parameter Definition List

Number of periods of casual gain (1-24)
Value of total casual gain for each period in kW

8.3.2.3 Assign Values

If specific occupancy data for the building is not available then apply tables A7.1 and A7.2 of the Guide, estimating the time scheduling and density of occupants from knowledge about the projected use of the building. (e.g.- 0.125 persons/m^2., 8a.m. to 5p.m. for a modern open plan office). Where in doubt, assume the maximum possible occupancy.

8.3.2.4 Rationale

The specific heat emissions for human occupants under various circumstances are well known. Occupancy patterns and densities for commercial and light industrial buildings should be fairly accurately specified by the projected use of the building. More uncertainty is likely in the case of residential buildings.

8.3.2.5 Reference

Section A7 of the CIBSE Guide.

8.3.2.6 Quality Assurance
The level of uncertainty in the specification of the casual gain levels due to occupancy can be comparatively high due to lack of knowledge about the movement of occupants around the building.

8.3.2.7 Further Information
--

8.4 EQUIPMENT
This section deals with all equipment that creates a net heat input to some part of the building being modelled, except those which are modelled in sections 9 and 10.

8.4.1 Heat Gain

8.4.1.1 Description
Sensible and latent heat gains. May include negative heat gains due to absorption of latent heat or net heat transfer out of a modelled zone.

8.4.1.2 Parameter Definition List

The number of periods of casual gain	(integer from 1 to 24)
The start of each period of casual gain	(integer hour from 1 to 24)
Value of total casual gain in each zone for each scheduled period	(in kW)
Proportion of casual gain that is radiant	(%)

8.4.1.3 Assign Values
Create casual gain profile for each type of equipment separately, then amalgamate them to get a single schedule for each zone. It is best to use specific data for each piece of equipment, if available, rather than use standard values. Some useful data is to be found in CIBSE tables A7.7, A7.10, A7.11 and A7.12, but tables A7.8 and A7.9 should be ignored as they are out of date. For lighting simply multiply the rated wattage of the bulbs used by the number of bulbs in the zone, for the lit period. To determine the proportion of the casual gain that is radiant, add together the total radiant gains from all sources for the 24 hours and divide by the total casual gain (both radiant and convective). For example, fluorescent lights are almost 100% radiant, whereas low temperature equipment gives almost all convective gains.

8.4.1.4 Rationale
Casual gains are well modelled as an instantaneous heat gain, split between the surfaces of the zone and the air node.

8.4.1.5 Reference
CIBSE A7

8.4.1.6 Quality Assurance
Casual gains are a major contribution to the overheating risk, particularly in office buildings and small factories. It is therefore important that no sizeable source of casual gain in the studied zones are ignored.

8.4.1.7 Further Information
Moderate errors in the convective/radiant split will not lead to large errors in the predicted peak temperature under normal circumstances as most of the heat reaches the air node in any case. Longwave radiant loss through the windows is not modelled, but this will only lead to small errors under normal circumstances.

8.4.2 Equipment Gain Profile

8.4.2.1 Description
The hourly scheduled casual gains due to equipment.

8.4.2.2 Parameter Definition List

The number of periods of casual gain	(integer from 1 to 24)
The start of each period of casual gain	(integer hour from 1 to 24)
Value of total casual gain in each zone for each scheduled period	(in kW)

8.4.2.3 Assign Values

Create casual gain profile for each type of equipment separately, then amalgamate them to get a single schedule for each zone. It is best to use specific data for each piece of equipment, if available, rather than use standard values. Some useful data is to be found in CIBSE tables A7.7, A7.10, A7.11 and A7.12, but tables A7.8 and A7.9 should be ignored as they are out of date. For lighting simply multiply the rated wattage of the bulbs used by the number of bulbs in the zone, for the lit period.

8.4.2.4 Rationale

Casual gains are well modelled as an instantaneous heat gain to the zone.

8.4.2.5 Reference

CIBSE A7, A8

8.4.2.6 Quality Assurance

If there is uncertainty in the scheduling or values of casual gains from various sources, perform runs with the extreme values and see if this affects the overheating risk prediction.

8.4.2.7 Further Information

Accurate values for the casual gains are necessary for the accurate prediction of overheating risk, particularly in buildings with heavy electrical equipment. In general the exact figures for the casual gain from the equipment installed must be obtained from the manufacturer rather than use standard CIBSE data which only pertains to a limited range of type of equipment.

8.5 USER OPERATED BUILDING CONTROLS

Not modelled in this PAM.

8.5.1 Heat Gain

8.5.1.1 Description

--

8.5.1.2 Parameter Definition List

--

8.5.1.3 Assign Values

--

8.5.1.4 Rationale

--

8.5.1.5 Reference

--

8.5.1.6 Quality Assurance

--

8.5.1.7 Further Information

–

8.5.2 Time Schedules

8.5.2.1 Description

–

8.5.2.2 Parameter Definition List

–

8.5.2.3 Assign Values

–

8.5.2.4 Rationale

–

8.5.2.5 Reference

–

8.5.2.6 Quality Assurance

–

8.5.2.7 Further Information

–

SECTION 9.0 - PLANT DESCRIPTION

To be completed.

SECTION 10.0 - PLANT CONTROL DESCRIPTION

To be completed.

Appendix A: a summary of QA procedures for overheating risk assessment with BRE0001/BRE0002

This section summarises some QA procedures that are useful in order to successfully predict overheating risk using the BRE-ADMIT suite of programs.

1 General QA

1a: all input data should be checked against the data in the output file to detect any inconsistency

1b: wherever there is uncertainty in the input data, runs should be performed for the extreme cases to determine if the errors are of significance to the assessment.

1c: wherever calculated values are used (eg for material properties and ventilation rates) these should be compared with typical values from CIBSE Guide or elsewhere.

2 Specific QA

2.1 Constructions

2.1a: Check that all internal elements have their U-value set to 0 (a nominal value), and that external elements have their values set to appropriate U-values atking into account the surface coefficients. 2.1b: Check that the value of the admittances used are those for an internal or external element as appropriate.

2.1c: Make sure the order of the layers is correct (i.e. the appropriate layer is adjacent to the zone). In particular, if an assymmetric construction occurs more than once in two different orientations, check that the correct order of elements is used for each.

2.1d: Where a construction is explicitly modelled, the calculated values of the thermal parameters should be compared against those for a similar construction in the Guide.

2.1e: In TF check that the signs of lags on the thermal parameters are correct.

2.1f: When transfering information to HEATCOOL, check that appropriate values of the internal and external surface coefficients have been used when calculating the thermal parameters.

2.1g: When using TF, check that the order of layers is appropriate to the location in the modelled zone.

2.1h Take the exposure of the site into account when choosing the surface coefficients.

2.1i Take the likely ground reflectance of the site, the site exposure and shading into account as described in BRE0002 when choosing the external surface coefficient of an external element.

2.1j When making manual calculations always check them for errors.

2.2 Weather data

It is useful to do runs using the k_d and k_D for more than one degree of risk and compare the results. This gives a more accurate assessment of the degree of risk of overheating.

2.3 Location

Values of latitude accurate to less than one degree are adequate.

2.4 Computational parameters

In BRE0002 the value C of the number of cycles per day must be set to 1.

2.5 Surface coefficients

Make sure that all surface coefficients used are appropriate to the orientation, externality and exposure of the surface concerned.

2.6 Ventilation rates

2.6.1 As this is a common area of uncertainty, the choice of ventilation rate requires parametric excursions, to determine the dependance of the predicted degree of overheating risk on variation of the ventilation rate.

2.6.2 If a high degree of accuracy is required, a manual calculation should be performed to determine the ventilation through windows as described above.

2.7 Shading factors

This is an area of considerable uncertainty. As the method used to represent shading is very ad hoc, there is inevitably a high degree of uncertainty here. The most useful QA procedure here is to do several runs with different values of the shading parameters and see how it affects the results.

2.8 Choice of zone

If in doubt about which zones to model for overheating risk assessment, do as many as possible.

2.9 Furniture

Where some knowledge of the furniture in a zone exists it is worth attempting to model it using the method described in section 7.6.1 of BRE0001.

2.10 Solar coefficients

Solar coefficients require parametric variation to determine the effect of any uncertainty in them.

2.11 Glazing

2.11a: Area of glazing (expressed as a precentage of wall) should be the gross (not nett) area, as this assumption is made in the standard U-values and solar gain factors.

2.11b: It is important to use an appropriate correction for the U-values for horizontal glazing.

2.12 Occupancy

Make sure that all sources of casual gain are taken into account. As casual gains are prone to uncertainty and an important factor in overheating risk it is particularly useful here to determine the effects of different casual gains profiles.

2.13 Outputs

As a simple QA check to avoid misreading results, the tabular results and the results from the graph should be compared.

EXAMPLE PAMDOC 2

OVERHEATING RISK ASSESSMENT

FOR OFFICES

IEA21RN271/92
This document supersedes IEA21RN144/91

PERFORMANCE ASSESSMENT METHOD

OVERHEATING RISK ASSESSMENT IN OFFICES

School of Architecture
University of Newcastle upon Tyne
NE1 7RU

CONTENTS

0.0 PAM IDENTIFICATION

Identifier	:	NU002V6-Com.
Purpose	:	Overheating Risk Assessment
Application	:	Non-residential : Offices
Program	:	SERI-RES, PC. Version 1.2
Date	:	2-9-93

Author s	:	Wiltshire, T.J., Warren, B.F., Sodagar, B.
Address of Author s	:	School of Architecture University of Newcastle upon Tyne NE1 7RU Tel : 091 222 6012 Fax : 091 261 1182 Telex : 53654 UNINEW G

1.0 DEFINITION OF PERFORMANCE ASSESSMENT METHOD

1.1 Purpose

1.1.1 Purpose

Overheating Risk Assessment

1.2 Applicability

1.2.1 Building Type

Non-residential: Offices

1.2.2 Environmental Control System

Natural ventilation
Mechanical ventilation
Mechanical cooling

1.2.3 Climatic Zone

Temperate

1.2.4 Program

SERI-RES , PC Version.1.2

1.2.5 Resources

IBM compatible 386 PC

1.2.6 Further Information

This document is for use with small offices that would normally be considered as single zones. Large offices in which there might be a temperature difference between the core and perimeter spaces, or in offices which are high enough toproduce vertical temperature differences, and/or the operating conditions are such to produce a non-uniform environment, would have to be split into several zones (See 7.1.3 for zone definition). In the absence of further information it is suggested that if a space is larger than 6m x 6m, it can no longer be treated as a single zone.

2.0 PROCEDURE

2.1 Procedure

2.1.1 Define information required

as set out in 3.1

2.1.2 Configure Program

Select programme version set out in 4.1
Select sub models as set out in 4.2
Select computational parameters as set out in 4.3
Set initial conditions as set out in 4.4

2.1.3 Describe site and climate

Site as set out in Section 5.1
Climate as set out in Section 5.2

2.1.4 Describe zoning procedure to program

as set out in Section 6

2.1.5 Describe building to Program

as set out in section 7

2.1.6 Describe building operation to Program

as set out in Section8

2.1.7 Describe ventilation process

as set out in Section 8

2.1.8 Describe plant to Program

as set out on Section 9

2.1.9 Describe plant operation to Program

as set out in Section 10

2.1.10 Process output data

as set out in Section 3

2.1.11 Interpret information

as set out in Section 3

2.1.12 Quality Assurance

See QA in all other sections

3.0 INFORMATION DEFINITION

3.1 Information Required from the performance assessment

3.1.1 Description

An assesment is required of the risk of overheating taking place.

3.1.2 Results required

Name : Zone temperature
Symbol : T_Z
Units : ^oC

Definition : The uniform air temperature of the zone determined on the approximate basis of 3/8 convective heat transfer and 5/8 radiant heat transfer.

Name : Time period
Symbol : H
Units : Hours

Definition : The time step for the desired output.

Name : Overheating period
Symbol : Cool
Units : Hours

Definition : The sum of the hours above the selected value of T_Z (See Section 3.1.7)

3.1.3 Assign Values

Overheating is said to occur if the air temperature of a zone rises above a specified value. The specified value of T_Z for which overheating is said to occur is set at 27 ^oC.

The sum of consecutive time periods for which the zone temperature exceeds 27 ^oC is said to represent an overheating risk on the basis of the experience of the user or other information to which the user has access. (See Section 3.4)

3.1.4 Rationale

Zone temperature : 27 ^oC is the temperature above which people are generally judged to be uncomfortable.

Time period : Hours are judged to be suitably small time steps.

3.1.5 Reference

CIBSE GUIDE, Section A8, The Chartered Institution of Building Services Engineers, London, 1986.

3.1.6 Quality Assurance

Check activity and air velocity if possible.

3.1.7 Further Information

The figure of 27 ^{o}C is assumed to apply when people are normally clothed doing sedentary work and under conditions of low air velocity.

The sum of consecutive time periods for which the zone temperature exceeds 27 ^{o}C is calculated by assuming a cooling system of negligible capacity (0.001 KW) to prevent the zone air temperature rising above 27 ^{o}C. As the capacity of the system is too small to have any effect, the total hours of operation of equipment represent the number of hours in which the air temperature of the zone rises above 27 ^{o}C.

3.2 POST PROCESSING OF OUTPUT

3.2.1 Description

For selected zone(s) the number of hours in the year when the zone temperature is above 27 ^{o}C is required.

3.2.2 Program output variable list

As 3.1.2

3.2.3 Process Outputs

None

3.2.4 Rationale

N/A

3.2.5 Reference

N/A

3.2.6 QualityAssurance

N/A

3.2.7 Further Information

None

3.3 FORM OF PRESENTATION

3.3.1 Description

Results are generally presented in tabular and graphical forms.

3.3.2 Presentation

Tables:

Column 1:	Column 2:
Name : Room (Heading)	Number of hours zone temperature greater than 27 °C
Symbol : None	None
Units : N/A	Hours
Definition : Name(s) of zone(s)	as name

Graphs

X - axis :	Y - axis :
Name : Hours	Deg C
Symbol : None	None
Units : Time	Deg C
Definition : The hours 0 - 24 for a selected day.	The zone temperature hour by hour for a selected day day.

3.3.3 Assign Values

Tables :
Column 1 :The number of zones may be each modelled zone or selected zones as required.
Column 2 : Whole numbers of hours

Graphs:
X - axis :The hours 0 to 24 with major intervals of one hour.
Y - axis : Range to accomodate minimum ambient temperature and maximum zone temperature with a major interval of 1 deg C.

3.3.4 Rationale

Is considered to provide the appropriate information.

3.3.5 Reference

N/A

3.3.6 Quality Assurance

N/A

3.3.7 Further Information

The tables and graphs are produced from the SERI-RES output using a separate spreadsheet and plotting package.

3.4 INFORMATION INTERPRETATION

3.4.1 Description

The results are interpreted with respect to specified criteria.

3.4.2 Interpretation

If the zone temperature exceeds a given value for more than a particular period of time the zone is said to overheat.

3.4.3 Assign Values

The limiting zone temperature is 27 ^{o}C.
The time period for which the zone temperature exceeds 27 ^{o}C is a matter of judgement on the part of the user. If not specified it may be taken as 50 hours (See also Section 3.4.7).

3.4.4 Rationale

See Section 3.1.4

3.4.5 Reference

CIBSE GUIDE, Section A8.

3.4.6 Quality Assurance

None

3.4.7 Further Information

The values given in 3.4.3 are generally accepted but values other than 27 ^{o}C and 50 hours may be used if specific requirements have to be achieved.

4.0 PROGRAM CONFIGURATION

4.1 Program Version

4.1.1 Title

SERI-RES

4.1.2 Program Author

The Solar Energy Research Institute - USA

4.1.3 Vendor

The Energy Technology Support Unit (ETSU) of the Department of Energy

4.1.4 Version Number

PC Version 1.2

4.1.5 Date of Release

November 1987

4.1.6 Quality Assurance

4.1.6.1 Installation of simulation code on computer

This may involve compilation of the code on the new machine. It is well worth checking that the new installation functions correctly, since it will subsequently be used many times. The most obvious way to test it is to run a simulation which has previously been carried out on a system known to be sound. If example files are provided by the program they should be run first to check the installation functions correctly. The files EXAM.B, EXAM.R and EXAM.S are provided by SERI-RES in order to verify correct installation and operation.

It is vital to ensure that potential users of program are familiar with limitations arising from shortcoming in the code, for example any bugs in the program.

4.1.6.2 Installation of MET data files

It is vital to ensure that the type of MET file installed is suited for use with the program. The principal items to check are:

- that individual variables are read correctly, that is they are in the right positions within the file and in the right units, and
- that timing conventions are being correctly observed.

These requirements can be quickly checked by using the model to regenerate the climate data which has been read, and checking the values obtained with known correct results.

4.1.7 Further Information

4.1.7.1 Installation of presentation packages

If a utility is used to extract or format the outputs of simulations, the reliability of such a utility must have been proven. This may be checked by generating limited quantities of formatted (or person readable) data which is compared with the more comprehensive data in the processed unformatted output file.

If presentation packages are used for presentation of data, their soundness must also have been checked. The checks may be carried out for example by comparing the total, average, maximum and minimum values generated by the presentation tool against the formatted values. When graphs are produced, checks on individual points can be used to establish that the quantity being plotted and its scaling are as intended.

4.2 USER SUB MODEL SELECTION

4.2.1 No sub models in SERI-RES

4.2.1.1 Description

N/A

4.2.1.2 **Sub Model : Name**

N/A

4.2.1.3 **Select Sub Model Method**

N/A

4.2.1.4 **Rationale**

N/A

4.2.1.5 **Reference**

N/A

4.2.1.6 **Quality Assurance**

N/A

4.2.1.7 **Further Information**

N/A

4.3 USER SELECTED COMPUTATIONAL PARAMETERS

4.3.1 Computational Parameter 1

4.3.1.1 Description

Each opaque construction layer may have a user specified number of nodes at which conditions are calculated .

4.3.1.2 **Computational Parameter Definition List**

Name : Number of Nodes
Symbol : Nodes
Units : Dimensionless, integer

4.3.1.3 **Assign Values**

The SERI-RES default value is 1. It is proven the number of nodes may have considerable effects on the calculated results.

A relaxed version of the method proposed by Waters and Wright may be suggested as the criterion for the distribution of number of nodes between different layers of construction.

The Waters and Wright method is as follows:

A ratio B (s^{-1}) is calculated for each layer of all building components

$$B_x = a_x / d_x^2$$

Where d_x = thickness of layer x (m)
a_x = thermal diffusivity (m^2/s) of layer x given by:

$$a_x = k_x / p_x \, cp_x$$

Where k_x = material conductivity of layer x (W/m °C)
p_x = material density of layer x (Kg/m^3)
cp_x = material specific heat of layer x (J/Kg °C)

In the strict version of the Waters and Wright Method, the largest B value of all layers is designated B_{max} and the layer with B_{max} is given one node per layer. The number of nodes in all other layers is then determined by the following formula:

$$n = (B_{max} / B_x)^{0.5}$$

Where n = the number of nodes for layer x

As the application of the Water and Wright Method may lead to unnecessary large number of nodes requiring excessive computational time, a relaxed version of this method may be proposed. Halcrow (1991) suggest that the layer with a B Value closest to 0.25×10^{-3} be designated B_{max} and the number of nodes then be calculated using the above formula for all layers with smaller B values. For a internal layers, in a multilayer construction, with a B value less than the B_{max} value, one extra node is added to the calculated number of nodes (n). Layers with B values greater than 5×10^{-3} is recommended to be treated as pure resistance. For layers with B values between 0.25×10^{-3} and 5×10^{-3} one node per layer should be used.

This relaxed version of the Waters and Wright Method, is examined and confirmed by Dr. Wright one of the author of the original method.

Note that there must always be one node within each layer so if the calculated number of nodes in any layer is 2, so that there are nodes only on the layer boundaries, the number of nodes should be changed to either 1 or 3.

It is been reported that " above about 5 nodes per layer, rounding errors in the numerical treatment within the computer itself may become significant"(Pinney 1990). Therefore, a maximum of 5 nodes per layer is recommended.

4.3.1.4 **Rationale**

The execution time (and cost) of a simulation depends in a linear way upon the number of mass nodes used. Therefore, the user must judge the selection of the level of detail in modelling capacity elements.

4.3.1.5 **Reference**

A Review of SERI-RES Parameters, YARD, August 1990.
Waters, J.R. and Wright, A.J. Criteria for the distribution of Nodes in Multilayer WALLS in finite-difference thermal modelling. Building and Environment, Vol.20, No. 3, 1985.
Halcrow Gilbert Associates Limited, Performance assessment methodology development project, Final Report, August 1991.
Pinney, A.A. Applicability Study 1, Research Report 12, The effect of thermal node placement on the predicted energy consumption and internal temperatures in the program SERI-RES. Leicester Polytechnic, March 1990.

4.3.1.6 **Quality Assurance**

N/A

4.3.1.7 **Further Information**

None

4.3.2 Computational parameter 2

4.3.2.1 **Description**

Coefficient to multiply infiltration rate predicted by wind and temperature dependent formula, which is used whenever Infiltration Rate in ZONES Section is defaulted.

4.3.2.2 **Parameter Definition List**

Name : Infiltration Mult.
Symbol : Infil Mult
Units : Dimensionless.

4.3.2.3 **Assign Values**

Program default value =1.00

4.3.2.4 **Rationale**

As infiltration rate is usually fixed by the user, the value used is program default.

4.3.2.5 **Reference**

SERI-RES Manual Version 1.2

4.3.2.6 **Quality Assurance**

N/A

4.3.2.7 **Further Information**

None

4.3.3 Computational Parameter 3

4.3.3.1 **Description**

The maximum number of iterations allowed in calculations of zone air temperatures.

4.3.3.2 **Parameter Definition List**

Name : Maximum number of iterations for zones
Symbol : Max. Zone ,
Units : Dimensionless.

4.3.3.3 **Assign Values**

Program default value = 50

4.3.3.4 **Rationale**

Ensures convergence, i.e. prevents simulation continuing indefinitely.

4.3.3.5 **Reference**

SERI-RES Manual Version 1.2

4.3.3.6 **Quality Assurance**

N/A

4.3.3.7 **Further Information**

None

4.3.4 Computational Parameter 4

4.3.4.1 **Description**

Criterion for defining convergence for zone air temperature calculations.

4.3.4.2 **Parameter Definition List**

Name : Convergence for zone
Symbol : Zone Crit.,
Units : Deg C.

4.3.4.3 **Assign Values**

Program default value = 0.050°C

4.3.4.4 **Rationale**

Further reductions do not significantly affect the simulation results.

4.3.4.5 **Reference**

SERI-RES Manual Version 1.2

4.3.4.6 **Quality Assurance**

N/A

4.3.4.7 **Further Information**

None

4.3.5 Computational parameter 5

4.3.5.1 **Description**

Maximum number of iterations allowed in calculations of Trombe wall air gap temperatures with thermocirculation.

4.3.5.2 **Parameter Definition List**

Name : Maximum number of Iterations for Trombe Walls
Symbol : Max. Trom.
Units : Dimensionless.

4.3.5.3 **Assign Values**

Program default value = 50

4.3.5.4 **Rationale**

Ensures convergence, i.e. prevents simulation continues indefinitely.

4.3.5.5 **Reference**

SERI-RES Manual Version 1.2

4.3.5.6 **Quality Assurance**

N/A

4.3.5.7 **Further Information**

None

4.3.6 Computational Parameter 6

4.3.6.1 **Description**

Criterion for defining convergence for Trombe wall air temperature calculations.

4.3.6.2 **Parameter Definition List**

Name : Convergence for Trombe Wall
Symbol : Trom Crit,
Units : Deg C

4.3.6.3 **Assign Values**

Program default value = 0.050°C

4.3.6.4 **Rationale**

Further reductions do not significantly affect the simulation results.

4.3.6.5 **Reference**

SERI-RES Manual Version 1.2

4.3.6.6 **Quality Assurance**

N/A

4.3.6.7 **Further Information**

None

4.3.7 Computational Parameter 7

4.3.7.1 **Description**

Base temperature to use for calculating heating degree days

4.3.7.2 **Parameter Definition List**

Name : Heating Degree Day Base temperature
Symbol : H.D.D. Base
Units : Deg C

4.3.7.3 **Assign Values**

Program default value =18.3°C

4.3.7.4 **Rationale**

Historically the temperature of the outside air above which heating is assumed not to be required.

4.3.7.5 **Reference**

SERI-RES Manual Version 1.2

4.3.7.6 **Quality Assurance**

N/A

4.3.7.7 **Further Information**

None

4.3.8 Computational Parameter 8

4.3.8.1 **Description**

Base temperature to use for calculating cooling degree days.

4.3.8.2 **Parameter Definition List**

Name : Cooling Degree Day Base temperature
Symbol : C.D.D. Base
Units : Deg C

4.3.8.3 **Assign Values**

Program default value =18.3°C

4.3.8.4 **Rationale**

Historically the temperature of the outside air below which cooling is assumed not to be required.

4.3.8.5 **Reference**

SERI-RES Manual Version 1.2

4.3.8.6 **Quality Assurance**

N/A

4.3.8.7 **Further Information**

In overheating risk assessments in which the internal air temperatures are usually allowed to fluctuate freely (free floating), parameters such as C.D.D. Base are not required. However, a value must be input in PARAMETERS Section, e.g. the default value.

4.3.9 Computational Parameter 9

4.3.9.1 **Description**

Angle of incidence which is assumed for the calculation of diffuse radiation.

4.3.9.2 **Parameter Definition List**

Name : Angle of incidence
Symbol : Dif. Ang
Units : Degrees

4.3.9.3 **Assign Values**

Program default value = 60°

4.3.9.4 **Rationale**

Don't know

4.3.9.5 **Reference**

SERI-RES Manual Version 1.0

4.3.9.6 **Quality Assurance**

N/A

4.3.9.7 **Further information**

None

4.3.10 **Computational Parameter 10**

4.3.10.1 **Description**

The mathematical equations (created by the program) representing the thermal .model of the building (created by user) are solved at discrete intervals of time called the time step.

4.3.10.2 **Parameter Definition List**

Name : Time step
Symbol : None
Units : Dimensionless

4.3.10.3 **Assign Values**

The number of time steps per hour suggested by the program.

4 3.10.4 **Rationale**

The suggested value is appropriate as it is calculated based on the level of the complexity of the problem at hand.

4.3.10.5 **Reference**

SERI-RES Manual Version 1.2

4.3.10.6 **Quality Assurance**

N/A

4.3.10.7 **Further information**

User may define a smaller time step (at the expense of increased computational time) than that suggested by the program. However, he/she can not assign a value greater than that suggested by the program.

4.4 USER SELECTED INITIAL CONDITIONS

4.4.1 Initial Conditions 1

4.4.1.1 **Description**

The initial temperatures for all mass and air nodes may be set at a suitable temperature.

4.4.1.2 **Parameter Definition List**

Name : Node temperature
Symbol : Init. Temp.
Units : Deg C

4.4.1.3 **Assign Values**

Program default value = 18.3°C

4.4.1.4 **Rationale**

Experience has shown that this is a reasonable initial temperature that will allow for a quick and stable convergence on the actual conditions at each node.

4.4.1.5 **Reference**

i) SERI-RES Manual Version 1.2
ii) YARD Report Ref. PM1020/MP-2
"An Investigation into The Convergence Criteria for SERI-RES"
August 1990

4.4.1.6 **Quality assurance**

N/A

4.4.1.7 **Further Information**

None

4.4.2 Initial Conditions 2

4.4.2.1 **Description**

Day of week of the first day in the weather file, where Monday = 1, Tuesday = 2, etc. (the SERI-RES manual incorrectly states that it is the day of week of January 1). Can be used to adjust weekday and weekend distinction when using weather data for a particular calendar year. The default value is 1.

4.4.2.2 **Parameter Definition List**

Name : Week Day
Symbol : Week Day
Units : Dimensionless.

4.4.2.3 **Assign Values**

1=Monday.... 7=Sunday, appropriate to the first day in weather year used in simulations.

4.4.2.4 **Rationale**

N/A

4.4.2.5 **Reference**

i) SUN workstation calendar
ii) SERI-RES Manual Version 1.2

4.4.2.6 **Quality Assurance**

N/A

4.4.2.7 **Further Information**

None

4.4.3 Initial conditions 3

4.4.3.1 Description

The first and last days in the calendar over which the simulation is to be run, entered as a three letter month string followed by the day number in the month.

4.4.3.2 Parameter Definition List

Start/stop days

Dimensionless

4.4.3.3 Assign Values

Standard values:

January to December runs:	JAN 1. DEC 31.
October to September runs:	OCT 1. SEP 30.
Winter sample day runs:	JAN 1. JAN 15.
Spring sample day runs:	APR 1. APR 15.
Summer sample day runs:	JUL 1. JUL 15.

4.4.3.4 Rationale

N/A

4.4.3.5 Reference

A Review of SERI-RES Parameters, YARD, August 1990.

4.4.3.6 Quality Assurance

N/A

4.4.3.7 Further Information

For annual runs the start/stop dates must correspond to the beginning and end of the weather periods, for example from October 1st to September 30th for all the weather years constructed by Oscar Faber, as well as the CIBSE Kew 1964-65 year, and January 1st to December 31st for the Kew Trial Reference Year.

For the winter, spring and summer design sample days, the runs are defined to start on the first of the month and finish on the 15th. Data is output on the 15th day, thus allowing 14 days of preconditioning for the design to stabilise.

See Climate Description for more details on weather data.

5.0 CONTEXT DESCRIPTION

5.1 Site Description

5.1.1 Location

5.1.1.1 Description

The site is described by its relative position to reference points, e.g by its latitude, longitude and altitude

5.1.1.2 Parameter Definition List

Name : Latitude
Symbol : LAT.
Units : Degrees (North +ve; South -ve)
Definition : The distance north or south of the equator

Name : Longitude
Symbol : LONG.
Units : Degrees (East +ve; West -ve)
Definition : The distance east or west of Greenwich

Name : Altitude
Symbol : ELEV.
Units : Metres
Definition : Height (elevation) above sea level

5.1.1.3 Assign Values

Latitude, longitude and altitude of the most appropriate weather site used with the simulation

5.1.1.4 Rationale

Actual site weather data is not always available.

5.1.1.5 Reference

Met Office weather tables

5.1.1.6 Quality Assurance

N/A

5.1.1.7 Further Information

None

5.1.2 Site Exposure

5.1.2.1 Description

Extent to which the site is exposed to wind and rain.

5.1.2.2 **Parameter Definition List**

Name : Site exposure
Units : Dimensionless.

5.1.2.3 **Assign Values**

Local conditions of exposure of the actual site.

5.1.2.4 **Rationale**

The air infiltration rates and the outside surface resistance of the building envelopes depend on the local conditions of exposure.

5.1.2.5 **Reference**

CIBSE GUIDE, Tables A3.6 and A4.12 .The Chartered Institution of Building Services Engineers, London, 1986.

5.1.2.6 **Quality Assurance**

N/A

5.1.2.7 **Further Information**

None

5.1.3 Ground Reflectivity

5.1.3.1 **Description**

Fraction of short wave solar radiation striking the ground surrounding the design that is reflected back

5.1.3.2 **Parameter Definition List**

Name : Ground reflectivity
Units : Dimensionless.

5.1.3.3 **Assign Values**

Standard value is 0.2 for urban setting in temperate localities.

5.1.3.4 **Rationale**

Typical value for built up area

5.1.3.5 **Reference**

i) SERI-RES Manual Version 1.2
ii) CIBSE GUIDE, Table A2.31 The Chartered Institution of Building Services Engineers, London, 1986.

5.1.3.6 **Quality Assurance**

N/A

5.1.3.7 **Further Information**

A constant value can be used throughout the year, or a schedule of monthly values. The value now used universally in CAP/Yard and OFCE is that used by EMC in their test cell studies, and is within the range of 0.2 to 0.3 recommended in the SERI-RES version 1.0 manual.

Additionally, the SERI-RES manual suggests that the ground reflectivity may in fact vary from 0.1 for extremely dark surface to 0.7 or more for freshly snow.

The Applicability Group at Leicester Polytechnic (ETSU Applicability Analysis Project) have noted that this parameter is critical in the prediction of the performance of a passive solar building and that results are very sensitive to it. They suggest that parameter should be adjusted when the site layout is known.

5.1.4 Ground Temperature

5.1.4.1 **Description**

The temperature that the simulation takes the ground to be at for the purpose of heat transfer calculations between the zone and the ground on which it is built.

5.1.4.2 **Parameter Definition List**

Name : Ground Temperature
Unts : Deg C.

5.1.4.3 **Assign Values**

A monthly profile with each monthly value being the mean ambient temperature for the previous month for the weather site used for the simulation.

5.1.4.4 **Rationale**

The heat flux through the floor is proportional to the ground temperature, and lags air temperature by about one or two months. A lag of one month is suggested by SERI-RES Manual.

5.1.4.5 **Reference**

SERI-RES Manual.Version 1.2

5.1.4.6 **Quality Assurance**

N/A

5.1.4.7 **Further Information**

None

5.1.5 External site Shading

5.1.5.1 **Description**

Surrounding buildings , trees ,etc. on the site may shade the design.

5.1.5.2 **Parameter Definition List**

Distance - L(m) - The mean distance between the design and the object that may shade the design.
Height - H(m) - The mean height of the object that may shade the design

$H = H_0 - 1.2$

Where H_0 is the height of the object.

5.1.5.3 **Assign Values**

IF [H_0.GT.1.2] THEN
  $H = H_0 - 1.2$
  L = as measured from site plan
ELSE
  No overshading by object
ENDIF

5.1.5.4 **Rationale**

External shading by trees and surrounding buildings on site etc. is taken into account by using a skyline profile. This splits the horizon into 20 degrees sectors from East to West.. For each sector an angle is given as that which is subtended by the average obstruction height in the sector and the face of the design being shaded. As all windows see the same skyline profile it is not correct to give the actual obstruction height as some windows will be ground floor and some will be first floor or above. Work done by NBA Tectonics on behalf of ETSU suggests that by reducing the obstruction heights by 1.2m an acceptable compromise can be achieved.

5.1.5.5 **Reference**

"A Study of Passive Solar Housing Estate Layout"
Contractor - NBA Tectonic, London
Ref. - ETSU, S 1126
1988

5.1.5.6 **Quality Assurance**

N/A

5.1.5.7 **Further Information**

None

5.2 Climate Description

5.2.1 **Description**

Hourly data values are required for a full year. This data should be a real year of weather data that represents, as closely as possible, the average weather over the last 20 years.

5.2.2 **Climatic Variables List**

Direct normal (kJ/m^2) - That part of the total solar radiation that strikes a horizontal surface, without first being reflected, at 90° to that surface.
Global horizontal (kJ/m^2) - The total solar radiation that strikes a horizontal surface.
Dry bulb temperature (°C) - The mean hourly dry bulb temperature of the air.
Dew point temperature (°C) - The mean hourly dew point temperature of the air.
Wind speed (m/s) - The mean hourly wind speed .

5.2.3 **Assign Values**

The site weather data of the most appropriate weather site used with the simulation.

5.2.4 **Rationale**

Actual site weather data is not always available.

5.2.5 **Reference**

i) SERI-RES Manual Version 1.2
ii) Met Office Data
iii) S.J.Irving, The CIBSE Example Weather Year
"Weather data and its Applications - A symposium for Building Services Engineers"
9th March 1988

5.2.6 **Quality Assurance**

N/A

5.2.7 **Further Information**

Before 1990, most of the studies in the passive solar programme used weather data from Kew. This has now been supplemented with data for 11 further stations. the files for which were created by OFCE using data supplied by the Meteorological Office.

Data for the following weather stations is held at YARD and OFCE:

Kew:

File Name	Year	Notes
Q6465.R	1964-65	CIBSE Example Year
KEWTRY.R		Loxsom Test Reference Year
Q1959.R	1959	
Q1968.R	1968	

The Loxsom year consists of representative individual months from the period 1959 to 1968.

The above weather years run from January 1 to December 31 except for the CIBSE year which runs from October 1 to September 30.

The weather data files created by OSCAR Faber in 1989 are shown below:

File Name	Approximate Location	Synoptic Data	Radiation Data	Year	Start Day
GLASG.R	Glasgow	Abbotsinch	Dunstaffnage	1972-73	Thursday
CAMBO.R	Cornwall	St.Mawgan	Camborne	1981-82	Thursday
NORWI.R	East Anglia	Marham	Hemsby	1981-82	Thursday
ALDER.R	Northern Ireland	Aldergrove	Aldergrove	1977-78	Saturday
MANCH.R	West Central England	Ringway	Aughton	1984-85	Monday
ABERD.R	East Scotland Aberdeen	Dyce	Aberdeen	1980-81	Wednesday
HEATH.R	Outer London	Heathrow	Bracknell	1979-80	Monday
DUNDE.R	East Scotland Dundee	Leuchars	Mylne	1980-81	Wednesday
FINNI.R	Sheffield	Finningley	Finningley	1986-87	Wednesday
ABERP.R	Central Welsh	Aberporth	Aberporth	1972-73	Thursday
ESKDA.R	South Central Scotland	Eskdalemuir	Eskdalemuir	1971-72	Thursday

Synoptic data-hourly temperatures and wind speed.
Radiation data-hourly solar data.

It should be noted that all these weather years run from October 1st to September 30th.

6.0 ZONING

6.1 Description

6.1.1 Modelled Zones

6.1.1.1 Description

Those zones for which an assessment of overheating risk is required.
(See 7.1.3 for zone definition)

6.1.1.2 Parameter Definition List

Environmental control set Points : heating and venting setpoints.
Occupancy/usage - The number of assumed occupants and the use to which the space is to be put.
Position - Whether the space faces north, east, etc; the number of external walls that the space has.
Windows - Whether the windows face north, east, etc; the area of external glazing that bounds the space.
Thermal Mass - The constructions used for any opaque walls/floors/ceilings bounding or being enclosed within the space.

6.1.1.3 Define Zone

a) a specified zone (a single office)
b) all zones in an office building
c) the zone or zones estimated to be most likely to suffer from overheating

For the case C, a judgement has to be made which would normally take into account occupancy, incidental gains, glazing area and orientation.

6.1.1.4 Rationale

Zones likely to overheat are highly dependent on the heat input by people (metabolic heat), incidental gains, glazing area, and orientation.

6.1.1.5 Reference

SERI-RES Manual Version 1.2

6.1.1.6 Quality Assurance

N/A

6.1.1.7 Further Information

Both the modelling time and the machine run-time are directly dependent on the number of zones used to represent the building.

6.1.2 Adjacent Unmodelled Zones

6.1.2.1 **Description**

The adjacent zones will have an effect on the thermal conditions of the modelled zone. These adjacent unmodelled zones therefore require some simple short description in order that their effects on the design may be taken into account.

6.1.2.2 Parameter Definition List

Zone Temperature - The temperature of the unmodelled zones adjacent to modelled zone.

6.1.2.3 **Assign Values**

Zone Temperature : Same as temperature in modelled zone.

6.1.2.4 **Rationale**

The adjacent zones and the modelled zone are thermally identical.

6.1.2.5 **Reference**

SERI-RES Manual Version 1.2

6.1.2.6 **Quality Assurance**

N/A

6.1.2.7 **Further Information**

Although it may be assumed that there is no heat flow between the party wall seperating a zone from its thermally identical adjacent zone, care should be exercised to take into
account the effect of the thermal heat storage capacity of the party wall which would influence the thermal response of the zone under investigation.

Modelling of party walls may be best illustrated by an example.Suppose the surface area of the party wall separating zone B (the unmodelled adjacent zone) and zone A (the modelled zone) is 8m2. Let's assume the party wall is a plastered dense block wall.

It may be assumed that half of the total thermal heat storage capacity of the party wall is effectively attributed to zone A and the other half to zone B. This may be done by entering half of the wall area in the WALLS Section in the SERI-RES Building Description input
data file. The effect of the reduction in the actual wall area should also be imposed on the
amount of solar radiation received by the wall. In a similar way, this may be done by entering half
of the calculated Side Solar Coef using EMC algorithm. Imagine the calculated fraction of
solar absorbed by the party wall (using the full 8m2 area for the party wall) is 0.12. Half of this, 0,06 will be input as both Front and Back Solar Coef.

For the example illustrated above, the WALLS section will be as follows:

WALLS

*	WALL	FRONT/INTERIOR SIDE			BACK/EXTERIOR SIDE	WALL		
*	TYPE	ZONE	SURF	SOLAR	ZONE OR SURF	SOLAR	AREA	
*		NAME	COIF	COEF	SURFACE,	COEF	COEF	
*			[W/C	[FRAC]	AMBIENT,	[W/C	[FRAC]	[SM]
*			-SM]		GROUND			
	PWALL	ZONEA	8.3	0.06	ZONEA	8.3	0.06	4.0

The other input sections will be the same as the wall was a wall separating two modelled zones.

6.2 INTERZONAL COUPLING

6.2.1 Interzonal coupling :Air Flow

6.2.1.1 Description

Air flow between zones is not explicitly modelled by the simulation program. It is necessary to model air flow as a conductance between zones, or between a zone and the outside world.

6.2.1.2 Parameter Definition List

Air flow rate - V (m^3/s) - The volumetric air flow rate between two zones or between a zone
and the outside world.
Density - p (kg/m^3) - The density of air.
Specific Heat Capacity - C_P (kJ/kg.K) - The specific heat capacity of air.

6.2.1.3 Assign Values

Conductance = Air flow rate x p x C_p

6.2.1.4 Rationale

None

6.2.1.5 Reference

None

6.2.1.6 Quality Assurance

N/A

6.2.1.7 Further Information

None

6.2.2 Interzonal Coupling : Shortwave

6.2.2.1 Description

An opening between two zones will not only allow air movement but will also allow solar transfer. The SOLAR TRANSFER is the fraction of total solar radiation transmitted into the source zone which is transferred to the sink zone through an internal window or opening. Similarly, the REVERSE TRANSFER is the fraction of total solar radiation transmitted into the sink zone which is transferred into the source zone.

6.2.2.2 Parameter Definition List

Area - A_o (m^2) - Area of opening.
Wall Area - A_w (m^2) - Area of all opaque walls, internal windows and other openings in the zone.
Window Area - A_{wn} (m^2) - Area of all external windows in the zone.
Ceiling Area - A_c (m^2) - Area of the ceiling/roof in the zone.
Floor Area - A_f (m^2) - Area of the floor in the zone.
Wall Coefficient - C_w - Proportion of incoming solar radiation striking walls that is absorbed by them.
Window Coef. - C_{wn} - Proportion of incoming solar radiation striking the windows that passes through them.
Ceiling Coef. - C_c - Proportion of incoming solar radiation striking the ceiling that is absorbed by it.
Floor Coef. - C_f - Proportion of incoming solar radiation striking the floor that is absorbed by it.

6.2.2.3 Assign Values

$$\text{Proportion of solar transferred} = 0.94 * (A_o*C_w) / [((A_o+A_w)*C_w) + A_{wn}*C_{wn} + A_f*C_f + A_c*C_c]$$

Areas are taken from drawings.
$C_w = 0.60$
C_{wn} = window shading coef.
$C_f = 0.85$
$C_c = 0.30$

6.2.2.4 Rationale

None

6.2.2.5 Reference

A Review of SERI-RES Parameters, YARD, August 1990.

6.2.2.6 Quality Assurance

N/A

6.2.2.7 Further Information

None

7.0 BUILDING DESCRIPTION

7.1 Zone Geometry

7.1.1 Description

The design is described in terms of areas and heights and external surface orientations(See 6.1.1.2).

7.1.2 Parameter Definition List

Dimensions (m) - The lengths , heights and widths of all walls, floors, windows, ceilings, roofs etc. If the zone has a sloping ceiling or is on two levels, an average value is calculated such that the overall volume of air in the zone is correct.
For external surfaces the azimuth orientation of the surface is entered. Orientations are measured clockwise from North. Therefore; North=0, East=90, South=180 and West 270 degrees.
The tilt of a surface is measured from horizontal. Standard values are; Horizontal=0 and vertical walls=90 degrees.

7.1.3 Assign Values

Measured from drawings.
The dimensions (m) of a ZONE (ZONES: a SERI-RES term taken to denote a part of the building with specified operating conditions and uniform temperature)are measured as follows;
from the center of internal elements, e.g walls, floors, ceiling, and,
from the inside surfaces of all external elements, e.g. external walls, roofs, etc.

7.1.4 Rationale

Keeps the building volume correct.

7.1.5 Reference

"DL&E/CAP Joint Methodology for Use of Scribe on ETSU Design Studies - Report on Methodology Trials"
DL&E Consultancy Group
CAP Scientific Ltd.
February 1988

7.1.6 Quality Assurance

All dimensions should add up consistently through any cross-section of the building.

7.1.7 Further Information

Standard adopted by all participants in ETSUs Passive Solar Programme for consistency.

7.2 SHADING DEVICES (EXTERNAL)

7.2.1 Shading device 1 : Overhangs

7.2.1.1 **Description**

A surface may be shaded by an overhang which projects out at 90° from the plane of the surface. The overhang is described as its distance above the shaded surface and the distance it projects away from the surface. It is assumed to be infinitely long .

7.2.1.2 **Parameter Definition List**

Distance - D (m) - Vertical distance from the top of the surface being shaded to the underside of the overhang.
Projection - P (m) - Distance overhang projects, at 90°, from the surface being shaded.

7.2.1.3 **Assign Values**

Measured from drawings provided.

7.2.1.4 **Rationale**

N/A

7.2.1.5 **Reference**

SERI-RES Manual Version 1.2

7.2.1.6 **Quality Assurance**

N/A

7.2.1.7 **Further Information**

None

7.2.2 Shading device 2 : Screen Walls

7.2.2.1 **Description**

A surface may be shaded by a vertical wall runing parallel to that surface. The screen wall is described as its distance from the shaded surface and its height. It is assumed to be infinitely long.

7.2.2.2 **Parameter Definition List**

Distance - D (m) - Distance of screen wall from the face of shaded surface.
Height -H (m) - The height of the screen wall above the bottom of the surface being shaded.

7.2.2.3 **Assign Values**

Measured from drawings provided.

7.2.2.4 **Rationale**

N/A

7.2.2.5 **Reference**

SERI-RES Manual Version 1.2

7.2.2.6 **Quality assurance**

N/A

7.2.2.7 **Further Information**

None

7.2.3 Shading Device 3 : Sidefins

7.2.3.1 **Description**

A surface may be shaded by projections at the side of the surface, called sidefins. Sidefins are assumed to be infinitely high.

7.2.32 **Parameter Definition List**

Distance - D (m) - Distance of sidefin from side of surface being shaded.
Projection - P (m) - Distance of sidefin projects, at 90°, from the surface being shaded.

7.2.3.3 **Assign Values**

Measured from drawings provided.

7.2.3.4 **Rationale**

N/A

7.2.3.5 **Reference**

SERI-RES Manual Version 1.2

7.2.3.6 **Quality Assurance**

N/A

7.2.3.7 **Further Information**

None

7.2.4 Shading Device 4 : Side Screen

7.2.4.1 **Description**

A surface may be shaded by a vertical obstruction at right angles from the plane of the shaded surface. The side screen is described by its distance from one side of the shaded surface and its height. The side screen is assumed to be infinitely long.

7.2.4.2 **Parameter Definition List**

Distance - D (m) - Distance of side screen from side of shaded surface.
Height - H (m) - Height of side screen.

7.2.4.3 **Assign Values**

Measured from drawing provided.

7.2.4.4 **Rationale**

N/A

7.2.4.5 **Reference**

SERI-RES Manual Version 1.2

7.2.4.6 **Quality Assurance**

N/A

7.2.4.7 **Further Information**

None

7.3 SHADING DEVICES (INTERNAL)

7.3.1 Shading Device 1 : Curtains and blinds

7.3.1.1 **Description**

Internal shading devices may be used to control the amount of direct solar radiation transmitted through windows.

7.3.1.2 **Parameter Definition List**

Name : Shading coefficient
Symbol : SHADING COEF.
Units : dimensionless
Definition : the fraction of the total window area able to transmit solar radiation.

Name : U - value
Symbol : U Value
Units : W/m^2K
Definition : The total heat transfer rate through the glazing system (air-to-air)

7.3.1.3 **Assign Values**

Shading coefficient:

Standard values:
0 if the window is completely covered
1 if the window is unobstructed
0.765 for single and double glazing without any shading device, e.g. blinds, etc.
0.68 for Kappafloat. without any shading device.
For windows with shading devices, appropriate values should be obtained from manufacturers data.

U - Value

5.4 for single glazing
2.9 for double glazing
2.0 for Kappafloat
Other values for different glazing, e.g. heat absorbing or reflecting, may be obtained from manufacturers data.
If shading devices are incorporated into the design of windows, U - values must be modified to take the effect of the device into account.

7.3.1.4 **Rationale**

The internal shading devices affect the heat and solar transfer through windows.

7.3.1.5 **Reference**

A Review of SERI-RES Parameters, YARD, August 1990.

7.3.1.6 **Quality Assurance**

N/A

7.3.1.7 **Further Information**

The shading coefficient of the glazing system may be scheduled to model the use of movable internal shading devices, such as movable insulation, shutters during the day, closing of curtains at night, and so on.

The U - Value of a window system with a shading device may be calculated as follows;
$1/U = 1/U_g + 1/U_s$
Where U_g is the U - Value of the glass and U_s the U - Value of the shading device.

7.4 CONSTRUCTION (EXTERNAL ELEMENTS)

7.4.1 Walls

7.4.1.1 **Description**

A wall may be described in three different ways:
1) By use of walls that are pure resistance.
2) By use of walls that have one or more layers of materials with heat capacity.
3) By combination of the above two.

7.4.1.2 **Parameter Definition List**

For each layer in the wall:
Conductivity - (W/m.K) - for material layer made of.
Density (kg/m3) - for material layer made of.
Specific Heat Capacity (J/kg.K) - for material layer made of.
Thickness (m) - of layer.
Number of nodes in each layer (default value is 1).

7.4.1.3 **Assign Values**

Material properties are either specified by the designer, looked up in tables or obtained from manufacturers.
Thicknesses specified by designers or from manufacturers.

7.4.1.4 **Rationale**

N/A

7.4.1.5 **Reference**

i) CIBSE Guide A3
ii) ASHRAE Guide
iii) IEA Annex 4 Report
iv) SERI-RES Manual Version 1.2

7.4.1.6 **Quality Assurance**

N/A

7.4.1.7 **Further Information**

The maximum number of layers that SERI-RES can consider is six. Layer #1 corresponds to the front, or interior side of the wall, the last layer specified corresponds to the back, or exterior side of the wall.

CAP/YARD and OFCE model walls as multi-layerd mass walls. While an entry of the form of "pure resistance" is not used to define a complete wall construction, it is nevertheless used to represent air cavities within the wall and layers of the wall with low thermal mass.

7.4.2 Floors

All as 7.4.1

7.4.2.Further Information

For ground floors, CAP/YARD and OFCE use the construction specified by the architects, and additionally include a 1.0 metre layer of soil in the description of the ground floor. A layer of hardcore consisting of 0.15m of materials such as rubble is also considered.

7.4.3 Roofs

All as 7.4.1

7.5 SURFACE PROPERTIES (EXTERNAL ELEMENTS)

7.5.1 Solar Absorbtivity

7.5.1.1 Description

Proportion of the total short wave solar radiation striking a surface that is absorbed by that surface.

7.5.1.2 Parameter Definition List

Name : Solar Absorbtivity
Symbol : SOLAR COEF.
Units : Dimensionless

7.5.1.3 Assign Values

Material properties are either specified by the designer, look- up in tables or obtained from manufacturers.

7.5.1.4 Rationale

N/A

7.5.1.5 Reference

SERI-RES Manual Version 1.2
CIBSE Guide, Section A3
ASHRAE Guide

7.5.1.6 Quality Assurance

N/A

7.5.1.7 Further Information

SOLAR COEF. of the external surface of the external elements is the absorptivity of the
wall surface, if the exterior side is specified as AMBIENT (for an external wall which receives no solar radiation) or GROUND (for the ground floor), this parameter is not used.
For the internal surfaces of external elements, SOLAR COEF. is calculated using the reflection algorithm given in 7.7.1.

The SERI-RES default value is <AREA>, which causes the Total Solar Available(i.e.
after SOLAR and REVERSE TRANSFER have been taken into account) to be apportioned accordingly to the wall area (so all wall, floor and ceiling surface in the zone are assumed to have the same absorptivity). Alternatively, it is reasonable to assume that all the
vertical walls have the same absorptivity on their internal surface, and under this assumption, this parameter may be left as <AREA>, provided that values for floor and ceiling surface calculated according to the algorithm are entered explicitly.

7.5.2 Longwave Emissivity

7.5.2.1 Description

The emissivity is the relative ability of a material to emit radiant energy.
Radiative heat transfer which depends upon the emissivity and the shape of the surfaces exchanging energy by radiation, is not modelled explicitly in SERI-RES. Heat transfer by radiation and convection at the surfaces of building elements is treated as flow through thermal resistances which are combined to give surface coefficients.

7.5.2.2 Parameter Definition List

N/A

7.5.2.3 Assign Values

N/A

7.5.2.4 Rationale

N/A

7.5.2.5 Reference

N/A

7.5.2.6 Quality Assurance

N/A

7.5.2.7 Further Information

N/A

7.5.3 Surface Coefficient

7.5.3.1 Description

The combined radiant and convective thermal coefficient at the outside surface of the building elements.

7.5.3.2 Parameter Definition List

Name : Surface Coefficient
Symbol : SERF COEF
Units : W/m^{2}K

7.5.3.3 Assign Values

Walls ; 16.7
Roofs ; 22.7
Ground floors : 99.0

7.5.3.4 Rationale

Test Cell Studies

7.5.3.5 **Reference**

SERI-RES Manual Version 1.2
CIBSE Guide, Section A3
A Review of SERI-RES Parameters, YARD, August 1990.

7.5.3.6 **Quality assurance**

N/A

7.5.3.7 **Further Information**

The value of 99.0 for ground floors simply ensures that the ground floor is thermally well connected to GROUND temperature node.

7.6 CONSTRUCTION (INTERNAL ELEMENTS)

All as 7.4

7.7 SURFACE PROPERTIES (INTERNAL ELEMENTS)

7.7.1 Solar Absorbtivity

7.7.1.1. **Description**

The fraction of the total solar energy available in the zone on the interior side (i.e after SOLAR and REVERSE TRANSFER have been taken into account) which is absorbed by the wall, floor or ceiling.

7.7.1.2 **Parameter Definition List**

Name : Solar Absorbtivity
Symbol : SOLAR COEF
Units : Dimensionless

7.7.1.3 **Assign Values**

The SERI-RES default value is <AREA>, which causes the Total Solar Available(i.e. after SOLAR and REVERSE TRANSFER have been taken into account) to be apportioned accordingly to the wall area (so all wall, floor and ceiling surface in the zone are assumed to have the same absorptivity).

A better estimate of solar radiation distribution for a zone can be obtained by using the following algorithm. The method determines the way in which solar radiation entering a zone is distributed around the surfaces in that and how much is lost back out of the windows.

Wall Area - A_w (m^2) - Area of all opaque walls, internal windows and openings in the zone.
Window Area - A_{wn} (m^2) - Area of all external windows in the zone.
Ceiling Area - A_c (m^2) - Area of the ceiling/roof in the zone.
Floor Area - A_f (m^2) - Area of the floor in the zone.
Wall Coefficient - C_w - Absorption factor for walls - 0.60
Window Coef. - C_{wn} - Shading coef. for windows - 0.765 (double glazing)

Ceiling Coef. - C_c - Absorption factor for ceiling - 0.30
Floor Coef. - C_f - Absorption factor for floors - 0.85
Proportion of solar lost directly to zone air node = 0.06

Proportion of solar lost through windows $= 0.94 * (A_{wn}*C_{wn}) / (A_w*C_w + A_{wn}*C_{wn} + A_f*C_f + A_c*C_c)$

Proportion of solar absorbed by the ceiling $= 0.94 * (A_c*C_c) / (A_w*C_w + A_{wn}*C_{wn} + A_f*C_f + A_c*C_c)$

Proportion of solar absorbed by the floor $= 0.94 * (A_f*C_f) / (A_w*C_w + A_{wn}*C_{wn} + A_f*C_f + A_c*C_c)$

Proportion of solar absorbed by the walls $= 0.94 * (A_w*C_w) / (A_w*C_w + A_{wn}*C_{wn} + A_f*C_f + A_c*C_c)$

7.7.1.4 **Rationale**

This method provides better estimate of the fraction of in coming solar radiation lost back out of the windows than using either the programme default or any other fixed proportion but does not take the time or effort required to do a full iterative calculation.

7.7.1.5 **Reference**

i) EMC Test Cell Studies 1: Solar - Lost
ii) EMC Test Cell Studies 1: Solar distribution

7.7.1.6 **Quality Assurance**

The sum of the solar coefficients plus the solar lost to the air node should equal 1.

7.7.1.7 **Further Information**

As it is reasonable to assume that all the vertical walls have the same absorptivity on their internal surface, and under this assumption,SOLAR COEF may be left as <AREA>,provided that values for floor and ceiling surface calculated according to the algorithm are entered explicitly.

The value chosen for "solar to air fraction" is not critical as the predictions of fuel use and air air temperature are insensitive to this parameter.(Based on the results of EMC Test Cell Studies).

7.7.2 **Longwave Emissivity**

As 7.5.2

7.7.3 **Surface Coefficient**

7.7.3.1 **Description**

The combined radiant and convective thermal coefficient at the inside surface of the building elements.

7.7.3.2 **Parameter Definition List**

Name : Surface Coefficient
Symbol : SURF COEF
Units : W/m^2K

7.7.3.3 **Assign Values**

Walls ; 8.3
Floors ;7.1
Ceiling ; 10

7.7.3.4 **Rationale**

Test Cell Studies

7.7.3.5 **Reference**

SERI-RES Manual Version 1.2
CIBSE Guide, Section A3.
A Review of SERI-RES Parameters, YARD, August 1990.

7.7.3.6 **Quality assurance**

N/A

7.7.3.7 **Further Information**

Values given in 7.7.3.3 are for surfaces of high emissivity (0.90) to represent most building materials.

7.8 Window Properties

7.8.1 Window Conduction

7.8.1.1 **Description**

The combined thermal conduction of the glazing and the frame, including multiple layers of glazing, special coatings and surface resistances.

7.8.1.2 **Parameter Definition List**

Name : Window Conduction
Symbol : U-value
Units : (W/m2.K)

7.8.1.3 **Assign Values**

See 7.3.1.3
(Any other glazing type must be looked up or calculated)

7.8.1.4 **Rationale**

Results of Test Cell Studies

7.8.1.5 **Reference**

CIBSE Guide A - values without curtains.
A Review of SERI-RES Parameters

7.8.1.6 **Quality Assurance**

N/A

7.8.1.7 **Further Information**

See 7.3.1.7

7.8.2 Window Shading Coefficient

7.8.2.1 **Description**

The fraction of the total window area able to transmit solar radiation (fraction of window cavity that is glazed).

7.8.2.2 **Parameter Definition List**

Name : Shading Coefficient
Symbol : SHADING COEF
Units : Dimensionless.

7.8.2.3 **Assign Values**

See 7.3.1.3

7.8.2.4 **Rationale**

Results of Test Cell Studies

7.8.2.5 **Reference**

A review of SERI-RES Parameters, YARD, August 1990.

7.8.2.6 **Quality Assurance**

N/A

7.8.2.7 **Further Information**

See 7.3.1.7

7.8.3 Extinction Coefficient

7.8.3.1 **Description**

Extinction coefficient of glazing material per unit thickness (mm)

7.8.3.2 **Parameter Definition List**

Name : Extinction Coefficient
Symbol : EXTINCTION COEF
Units : 1/mm

7.8.3.3 **Assign Values**

Default value by SERI-RES = 0.0197

7.8.3.4 **Rationale**

None

7.8.3.5 **Reference**

SERI- RES Manual Version 1.2

7.8.3.6 **Quality Assurance**

N/A

7.8.3.7 Further Information

None

7.8.4 Refractive Index

7.8.4.1 **Description**

Index of refraction of glazing material

7.8.4.2 **Parameter Definition List**

Name : Refractive Index
Symbol : INDEX OF REFRACTION
Units : Dimensionless

7.8.4.3 **Assign Values**

1.526

7.8.4.4 **Rationale**

Standard value for glass.
Values for non-glazed windows come from manufacturers data.

7.8.4.5 **Reference**

SERI-RES Manual Version 1.2

7.8.4.6 **Quality Assurance**

N/A

7.8.4.7 **Further Information**

None

8.0 BUILDING OPERATION DESCRIPTION

8.1 VENTILATION

8.1.1 Adventitious

8.1.1.1 Description

That air exchange between the zone and ambient that will occur at all times due to natural leakage with windows closed and/or mechanical ventilation off.

8.1.1.2 Parameter Definition List

Name : Adventitious air flow
Symbol : INFIL. RATE
Units : AC/H

8.1.1.3 Assign Values

As may have been determined by calculation, tests, or a prescribed value. In the absence of a reliable and referenced source, the guidance given in CIBSE Guide should be used. For small offices this is normally 1 AC/H.

8.1.1.4 Rationale

None

8.1.1.5 Reference

CIBSE Guide, Section A4, Table A4.12

8.1.1.6 Quality Assurance

N/A

8.1.1.7 Further Information

SERI-RES makes no distinction between different modes of ventilation such as adventitious or occupant defined. Everything is lumped under the heading INFIL.RATE in the Building Description Input File. In practical terms, INFIL.RATE is made up of appropriate combination of adventitious and occupant defined ventilation.

8.1.2 Occupant Defined

8.1.2.1 Description

That air exchange between the zone and ambient that occurs as a result of deliberate action on the part of the occupants of the zone such as by opening windows or using mechanical ventilation. This may be required to satisfy occupancy requirements, to reduce zone temperatures if they rise too high and/or to reduce condensation and other pollutants in zones

8.1.2.2 **Parameter Definition List**

Name : User defined air flow
Symbol : INFIL.RATE
Units : AC/H

8.1.2.3 **Assign Values**

12 litre/s per person. This is the minimum necessary for air quality control. It is assumed that for small offices this value can be provided via openable windows or a simple mechanical ventilation system. Depending on incidental gains, i.e. solar and casual gains, this may be enough to ensure that overheating does not take place.

8.1.2.4 **Rationale**

Recommended outdoor air supply rate for small private offices.

8.1.2.5 **Reference**

CIBSE Guide

8.1.2.6 **Quality Assurance**

N/A

8.1.2.7 **Further Information**

Recommended outdoor air supply given in 8.1.2.3 is for offices in which some smoking is allowed.

An estimate of the ventilation rate through openable windows to a zone can be made using the following procedures which have been derived from Tables A.4.4 and A.4.5 of the CIBSE Guide. Four cases are considered, single sided and cross ventilation due either to buoyancy or wind for single openings. The following assumptions have been made:
Internal temperature (t_i) = 25 ^oC which is judged to be when people will start to open windows.
Mean external temperatures (t_o) for the months May to September and between the hours 0800 to 1700 derived using Tables A 2.8 and A 2.9 of the CIBSE Guide. The derived values are given in table 8.1.2.7a.
Average daily wind speed (u) for the months May to September taken from Table A 2.7 of the CIBSE Guide given in table 8.1.2.7a.
Discharge Coefficient (C_d) = 0.61.
Difference in mean Pressure Coefficient (dC_p) = 1.0.

Table 8.1.2.7a Values of t_i and u

Month	t_i = Mean temperature during working hours (^oC)	u = Average wind speed (m/s)
May	19.30	4.0
June	19.47	3.7
July	24.44	3.4
August	22.74	3.4
September	20.12	3.2

1) Single Sided Ventilation

a) Temperature only

$$Q = 1/3\ C_d\ A\ J\ \left((t_i - t_o)\ h\ g\ /\ (t_i + 273) \right)^{0.5} \quad (m^3/s)$$

(8.1.2.7.a)

Where Q is ventilation rate(m3/s), A is the openable window area (m^2), J is a factor depending on angle of opening for side or centre pivoted windows values for which are given in Table 8.1.2.7b.and h is the height of the window (m) from sill to head. For sliding windows J is taken as 1.0 when it is fully open or the appropriate fraction of opening, e.g. 0.5 when the window is half open.

Table 8.1.2.7b Values of *J*

Opening Angle	Side Mounted	Centre Pivoted
0	0	0
30	0.6	0.7
60	0.9	0.91
90	1.05	0.98

Substituting the values for C_d (0.61) and t_i (25 °C) and the monthly values of t_o in equation 8.1.2.7a will give:

$Q_{May} = 0.089\ A\ J\ (h)^{0.5}$ (m^3/s)
$Q_{Jun} = 0.087\ A\ J\ (h)^{0.5}$
$Q_{Jul} = 0.029\ A\ J\ (h)^{0.5}$
$Q_{Aug} = 0.056\ A\ J\ (h)^{0.5}$
$Q_{Sep} = 0.082\ A\ J\ (h)^{0.5}$

b) Wind only

$$Q = 0.025\ A\ u_r \quad (m^3/s) \qquad (8.1.2.7b)$$

Where u_r is the mean wind speed (m/s) at height equal to building height calculated from:

$$u_r = u\ F \quad (m/s) \qquad (8.1.2.7c)$$

Where F is wind speed correction factor taking into account height of the zone above ground level and type of terrain obtained fromTable A 2.12 of the CIBSE Guide and are given in table 8.1.2.7c.

Thus:

$$Q = 0.025\ A\ u\ F \quad (m3/s) \qquad (8.1.2.7.d)$$

Substituting the monthly values for u (from Table 8.1.2.7a) in equation 8.1.2.7d will yield:

$Q_{May} = 0.100\ A\ F$ (m^3/s)
$Q_{Jun} = 0.092\ A\ F$
$Q_{Jul} = 0.085\ A\ F$
$Q_{Aug} = 0.085\ A\ F$

$Q_{Sep} = 0.080\ A\ F$

Table 8.1.2.7c Values of F

Height of window above ground	Terrain			
	Country Open Flat	Country With scattered windbreaks	Urban	City
5	0.89	0.72	0.52	
10	1.00	0.82	0.62	0.45
20	1.13	0.95	0.74	0.58
30	1.21	1.03	0.82	0.64
40	1.27	1.09	0.88	0.71
50	1.32	1.14	0.93	0.76

2) Cross Ventilation

a) Temperature only

Q = double value from 1(a) above

b) Wind only

$$Q = C_d\ A_w\ u_r\ (dC_p)^{0.5} \quad (m^3/s) \qquad (8.1.2.7e)$$

Or,

$$Q = 0.61\ Aw\ u\ F \quad (m3/s) \qquad (8.1.2.7f)$$

Where A_w is given by:

$$1/A_w{}^2 = 1/A_1{}^2 + 1/A_2{}^2 \qquad (8.1.2.7g)$$

Where A_1 and A_2 are the window areas on the different room sides.

The above method is an approximation of the methods outlined in the CIBSE Guide. When site weather data is available and values for mean temperature and wind speed can be obtained it is suggested that the Guide methods are used.

For overheating risk assessments it is suggested that the airflows due to buoyancy and wind are calculated and the lowest figure taken.

8.1.3 Ventilation Time Schedules

8.1.3.1 Description

A day is divided into a number of distinct intervals which may or may not span the complete day.

8.1.3.2 **Parameter Definition List**

Name : Ventilation time schedules
Symbol : HR
Unit : Time, hours (integers)

8.1.3.3 **Assign Values**

Adventitious ventilation : 0 - 24 (24 hours a day)
Occupant defined ventilation : Starting time - finishing time (See 8.2.1.3)

8.1.3.4 **Rationale**

Adventitious ventilation takes place at all times due to natural leakage.
Occupant ventilation will occur at the period in which offices are occupied.

8.1.3.5 **References**

None

8.1.3.6 **Quality Assurance**

N/A

8.1.3.7 **Further information**

None

8.2 ENVIRONMENTAL CONTROL

8.2.1 Parameters

8.2.1.1 **Description**

The only environmental parameter that can be controlled in SER-IRES is the zone temperature. The heating, cooling and venting have set point temperatures specified. When the zone temperature falls below the heating set point the heating is switched on, when it rises above the venting set point the venting is switched on.

8.2.1.2 **Parameter Definition List**

Name : Zone Temperature
Symbol : Tz
Unit : ^{o}C

Definition : Tz (°C) - This is calculated assuming that the zone has a uniform temperature. It is neither the air temperature nor the radiant temperature but roughly due to 3/8 convective and 5/8 radiant heat transfer.

8.2.1.3 **Assign Values**

IF [Tz . LT. Heating Set Point 1 AND [Weekday (Starting Time - Pre Heat Period) - (Finishing Time)]] THEN
Heating is ON
ELSE

IF [Tz. LT. Heating Set Point 2 AND [Weekday (Finishing Time) - (Starting Time - Pre Heat Period) AND [weekend]]]THEN
Heating is ON
ELSE
Heating is OFF
ENDIF
IF [Tz.GT.Venting Set Point AND [Weekday (Starting Time) - (Finishing Time)]] THEN
Venting is ON
ELSE
Venting is OFF
ENDIF
IF [Tz. GT. Cooling Set Point AND [Weekday (Starting Time) - (Finishing Time)]] THEN
Cooling is ON
ELSE
Cooling is OFF
ENDIF

If values for set points are not specified then:
Heating Set Point 1 = 20 ^{o}C
Heating Set Point 2 = 12 ^{o}C
Venting Set Point = 25 ^{o}C
Venting Rate = from 8.1.2.7
Cooling Set Point = 27 ^{o}C
Starting Time = 7am
Finishing Time = 6pm
Pre Heat Period = 1 hour

8.2.1.4 Rationale

It is assumed that occupants will induce ventilation, e.g. by opening windows, before the temperature reaches the venting set point, e.g. 25 ^{o}C.

8.2.1.5 Reference

CIBSE Guide
SERI-RES manual version 1.2.

8.2.1.6 Quality Assurance

N/A

8.2.1.7 Further Information

The heating system needs to be switched on before the Starting Time to bring the temperature to the set point at the Starting Time. Pre Heat Period depends on the thermal response of the structure and the capacity and the efficiency of the heating system.
The internal air temperature of offices may not allowed to drop below a limit, e.g. 12 ^{o}C, to prevent the problems of condensation, etc.
See 3.1.7 for cooling system
See 8.2.2 for time schedules

8.2.2 Time Schedules

8.2.2.1 Description

A day is divided into a number of distinct intervals which may or may not span the complete day.

8.2.2.2 **Parameter Definition List**

Name : Time schedules
Symbol : HR
Units : Time, hours (integers)

8.2.2.3 **Assign Values**

Heating:
ON all day (If Tz LT. Heating Set Points)

Venting:
ON Weekday From Starting Time to Finishing time.

8.2.2.4 **Rationale**

The period in which offices are occupied.

8.2.2.5 **Reference**

None

8.2.2.6 **Quality Assurance**

N/A

8.2.2.7 **Further Information**

See 8.2.1.3 for default values.

8.3 OCCUPANCY

8.3.1 Heat Gain

8.3.1.1 **Description**

One of the sources of the heat generation in buildings is the metabolic heat of the occupants. The rate of the heat input into the zone from people mainly depends on the level of their activity.

8.3.1.2 **Parameter Definition List**

Name : Occupancy heat gain
Symbol : Internal Gain
Units : KW

N.B. Internal Gain will be an appropriate combination of all casual gains (See 8.4).

8.3.1.3 **Assign Values**

100 Watts sensible/person

40 Watts latent/person

See 8.3.1.7

8.3.1.4 **Rationale**

Heat emission from the human body at the degree of activity typical to office workers.in a typical office environment (21 ^{o}C)

8.3.1.5 **Reference**

CIBSE Guide ,Section A 7, Table A7.1

8.3.1.6 **Quality Assurance**

N/A

8.3.1.7 **Further Information**

The sensible heat output at 27 ^{o}C air temperature (overheating risk limit) is approximately 65 Watts/person and if overheating occurs it may be worthwhile to carry out a check using this figure.

8.3.2 **Occupancy Profile**

8.3.2.1 **Description**

Occupancy schedules are used to define the rate and pattern of the heat input by the occupants into zones.

8.3.2.2 **Parameter Definition List**

Name : Occupancy time schedules
Symbol : HR
Unit : Time, hour (integers)

Name : Occupancy heat gain
Symbol : Internal gain
Units : KW

N.B. See 8.3.1.2

8.3.2.3 **Assign Values**

If a schedule is not defined THEN:

200 Watts sensible during working hours (Starting time - Finishing Time)

8.3.2.4 **Rationale**

As 2 persons usually occupy small offices during business hours, then :
2 * 100 Watts sensible/person = 200 Watts.

8.3.2.5 **Reference**

None

8.3.2.6 **Quality Assurance**

N/A

8.3.2.7 **Further information**

See 8.2.2 for Time Schedule

8.4 EQUIPMENT

8.4.1 Heat Gain

8.4.1.1 **Description**

Heat generated from equipment contributes to the total heat gain.

8.4.1.2 **Parameter Definition List**

Name : Equipment heat gain
Symbol Internal gain
Units : KW

N.B. Internal gain will be an appropriate combination of all casual gains, e.g. from occupants, equipment, lighting, casing losses, hot water losses, etc.

8.4.1.3 **Assign Values**

If not specified then:
50 W/m^2 from equipment during working hours.
10 w/m^2 from lighting from (Starting time - 1) - Finishing time.

8.4.1.4 **Rationale**

The normal levels of gains in most offices.
One hour extra in addition to working hours for lighting is for cleaning purposes.

8.4.1.5 **Reference**

CIBSE Guide

8.4.1.6 **Quality Assurance**

N/A

8.4.1.7 **Further Information**

50 W/m^2 from equipment assuming a Hi-tech office, i.e. one VDU per person and one central printer.
10 W/m2 from lighting assuming tubular fluorescent lights.
See 8.2.1.3 for time schedules.

8.4.2 Equipment Gain Profile

8.4.2.1 **Description**

Equipment Gain Profiles may be used to determine the rate and pattern of the heat generated by equipment.

8.4.2.2 **Parameter Definition List**

Name : Equipment time schedules
Symbol : HR
Units : Time, hour (integers)

Name : Equipment heat gains
Symbol : Internal gain
Units : KW

N.B. See 8.4.1.2

8.4.2.3 **Assign Values**

If not sepecified use values given in Section 8.4.1.3

8.4.2.4 **Rationale**

Constant occupancy and consequently use of equipment in offices.

8.4.2.5 **Reference**

None

8.4.2.6 **Quality Assurance**

N/A

8.4.2.7 **Further information**

None

9.0 PLANT DESCRIPTION

N/A - SERI-RES cannot model plant or its controls.

EXAMPLE PAMDOC 3

Assessment of overheating risk in commercial buildings, required by authorities in order to allow cooling.

SECTION 0 - PAM IDENTIFICATION

IDENTIFIER: EMPA 0001

PURPOSE: Assessment of overheating risk in commercial buildings, required by authorities in order to allow cooling.

APPLICATION: Active heating, natural ventilation at occupancy time, natural and artificial lighting, no blinds.

PROGRAM: DOE-2.1D

DATE: May 30 1991
Revised Oct. 24 1991, Aug. 17 1992, July 8 1993

AUTHOR: Gerhard Zweifel

ADDRESS: EMPA
Building Equipment Section

CH-8600 Dübendorf

Tel: +41 1 823 4275
Fax: +41 1 821 6244
Telex: 825 345

SECTION 1 - DEFINITION OF A PERFORMANCE ASSESSMENT METHOD

1.1 PURPOSE

1.1.1 Assessment of overheating risk, required by authorities to allow cooling.

1.2 APPLICABILITY

1.2.1 Building type: Commercial.

1.2.2 Environmental system:

Active heating;
Natural ventilation during occupancy time;
Natural and artificial lighting.

1.2.3 Climate zone:

Temperate.

1.2.4 Program:

DOE-2.1D or higher

1.2.5 Resources:

VAX(VMS), SUN(UNIX), PC(MS-DOS)

1.2.6 Further Information:

None.

SECTION 2 - PROCEDURE

2.1 PROCEDURE

2.1.1 Define information requirement:

As set out in Section 3.1

2.1.2 Configure program:

Select program version set out in section 4.1.

Select program sub models as set out in section 4.2.

Select computational parameters as set out in section 4.3.

Set initial conditions as set out in section 4.4.

2.1.3 Describe Site and climate:

Site as set out in section 5.1.

Climate as set out in section 5.2.

2.1.4 Describe zoning procedure to program:

As set out in section 6.

2.1.5 Describe building to program:

As set out in section 7.

2.1.6 Describe building operation to program:

As set out in section 8.

2.1.7 Describe Ventilation process:

As set out in section 8.

2.1.8 Describe plant to program:

As set out in section 9.

2.1.9 Describe plant operation to program:

See section 10.

2.1.10 Process output data:

As set out in section 3.

2.1.11 Interpret information

As set out in section 3.

2.1.12 Quality Assurance

As set out in the appropriate subsections.

SECTION 3 - INFORMATION DEFINITION

3.1 INFORMATION REQUIREMENT FROM THE PERFORMANCE ASSESSMENT

3.1.1 Description

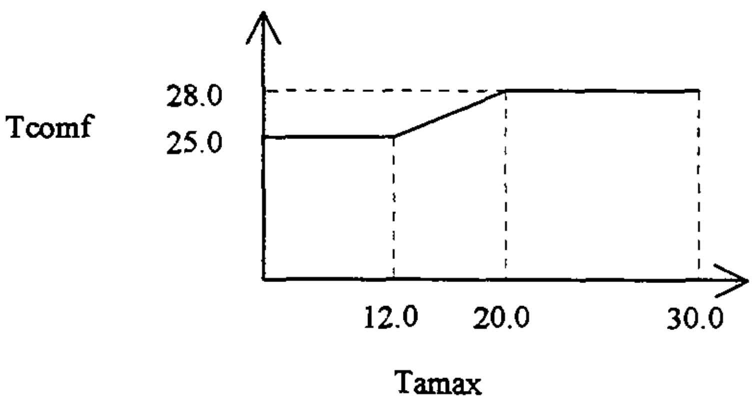
Overheating in a particular zone of a commercial building occurs, if the zone air temperature in a representative module of the zone exceeds an outdoor temperature dependent upper comfort level by a certain number of hours and degrees during the period defined in section 4.3.2. Days with a max. outdoor temperature > 30 °C are not counted, because exceeding of the comfort level during these few days can be accepted. Although the air temperature is not the only parameter for thermal comfort, it is taken here because DOE-2 to date does not give access to surface temperatures.

3.1.2 Results required:

For each zone selected according to section 6:
The number of degree-hours, n_{exc}, in Kh, by which the zone air temperature, T_{zone}, in °C, exceeds an upper comfort level, T_{comf}, in °C, during occupancy time only.

3.1.3 Assign Values:

The upper comfort level, T_{comf}, is a function of the daily maximum of the ambient air drybulb temperature, T_{amax}, according to the following graph:



The number of exceeded degree-hours, n_{exc}, is:

$n_{exc} = \text{sum}(T_{zone} - T_{comf})$, when $T_{zone} > T_{comf}$, occupancy time only.

3.1.4 Rationale:

Procedure is according Swiss standard SIA 382/3.

3.1.5 Reference:

- Standard SIA V 382/3.

3.1.6 Quality Assurance:

Daily minimum and maximum zone temperatures during occupancy time should be investigated as an additional plausibility check.

3.1.7 Further Information

None.

3.2 PROCESS OUTPUT DATA

3.2.1 Description

Although the zone temperature given as a result from DOE-2 does not exactly represent the zone a i r temperature due to combined inside film coefficients, it is further used in the program as the air temperature for the HVAC system, and therefore it is also taken here as the zone air temperature. The calculation of n_{exc} can be done within DOE-2 without further post processing, using a utility developped by EMPA.

3.2.2 Program outputs:

n_{exc} can be processed within DOE-2 by using the functional input KELVINH, developped by EMPA (see section 4.2.3). It is clearly shown in the output file.

For additional quality assurance presentations according to section 3.2.6:

HOURLY-REPORT in DOE-2 SYSTEMS Program part:
- Variable type GLOBAL,
  Variable-List = (8) (= T_{amb})
For each zone:
- Variable type U-name of ZONE,
  Variable-List = (6) (= T_{zone})

REPORT-SCHEDULE must represent only occupancy hours.

REPORT-FREQUENCY = DAILY (for case 2, section 3.3.6) (summaries only, no graph).

3.2.3 Process Outputs:

Processing according to 3.1.3 is done in DOE-2 with function KELVINH.
Processing for additional QA information according to 3.2.6 has to be

done outside of DOE-2 in the case of the graph.

3.2.4 Rationale

No access to surface temperatures or exact zone air temperature in DOE-2.
Post processing is avoided with KELVINH function.

3.2.5 Reference

DOE-2 Engineer's Manual;
Documentation of EMPA standard input.

3.2.6 Quality Assurance

For each zone the daily max. of the zone temperature and the outdoor temperature should be provided as an additional information, presented according to 3.3.6.

3.2.7 Further Information

None.

3.3 FORM OF PRESENTATION

3.3.1 Description

Table

3.3.2 Presentation

1 line for each zone, showing:

Zone name n_{exc}[Kh] pass(yes/no)

3.3.3 Assign Values

n_{exc} as defined in 3.1.3.

3.3.4 Rationale

None.

3.3.5 Reference

None.

3.3.6 Quality assurance

Presentation of the additional information required in 3.2.6:

(1) If possible: Graph with daily maxima of zone temperature plotted against corresponding daily maxima of outdoor temperature.

(2) As minimum alternative, if (1) not possible: Daily summaries with min., max., sum and average of outdoor and zone temperatures.

3.3.7 Further Information

None.

3.4 INFORMATION INTERPRETATION

3.4.1 Description

Comparison to threshold value.

3.4.2 Interpretation:

No further interpretation needed.

3.4.3 Assign Values

Overheating exists when $n_{exc} > 30$ Kh.

3.4.4 Rationale

Simple criterion for pass/failure needed.

3.4.5 Reference

None at present.

3.4.6 Quality Assurance:

Careful examination of the information defined in 3.3.6.

3.2.8 Further Information

None.

SECTION 4 - PROGRAM CONFIGURATION

4.1 PROGRAM VERSION

4.1.1 Title

DOE-2.1D or higher.

4.1.2 Program author:

Simulation Research Group
Lawrence Berkeley Laboratory
University of California
Berkeley, Ca 94720, USA

4.1.3 Vendor

Mainframe:	Author, distribution in CH by EMPA
Micro-Versions:	Acrosoft International Inc., Denver, Col., USA (W. Gygli, Schwerzenbach for CH)

4.1.4 Version number

DOE-2.1D (Mainframe, VMS or UNIX) or

Micro-DOE-2.1D-DX (386 PC's only)

4.1.5 Date of release:

March 1990

4.1.6 Quality assurance:

Mainframe VAX:

Normally installed from EMPA backup tape; tests can be made by running test inputs or old own inputs and comparing results. Weather data are binary and usually cannot be tested.

PC's:

- Follow MICRO-DOE2 User's Guide for installation (Install batch on floppy).
- Make test runs with sample inputs SAMP**.INP
- Compare results with manual
- Delete BDLLIB.TMP file from harddisk (unit mismatch with metric inputs)

- Copy binary weather data files as appropriate

- Perform test runs with own inputs as appropriate

- Check CONFIG.SYS file when facing problems with running the program

- Program not compatible with HIMEM.SYS from MS WINDOWS

4.1.7 Further information:

DOE-2 Sample Run Book

MICRO-DOE2 User's Guide, Acrosoft International Inc., Jan. 1990

4.2 USER SUB MODEL SELECTION

4.2.1 Sub Model 1:

4.2.1.1 Description:

Model for the simulation of the adventitious and the user defined ventilation (infiltration model). A model with a constant, wind speed-independent air change rate is selected. See also 8.1.1 and 8.1.2.

4.2.1.2 INF-METHOD under SPACE-CONDITIONS

4.2.1.3 Select sub model method:

Chose INF-METHOD = AIR-CHANGE and use keyword INF-FLOW/AREA.

4.2.1.4 Rationale:

See 8.1.1.4 and 8.1.2.4.

4.2.1.5 Reference:

DOE-2 Reference manual.

4.2.1.6 Quality Assurance:

Check infiltration air change values from hourly report [VARIABLE-TYPE = u-name of SPACE, VARIABLE-LIST = (39)].

4.2.1.7 Further Information:

None.

4.2.2 Sub Model 2:

4.2.2.1 Description:

Heat emission of electrical equipment: In DOE-2 the emitted heat of the equipment is normally 70 % radiative and 30 %

convective, the same as for the people. There is no user influence via inputs.

But there is the possibility of defining 'functional values', i.e. pieces of program code that can be entered via the input and overwrite the original code, without the necessity of recompiling the program.

A function has been developped by EMPA to enable the user to define himself the radiative/convective split for equipment, by adding a part of equipment emitting purely convective.

The recommended split is: 40 % radiative, 60 % convective.

4.2.2.2 Function 'EQUI-DIRECT'

4.2.2.3 Select sub model method:

Use function 'EQUI-DIRECT' provided by EMPA as 'space-after'-function.

Enter 43 % of the total equipment heat gain value in W/m^2 for the purely convective part (0, 2.15 or 6.45 W/m^2; see 8.4.1 for the rest).

4.2.2.4 Rationale:

Split in DOE-2 is considered as unrealistic.

4.2.2.5 Reference:

DOE-2 Reference manual;
DOE-2.1D Supplement.

4.2.2.6 Quality Assurance:

Operation of the functional input can be checked by adding a print statement or be performing 2 runs, with and without functional input.

4.2.2.7 Further Information:

None.

4.2.3 Sub Model 3:

4.2.3.1 Description:

A functional input was created to directly calculate the necessary information (see section 3.2) within the program.

4.2.3.2 Function 'KELVINH'

4.2.3.3 Select sub model method:

Use function 'KELVINH' provided by EMPA as SUBROUTINE-FUNCTION TEMDEV-2 and function 'IRSCHPR' as SUBROUTINE-FUNCTION DAYCLS-1.

4.2.3.4 Rationale:

Post processing can be avoided.

4.2.3.5 Reference:

DOE-2.1D Supplement.

4.2.3.6 Quality Assurance:

Examine carefully additional information according to 3.2.6 and 3.3.6.

4.2.3.7 Further Information:

None.

4.3 USER SELECTED COMPUTATIONAL PARAMETERS

4.3.1 Computational Parameter 1

4.3.1.1 Description:

Weighting factors.

4.3.1.2 Computational Parameters Definition List:

N/A.

4.3.1.3 Assign Values:

Custom weighting factors ('FLOOR-WEIGHT = 0.' under 'SPACE-CONDITIONS').

4.3.1.4 Rationale:

Gives more exact results for the special case than the otherwise used interpolation between ASHRAE standard weighting factors.

4.3.1.5 Reference:

DOE-2 Reference manual.

4.3.1.6 Quality Assurance:

Check weighting factor VERIFICATION report LV-K in output file.

4.3.1.7 Further Information:

None.

4.3.2 Computational Parameter 2

4.3.2.1 Description:

Run period.

4.3.2.2 Computational Parameters Definition List:

N/A.

4.3.2.3 Assign Values:

April 16 1987 through Oct. 15 1987.

4.3.2.4 Rationale:

Period with overheating potential, according to standard SIA 382/3. 1987 gives calendar with best peak day - weekday relation (peaks not during weekends).

4.3.2.5 Reference:

None.

4.3.2.6 Quality Assurance:

Check VERIFICATION report LV-A.

4.3.2.7 Further Information:

None.

4.4 USER SELECTED INITIAL CONDITIONS

4.4.1 Initial Condition 1

4.4.1.1 Description:

'LOADS' calculation space temperature.

4.4.1.2 Parameter Definition List:

Keyword 'TEMPERATURE' in command 'SPACE-CONDITIONS'.

4.4.1.3 Assign Values:

28 °C.

4.4.1.4 Rationale:

Equal to upper comfort level where most likely to be exceeded. Highest accuracy needed at this point.

4.4.1.5 Reference:

DOE-2 Reference manual.

4.4.1.6 Quality Assurance:

None.

4.4.1.7 Further Information:

None.

SECTION 5 - CONTEXT DESCRIPTION

5.1 SITE DESCRIPTION

5.1.1 Location

5.1.1.1 Description (only data with a recommendation mentioned)

Latitude;
Longitude;
Altitude;
Time zone;
Daylight saving time;
Holidays;

5.1.1.2 Parameter definition list

Latitude, Longitude: Geographic data in degrees, according to international rules.
Altitude: Height over sea level, in m.
Time zone: Greenwich = 0, east = negative, west = positive.
Daylight saving time: US daylight saving period.
Holidays: enable/disable US holidays.

5.1.1.3 Assign values

BUILDING-LOCATION command:

Keywords LATITUDE, LONGITUDE, ALTITUDE:
Predefined values provided by EMPA in case of standard weather station locations. Define according to Reference Manual for other locations.
TIME-ZONE = -1.
DAYLIGHT-SAVINGS = NO under BUILDING-LOCATION
HOLIDAY = NO under

5.1.1.4 Rationale

Daylight savings: US period not appropriate for CH.

Holidays: US holidays not appropriate for CH.

5.1.1.5 Reference

DOE-2 Reference manual.

5.1.1.6 Quality Assurance

Check VERIFICATION report LV-A.

5.1.1.7 Further Information

See DOE-2 Reference Manual for description of further parameters.

5.1.2 Site Exposure

There is no way to describe the site exposure with the chosen infiltration model. The weather data are thought to be exactly fitting for the site.

5.1.3 Ground reflectivity

Leave program default value (=0.2).

5.1.4 Ground temperature

From weather data file, no user influence.

5.1.5 External shading

5.1.5.1 Description

Shading by external obstacles like landscape, neighbour buildings etc. and by parts of considered building in case of a complicated floor plan.

5.1.5.2 Parameter definition list

BUILDING-SHADE and/or FIXED-SHADE commands.

5.1.5.3 Assign values

Define geometry as appropriate to project, according to Reference Manual.

5.1.5.4 Rationale

Can be important.

5.1.5.5 Reference

DOE-2 Reference Manual.

5.1.5.6 Quality Assurance

Check VERIFICATION report LV-J.

5.1.5.7 Further Information

None.

5.2 CLIMATE DESCRIPTION

5.2.1 Description

Full year hourly weather data files are required. Since these files are provided only by EMPA in CH and the user has no influence but the choice of the appropriate file, no detailed description of the files is given here.

5.2.2 Climatic Variables List

Currently the user has normally weather data files for a design year and 16 locations available:
ALTDORF, BASEL, BERN, LA CHAUX DE FONDS, CHUR, DAVOS, GENEVA, GLARUS, INTERLAKEN, LOCARNO, LUZERN, SAMADEN, SION, ST. GALLEN, ZUERICH-KLOTEN, ZUERICH SMA

5.2.3 Assign Values

The location closest to the site or best representing the site is to be chosen. There is a map available with climatic zones of Switzerland. More weather data files can be provided by EMPA if necessary, for all the stations of the Swiss automatic monitoring network.

5.2.4 Rationale

Climate of exact site mostly not available.

5.2.5 References

See DOE-2 Reference Manual for detailed description of weather data files (TRY format).

5.2.6 Quality Assurance

Check header of any SUMMARY report for the confirmation of the choice of the appropriate weather data file.

5.2.7 Further Information

For radiation transformation algorithms:
D.G.Erbs et al: Estimation of the Diffuse Radiation Fraction for Hourly, Daily and Monthly-Average Global Radiation, Solar Energy Vol. 28 No 4, pp 293-302, 1982;
Richard Perez et al: An Anisotropic Hourly Diffuse Radiation Model..., Solar Energy Vol. 36 No 6, pp 481-497, 1986.

SECTION 6 - ZONING DESCRIPTION

6.1 ZONE DESCRIPTION

6.1.1 Modelled Zones

6.1.1.1 Description

Typical zone.

6.1.1.2 Parameter definition list

N/A.

6.1.1.3 Define Zone

Follow the following procedure to chose zones to be considered:

Divide the building into the lowest possible number of areas with spaces of the same or enough similar operation and construction, and with the same orientation;

Pick from these areas those with a ratio of more than 10 % of the total building area for which air conditioning is envisaged;

Pick from these areas all those with orientations in the sectors between E - SE and SW - W;

If an area found is equal to a space, the modelled zone is this space;
if an area consists of several spaces (the more frequent case), the modelled zone is the one of these spaces, which represents best the whole group of spaces.

Areas with orientations out of the sectors defined above have to be treated in the same way,
- if overheating occurs in the zones mentionned above,
- if there is a group with harder operational conditions (higher internal gains).

6.1.1.4 Rationale

The orientations E, SE and SW are most likely to have overheating according to experience.

6.1.1.5 Reference

None.

6.1.1.6 Quality Assurance

Include all questionable zones in performance assessment in case of uncertainty.

6.1.1.7 Further Information

None.

6.1.2 Adjacent Unmodelled Zones

6.1.2.1 Description

Zones selected for modelling are normally surrounded by zones of the same type, using adiabatic interior walls. This means algorithmically, that there is no heat transfer calculated through the wall, but the wall is taken into account for the calculation of the weighting factors, i.e. the inertia of the room.

In special cases it may be appropriate to model the adjacent zone.

6.1.2.2 Parameter definition list

INT-WALL-TYPE, takes codeword ADIABATIC, as opposed to NEXT-TO = xyz in the case of modelled adjacent zones.

6.1.2.3 Assign Values

INT-WALL-TYPE = ADIABATIC.

NEXT-TO = U-name of adjacent zone in case of explicit modelling.

6.1.2.4 Rationale

No net heat flow through wall, but accounted for thermal mass with adiabatic walls.

6.1.2.5 Reference

DOE-2.1D Supplement.

6.1.2.6 Quality Assurance

Check VERIFICATION report LV-F.

6.1.2.7 Further Information

None.

6.2 INTERZONAL COUPLING

6.2.1 Inter Zonal Coupling: Airflow

No description

6.2.2 Inter Zonal Coupling: Shortwave

6.2.2.1 Description

Shortwave radiation exchange is only calculated for sunspaces and adjacent spaces. Sunspaces are defined as spaces with interior windows. This case is not considered in this PAM.

6.2.2.2 Parameter definition list

None.

6.2.2.3 Assign Values

None.

6.2.2.4 Rationale

Sunspace simulation, especially for the in commercial buildings expected big atria, is a difficult task and should be treated in a separate PAM. The DOE-2 sunspace algorithm is not designed for this task.

6.2.2.5 Reference

DOE-2.1D Supplement.

6.2.2.6 Quality Assurance

None.

6.2.2.7 Further Information

None.

SECTION 7 - BUILDING DESCRIPTION

7.1 GEOMETRY

7.1.1 Description

Generally done by specifying orientation, coordinates of origin, length and height for all building components (building, spaces, walls, windows) in a hierarchic way. Although for interior walls there is a possibility to describe without geometry (i.e. only by area), geometry is required for this PAM because of the daylighting calculation.
Only the variables with special requirements are described in detail below.
Windows are defined as net glass area within a separate piece of exterior wall with the properties of the frame.

7.1.2 Parameter Definition List

For space within building:
AREA in m2, VOLUME in m3;
Not to use:
SHAPE=BOX, HEIGHT in m, WIDTH in m, DEPTH in m.

For wall within space:
HEIGHT in m, WIDTH in m,
Not to use:
LOCATION (=FRONT, BACK, LEFT...).

For window within wall:
HEIGHT in m, WIDTH in m,

7.1.3 Assign Values

Space:

AREA: Net space floor area (between inner surfaces of space).

VOLUME: Net space volume, excluding walls.

Exterior walls:

HEIGHT: Between top of floor and top of ceiling;
WIDTH: Between centers of insulation layer (or center of wall if homogeneous) of interior walls.

Interior walls:

HEIGHT: Between upper surface of floor and lower surface of ceiling; WIDTH: From inner surface of exterior walls and between centers of insulation layer (or center of wall if homogeneous) of interior walls.

Floors and ceilings:

HEIGHT and WIDTH: From inner surface of exterior walls and between centers of insulation layer (or center of wall if homogeneous) of interior walls.

Windows:

HEIGHT and WIDTH: Overall values including frame for exterior wall considered as frame; net glass values for WINDOW.

7.1.4 Rationale

AREA: According to standards, used as reference area for gain definitions.

VOLUME: Used for ventilation purposes.

HEIGHT and WIDTH of walls: Used for inertia calculation where parts covered by walls can be activated.

HEIGHT and WIDTH of windows: Glass values can be used for definition of windows, instead of using correction values for frame part.

7.1.5 References

See DOE-2 Reference Manual for exact meaning of geometry variables.
SIA 180/4, SIA 416;
Th. Frank: Oberflaechentemperaturen von besonnten Fensterglasscheiben und ihre Auswirkungen auf das Raumklima und Komfort, Schlussbericht zum NEFF-Projekt 266.

7.1.6 Quality Assurance

Check orientations of exterior walls and windows by examining verification report LV-D.

7.1.7 Further Information

None.

7.2 SHADING DEVICES (EXTERNAL)

7.2.1 External shades like overhangs and fins:

Define geometry as appropriate using the related keywords according to DOE-2.1D Supplement.

7.3 SHADING DEVICES (INTERNAL)

None.

7.4 CONSTRUCTION

7.4.1 Walls

7.4.1.1 Description

All constructions (exterior and interior walls, roofs, floors ...) are described the same way in DOE-2:
MATERIALS are described with their properties THICKNESS, DENSITY, SPECIFIC HEAT and THERMAL CONDUCTANCE.

LAYERS are described as a series of MATERIALS, with their THICKNESS, if other than indicated in MATERIALS, and with an inside air film resistance.

CONSTRUCTIONS are assigning LAYERS to specific elements.

MATERIALS and LAYERS with their precalculated response factors can be put in and called from a library. This is the way users are advised to go: Take all the MATERIALS and LAYERS from a library provided by EMPA.

7.4.1.2 Parameter Definition List

List of Materials and layers with a name according to description above.

7.4.1.3 Assign Values

Chose name of LAYERS fitting with project. Inside film resistance is defaulted to 0.125 m^2K/W
If special construction, not to find in library, look up properties in references indicated below.
If not to find there, ask EMPA.

7.4.1.4 Rationale

Procedure prevents user from choosing materials properties and assures values to be consistent with standards.

7.4.1.5 Reference

DOE-2.1 Reference Manual,
SIA 279, SIA 381/1;
R. Sagelsdorff: Element 23, Waermeschutz im Hochbau, 1984.

7.4.1.6 Quality Assurance

EMPA has provided and access to standard materials properties.
Consideration of thermal bridges can be included in properties.

7.4.1.7 Further Information

None.

7.4.2 Floors

See walls.

7.4.3 Carpets:

Part of floor.

7.4.4 Roofs

See walls.

7.5 SURFACE PROPERTIES (EXTERNAL ELEMENTS)

7.5.1 Solar Absorbtivity

7.5.1.1 Description

n/a

7.5.1.2 Parameter definition list

ABSORPTANCE under CONSTRUCTION

7.5.1.3 Assign Values

Change the default value (= 0.7) according to references below, if type of surface known.

7.5.1.4 Rationale

Improve value according to knowledge of project.

7.5.1.5 Reference

DOE-2.1 Reference Manual,
SIA 279, SIA 381/1;

7.5.1.6 Quality Assurance

Library with proper values will be provided by EMPA.

7.5.1.7 Further Information

None.

7.5.2 Long wave Emissivity

Program default values, no user access.

7.6 CONSTRUCTION (INTERNAL ELEMENTS)

7.6.1 Walls

See 7.4.1

7.6.2 Floors

See 7.4.1

7.6.3 Ceiling

See 7.4.1

7.6.4 Suspended Ceiling

Only specially treated with mechanical ventilation, otherwise part of 7.6.3, with air gap as a resistance.

7.6.5 Carpets

Part of floor.

7.6.6 Furniture

7.6.6.1 Description

Furniture is accounted for by defining a type, the fraction of the floor covered by it and the weight per total floor area.

7.6.6.2 Parameter Definition List

Keywords under SPACE-CONDITIONS:
FURN-TYPE: Density of furniture (LIGHT = 650 kg/m3, HEAVY = 1300 kg/m3).
FURN-FRACTION: Part of total floor area covered by furniture, (Number between 0. and 1.)
FURN-WEIGHT: Total weight of furniture in kg, devised by total floor area.

7.6.6.3 Assign Values

FURN-TYPE = LIGHT;
FURN-FRACTION = 0.3;
FURN-WEIGHT = 25.

7.6.6.4 Rationale

None.

7.6.6.5 References

DOE-2 Reference Manual

7.6.6.6 Quality Assurance

None.

7.6.6.7 Further Information

None.

7.6.7 Curtains

Part of internal shading devices, not treated in this PAMDOC..

7.7 SURFACE PROPERTIES (INTERNAL ELEMENTS)

7.7.1 Solar Absorbtivity

7.7.1.1 Description

There is no way to specify the absorptivity for internal elements, but the distribution of the solar radiation entered in the room to the different elements can be influenced by defining fractions. As default, the fractions are 0.6 for the floor, and the rest of 0.4 distributed to all the other elements according to their surface areas.

7.7.1.2 Parameter definition list

SOLAR-FRACTION under EXTERIOR-WALL, INTERIOR-WALL, FLOOR, ROOF.

7.7.1.3 Assign Values

Leave to default.

7.7.1.4 Rationale

No general rule can be given.

7.7.1.5 Reference

DOE-2.1 Reference Manual.

7.7.1.6 Quality Assurance

None.

7.7.1.7 Further Information

None.

7.7.2 Long wave Emissivity

Program default values, no user access.

7.8 WINDOW PROPERTIES

7.8.1 Description

Choice of the best fitting glass type out of a library with the help of a table with number of glasses, transmission, reflection, visible transmission etc.

Alternative: Shading coefficient to ASHRAE standard glass type, not to use.

7.8.2 Parameter Definition List

Keywords under GLASS-TYPE:
PANES = Number of panes,
GLASS-TYPE-CODE = Number from table,
GLASS-CONDUCTANCE = U-value of glass, without exterior film coefficient.
VIS-TRANS = Visible transmission (for daylight calculations).

7.8.3 Assign Values

Values are to be defined as follows:

PANES according to actual number of panes;

GLASS-TYPE-CODE to be chosen that transmittance and reflectance values in Reference Manual table meet actual values (with subscript e, to be found in reference mentioned below, tables 6-8 on pages 58-63) as close as possible.

GLASS-CONDUCTANCE to be defined, that entered value, corrected by an outside film coefficient of 23 W/m2K, corresponds to value "k" in tables mentioned above.

VIS-TRANS to be entered corresponding to value "tau" (last column) in tables mentioned above).

Values for normal uncoated double glazing (4/12/4 mm):
PANES = 2;
GLASS-TYPE-CODE = 2 (transmission/reflection 0.71/0.16, should be 0.71/0.14);
GLASS-CONDUCTANCE = 3.67;

VIS-TRANS = 0.81.

Values for normal uncoated triple glazing (4/12/4/12/4 mm):
PANES = 3;
GLASS-TYPE-CODE = 3 (transmission/reflection 0.61/0.15, should be 0.61/0.18);
GLASS-CONDUCTANCE = 2.35;
VIS-TRANS = 0.74.

Values for IR reflective coated double glazing (4/12/4 mm):
PANES = 2;
GLASS-TYPE-CODE = 9 (transmission/reflection 0.45/0.31, manufacturer example: 0.46/0.26);
GLASS-CONDUCTANCE = 1.62;
VIS-TRANS = 0.75.

7.8.4 Rationale

Best possible way of description in program versions up to 2.1D (more possibilities in future 2.1E)

7.8.5 References

DOE-2 Reference Manual,
Th. Frank: Oberflaechentemperaturen von besonnten Fensterglasscheiben und ihre Auswirkungen auf das Raumklima und Komfort, Schlussbericht zum NEFF-Projekt 266.

7.8.6 Quality Assurance

EMPA will provide library with glass type description.

7.8.7 Further Information

None.

8.1 VENTILATION

8.1.1 Adventitious

8.1.1.1 Description

This is only to describe the nightly infiltration for the case where there is no night ventilation through open windows. Therefore it is of minor importance. Among the different ways of defining infiltration air changes, the one which gives a constant air change without wind speed-dependence is chosen (see also 4.2.1).

8.1.1.2 Parameter Definition List

INF-FLOW/AREA is the volume of air in m^3/m^2h. This has to be entered for a wind speed-independent infiltration airchange.
INFILTRATION-SCHEDULE is used to define the time-dependence.

8.1.1.3 Assign Values

See 8.1.2.3

8.1.1.4 Rationale

The same definition keywords are used to define the user defined daytime ventilation (see below), which is desired to be constant at the level of the minimum outside air per person.

8.1.1.5 References

DOE-2 Reference Manual

8.1.1.6 Quality Assurance

Check hourly report values [VARIABLE-TYPE = U-name of SPACE, VARIABLE-LIST = (39)].

8.1.1.7 Further Information

None.

8.1.2 Occupant Defined for Air Quality Control

8.1.2.1 Description

Daytime: A constant air exchange according to the required minimum airchange per person according to Swiss standards is to be used.
Nighttime: No user defined ventilation.

8.1.2.2 Parameter Definition List

8.1.2.3 Assign Values

INF-FLOW/AREA must be set to a value which leads to an air flowrate of 25 m^3/h per person (exception: 50 m^3/h per person when smoking cannot be prohibited).
INFILTRATION-SCHEDULE values = 1.0 during occupancy time (see 8.3), and to a factor which leads to an air change in the room of 0.4 h^{-1} during non-occupancy time.

8.1.2.4 Rationale

This is supposed to be the equivalent of an ideal window opening pattern which gives as the average exactly the required air change.

8.1.2.5 References

DOE-2 Reference Manual,
SIA 382/1: "Lueftungstechnische Anlagen, Technische Anforderungen".

8.1.2.6 Quality Assurance

See 8.1.1.6.

8.1.2.7 Further Information

None.

8.1.3 Occupant Defined for Air Temperature Control

None.

8.1.4 Ventilation Time Schedules

See 8.1.1 and 8.1.2

8.2 ENVIRONMENTAL CONTROL

8.2.1 Parameters

8.2.1.1 Description

Proportional band for control of heat emission.
Set points for heating and cooling are to be defined by schedules (see 8.2.2), although cooling is not available.

8.2.1.2 Parameter Definition List

THROTTLING-RANGE = proportional band in K.
Temperature is controlled to stay within setpoint +/- half the entered value.

8.2.1.3 Assign Values

THROTTLING-RANGE = 2.0.

8.2.1.4 Rationale

Reasonable, realistic value.

8.2.1.5 References

DOE-2 Reference Manual

8.2.1.6 Quality Assurance

See 8.2.2.6.

8.2.1.7 Further Information

None.

8.2.2 Time Schedules

8.2.2.1 Description

See 8.2.1.1

8.2.2.2 Parameter Definition List

HEAT-TEMP-SCH under ZONE-CONTROL defines the (time-dependent) setpoint for heating.

COOL-TEMP-SCH under ZONE-CONTROL defines the (time-dependent) setpoint for cooling.

8.2.2.3 Assign Values

HEAT-TEMP-SCH is to be defined that the setpoint for heating is 20 °C during occupancy hours and 16 °C during non-occupancy hours (see 8.3).

COOL-TEMP-SCH is to be defined that the setpoint for cooling is always 26 °C.

8.2.2.4 Rationale

Standard values. Cooling setpoint must be defined although it will have no effect.

8.2.2.5 References

SIA 384/2, SIA 382/2.

8.2.2.6 Quality Assurance

Check temperatures for heating case in hourly report [VARIABLE-TYPE = U-name of ZONE, VARIABLE-LIST = (6)].

8.2.2.7 Further Information

None.

8.3 OCCUPANCY

8.3.1 Heat Gain

8.3.1.1 Description

Number of people in zone.
Sensible and latent heat gain per person for typical office (sitting) activity.

8.3.1.2 Parameter Definition List

AREA/PERSON;
PEOPLE-HG-SENS, sensible heat gain per person in W;
PEOPLE-HG-LAT, latent heat gain per person in W;

8.3.1.3 Assign Values

AREA/PERSON = 10 m2 per person (by default, medium occupancy; high occupancy = 5 m2 per person, low occupancy = 20 m2 per person).
PEOPLE-HG-SENS = 63. W;
PEOPLE-HG-LAT = 68. W.

8.3.1.4 Rationale

According to standard.

8.3.1.5 References

DOE-2 Reference Manual,
SIA-382/2-3.

8.3.1.6 Quality Assurance

Check appropriate reports.

8.3.1.7 Further Information

None.

8.3.2 Occupancy Profile

8.3.2.1 Description

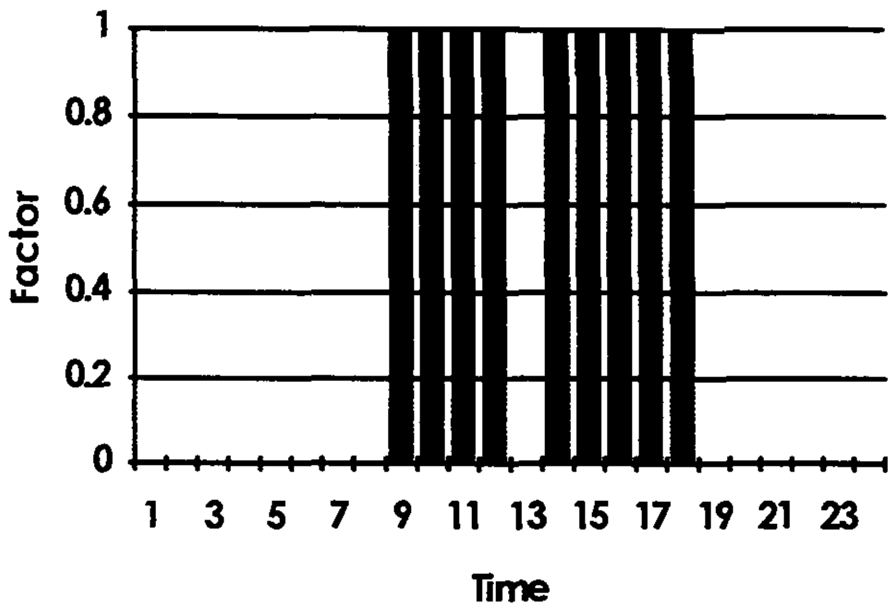
Schedule for description of presence of occupancy.

8.3.2.2 Parameter Definition List

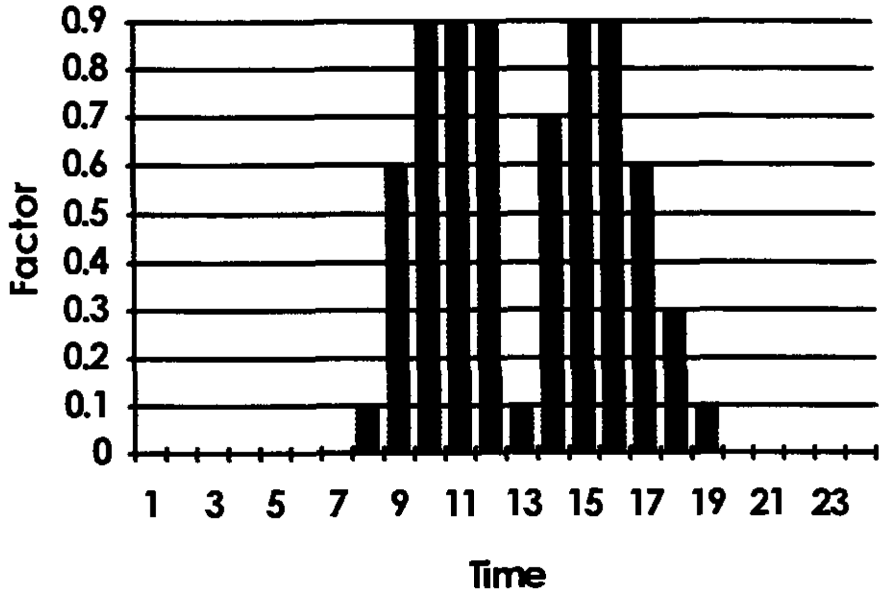
PEOPLE-SCHEDULE is a schedule with a multiplier for the people heat gains defined by the above mentioned keywords.

8.3.2.3 Assign Values

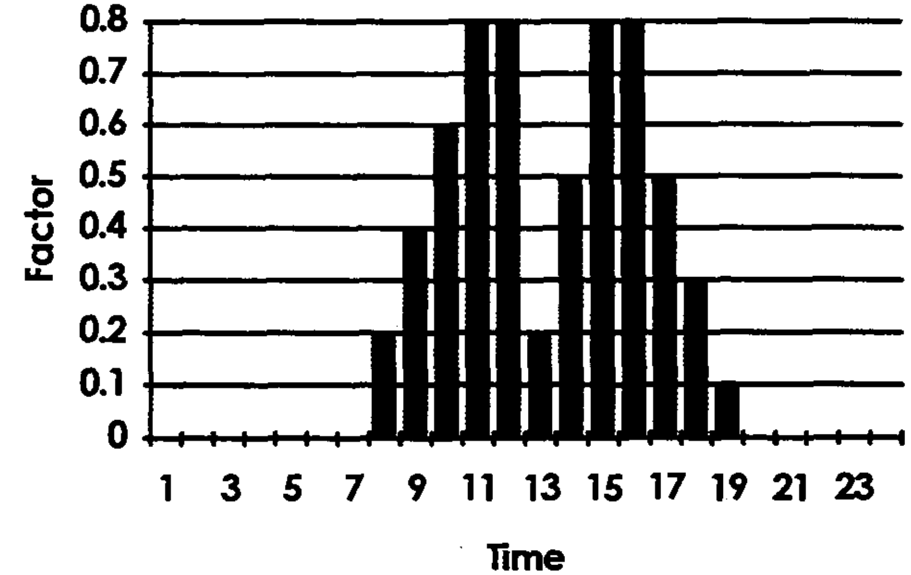
Different schedules dependent on office size:



Single office(1 - 2 persons)



3 - 6 persons per office:



more than 6 persons per office

8.3.2.4 Rationale

According to standard.
Daylight saving time is taken into account here in form of a 1 hour shift, instead of under BUILDING-LOCATION. See also 5.1.1.4.

8.3.2.5 References

See DOE-2 Reference Manual for description of schedules.
See SIA 382/3 for schedules.

8.3.2.6 Quality Assurance

Check VERIFICATION report LV-G and hourly reports values.

8.3.2.7 Further Information

None.

8.4 EQUIPMENT

8.4.1 Heat Gain

8.4.1.1 Description

Maximum heat gain (only sensible is considered) from light and equipment. See 8.5 for reduction to lighting load due to daylighting and 4.2.2 for equipment model.

8.4.1.2 Parameter Definition List

LIGHTING-W/AREA: Max. heat gain from artificial lighting in W/m2, if all is on in zone.
EQUIPMENT-W/AREA: Same for equipment other than lighting (computers, machines...). Note that only 57 % of max. value to be entered here, because rest is defined under function 'EQUI-DIRECT' (see 4.2.2) to provide an appropriate split between radiation and convection.

8.4.1.3 Assign Values

LIGHTING-W/AREA = 10.0,
EQUIPMENT-W/AREA = 57 % of max. heat gain (0 for low, 2.85 for medium, 8.55 for high equipment level).

8.4.1.4 Rationale

Lighting: Considered as the minimum possible value for required illuminance in offices, according to standards.
Equipment: Technical equipment levels with above defined occupancy, according to standard.

8.4.1.5 References

DOE-2 Reference Manual,
SIA-382/3.

8.4.1.6 Quality Assurance

Check hourly report values.

8.4.1.7 Further Information

Extensive reviewing and questioning has been done and is still underway by EMPA and other researchers in Switzerland.

8.4.2 Equipment Gain Profile

8.4.2.1 Description

Schedule for description of operation of lighting and equipment.

8.4.2.2 Parameter Definition List

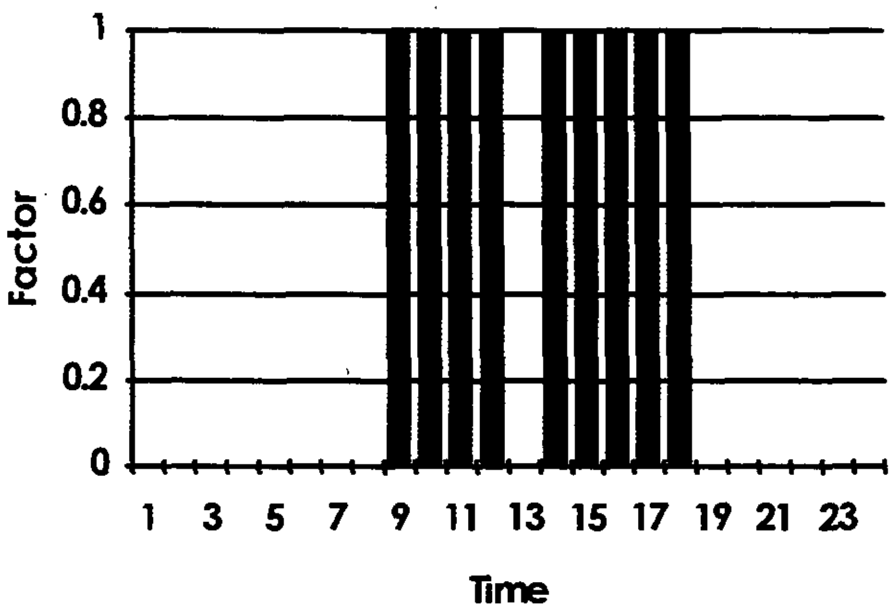
LIGHTING-SCHEDULE is a schedule with a multiplier for the maximum lighting heat gains defined by the above mentioned keywords.

EQUIP-SCHEDULE is a schedule with a multiplier for the maximum equipment heat gains defined by the above mentioned keywords.

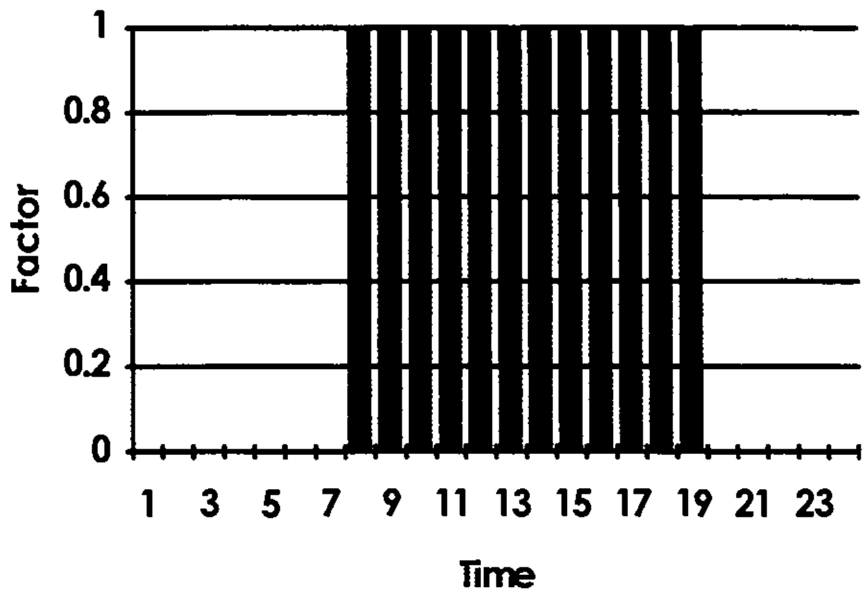
8.4.2.3 Assign Values

LIGHTING-SCHEDULE:

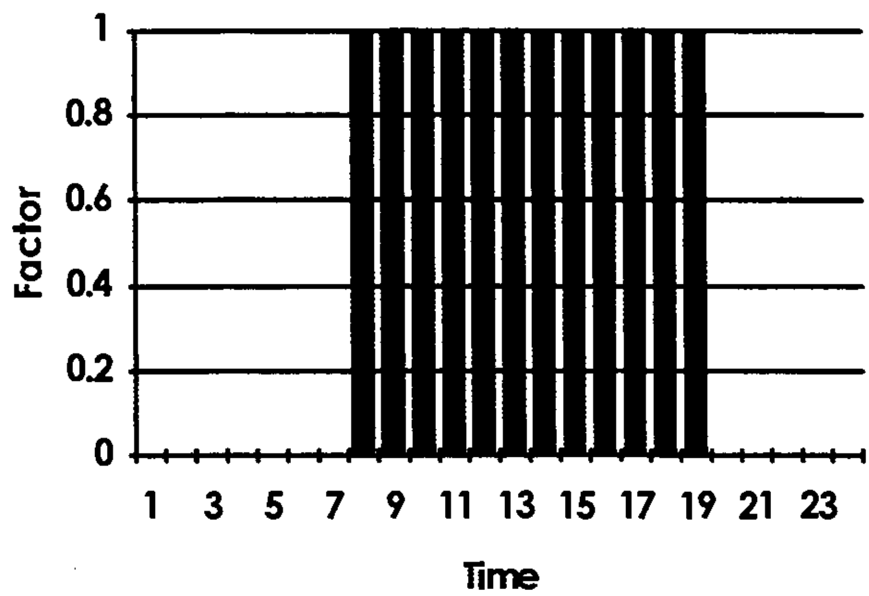
Different schedules dependent on office size:



Single office(1 - 2 persons)



3 - 6 persons per office



more than 6 persons per office

EQUIP-SCHEDULE: Same as PEOPLE-SCHEDULE.

8.4.2.4 Rationale

Daylight saving time is taken into account here instead of under BUILDING-LOCATION.
According to standard.

8.4.2.5 References

8.5 USER OPERATED BUILDING CONTROLS

8.5.1 Lighting Control

8.5.1.1 Description

Lighting is controlled automatically according to the daylighting and a defined illuminance setpoint. This is supposed to replace an "ideal" user who turns off the light as soon as the illuminance is sufficient.

8.5.1.2 Parameter Definition List

DAYLIGHTING is a codeword which allows the program to do a daylighting calculation.
LIGHT-SET-POINT1 is the setpoint in lux for the first zone fraction.
LIGHT-SET-POINT2 is the setpoint in lux for the second zone fraction.
ZONE-FRACTION1 is the fraction of the zone controlled by the first setpoint.
ZONE-FRACTION2 is the fraction of the zone controlled by the first setpoint.
LIGHT-REF-POINT1 is the coordinates of a reference point for one of two zone fractions.
LIGHT-REF-POINT2 is the coordinates of the reference point for the second zone fraction.
LIGHT-CTRL-TYPE1 is the type of control for the first fraction (stepped or dimmed).
LIGHT-CTRL-TYPE2 is the type of control for the second fraction.
LIGHT-CTRL-STEPS is the number of steps for a stepped light control.

8.5.1.3 Assign Values

DAYLIGHTING = YES;
LIGHT-SET-POINT1 = 300. for single offices (1 - 2 persons)
LIGHT-SET-POINT1 = 500. for larger offices (more than 2 persons)
(these are recommended values; for compliance with Swiss standard, this must be set to 11, the minimum, which means the light stays off in the 5 m perimeter zone);
LIGHT-SET-POINT2 =500.;
ZONE-FRACTION1 = the division of the area of the part of the zone less than 5 m from the exterior walls with windows, by the total zone area, or 1.0 if depth less than 5 m;
ZONE-FRACTION2 = the division of the area of the part of the zone more than 5 m from the exterior walls with windows, by the total zone area, or 0. if depth less than 5 m.
LIGHT-REF-POINT1 = horizontally center of first zone

fraction or center of zone, respectively; vertically on desktop level (0.8 m);
LIGHT-REF-POINT2 = same for second zone fraction;
LIGHT-CTRL-TYPE1 = STEPPED;
LIGHT-CTRL-TYPE2 = STEPPED;
LIGHT-CTRL-STEPS = 1.0.

8.5.1.4 Rationale

5 m is the room depth considered as the maximum to be managed by one single control, according to lighting specialists. Also, in this area the light must always stay off according to standard.
1 step means switching on/off, which is to be represented (no sophisticated light control requested).

8.5.1.5 References

DOE-2.1D Supplement;
Vollzugsordner Energie, Kanton Zuerich;
SIA V 382/3.

8.5.1.6 Quality Assurance

Check hourly reports on lighting loads.

8.5.1.7 Further Information

None.

SECTION 9 - PLANT DESCRIPTION

9.1 REAL SYSTEM REPLACER

9.1.1 Description

There is no system assumed for this PAM. This is done in DOE-2 with a dummy system, which only considers the control and summarises the energies. The program part SYSTEMS has to be used, because only there floating temperatures are calculated.

9.1.2 Parameter Definition List

SYSTEM-TYPE: defines the system type to be chosen out of the existing types.

9.1.3 Assign Values

SYSTEM-TYPE = SUM.

9.1.4 Rationale

See 9.1.1.

9.1.5 References

DOE-2 Reference Manual

9.1.6 Quality Assurance

None.

9.1.7 Further Information

None.

SECTION 10 - PLANT CONTROL DESCRIPTION

10.1 Heating AND COOLING CONTROL

10.1.1 Description

Only the operation of heating and cooling has to be defined by a schedule, to provide heating and avoid cooling.

10.1.2 Parameter Definition List

COOLING-SCHEDULE: Schedule to define cooling availability.
HEATING-SCHEDULE: schedule to define heating availability.

10.1.3 Assign Values

COOLING-SCHEDULE: Always off;
HEATING-SCHEDULE: Always on;

10.1.4 Rationale

See 10.1.1.

10.1.5 References

DOE-2 Reference Manual

10.1.6 Quality Assurance

Check SUMMARY report SS-A.

10.1.7 Further Information

None.

SECTION 0 - PAM IDENTIFICATION

IDENTIFIER: EMPA 0002

PURPOSE: Assessment of overheating risk in commercial buildings required by authorities to allow cooling.

APPLICATION: Active heating, natural ventilation at occupancy time, natural ventilation through open windows at night, natural and artificial lighting, no blinds.

PROGRAM: DOE-2.1D

DATE: June 14 1991
revised Oct. 24 1991, Aug. 26 1992, July 8 1993

AUTHOR: Gerhard Zweifel

ADDRESS: EMPA
Building Equipment Section

CH-8600 Dübendorf

Tel: +41 1 823 4275
Fax: +41 1 821 6244
Telex: 825 345

SECTION 1 - DEFINITION OF A PERFORMANCE ASSESSMENT METHOD

1.1 PURPOSE

1.1.1 Assessment of overheating risk, required by authorities to allow cooling.

1.2 APPLICABILITY

1.2.1 Building type: Commercial.

1.2.2 Environmental system:

Active heating;
Natural ventilation during occupancy time;
Natural ventilation through open windows at night;
Natural and artificial lighting.

1.2.3 Climate zone:

Temperate.

1.2.4 Program:

DOE-2.1D or higher

1.2.5 Resources:

VAX(VMS), SUN(UNIX), PC(MS-DOS)

1.2.6 Further Information:

None.

SECTION 2 - PROCEDURE

2.1 PROCEDURE

2.1.1 Define information requirement:

As set out in Section 3.1 of PAM doc EMPA 0001

2.1.2 Configure program:

Select program version set out in section 4.1 of PAM doc EMPA 0001.

Select program sub models 1 and 2 as set out in section 4.2 of PAM doc EMPA 0001 and sub model 3 and 4 as set out in section 4.2.3 and 4.2.4.

Select computational parameters as set out in section 4.3 of PAM doc EMPA 0001.

Set initial conditions as set out in section 4.4 of PAM doc EMPA 0001.

2.1.3 Describe Site and climate:

Site as set out in section 5.1 of PAM doc EMPA 0001.

Climate as set out in section 5.2 of PAM doc EMPA 0001.

2.1.4 Describe zoning procedure to program:

As set out in section 6 of PAM doc EMPA 0001.

2.1.5 Describe building to program:

As set out in section 7 of PAM doc EMPA 0001.

2.1.6 Describe building operation to program:

As set out in section 8 of PAM doc EMPA 0001.

2.1.7 Describe Ventilation process:

As set out in section 8.

2.1.8 Describe plant to program:

As set out in section 9.

2.1.9 Describe plant operation to program:

As set out in section 10.

2.1.10 Process output data:

As set out in section 3 of PAM doc EMPA 0001.

2.1.8 Interpret information

As set out in section 3 of PAM doc EMPA 0001.

2.1.9 Quality Assurance

SECTION 4 - PROGRAM CONFIGURATION

4.1 PROGRAM VERSION

See PAM doc EMPA 0001.

4.2 USER SUB MODEL SELECTION

4.2.1 Sub Model 1:

See PAM doc EMPA 0001.

4.2.2 Sub Model 2:

See PAM doc EMPA 0001.

4.2.3 Sub Model 3:

4.2.3.1 Description:

A functional input was created to directly calculate the necessary information (see section 3.2) within the program.

4.2.3.2 Function 'KELVINH'

4.2.3.3 Select sub model method:

Use function 'KELVINH' provided by EMPA as SUBROUTINE-FUNCTION RESYS-4Z and function 'IRSCHPR' as SUBROUTINE-FUNCTION DAYCLS-1.

4.2.3.4 Rationale:

Post processing can be avoided.

4.2.3.5 Reference:

DOE-2.1D Supplement.

4.2.3.6 Quality Assurance:

Examine carefully additional information according to 3.2.6 and 3.3.6.

4.2.3.7 Further Information:

None.

4.2.4 Sub model 4:

4.2.4.1 Description:

Open window ventilation model.

4.2.4.2 'SHERMAN-GRIMSRUD': Model with a user defined opening area for the natural ventilation.

Function 'WINVENT' to ensure proper window opening control.

Function 'NEUT_LEV' to ensure correct neutral level.

4.2.4.3 Select Sub Model Method:

Chose VENT-METHOD = S-G in connection with SYSTEM-TYPE = RESYS
Area to be defined as representing a 10 cm opening of all openable windows of the zone for night ventilation according to figure below.

Use function 'WINVENT' provided by EMPA as subroutine-function 'RESYS-3Z'.

Use function 'NEUT-LEV' provided by EMPA as 'zone-before'-function.

4.2.4.4 Rationale:

There is no need for an estimate of the air change, which is very difficult and decisive for the result. The 10 cm opening of all windows represents a practicable way for night ventilation.

The control of window openings as modelled by the program does not meet the requirements. The windows are controlled according to a setpoint, defined by a schedule, for the room air temperature. This means that the windows can be closed at any time if the setpoint is reached, which is to be avoided. The function 'WINVENT' provides a control strategy, which opens the windows temperature dependent at the end of the operation time and leaves them open during the whole night or weekend. The decision temperature is similar to the limit for the overheating definition (see section 3 of PAM doc EMPA 0001).

The neutral level is not set correctly, if the ventilation type is not equally 'SHERMAN-GRIMSRUD' in both program parts LOADS and SYSTEMS. Since the user is advised to do so, the function 'NEUT_LEV' is needed.

4.2.4.5 Reference:

M.H. Sherman and D.T. Grimsrud: "Measurement of Infiltration Using Fan Pressurisation and Weather Data", October 1980, LBL-10852.

DOE-2.1D Supplement, p.2.74. and 3.33

4.2.4.6 Quality Assurance:

There is no way to check the resulting air change values. Since the window ventilation is the only way to remove heat from the zone, it can be checked by looking at the hourly report values for the heat extraction [VARIABLE-TYPE = U-name of ZONE, VARIABLE-LIST = (8)].

4.2.4.7 Further Information:

None.

SECTION 8 - BUILDING OPERATION DESCRIPTION

8.1 VENTILATION

8.1.1 Adventitious

See PAM doc EMPA 0001.

8.1.2 Occupant Defined for Air Quality Control

See PAM doc EMPA 0001.

8.1.3 Occupant Defined for Air Temperature Control

8.1.3.1 Description

Two schedules are used to define the open window night ventilation: One which defines when windows are allowed to be open, and one which gives the conditions under which they really are. This, again, represents an automatic control which is supposed to replace the ideal occupant. This is in connection with sub model 4 according to section 4.2.4, which partly changes the original effects of the described schedules.

8.1.3.2 Parameter Definition List

NATURAL-VENT-SCH: defines the time when windows are allowed to be open;

VENT-TEMP-SCH: defines the conditions for the windows to be open. This means the minimum temperature to which the zone may be cooled down by natural night ventilation.

8.1.3.3 Assign Values

NATURAL-VENT-SCH: Closed (0) during occupancy time, open (1) during the non-occupancy-time;
VENT-TEMP-SCH: 21 °C during occupancy time, 17 °C during non-occupancy time.

8.1.3.4 Rationale

This is only to represent night time ventilation; day time ventilation is included in "infiltration", see 8.1.2.
The temperature is set to the upper boundary of the heating control proportional band, to avoid the heating system heat up the zone in the morning due to undercooling from night ventilation.

8.1.3.5 References

DOE-2.1D Supplement.

8.1.3.6 Quality Assurance

See 4.2.4.6.

8.1.3.7 Further Information

None.

8.2 ENVIRONMENTAL CONTROL

See PAM doc EMPA 0001.

8.3 OCCUPANCY

See PAM doc EMPA 0001.

8.4 EQUIPMENT

See PAM doc EMPA 0001.

8.5 USER OPERATED BUILDING CONTROLS

See PAM doc EMPA 0001.

SECTION 9 - PLANT DESCRIPTION

9.1 HEATING

9.1.1 Description

Heating to the zone is provided by a "baseboard" system. Normally, this is only true if a max. baseboard emittance other than 0 (the default) is defined. This is not set by the program's design calculation. A high value, which the user is sure will be able to heat the zone, should be used.

9.1.2 Parameter Definition List

BASEBOARD-RATING under ZONE command: Max. emittance of baseboard system in W (negative number for heating).
BASEBOARD-SOURCE under SYSTEM command: Defines where heat for this system comes from.

9.1.3 Assign Values

BASEBOARD-RATING = negative number, large enough to heat the zone.
BASEBOARD-SOURCE = HOT-WATER.

9.1.4 Rationale

See 9.1.1. Correct heating is important for overheating assessment during intermediate season, because otherwise inadequately low starting temperatures could reduce the overheating risk.
Baseboard-source is set to electric for some system types, which is not ideal for future applications and for the checking of some reports.

9.1.5 References

DOE-2 Reference Manual

9.1.6 Quality Assurance

Check by looking at the hourly report values [VARIABLE-TYPE = U-name of ZONE, VARIABLE-LIST = (15)] if heating performs as desired.

9.1.7 Further Information

None.

9.2 AIR SYSTEM

9.2.1 Description

Although there is no air system assumed for this PAM, there has to be defined one with a couple of mandatory entries, in order to enable the program to perform the night ventilation mentioned above.

9.2.2 Parameter Definition List

Under ZONE command:
DESIGN-HEAT-T: Zone temperature in °C for heating system design purpose, mandatory, but nor used, because there is no actual system.
DESIGN-COOL-T: Zone temperature in °C for cooling system design purpose, mandatory, but nor used, because there is no actual system.
Under SYSTEM command:
SYSTEM-TYPE: defines the system type to be chosen out of the existing types.

9.2.3 Assign Values

DESIGN-HEAT-T = 20.
DESIGN-COOL-T = 26.
SYSTEM-TYPE = RESYS.

9.2.4 Rationale

See 9.2.1.

9.2.5 References

DOE-2 Reference Manual, DOE-2.1D Supplement.

9.2.6 Quality Assurance

Check VERIFICATION report SV-A for design values.

9.2.7 Further Information

None.

10.1 HEATING CONTROL

10.1.1 Description

The baseboard heating is to be controlled thermostatically, which is to describe the usual radiators with thermostatic valves.

10.1.2 Parameter Definition List

BASEBOARD-CONTROL: Defines the control type of the heating system.

10.1.3 Assign Values

BASEBOARD-CONTROL = THERMOSTATIC.

10.1.4 Rationale

See 10.1.1.

10.1.5 References

DOE-2 Reference Manual

10.1.6 Quality Assurance

Check by looking at the hourly report values [VARIABLE-TYPE = U-name of ZONE, VARIABLE-LIST = (15)] if heating performs as desired.

10.1.7 Further Information

None.

10.2 AIR SYSTEM CONTROL

10.2.1 Description

There are a couple of control entries which are needed to avoid the program to simulate an air system.

10.2.2 Parameter Definition List

MAX-SUPPLY-T: Max. supply temperature for the air system, mandatory, but not used, because there is no air heating.
MIN-SUPPLY-T: Min. supply temperature for the air system,

mandatory, but not used, because there is no air cooling.
FAN-SCHEDULE: schedule to define air system operation.
COOLING-SCHEDULE: Schedule to define cooling availability.
HEATING-SCHEDULE: Schedule to define heating availability.

10.2.3 Assign Values

MAX-SUPPLY-T: 26 °C;
MIN-SUPPLY-T: 16 °C;
FAN-SCHEDULE: Always off;
COOLING-SCHEDULE: Always off;
HEATING-SCHEDULE: Always on;

10.2.4 Rationale

No air heating or cooling should be simulated.

10.2.5 References

DOE-2 Reference Manual, DOE-2.1D Supplement.

10.2.6 Quality Assurance

Check VERIFICATION report SV-A and SUMMARY report SS-A.

10.2.7 Further Information

None.

SECTION 0 - PAM IDENTIFICATION

IDENTIFIER: EMPA 0003

PURPOSE: Assessment of overheating risk in commercial buildings, required by authorities to allow cooling.

APPLICATION: Active heating, natural ventilation at occupancy time, natural and artificial lighting, with exterior or interior blinds.

PROGRAM: DOE-2.1D

DATE: June 19 1991,
revised Aug. 27 1992, July 9 1993

AUTHOR: Gerhard Zweifel

ADDRESS: EMPA
Building Equipment Section

CH-8600 Dübendorf

Tel: +41 1 823 4275
Fax: +41 1 821 6244
Telex: 825 345

SECTION 1 - DEFINITION OF A PERFORMANCE ASSESSMENT METHOD

1.1 PURPOSE

1.1.1 Assessment of overheating risk, required by authorities to allow cooling.

1.2 APPLICABILITY

1.2.1 Building type: Commercial.

1.2.2 Environmental system:

Active heating;
Natural ventilation during occupancy time;
Natural and artificial lighting.

1.2.3 Climate zone:

Temperate.

1.2.4 Program:

DOE-2.1D or higher

1.2.5 Resources:

VAX(VMS), SUN(UNIX), PC(MS-DOS)

1.2.6 Further Information:

Occupant operated exterior (or interior) blinds included.

2.1 PROCEDURE

2.1.1 Define information requirement:

As set out in Section 3.1 of PAM doc EMPA 0001.

2.1.2 Configure program:

Select program version set out in section 4.1 of PAM doc EMPA 0001.

Select program sub models as set out in section 4.2.

Select computational parameters as set out in section 4.3 of PAM doc EMPA 0001.

Set initial conditions as set out in section 4.4 of PAM doc EMPA 0001.

2.1.3 Describe Site and climate:

Site as set out in section 5.1 of PAM doc EMPA 0001.

Climate as set out in section 5.2 of PAM doc EMPA 0001.

2.1.4 Describe zoning procedure to program:

As set out in section 6 of PAM doc EMPA 0001.

2.1.5 Describe building to program:

As set out in section 7.

2.1.6 Describe building operation to program:

As set out in section 8.

2.1.7 Describe Ventilation process:

As set out in section 8 of PAM doc EMPA 0001.

2.1.8 Describe plant to program:

As set out in section 9 of PAM doc EMPA 0001.

2.1.9 Describe plant operation to program:

See section 10 of PAM doc EMPA 0001.

2.1.10 Process output data:

As set out in section 3 of PAM doc EMPA 0001.

2.1.11 Interpret information

As set out in section 3 of PAM doc EMPA 0001.

2.1.12 Quality Assurance

As set out in the appropriate subsections.

4.1 PROGRAM VERSION

See PAM doc EMPA 0001.

4.2 USER SUB MODEL SELECTION

4.2.1 Sub Model 1:

See PAM doc EMPA 0001.

4.2.2 Sub Model 2:

See PAM doc EMPA 0001.

4.2.3 Sub Model 3:

See PAM doc EMPA 0001.

4.2.4 Sub Model 4:

4.2.4.1 Description:

Model for visible transmission of blinds. The blades of the blinds are always as open as possible, but not more than the prevention of direct solar radiation penetration allows. For this, the visible transmission has to be defined solar angle dependent. This is done in this sub model.

4.2.4.2 WINVIS is a functional input which defines the visible transmission of the blinds as a function of the solar angle.

4.2.4.3 Use function 'WINVIS' provided by EMPA as 'window-before'-function.

4.2.4.4 Rationale:

In DOE-2 the visible transmission of the blinds can be defined by a schedule. This is rather difficult for the case of an 'ideal' user, who operates the blinds in a way to prevent direct solar radiation entering and at the same time to maximise the available amount of daylight, to avoid artificial lighting.

4.2.4.5 Reference:

DOE-2.1D Supplement;
Estimation of illumination reduction factors for simulation of blinds with DOE-2 (IEA21RN234/92).

4.2.4.6 Quality Assurance:

Check hourly report values for visible transmission [VARIABLE-TYPE = U-name of WINDOW, VARIABLE-LIST = (22)].

4.2.4.7 Further Information:

None.

SECTION 7 - BUILDING DESCRIPTION

7.1 Geometry

See PAM doc EMPA 0001.

7.2 SHADING DEVICES (EXTERNAL)

7.2.1 External shades like overhangs and fins

Define geometry as appropriate according to DOE-2.1D Supplement.

7.2.2 Exterior Blinds

7.2.2.1 Description

Movable exterior blinds are defined by a codeword, two separate time-dependent multipliers for the total and the visible transmission of the glass (schedules).

7.2.2.2 Parameter definition list

WIN-SHADE-TYPE: Type of device.
SHADING-SCHEDULE: Schedule for total transmission multiplier.
VIS-TRANS-SCHEDULE: Schedule for visible transmission multiplier. The latter is modified by the WINVIS function (see 4.2.4)

7.2.2.3 Assign Values

WIN-SHADE-TYPE = MOVABLE-EXTERIOR.

SHADING-SCHEDULE: THRU DEC 31 (ALL) (1,24) (0.21)

VIS-TRANS-SCH: THRU DEC 31 (ALL) (1,24) (1)

7.2.2.4 Rationale

The total transmission multiplier leads to a total transmission according to standards and is based on the assumption that all direct radiation is blocked by the blinds.
The visible transmission value is modified by sub model 4.2.4.

7.2.2.5 Reference

DOE-2.1D Supplement;
Estimation of illumination reduction factors for simulation of blinds with DOE-2 (IEA21RN234/92).

7.2.2.6 Quality Assurance

Check hourly report values for transmission [VARIABLE-TYPE = U-name of WINDOW, VARIABLE-LIST = (19)].

7.2.2.7 Further Information

None.

7.3 SHADING DEVICES (INTERNAL)

7.3.1 Internal Blinds

Normally none. If exceptionally applicable, description like external blinds, except WIN-SHADE-TYPE = MOVABLE-INTERIOR.

7.4 CONSTRUCTION

See PAM doc EMPA 0001.

7.5 SURFACE PROPERTIES (EXTERNAL ELEMENTS)

See PAM doc EMPA 0001.

7.6 CONSTRUCTION (INTERNAL ELEMENTS)

See PAM doc EMPA 0001.

7.7 SURFACE PROPERTIES (INTERNAL ELEMENTS)

See PAM doc EMPA 0001.

7.8 WINDOW PROPERTIES

See PAM doc EMPA 0001.

SECTION 8 - BUILDING OPERATION DESCRIPTION

8.1 VENTILATION

See PAM doc EMPA 0001.

8.2 ENVIRONMENTAL CONTROL

See PAM doc EMPA 0001.

8.3 OCCUPANCY

See PAM doc EMPA 0001.

8.4 EQUIPMENT

See PAM doc EMPA 0001.

8.5 USER OPERATED BUILDING CONTROLS

8.5.1 Lighting Control

See PAM doc EMPA 0001.

8.5.2 Control of External Shading

8.5.2.1 Description

A schedule which defines the automatic, radiation-dependent control of the exterior blinds is supposed to replace an "ideal" user who always closes the blinds when direct solar radiation penetrates into the zone.

8.5.2.2 Parameter Definition List

MAX-SOLAR-SCH: Schedule for control of movable blinds according to transmitted direct radiation.

8.5.2.3 Assign Values

```
MAX-SOLAR-SCH:
THRU DEC 31 (ALL)        HOURS=(1,24)
     RADIATIONS=(0.)
```

8.5.2.4 Rationale

The control schedule is reasonable, regarding the fact, that the defined radiation threshold is only the direct component, which is ideally kept to zero.

8.5.2.5 References

DOE-2.1D Supplement.

8.5.2.6 Quality Assurance

Check hourly report values for blind operation flag [VARIABLE-TYPE = U-name of WINDOW, VARIABLE-LIST = (23)].

8.5.2.7 Further Information

None.

SECTION 0 - PAM IDENTIFICATION

IDENTIFIER: EMPA 0004

PURPOSE: Assessment of overheating risk in commercial buildings required by authorities to allow cooling.

APPLICATION: Active heating, natural ventilation at occupancy time, natural ventilation through open windows at night, natural and artificial lighting, with exterior or interior blinds.

PROGRAM: DOE-2.1D

DATE: June 21 1991
Revised Oct. 30 1991, Aug. 27 1992, July 9 1993

AUTHOR: Gerhard Zweifel

ADDRESS: EMPA
Building Equipment Section

CH-8600 Dübendorf

Tel: +41 1 823 4275
Fax: +41 1 821 6244
Telex: 825 345

1.1 PURPOSE

1.1.1 Assessment of overheating risk, required by authorities to allow cooling.

1.2 APPLICABILITY

1.2.1 Building type: Commercial.

1.2.2 Environmental system:

Active heating;
Natural ventilation during occupancy time;
Natural ventilation through open windows at night;
Natural and artificial lighting.

1.2.3 Climate zone:

Temperate.

1.2.4 Program:

DOE-2.1D or higher

1.2.5 Resources:

VAX(VMS), SUN(UNIX), PC(MS-DOS)

1.2.6 Further Information:

Occupant operated exterior (or interior) blinds included.

SECTION 2 - PROCEDURE

2.1 PROCEDURE

2.1.1 Define information requirement:

As set out in Section 3.1 of PAM doc EMPA 0001

2.1.2 Configure program:

Select program version set out in section 4.1 of PAM doc EMPA 0001.

Select program sub models 1 and 2 as set out in section 4.2 of PAM doc EMPA 0001.

Select program sub model 3 and 4 as set out in section 4.2.3 and 4.2.4 of PAM doc EMPA 0002.

Select program sub model 5 as set out in section 4.2.4 of PAM doc EMPA 0003.

Select computational parameters as set out in section 4.3 of PAM doc EMPA 0001.

Set initial conditions as set out in section 4.4 of PAM doc EMPA 0001.

2.1.3 Describe Site and climate:

Site as set out in section 5.1 of PAM doc EMPA 0001.

Climate as set out in section 5.2 of PAM doc EMPA 0001.

2.1.4 Describe zoning procedure to program:

As set out in section 6 of PAM doc EMPA 0001.

2.1.5 Describe building to program:

As set out in section 7 of PAM doc EMPA 0003.

2.1.6 Describe building operation to program:

As set out in section 8 of PAM doc EMPA 0003.

2.1.7 Describe Ventilation process:

As set out in section 8 of PAM doc EMPA 0002.

2.1.8 Describe plant to program:

As set out in section 9 of PAM doc EMPA 0002.

2.1.9 Describe plant operation to program:

As set out in section 10 of PAM doc EMPA 0002.

2.1.10 Process output data:

As set out in section 3 of PAM doc EMPA 0001.

2.1.11 Interpret information

As set out in section 3 of PAM doc EMPA 0001.

2.1.12 Quality Assurance

As set out in the appropriate subsections.

SECTION 0 - PAM IDENTIFICATION

IDENTIFIER:	EMPA 0005
PURPOSE:	Assessment of overheating risk in commercial buildings, required by authorities to allow cooling.
APPLICATION:	Active heating, mechanical ventilation at occupancy time, natural and artificial lighting, no blinds.
PROGRAM:	DOE-2.1D
DATE:	Oct. 28 1991, rev. Aug. 27 1992, July 9 1993
AUTHOR:	Gerhard Zweifel

ADDRESS:

EMPA
Building Equipment Section

CH-8600 Dübendorf

Tel: +41 1 823 4275
Fax: +41 1 821 6244
Telex: 825 345

SECTION 1 - DEFINITION OF A PERFORMANCE ASSESSMENT METHOD

1.1 PURPOSE

1.1.1 Assessment of overheating risk, required by authorities to allow cooling.

1.2 APPLICABILITY

1.2.1 Building type: Commercial.

1.2.2 Environmental system:

Active heating;
Mechanical ventilation during occupancy time;
Natural and artificial lighting.

1.2.3 Climate zone:

Temperate.

1.2.4 Program:

DOE-2.1D or higher

1.2.5 Resources:

VAX(VMS), SUN(UNIX), PC(MS-DOS)

1.2.6 Further Information:

None.

SECTION 2 - PROCEDURE

2.1 PROCEDURE

2.1.1 Define information requirement:

As set out in Section 3.1 of PAM doc EMPA 0001

2.1.2 Configure program:

Select program version set out in section 4.1 of PAM doc EMPA 0001.

Select program sub models 1 - 3 as set out in section 4.2 of PAM doc EMPA 0001.

Select computational parameters as set out in section 4.3 of PAM doc EMPA 0001.

Set initial conditions as set out in section 4.4 of PAM doc EMPA 0001.

2.1.3 Describe Site and climate:

Site as set out in section 5.1 of PAM doc EMPA 0001.

Climate as set out in section 5.2 of PAM doc EMPA 0001.

2.1.4 Describe zoning procedure to program:

Zone description as set out in section 6.1.

Interzonal coupling as set out in section 6.2 of PAM doc EMPA 0001.

2.1.5 Describe building to program:

As set out in section 7 of PAM doc EMPA 0001.

2.1.6 Describe building operation to program:

As set out in section 8 of PAM doc EMPA 0001.

2.1.7 Describe Ventilation process:

As set out in section 8.

2.1.8 Describe plant to program:

As set out in section 9.

2.1.9 Describe plant operation to program:

As set out in section 10.

2.1.10 Process output data:

As set out in section 3 of PAM doc EMPA 0001.

2.1.11 Interpret information

As set out in section 3 of PAM doc EMPA 0001.

2.1.12 Quality Assurance

6.1 ZONE DESCRIPTION

6.1.1 Modelled Zones

6.1.1.1 Description

Typical zone.

6.1.1.2 Parameter definition list

N/A.

6.1.1.3 Define Zone

Follow the following procedure to chose zones to be considered:

Divide the building into the lowest possible number of areas with spaces of the same or enough similar operation, construction and the same orientation, served by the same ventilation system;

Pick from these areas those with a ratio of more than 10 % of the total building area for which air conditioning is envisaged;

Pick from these areas all those with orientations in the sectors E - SE and SW - W;

If an area found is equal to a space, the modelled zone is this space;
if an area consists of several spaces (the more frequent case), the modelled zone is the one of these spaces, which represents best the whole group of spaces.

Areas with orientations out of the sector defined above have to be treated in the same way,
- if overheating occurs in the zones mentioned above,
- if there is a group with harder operational conditions (higher internal gains).

6.1.1.4 Rationale

The orientations between E and W are most likely to have overheating.

6.1.1.5 Reference

None.

6.1.1.6 Quality Assurance

Examine other zones in cases of uncertainty.

6.1.1.7 Further Information

None.

6.1.2 Adjacent Unmodelled Zones

See PAM doc EMPA 0001.

SECTION 8 - BUILDING OPERATION DESCRIPTION

8.1 VENTILATION

8.1.1 Adventitious

8.1.1.1 Description

Among the different ways of defining infiltration air changes, the one which gives a constant air change without wind speed-dependence is chosen (see also 4.2.1).

8.1.1.2 Parameter Definition List

INF-FLOW/AREA is the volume of air in m^3/m^2h. This has to be entered for a wind speed-independent infiltration airchange.

8.1.1.3 Assign Values

Value that leads to an air change in the room of 0.2 h^{-1}.

8.1.1.4 Rationale

Tight building assumed.

8.1.1.5 References

DOE-2 Reference Manual

8.1.1.6 Quality Assurance

None.

8.1.1.7 Further Information

None.

8.1.2 Occupant Defined for Air Quality Control

No occupant defined ventilation.

8.1.3 Occupant Defined for Air Temperature Control

No occupant defined ventilation.

8.1.4 Ventilation time schedule

8.1.4.1 Description

Schedule to describe the nightly infiltration for the case where there is no mechanical ventilation.

8.1.4.2 Parameter Definition List

INFILTRATION-SCHEDULE.

8.1.4.3 Assign Values

On during non-operation hours of mechanical ventilation system, off during operation hours (see 10.2).

8.1.4.4 Rationale

Tight building assumed. Infiltration during operation of ventilation system suppressed by over pressure.

8.1.4.5 References

DOE-2 Reference Manual

8.1.4.6 Quality Assurance

Check infiltration hourly report values.

8.1.4.7 Further Information

None.

8.2 ENVIRONMENTAL CONTROL

See PAM doc EMPA 0001.

8.3 OCCUPANCY

See PAM doc EMPA 0001.

8.4 EQUIPMENT

See PAM doc EMPA 0001.

8.5 USER OPERATED BUILDING CONTROLS

See PAM doc EMPA 0001.

SECTION 9 - PLANT DESCRIPTION

9.1 HEATING

See PAM doc EMPA 0002.

9.2 AIR SYSTEM

9.2.1 Description

A constant volume air system has to be simulated, which has to provide the required amount of fresh air for the occupants. I should not have any cooling or heating capabilities, but must have a heat recovery device and some qualities according to Swiss recommendations. Some values have to be specified mandatorily.

9.2.2 Parameter Definition List

Under ZONE command:
DESIGN-HEAT-T: Zone temperature in °C for heating system design purpose, mandatory.
DESIGN-COOL-T: Zone temperature in °C for cooling system design purpose, mandatory.
ASSIGNED-FLOW: Fixed value for total system air flowrate in m^3/h;
OUTSIDE-AIR-FLOW: Minimum value for outside air flowrate in m^3/h

Under SYSTEM command:
SYSTEM-TYPE: defines the system type to be chosen out of the existing types.
RECOVERY-EFF: Constant heat recovery efficiency for whole period.
SUPPLY-STATIC: Design pressure difference for supply fan in mm Water gauge.
SUPPLY-EFF: Overall supply fan efficiency (motor included).
RETURN-STATIC: Design pressure difference for return fan in mm Water gauge.
RETURN-EFF: Overall return fan efficiency (motor included).

9.2.3 Assign Values

DESIGN-HEAT-T = 20.
DESIGN-COOL-T = 26.
ASSIGNED-FLOW = the value which corresponds to a flowrate of 25 - 30 m^3/h per person (non-smoking, the default) or 50 - 70 m^3/h per person (smoking). (higher value = normal energy requirements, lower value = enhanced energy requirements)
OUTSIDE-AIR-FLOW = the value which corresponds to a flowrate of 25 - 30 m^3/h per person (non-smoking, the default) or 50 - 70 m^3/h per

person (smoking).
SYSTEM-TYPE = SZRH.
RECOVERY-EFF = 0.65
SUPPLY-STATIC = 60.
SUPPLY-EFF = 0.625
RETURN-STATIC = 30.
RETURN-EFF = 0.625

9.2.4 Rationale

See 9.2.1.
ASSIGNED-FLOW is the only way to intentionally fix the air flow rate in DOE-2; all other keywords will allow the program's design routine to override the defined value.

9.2.5 References

DOE-2 Reference Manual, DOE-2.1D Supplement.

9.2.6 Quality Assurance

Check VERIFICATION report SV-A .

9.2.7 Further Information

None.

SECTION 10 - PLANT CONTROL DESCRIPTION

10.1 HEATING CONTROL

See PAM doc EMPA 0002.

10.2 AIR SYSTEM CONTROL

10.2.1 Description

Control entries which are needed to define the system's operation and to avoid the program to simulate air system heating or cooling capabilities.

10.2.2 Parameter Definition List

MIN-SUPPLY-T: Min. supply temperature in °C for the air system, mandatory input, but only used for design purposes, because there is no air cooling available (see COOLING-SCHEDULE below).
REHEAT-DELTA-T: Max. temperature difference in K, provided by reheat coil; mandatory input for chosen system type.
FAN-SCHEDULE: schedule to define air system operation.
COOLING-SCHEDULE: Schedule to define cooling availability.
HEATING-SCHEDULE: Schedule to define heating availability.

10.2.3 Assign Values

MAX-SUPPLY-T = 26.;
MIN-SUPPLY-T = 16.;
REHEAT-DELTA-T = 0.;
FAN-SCHEDULE: On whenever occupancy schedule has non-zero value (see 8.3.2 of PAM doc EMPA 0001);
COOLING-SCHEDULE: Always off;
HEATING-SCHEDULE: Always on;

10.2.4 Rationale

MAX-SUPPLY-T: Avoid subcooling in cold periods.
MIN-SUPPLY-T: Normal value, although unused since cooling off.
REHEAT-DELTA-T: No reheat coil should be simulated.
SCHEDULES: To provide proper operation.

10.2.5 References

DOE-2 Reference Manual, DOE-2.1D Supplement.

10.2.6 Quality Assurance

Check summary reports SS-A and SS-L to ensure proper operation..

10.2.7 Further Information

None.

SECTION 0 - PAM IDENTIFICATION

IDENTIFIER:	EMPA 0006
PURPOSE:	Assessment of overheating risk in commercial buildings, required by authorities to allow cooling.
APPLICATION:	Active heating, mechanical ventilation at occupancy time, natural and artificial lighting, with exterior or interior blinds.
PROGRAM:	DOE-2.1D
DATE:	Oct. 30 1991, rev. Aug. 28 1992, July 9 1993
AUTHOR:	Gerhard Zweifel
ADDRESS:	EMPA Building Equipment Section CH-8600 Dübendorf Tel: +41 1 823 4275 Fax: +41 1 821 6244 Telex: 825 345

SECTION 1 - DEFINITION OF A PERFORMANCE ASSESSMENT METHOD

1.1 PURPOSE

1.1.1 Assessment of overheating risk, required by authorities to allow cooling.

1.2 APPLICABILITY

1.2.1 Building type: Commercial.

1.2.2 Environmental system:

Active heating;
Mechanical ventilation during occupancy time;
Natural and artificial lighting.

1.2.3 Climate zone:

Temperate.

1.2.4 Program:

DOE-2.1D or higher

1.2.5 Resources:

VAX(VMS), SUN(UNIX), PC(MS-DOS)

1.2.6 Further Information:

Occupant operated exterior (or interior) blinds included.

SECTION 2 - PROCEDURE

2.1 PROCEDURE

2.1.1 Define information requirement:

As set out in Section 3.1 of PAM doc EMPA 0001

2.1.2 Configure program:

Select program version set out in section 4.1 of PAM doc EMPA 0001.

Select program sub models 1 -3 as set out in section 4.2 of PAM doc EMPA 0001 and sub model 4 as set out in section 4.2.4 of PAM doc EMPA 0003.

Select computational parameters as set out in section 4.3 of PAM doc EMPA 0001.

Set initial conditions as set out in section 4.4 of PAM doc EMPA 0001.

2.1.3 Describe Site and climate:

Site as set out in section 5.1 of PAM doc EMPA 0001.

Climate as set out in section 5.2 of PAM doc EMPA 0001.

2.1.4 Describe zoning procedure to program:

Zone description as set out in section 6.1 of PAM doc EMPA 0005.

Interzonal coupling as set out in section 6.2 of PAM doc EMPA 0001.

2.1.5 Describe building to program:

As set out in section 7 of PAM doc EMPA 0003.

2.1.6 Describe building operation to program:

As set out in sections 8.2 to 8.5 of PAM doc EMPA 0003.

2.1.7 Describe Ventilation process:

As set out in section 8.1 of PAM doc EMPA 0005.

2.1.8 Describe plant to program:

As set out in section 9 of PAM doc EMPA 0005.

2.1.9 Describe plant operation to program:

As set out in section 10 of PAM doc EMPA 0005.

2.1.10 Process output data:

As set out in section 3 of PAM doc EMPA 0001.

2.1.11 Interpret information

As set out in section 3 of PAM doc EMPA 0001.

2.1.12 Quality Assurance

As set out in the appropriate subsections.

Identifier	Purpose	Application	Program	Author(s)
BLAST001	Assessment of overheating risk	Commercial building with single room	BLAST	S. Huther
BRE 0001	Assessment of overheating risk	Evaluation at the early designs stage of small to medium buildings	BREADMIT	L. Roche, D. Bloomfield
BRE 0002	Analysis of the thermal performance of building construction elements	Conduction performance of all opaque layer constructions and of glazing	BREADMIT	L. Roche, D. Bloomfield
EMPA 0001	assessment of overheating risk in commercial buildings	Active heating, daytime natural ventilation, natural and artificial lighting	DOE2	G. Zweifel
EMPA 0002	assessment of overheating risk in commercial buildings	Active heating, daytime natural ventilation, nocturnal ventilation natural and artificial lighting	DOE2	G. Zweifel
EMPA 0003	assessment of overheating risk in commercial buildings	Active heating, daytime natural ventilation, natural and artificial lighting, blinds	DOE2	G. Zweifel
EMPA 0004	assessment of overheating risk in commercial buildings	Active heating, daytime natural ventilation, nocturnal ventilation, natural and artificial lighting, blinds	DOE2	G. Zweifel
EMPA 0005	assessment of overheating risk in commercial buildings	Active heating, mechanical ventilation, natural and artificial lighting	DOE2	G. Zweifel
EMPA 0006	assessment of overheating risk in commercial buildings	Active heating, mechanical ventilation, natural and artificial lighting, blinds	DOE2	G. Zweifel
ARD 0001	Assessment of overheating risk	Evaluation of design of commercial buildings of up to 50 zones	ENERGY 2	M. Holmes, P. Schild
*BDP 001	Monthly and annual energy audit	Analysis of the designs produced for Passive Solar Design Studies	ESP	A.J.A. Sluce
*BDP 002	Calculate the light switching function in a thermal zone	Provision of light switching function for input to ESPbps	MABEL	A.J.A. Sluce
*BDP 003	Over heating assessment	Non-domestic buildings	ESP	A.J.A. Sluce
*BDP 004	Performance on representative days	Non-domestic buildings	ESP	A.J.A. Sluce
*BDP 005	Calculation of annual and monthly energy consumption	Non-domestic buildings	ESP	A.J.A. Sluce
*BDP 006	Indication of the effect of solar gain on a building	Non-domestic buildings	ESP	A.J.A. Sluce
NU002V6-Com.	Overheating Risk Assessment	Office buildings	SERI-RES	J.T. Wiltshire, B.F. Warren, B. Sodagar
NU002V5	Overheating Risk Assessment	Houses	SERI-RES	J.T. Wiltshire, B.F. Warren, B. Sodagar
NU001V6	Annual "Useful" Energy Audit	Houses	SERI-RES	J.T. Wiltshire, B.F. Warren, B. Sodagar

SORANE PAMDOC1	Overheating Risk Assessment	Office buildings	TRNSYS	P. Jaboyedoff
vub-trn.010	Global PAMDOC: Overheating Risk Assessmen	Office buildings	TRNSYS	P. Verstraete
vub-trn.011	Zone air temperature and overheating integral	Office buildings	TRNSYS	P. Verstraete
vub-trn.012	Calculate the gains to each zone	Office buildings	TRNSYS	P. Verstraete
vub-trn.013	Calculate the external losses of each zone	Office buildings	TRNSYS	P. Verstraete
vub-trn.014	Calculate the capacitance of each zone	Office buildings	TRNSYS	P. Verstraete
vub-trn.015	Calculate the total losses of each zone	Office buildings	TRNSYS	P. Verstraete
TNO-BOUW-0001	Overheating Risk Assessment	Office buildings	VA114	A. Wijsman
TNO-BOUW-0002	Overheating Risk Assessment	Office buildings: with nocturnal ventilation	VA114	A. Wijsman

* A series of PAMDOCs were produced by Building Design Partnership (BDP) under another contract external to Subtask B and are included here for completeness.

IEA ANNEX 21 - SUBTASK B

CALCULATION OF THE ENERGY PERFORMANCE OF BUILDINGS

APPROPRIATE USE OF MODELS

FINAL REPORT

VOLUME 2

SECTION 3

INTERACTIVE CROSS REFERENCING

3.1 The Dynalink system

Although the MIS is a relatively sophisticated system and is capable of meeting all the requirements both of client and developer its development time was judged to be too long to enable it to be of use for PAM development within the Subtask time scale. As an interim measure work was put in hand to develop a simpler system which, although not having the capabilities of the MIS, could be used by Subtask members before the end of the project. Two simple systems were developed in parallel at Newcastle, UK and Sorane, Switzerland. Both systems were based on Word for Windows which, being in extensive use, had the advantage of making them readily accessible to a wide audience. After demonstration of both systems it was decided that the Swiss version, Dynalink, would be adopted and tested by Subtask members.(See Appendix 6 B for software user guide etc.)

3.2 General description of Dynalink

Within Subtask B of Annex 21 a number of performance assessment methods have been documented (PAMDOCs). The content of these PAMDOCs is strongly related to the manuals and input files of existing programs and provides complementary information for users of programs when carrying out performance assessments. To cross refer between these documents, for obtaining information and for carrying out quality control checks, would be a cumbersome and time consuming process for program user and PAMDOC developer alike if only hard copies of the documents were available (see Appendix). Fig 3.1 illustrates the relationship between the three main documents to which a PAM user would refer.

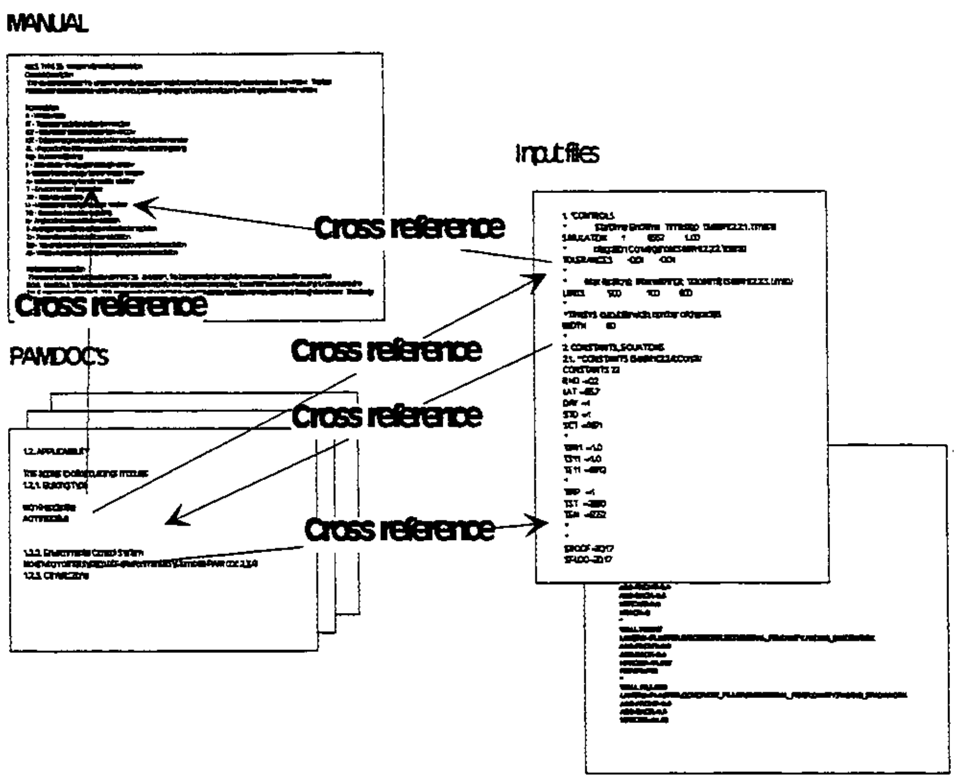


Fig. 3.1

While developing these documents, it was realised that these interactions could be better handled at development level and later at a user level if the PAMDOCs, reference input files, the already existing manual, and any specific quality assurance documents could be interactively related.

User tests have shown that PAMDOCs have little chance of being routinely used if they are not integrated in an interactive environment. The best solution would be to have the PAMDOCs integrated into the program's manual which should then be related to an interactive input and output system. However, this is impossible to achieve in an international IEA Annex as such systems do not exist for most of the programs and, if they do already exist, the access to such an evironment is only available to the program's developer. Therefore an intermediate solution using a program independent environment was chosen. This program is an intermediate solution which provides people, willing to actually use the PAMDOCs, with a tool to help them in their day to day tasks.

As a word processor is the best tool with which to work on documentation development, the application which generates interactive links between different documents has been developed under this environment using Word Basic Language.

Dynalink is an application developed under Microsoft Word for Windows to generate and use dynamic links (active cross-reference) between the different files that are used to perform an assessment with a simulation program.

The user of Dynalink, when providing the program input, is able to generate dynamic links (interactive cross referencing) between the input files, the program manual and the relevant PAMDOCs in order to access the information embodied in these files. (Fig 3.2)

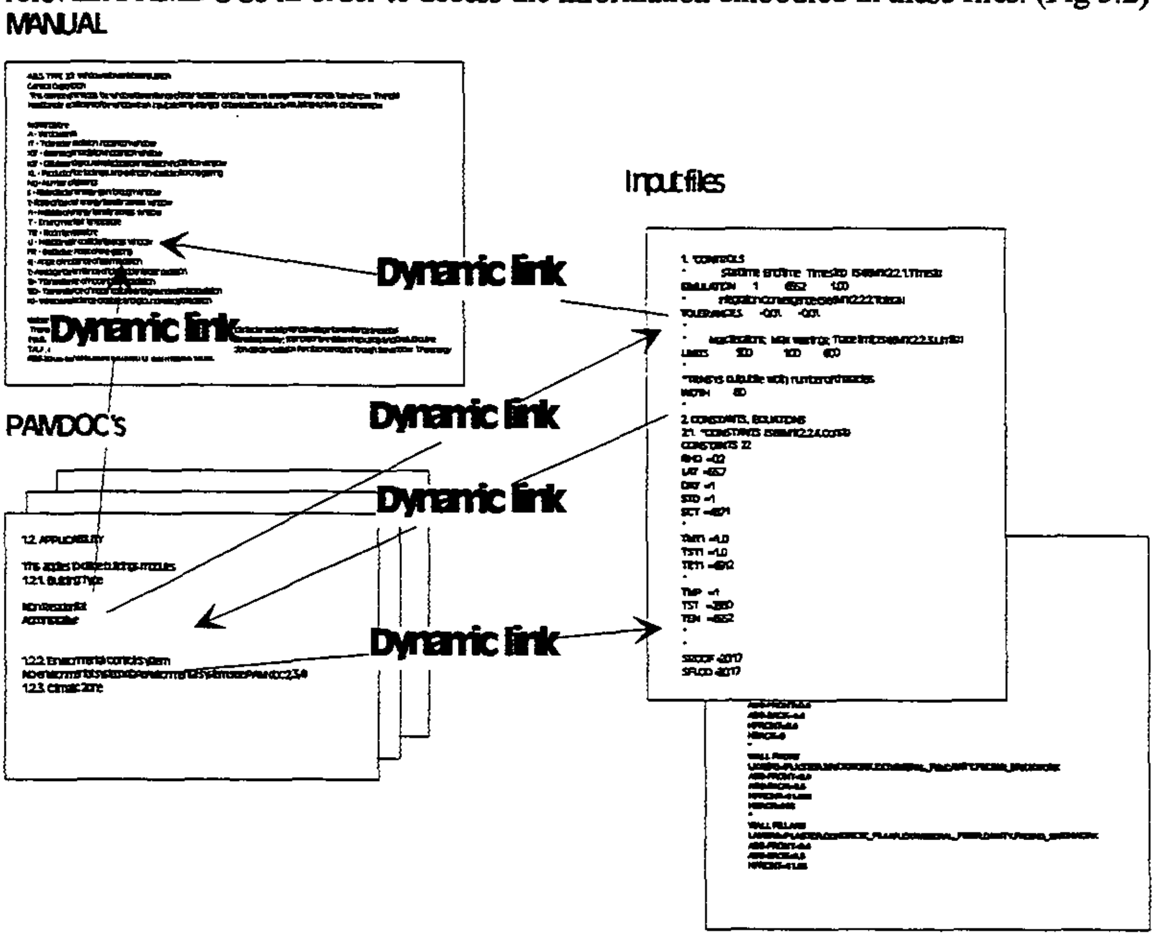


Fig. 3.2

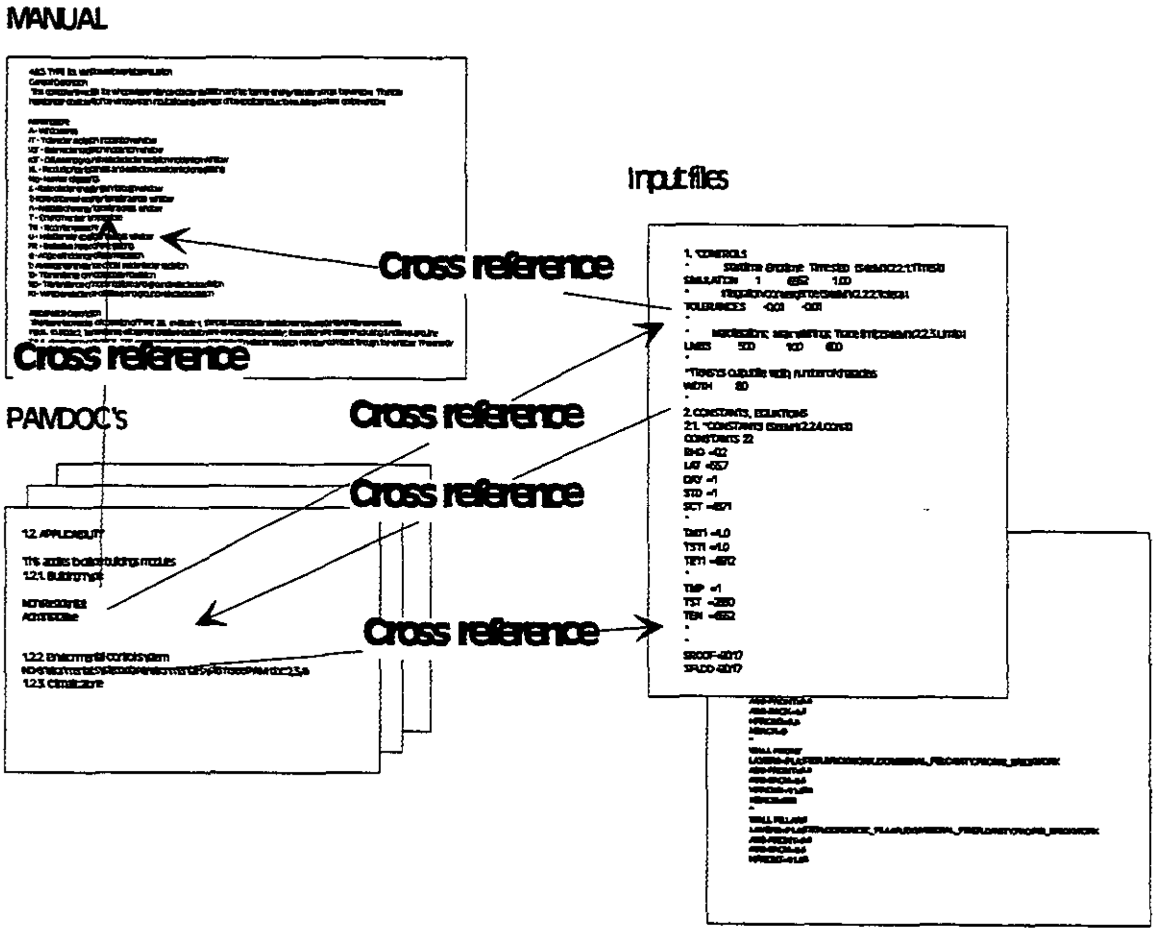
It allows simulation program users to generate dynamic links (or interactive cross-reference) between the PAMDOCs, some reference input files, the program's manual (embedded in the system for TRNSYS) and any other documentation.
The cross-references are marked in the text of the documents so that hardcopies also show these cross-references.

Table of contents

Manual for developers (from Section 1.)
and users (from Section 5. *[SeeM01(5.Runtim)]*)

1.Introduction

In the framework of the Subtask B of the Annex 21 entitled "Appropriate use of programs", Documentations (called PAMDOCs) on the Performance assessment method to be used for various programs have been developed.
The content of these different documentations is strongly related to the existing manuals and input files of existing programs.



For the development and for the use of these PAMDOC's, the different relationship between the Program's manual, PAMDOCs and input files, and possibly other documents (quality checks, ...) are very cumbersome to present on paper.
While developing these documents, it was felt that these interactions could be better handled at development level and later at a user level if the PAMDOCs, reference input files, the already existing manual, and also specific quality assurance documents could be interactively related.

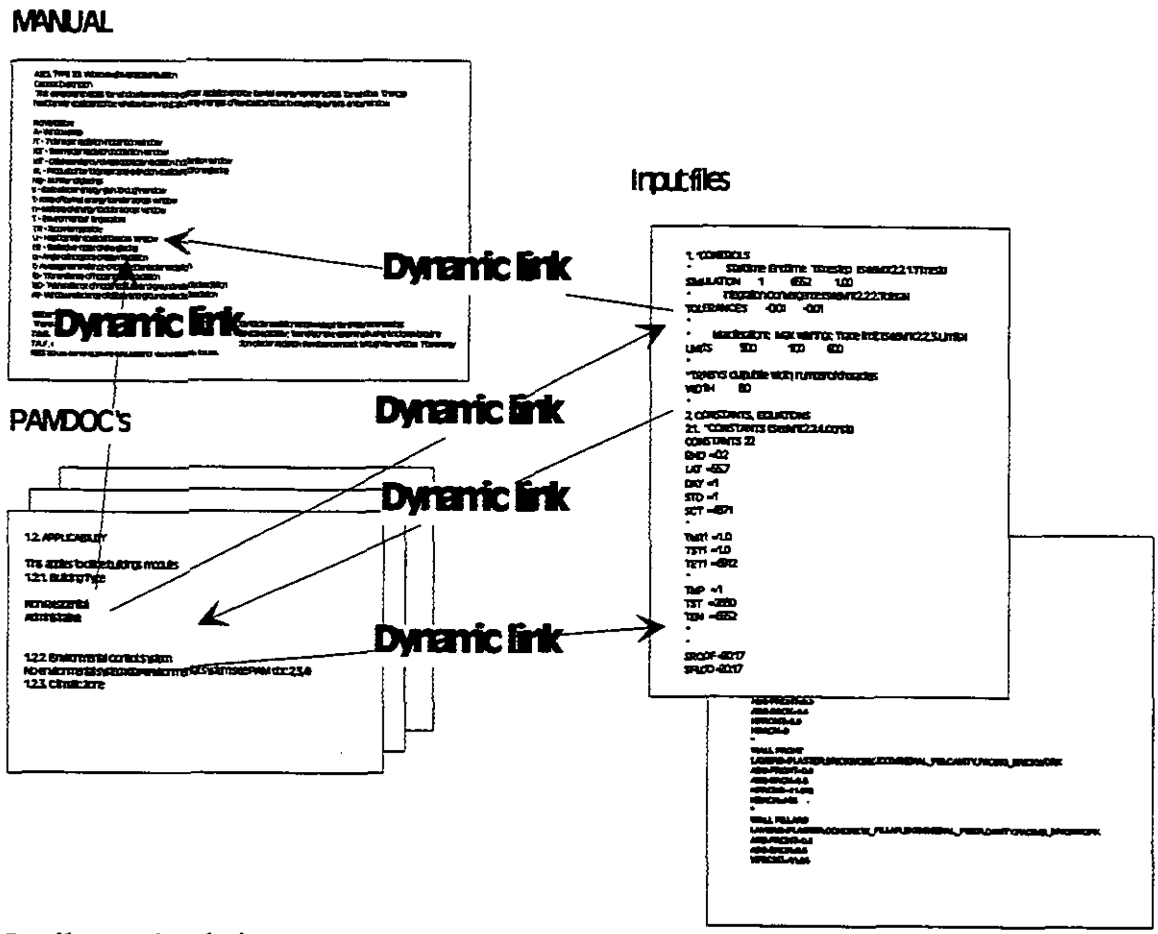
User tests have shown that the use of PAMDOCs has little chance to happen if PAMDOCs are not integrated in an interactive environment.
The best solution of course would be to have the PAMDOCs integrated into the program's manual which should then be related to an interactive input and output system. However, this is impossible to achieve in an international IEA Annex as, such systems do not exist for most of the programs, and if they do already exist, the access to such an environment is limited to the program's developer. Therefore, an intermediate solution allowing a program independant environment was chosen. This program is an intermediate solution which should allow people willing to actually use the PAMDOCs to have a tool that can help them in their day-to-day tasks.

As a word processor is the best tool for working on documentation under development, the application which generates interactive links between different documents has been developed under this environment (with Word Basic Language)

1.1.What is Dynalink ?

The aim of this program is to help developers (with DYNALINK) and program users (with DYNALINK run-time) in the development and use of PAMDOCs.

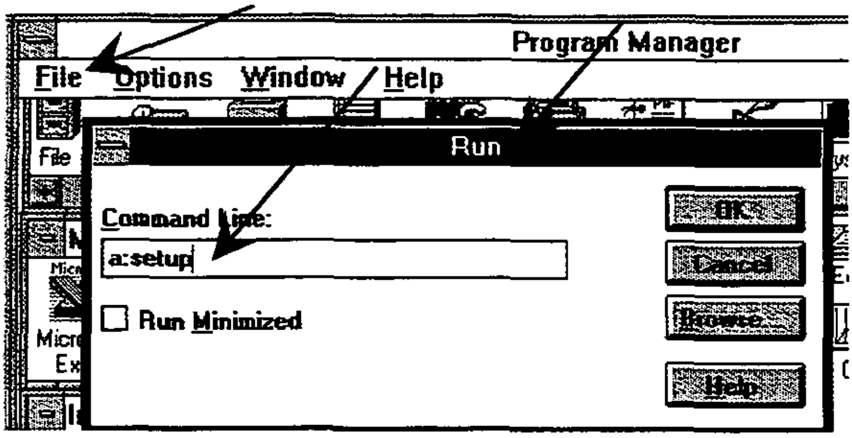
Dynalink is an application developed under Microsoft Word for Windows (version 2.0 US or UK, for other languages minor modifications should be done for the generation of the dynamic links, and has already been done for German) to generate and use dynamic links (active cross-references) between the different files that are used to perform an assessment with a simulation program.



It allows simulation program users to generate dynamic links (or interactive cross-references) between the PAMDOCs, some reference input files, the program's manual (embedded in the system for TRNSYS) and any other documentation.
The cross-references are marked in the text of the documents so that hardcopies also show these cross-references. The idea behind this is that the cross references must also be useful on hardcopies.

2.Installation of Dynalink

To install DYNALINK, you just have to insert the floppy disk number 1 into the drive and type ***a:setup*** in the dialog box **Command Line** of the Program Manager of Windows, by the **File** and **Run**



By default the Dynalink program is installed in the C:\IEA21B subdirectory, with documents for other programs in their respective subdirectories.
After installation you can double-click on the DYNLINK icon. If the Dynlink screen does not look like the standard Dynlink page ***[SeeM01(4.standa)]***, then you may have a problem with fonts (Fonts used are standard Windows True Type fonts like Arial). If 'error !' appears instead of the macrobutton text, you have to increase the length of the paragraph.

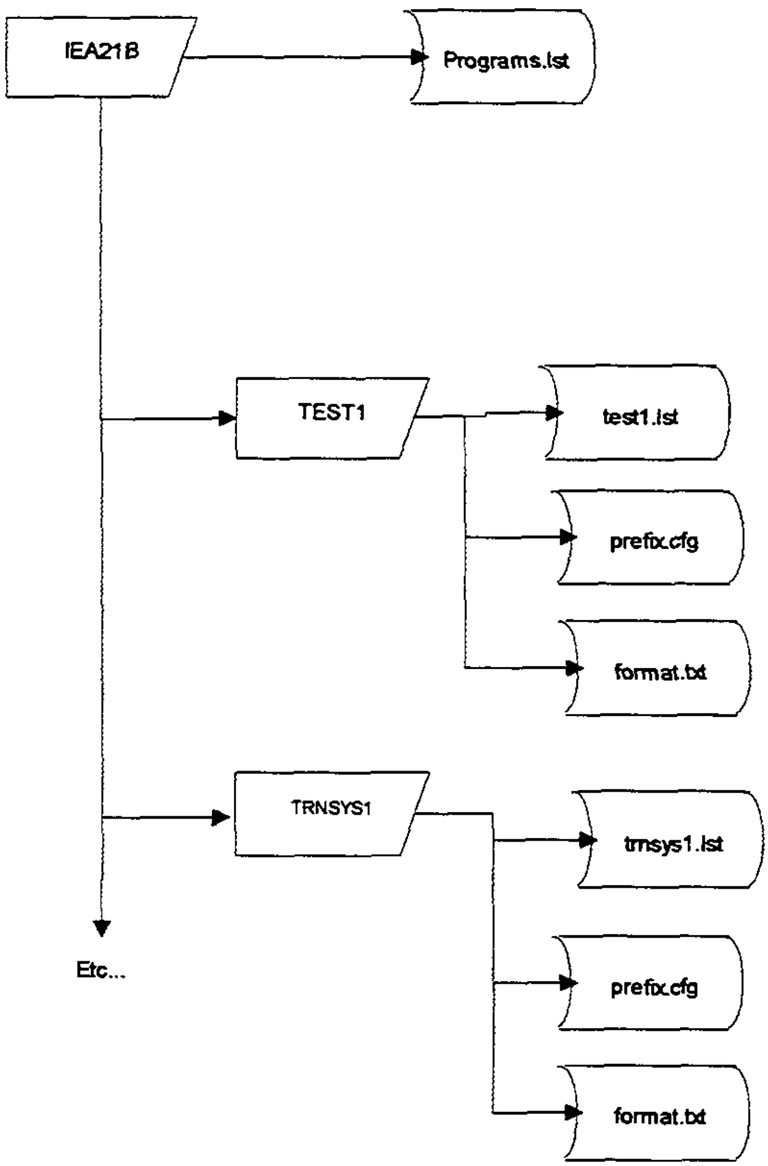
3.Setup for the use of DYNALINK

Once installed, the DYNALINK is ready for use by double-clicking on its icon (one for the developer, one for the run-time)

3.1.File structure

In order to allow the users to configure DYNALINK as per their requirements, a certain number of files have been defined.

The mandatory files that make the configuration of the DYNALINK program are represented on the following figure.



3.1.1.Configuration files

3.1.1.1.Application list

- The file ***Programs.lst*** (see example below) located in the subdirectory IEA21B (default name at installation) is mandatory, and must correspond to the list of the different subdirectories each containing a given program documentation.

"TEST1"
"TRNSYS1"
"DOE2EMPA"
"SERINEWC"
"VABITNO"
"BLASTGER"
"MANUAL"
"SHELL"

In this file, each name does correspond to a subdirectory for a given program with PAMDOCs, input files, manual, etc... in it. The name Manual and shell correspond respectively to the on-line manual, and to the PAMDOC shell.

3.1.1.2.Specific files

In each program subdirectory (for example **TRNSYS1**)

- The file ***Trnsys1.lst*** (see example below) located in the subdirectory **TRNSYS1**

"PAMDOC01.DOC"," overheating in office base case ","P01"
"PAMDOC02.DOC"," overheating in office with window opening ","P02"
"PAMDOC03.DOC"," overheating in office with movable blinds","P03"
"PAMDOC04.DOC","overheating in office with window opening+blinds","P04"
"BIDOFF01.DOC"," example of building input file ","B01"
"TRNOFF01.DOC"," example of input file deck for TRNSYS ","T01"
"MANUAL1.DOC"," TRNSYS Manual ","M1"
"QUALIT01.DOC"," Quality assurance ","Q01"

Each line of this file includes:

- the name of a file *"PAMDOC01.DOC"*
- the description of a file *" overheating risk in office base case"*
- the prefix related to this file *"P01"* which will be used for naming the links created later on (in this case one has chosen to have the following systematic prefixing: the prefix ***Pxx*** is for pamdoc's, the prefix ***Bxx*** is meant for building input files, the prefix ***Txx*** is meant for TRNSYS deck input files, ***Mxx*** for the manual files, ***Qxx*** for Quality assurance files). The prefix must have a length of 3 characters

- The file ***prefix.cfg*** (see example below) located in the subdirectory **TRNSYS1**

"See"

This file defines the prefix that will be displayed at the begining of the macro-button created when creating links.

- The file ***format.txt*** (see example below) located in the subdirectory **TRNSYS1**

"Arial", "12", 5, 1, 1, 0, 0, 0, 0, 0,"0pt","0pt"

This file configures the format of the macro-buttons created by DYNALINK (for more information refer to your Microsoft Word for Windows manual, under the command FormatCharacter, or under the Help under Word Basic Programming Language, under *FormatCharacter)*

The following is an abstract from the help menu

FormatCharacter
FormatCharacter [.Font = text,] [.Points = value,] [.Bold = number,] [.Italic = number,] [.Strikeout = number,] [.Hidden = number,] [.SmallCaps = number,] [.AllCaps = number,]
[.Underline = number,] [.Color = number,] [.Position = value,] [.Spacing = value,] [.UseAsDefault]

Corresponds to the Character dialog box (Format menu); applies character formatting to the selection.

.Font Name of font.
.Points Font size, in points.
.Bold Corresponds to the Bold check box.
.Italic Corresponds to the Italic check box.
.Strikeout Corresponds to the Strikethrough check box.
.Hidden Corresponds to the Hidden check box.
.SmallCaps Corresponds to the Small Caps check box.
.AllCaps Corresponds to the All Caps check box.
.Underline Corresponds to the Underline check box:

0 None
1 Single
2 Words Only
3 Double

Color of the text; for a list of colors, see CharColor.
.Position
The character's position in points, or as text specifying the amount and unit of measurement, relative to the baseline:

0 Normal
>0 Superscript by the specified distance.
<0 Subscript by the specified distance.

.Spacing Specifies the spacing between characters, in points, or a measurement in the form of text:

0 Normal
>0 Expanded by the specified distance.
<0 Condensed by the specified distance.

.UseAsDefault Corresponds to the Use As Default button; sets the character formats of the
Normal style.

Example

FormatCharacter .Spacing = "2 pt"

Sets character spacing for the selected text to an extra 2 points between characters.

See also

Formatting Statements and Functions

3.2.Preparing files to be used in DYNALINK

The numbering of the links is performed by using the standard heading facility available in Word for Windows.
When one wants to introduce files in the DYNALINK environment that have not been written in the Word for Windows environment, or that have not been structured using standard headings, it is possible to number them automatically.
Nevertheless, the numbering of the different sections and subsections of the file should follow the standard numbering of sections as defined in the PAMDOC Shell (notice that the section 4.0 must have a 4.0. in front so that it will be recognized as a heading level 0, see abstract ¯) for PAMDOCs at least.

4.0 - PROGRAM CONFIGURATION

4.1 PROGRAM VERSION

4.1.1 Title
Program title or acronym.

4.1.2 Program Author

Original author.

4.1.3 Vendor

Supplier of program.

Once your files are set up following this systematic numbering (i.e. the files have been written with another word processor, or in ASCII format), you can use the utilities provided with the DYNALINK program (see at the bottom of the screen)

For utilities see below
Utility to make headings with new files from its beginning.

These utilities will not work for files that are already listed in the file list (for example listed in the file TRNSYS1.lst in the subdirectory TRNSYS1).
The first utility allows one to select a file that has been loaded into Word for Windows, and to start its automatic numbering.
In case this first utility is not able to recognize a heading properly because of a typing mistake (i.e. **4 2.3.2** cannot be recognized as **4.2.3.2** (heading level 4) but as a level heading 1) or gets stuck in an indefinite loop (even after thorough check, this can happen with some exotic characters !!), one can stop it by pressing the **Esc** Key twice. One can then correct the typing mistake and place the cursor just above in the document, or if it was stuck in an indefinite loop, displace the cursor a little bit further down in the document (after the infinite loop), and then by double-clicking on the second utility, one can select again the same document and go on with automatic numbering from this point.

Error!

Once the end of the file is reached, one has to check that all numbering has been correctly set up (use Word commands **View**, **Outline**, **Show** up to level 4(on the toolbar)) by looking at an outline view of the file, then by showing up to level **4** only, then by renumbering by using the WORD built-in facilities (Menu **Tools**, **Bullet and Renumbering**, by selecting **Outline** and using the **legal sequence**).
After that for PAMDOCs files, the numbering and heading level should be consistent with the PAMDOC shell .

3.3.Modifying the file structure

Once a new file has been numbered accordingly to the Word for Windows standard heading system, one can integrate it into an existing subdirectory by adding a line into the file listing the files (**trnsys1.lst** for TRNSYS1 subdirectory for example) by following the format explained above, or if it is a new application, create a new subdirectory, add the same name into the file **programs.lst** in the **IEA21B** subdirectory
Any modification must follow the structure presented under File Structure (see figure at the begining).

4.Using DYNALINK to create links (Development phase)

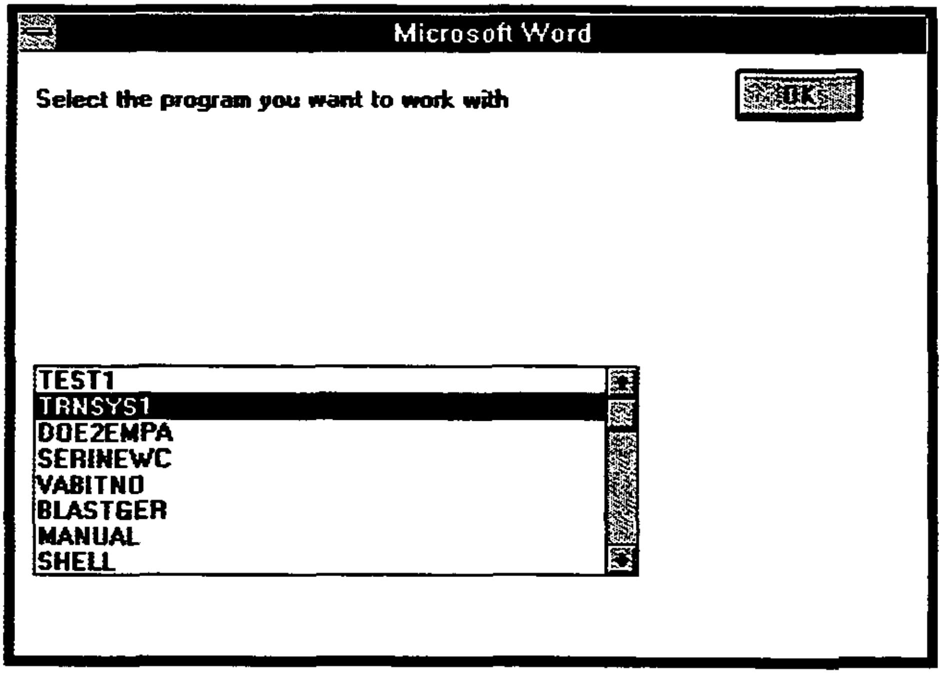
When using DYNALINK, one must be sure that the numbering of the sub-section in each file is correct and definitive. One should avoid modifying the numbering once links have been created as their names are related to the numbering. This is due to the fact that the macro-buttons also serve as reference in printed copies (see the example below)

7.2.1.2. Computational Parameter Definition List

The list of parameters is to be looked at in the manual *[SeeM1(4.8.4.Component Config)]:*
(end of example)

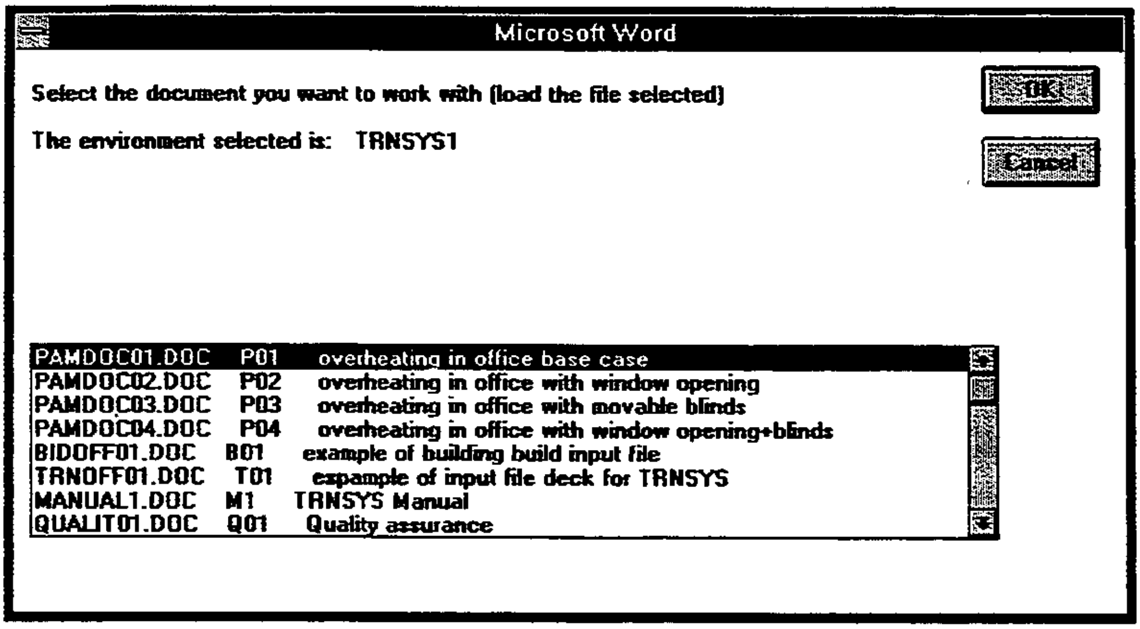
In the example above, the cross reference tells the reader to refer to the section 4.8.4. of the document M1 (Manual 1 in this case) under Component Config. Therefore it is obvious that the numbering automatically generated by DYNALINK should be definitive. Otherwise, the written references will not be valid anymore. It is possible to add new a sub-section with additional numbering it if does not alter the whole numbering structure (i.e. one could add a section 4.8.4.1 into the manual of the example above without disturbing the rest of the numbering).

1) When one has double-clicked on the DYNLINK icon, the first menu that appears is the program selection.

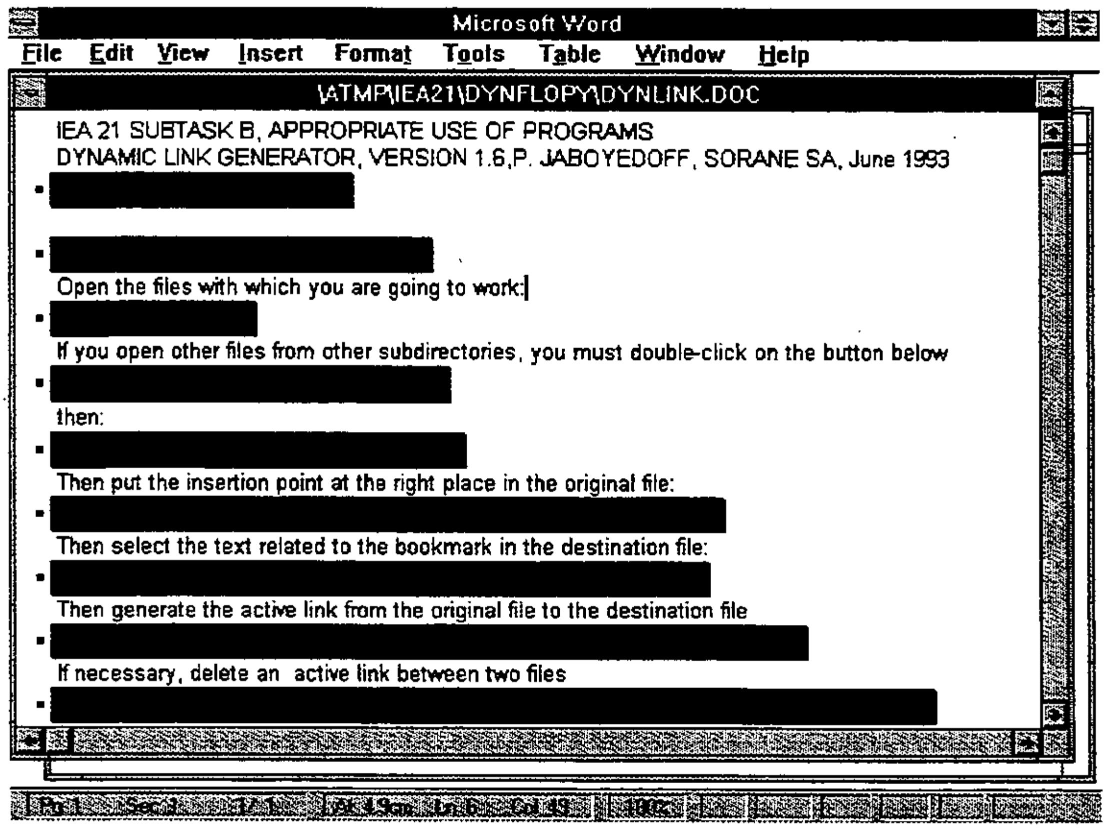


One selects the program with which one wants to work. In a session, DYNALINK allows one to work with only one program at a time .
However it is possible to have multiple session of Microsoft Word for Windows, and consequently work with different programs simultaneously, if your setup (the share.exe (from dos directory) should be loaded in the autoexec.bat) and machine configuration allows it (enough memory). The second session should be started by double-clicking on the original WORD icon, and then by opening the Dynlink.doc file from within WORD. This possibility can be useful for cross-comparison of PAMDOCs for different systems.

2) Once a program has been selected, the next mask presents the files listed in the configuration file trnsys1.lst. This mask appears each time one has double-clicked on the macro-button OPEN FILES



Once this mask has disappeared, the standard DYNALINK page appears (see below)



You can repeat this operation by double-clicking on the **open files** macro-button until you have opened the files you are going to work with.

Open the files with which you are going to work:
open files

3) Then select origin and destination file
Before creating a link, you must select the origin (the file from which the cross-reference starts), and the destination file. You can either select two different files, or select the same file as origin and destination. To do that double-click on the button shown below.

then:
select origin and destination files

4) Select the place to put the macro button by double-clicking on the button shown below;

put the cursor at the right place of the original file

Then put the cursor at the right place into the origin file.

5) Select the destination bookmark by double-clicking on the button shown below

Then select the text related to the bookmark in the destination file:
select the text related to the bookmark

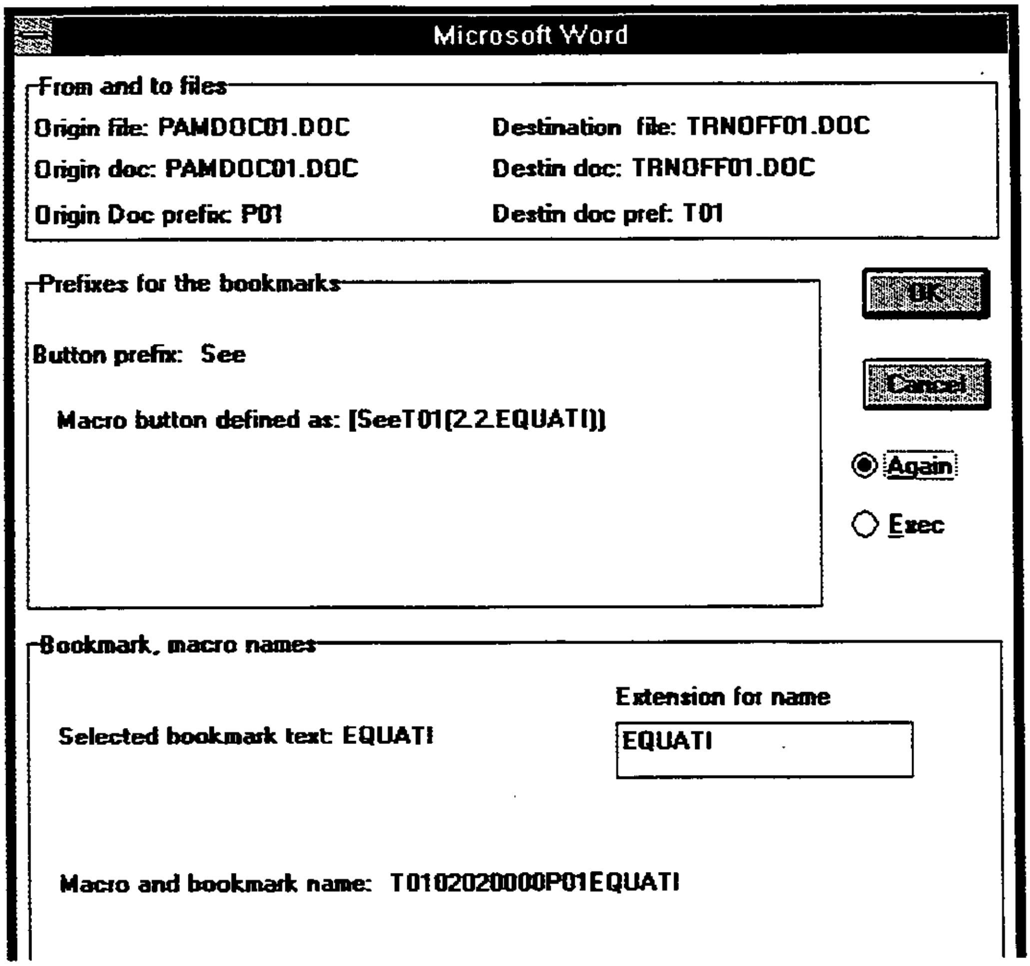
Then mark (highlight) the text related to the bookmark by clicking and dragging with the mouse where you want the bookmark to be inserted.

6) create the dynamic link by double-clicking on the button shown below

Then generate the active link from the original file to the destination file
generate the active link from the original file to the destination file .

When creating links, the file window must not be split into multiple panes, you must restore the window to a single pane first (See interactive help: *Help Help Index, Search, splitting windows, Goto Splitting a window or restoring a split window*), otherwise the link may not be created correctly

After double-clicking, this mask will appear



The macro and bookmark names have the following structure:

T0102020000P01EQUATI

T01 Destination prefix — 02020000 Section numbering — P01 Origin prefix — EQUATI extension for name of the link

Each link is unique.

You can only create links between files that are part of the list in the program subdirectory.

Each link is unique, if you try to create a new link that does already exist, it will not accept it, but you can copy existing macro-buttons within the same document.

When creating links inside a single document, the link cannot operate until the second window is closed (not pamdoc1.doc:2, but pamdoc1.doc)

7) if necessary remove the link between these two files in the orig to destin direction

If necessary, delete an active link between two files
erase an active link from the original file to the destination file

If a message box appears during the link erase action asking to go on with the search, click the "yes" box of this message box

4.0.1.Linking inside the same document

Link inside the same document, you cannot test the links before you have closed the second window with the extension **:2**

4.0.2.Configuration and limitations

Each file can have up to 150 links with other files (more if the memory configuration allows it). The bookmark number is not limited. The configuration on which the program was tested is a 486/DX2-66, with 8Mb RAM.

4.0.3.Utilities for hardcopies

One can mark the bookmarks in the files so that the paragraphs where they are located are shaded with a light pattern like this one.
One can add these patterns with the macro-button of DYNALINK:

utility to mark bookmarks in documents

They can be removed with the next macro-button of DYNALINK

utility to unmark bookmarks in documents

5.Using DYNALINK as run-time

To use dynalink as run-time environment, you need to double-click on the DynlinkRT icon.

Then the mask for program selection will appear. Select the desired application. Click on Ok.

After that, you need to open the files you want to work with. All files loaded are read-only. You cannot alter them while working with DynlinkRT.

5.1.Links between different documents

The dynamic links operate if the corresponding windows are opened, and if you are located in the directory where the files are located.

If you double-click on a macro-button and get the message 'window does not exist', it is because you have not opened the file that is called by the dynamic link, or because Word for Windows is not in the right directory.

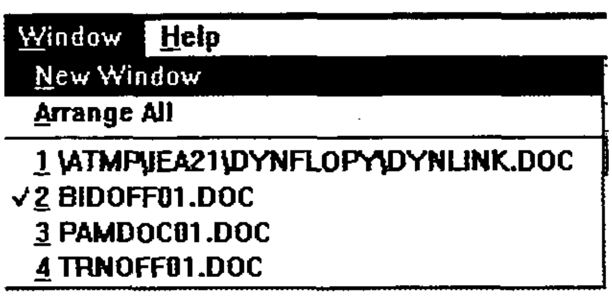
1) You must then double click on the macro-button entitled OPEN FILES on the dynlinrt.doc window and select the file that has the same prefix as the macro-button of the link you want to use.

Open the files with which you are going to work:
open files

2) You must double-click on the macro-button Back to the working directory

back to the working directory

Then the name of the file you are working with must appear without any path in front of it (see example below for Pamdoc01.doc, bidoff01.doc, trnof01.doc)



5.2.Cross reference within the same document

When using DYNALINK for a file which has cross references inside the same document, it is very convenient to split the window into two horizontal panes. By double clicking on Macro-buttons in the lower pane, the selected cross-reference appears in the top window pane (in Dynlink run-time, try this example: split the

Manual1.doc window in two horizontal panes, then select the bottom pane, and double-click on the following macro-button -> *[SeeM01(5.expl1)]* , the cross-reference text appears highlighted in the top window pane). This allows one to work in a file with inner cross-references in a systematic way, i.e. you can follow the file sequentially in the bottom pane, and see the cross-references in the top pane of the same file.

5.3.On-Line help facitilities

5.3.1.On-line manual

This manual is available on line by double-clicking on the macro-button entitled 'On line Dynlink Manual'

On Line Dynlink Manual

5.3.2.On-line shell description

The description of the PAMDOC structure (shell structure) is available on-line by double-clicking on the macro-button entitled 'On line shell description'

APPENDIX

The following is a sample from a document which relates the SERI-RES input data table requirements with the appropriate sections of a PAMDOC. The original document comprises 24 pages of similar information. This example illustrates the cumbersome nature of using paper based cross references.

1.SERI-RES DATA TABLE : RUNS

Table headers and sample entries:

```
------------------------------------------------------------------------------------------------
RUNS
*      RUN LABEL       STATION     GROUND    GROUND    -START-    -STOP-    SKYLINE    PAR.
*                       NAME        REFL.     TEMP.    MON DAY    MON DAY   PROFILE    TYPE
*                                  [FRAC]      [C]     [DATE]     [DATE]
*AAAAAAAAAAAAAAAA AAAAAAAAAA      S.SSSS    SSS.SS    AAA XX.    AAA XX.   AAAAAA     AAAAAA
 HDS/BAR/SE/I     KEW             0.2       TEMPG     OCT  1.    SEP 30.   SKY        NORMAL
------------------------------------------------------------------------------------------------
```

Parameter Name	PAMDOC Reference* Section	PAMDOC Reference* Page	Definition
RUN LABEL	0.0	2	A string of up to 16 characters which labels the simulation.
STATION NAME	5.2	22	A string of up to 10 characters which identifies the weather station and data used in the run (must be defined in the STATION section).
GROUND REFLECTANCE	5.1.3	20	A fraction which represents the proportion of solar radiation reflected by the ground.
GROUND TEMPERATURE	5.1.4	21	A constant or the name of a schedule (TEMPG is the standard name for the schedule) defining the ground temperature.
START/STOP DAYS	4.4.3	17	The first and last days in the calendar over which the simulation is to be run.
SKYLINE PROFILE	5.1.5	22	An arbitrary string of up to 6 characters identifying the type of skyline (must be defined in the SKYLINE.TYPES data section).
PAR. TYPE	4.3	10	A string of up to 6 characters identifying the set of run control parameters. It must be defined in the PARAMETERS input section unless the default <NONE> is used.

* PAMDOC Reference: Annual "Useful" Energy Audit, Ref. No. 3429/100V5, Date: 28.1.91.

IEA ANNEX 21 - SUBTASK B

CALCULATION OF THE ENERGY PERFORMANCE OF BUILDINGS

APPROPRIATE USE OF MODELS

FINAL REPORT

VOLUME 2

SECTION 4

COLLECTED DEVELOPMENT PAPERS

CONTENTS

PAPER 1

SELECTION OF ZONES FOR ASSESSMENT BY COMPUTER SIMULATION

B.Warren and B Sodagar
University of Newcastle upon Tyne (UK)
August 1993

Selection of zones for assessment by Computer Simulation.

1.0 General

This paper describes the work carried out in Subtask B relating to how a building is divided into zones for simulation as part of a performance assessment method.

After an initial discussion paper and a small internal survey carried out at TNO Building Construction and Research at Delft by Aad Wijsman (ref 1) a more extensive survey of consultants was conducted. Subtask B participants were each asked to survey a number of consultants to determine the zones they would select for overheating assessment based on the case study building and specification developed for PAM evaluation. Information was also requested on how the selection process was carried out. The structure of the survey was left to individuals, other than that it was to be based generally on the Wijsman approach, since it was not intended to obtain any fine grain information.

2.0 Summary

2.1 Introduction

One of the objectives of Subtask B is to ensure that a measure of consistency is achieved between workers carrying out the same assessment task. This cannot be achieved if different people choose different zones upon which to operate. Different results will be obtained leading possibly to different design decisions. This is particularly relevant where a design decision is reached by taking a zone, or selection of zones, to be typical of the whole building performance, or representative of the worst case, rather than assessing the performance of the whole building.

2.2 Objectives

a) To determine whether, for the same purpose and building, different people select different zones for overheating assessment.

b) To determine the methodologies used for zone selection with the aim of making recommendations.

2.3 Method

The method of investigation was to invite designers to select the zone or zones they would use when carrying out an overheating assessment on a specified office design. The building specification used was developed within Subtask B for PAM evaluation. Initially the survey was conducted amongst colleagues of Subtask B participants but was later extended to personnel in a selection of consultants' offices.

The results of the survey were compared with the results of simulations using Seri-Res.

2.4 Results

The results of the surveys confirmed that identification of zones for assessment may be very different from user to user and that the basis for selection is user experience. The minimum number of zones selected by a particular user was 2 and the maximum 15. The zone attracting the most votes from all the respondents was the South facing centre room on the middle floor. The simulation results indicated that the worst zone for overheating was the East facing centre room on the middle floor which was also confirmed by other members of the Subtask using different programs. This was probably due to a combination of high solar radiation, East gives the highest daily mean in June, and stored energy due to the heavyweight nature of the building. Only five out of the seventeen survey respondents selected a range of zones which included this worst case.

2.5 Conclusions

Unless very obvious cases exist, eg S facing highly glazed 'lightweight' spaces with high internal gains, or that the zones to be assessed are to answer specific questions, eg is the kitchen likely to overheat?, then user's selections of zones for assessment vary widely both in terms of the number selected and their position and orientation. It is likely that the overall performance of the respondents would have been better if the building had been thermally lightweight. Accumulated experience needs to be obtained and 'handed down', and simple selection techniques need to be developed possibly based on a range of simulated cases. Until this has been done, only experienced users should carry out assessments. Initial guidance may be obtained by reference to the comments of other Subtask members reproduced in Appendix 1.

3.0 Discussion

3.1 General

The problems relating to general aspects of 'zoning' are briefly presented and discussed. The intention of this paper is to discuss areas of work required to rationalise the problem and to propose possible solutions.

> It is likely that in the relatively near future (5 years) the increase in available computer power and their linking to CAD systems will enable rapid on line calculations to be performed on all the zones of a building so making the selection of zones for assessment redundant..Current research in this area should eventually enable a building designer to automatically apply a range of design tools, of which a simulation program could be one, to the building description held in a database. The designer would then have no need to fill in the simulation program input data files as this would be done automatically providing the building description is detailed enough and a zone is a room. Simulations would be refined as the building design is refined without recourse to actual design drawings.This is in the future; in the meantime designers have to select zones on which to carry out simulations and guidance on how zones are selected is necessary.

It is useful, at this stage, to describe what is meant by a zone. In general terms a zone may be any space, in or external to a building, to which particular attributes or conditions have been ascribed. The boundaries of the zone are the boundaries within which the ascribed attributes or conditions are assumed to exist and are not necessarily of a physical nature. Energy and mass transfer may take place across boundaries. In practice, zones are usually discrete rooms, parts of rooms, or groups of rooms where a room is any enclosed space and the boundaries are usually walls, floors and ceilings having dimensions and physical properties. A building may therefore have any number of zones from one, i.e the whole building, upwards. Where designers are concerned with thermal performance, zones are usually ascribed attributes of temperature and/or energy flow. The zones selected by engineers for design of the building services may often be different to those used for the modelling of thermal performance.

Most building simulation programs are based on balancing the energy flows in a thermal zone. This implies that in a thermal performance assessment the first decision to make is how to divide the target building into discrete zones. How problematic this is depends on the type of program being used and the complexity of the target building; whether the program can handle a multiplicity of zones and/or whether the building has a large number of zones. In practice, zoning a building is not always constrained by the details of the architectural plan. The building modeller tends to zone the target building so as to get the best information on the design issues of interest. In spite of the fact that zoning is probably the most important aspect of performance assessment there appear to be no fixed rules to follow.

In general, the task of zoning may be divided into three categories:-

1) Selection of zones for assessment.
2) Grouping spaces together into one zone.
3) Splitting spaces into more than one zone.

Items 2) and 3) above are different from item 1) in that although they all require an assessment of design and operational conditions to be made, items 2) and 3) also involve the consideration of modelling issues such as how to treat common internal walls.

In this paper attention is focussed mainly on zone selection for the purpose of overheating risk assessment although there is some discussion of items 2) and 3).

In some applications, for example overheating risk assessments, it might not be necessary to model all zones. If a reduced number of zones is used for an overheating assessment it is particularly important that the thermal mass of internal walls is properly allowed for. Experience has shown that this is a particularly error prone aspect. The use of a reduced number of zones necessitates selection of those which are judged to be prone to overheating and are either 'worst case' conditions or perhaps indicative of 'average' conditions. Two judgements involved here are 'might the zone overheat?' and by 'how much is it likely to overheat?'. In some instances a particular zone (room) may be so different from other spaces in terms of orientation, glazing area and incidental gains, for example, that it can be selected, on the basis of the designer's knowledge and experience, with a high degree of confidence. At the other extreme if all zones are judged to be 'the same' then, again, only one needs to be considered. In other situations the differences between zones may not be so clear cut and several zones may have to be considered to determine the 'worst case'. In general terms it can be stated that **the way in which zones are selected for assessment depends on the perceived differences between them.**
How well this process operates in practice is probably not really known since:-

1) Measurements on real buildings are not carried out often enough to compare with predictions

2) It is not expected that predictions will exactly match measurements or other assessments of discomfort in reality.

3) The issue is often clouded since fail-safe design solutions are frequently adopted i.e the use of high safety factors.

Nevertheless the process has to be carried out.
Whether or not a designer needs to identify a 'worst case' zone or one which is typical of a certain part of a building or range of zones depends on the question the designer needs to answer. If, for example, a naturally ventilated school is to be assessed, the designer may need to determine the worst comfort condition that is likely to occur and to do this must select a range of zones which are judged to contain the worst case. If, on the other hand, a decision on air conditioning is needed for a multi storey office block, then the designer may need to simulate zones judged to be typical, for example, of all rooms on each separate orientation.

3.2 Criteria for consideration.

The judgements made by a designer must take into account the combined influence of a range of design and operational criteria typified by the following:-

1) The orientation of the major areas of glazing.
2) The glazing type.
3) The orientation of external surfaces.
4) The influence of shading.
5) Level and pattern of occupation.
6) Lighting and other incidental gains.
7) Ventilation rate.
8) The building construction.
9) The dimensions of the spaces under consideration.

The overall effects of the above criteria have to be assessed for a number of spaces, compared with each other and a decision made as to whether they are different enough to warrant separate assessment i.e whether one zone is more likely to overheat than another.
As the number of zones dictates the amount of input data preparation, checking and

solution time, there is usually a tendency to reduce the number of zones to a minimum.
The extent to which values can be put to the criteria outlined above will vary depending upon the stage of building design for which an assessment is required. At early design stages, when the results of simulation may be expected to have the greatest influence on design decisions, little firm information is generally available and values appropriate to the building type and situation will have to be assumed. To a certain extent this reduces the problem of zone selection since many of the values pertaining to different zones will be the same.

3.3 The judgement process

The problem faced by the designer/modeller may be simply stated as determining (selecting) the minimum number of zones that need to be modelled (assessed). The designer is presented with a number of zones which have to be graded in terms of their potential tendency to overheat. In the majority of real situations there may be groups of zones which are readily eliminated since they are unlikely to cause problems. For example in a building without blinds all north facing zones are less likely to overheat than those facing south in which case north facing zones may be eliminated. The remaining zones must then be subject to a process of further refinement until finally a number of zones emerges which cannot be differentiated between in terms of overheating potential. These are the zones which have to be assessed for performance.

The process of judging the combined effects of the design and operational criteria which lead to zone selection may be carried out in three ways as follows:-

1) On the basis of the designer's knowledge and experience alone (an informed guess)
2) By the use of rules of thumb
3) By carrying out a simplified calculation as a preliminary to computer assessment.

It is clear that 2) and 3) above require that some form of initial zone selection must be made to enable rules of thumb or simplified calculation methods to be applied. This can only be done on the basis of knowledge and experience.

It is suspected that method 1) above is the one most commonly used. It is also the method likely to be the least consistent in terms of repeatability and quality assurance unless designers have the same experience.
To the writers' knowledge there are no well known rules of thumb.Any rules of thumb used will have been derived on the basis of formalised knowledge and experience. Members of the Subtask, although having no knowledge of commonly used methods, have made suggestions regarding possible approaches to the problem. (Appendix 1: PV, AW, GZ,Sonja H)
A variety of simple calculations and other assessment methods does exist, ranging from simple steady state heat gain calculations to the use of graphical methods as published by the BRE.

3.4 Proposals for further investigation

In the interests of quality assurance, and to achieve a measure of consistency when carrying out performance assessments, it is clearly desirable to promote a methodology based either on accepted 'rules of thumb' or some simple 'pre-assessment' calculations.
Little concerning these methods has been documented and it is clear that some form of

investigation is required which will at least allow current approaches to be documented and made open to inspection.
It is suggested that a procedure similar to that below could be followed:-

1) Conduct a survey aimed at appropriate practitioners to obtain information on the following issues:-

a) What methods are currently used for selection of zones for assessment
b) What rules of thumb are used if any.
c) What pre-assessment calculation methods are used if any

2) Analyse the results of the survey to determine whether any common areas exist.

3) Test the methods by using simulation studies.

4) Develop new methods and retest.

5) Recommend methodology to be used.

3.5 Other zone related problems

The foregoing discussion has centred on the basic problem of zone selection but, as suggested earlier, two other difficulties remain; the problem of combining spaces together into a single zone and that of splitting spaces into smaller zones for ease of handling.

3.5.1 Grouping spaces together into one zone:

In order to reduce the number of zones to be modelled it is often useful to combine spaces sharing similar conditions of orientation, incidental gains, occupation pattern etc. An approach to this may, for example, be as follows:-

IF [They are assumed to have a similar control regime or conditioning system]
IF [They are assumed to have similar casual gains (occupancy and equipment)]
IF [They are assumed to have similar solar gains, i.e having window(s) of the same size and properties facing the same orientation]
IF [They are assumed to have similar construction]
THEN spaces may be grouped together (An alternative is that one zone may be taken to represent all zones)
IF [the dimensions of the new space are bigger than X * Y * Z]
THEN Spaces should be designated as separate zones.
ENDIF

For the above to be valid a judgement has to be made on what constitute 'similar' attributes or conditions of the spaces. In the case of construction, for example, 'similar' may often mean 'the same' but aspects such as incidental gains are unlikely to be <u>exactly</u> the same so a judgement as to how close they are has to be made. A possible approach could be to calculate the value of the thermal response for each space and consider similarity. *

* In the UK a parameter f expressing the thermal response of a zone has been used $f=(\Sigma AY+Cv)/(\Sigma AU+Cv)$ where A is surface area, Y the admittance of the surface, U the thermal transmittance and Cv the specific ventilation loss.

At early stages in building design, simulations may be required when detailed design and operational information is not available. In these cases the situation may be eased since assumptions regarding some of the attributes and conditions of zones will have to be made with the result that they will be the *same* for a whole range of spaces rather than *similar* as would be the case when more detailed information becomes available.

The question remains, can advice be given which will enable the judgement of similarity to be made on a rational and consistent basis?

The answers to these sorts of questions can only be obtained by following an investigation similar to that outlined in 3.4 above and/or by carrying out a series of structured sensitivity studies to determine how dissimilar zone conditions/attributes can be without leading to different design, or other, decisions being made.

Another issue which must be addressed when grouping spaces into one zone is how to take into account the effect of elements which are not explicitly modelled. For example the thermal capacity of these elements, e.g. partitions, should be added to the thermal heat storage capacity of the new zone. The most appropriate way of doing this needs to be determined.

3.5.2 Splitting spaces into smaller zones.

Although this is a different problem to that of 3.5.1 above a similar set of issues needs to be addressed if progress is to be made.

Strategies relating to the problems of zoning are currently ill-defined and documented although they constitute an important element of performance assessment.

If they are to be formalised to enable guidance to be given to users of performance assessment methods then further research is required.

4.0 Investigations

A series of surveys was conducted to obtain information about how a program user selects the zone or zones of a building upon which to carry out performance assessments. As the Subtask is particularly concerned with zone selection with respect to the assessment of overheating in offices, the specification of the office building used for PAMDOC testing was also used for this study. Fig.1 shows the basic floor layout of the building and the room identification letters.

An internal survey conducted by the Netherlands (Ref.1) on a group of five users showed that when asked to select zones for the overheating risk assessment in the office building a variety of answers was obtained. Switzerland conducted a similar exercise with similar results. A small survey of UK practitioners was carried out by Newcastle University.

4.1 Results from surveys

Table 1, taken from the early survey carried out at TNO (Netherlands), shows how 5 different users would select zones for simulation to assess overheating. It is clear from this small sample that different users have considerably different opinions. User 2, for example only thought that the corner offices needed to be simulated whilst User 5 thought that it only necessary to simulate the standard offices. The number of zones selected for simulation by different users varied from 3 by User 4 to 12 by User 3 which could be interpreted as a measure of their confidence in selection. No order of priority was asked for and the number of selections made was up to the user. It is interesting to observe that no particular zone was selected by *all* the users. On the basis of the experience of the users the zones A5, O5 and C5, each selected by four users out of five, may be interpreted as representing the zones most likely to overheat.

The zones of the Office Building selected by all the users taking part in the surveys together with those selected by the participants of the Subtask, are recorded in Table 2. The entries in the table are the zones selected for computer simulation by a total number of 17 users. A user may have chosen one or more zones for simulation and, again, no priorities are given. Again the wide range of zones selected by different users is apparent covering all orientations. The number of zones selected by different users ranges from 2 to 13. Since each selection made by a user is equivalent to a simulation and there is only one 'correct' result a large number of simulations are redundant. Table 3 shows how all selections are distributed with respect to orientation and floor indicating that the most popular zone is room A and the most popular floor the third.

Fig 2 graphically shows the distribution of selections according to room and floor indicating the overall popularity of selections.

As long as the available computing power and time resource prevents calculations being performed on all zones particular zones have to be selected to represent the building. Figure 2 illustrates those zones of the office building which have been judged by the respondents to represent an overheating risk and illustrates the level of priority, in terms of votes cast, given to the zones for assessment. In Fig 2 all votes have been given the same priority as far as the respondents are concerned. The South facing rooms on the third floor are judged to be the most critical with respect to overheating. As was expected, people tend to model the south facing zones as they are perceived to receive higher quantities of solar radiation. Zones facing east and west are considered to be important because of gains during mornings and afternoons respectively. From Figure 2 one general rule may be drawn; zones facing orientations from East to West through South are perceived as likely to suffer from overheating.

All corner offices enjoy the same design and operational criteria, as do the standard offices although there are small differences in operational criteria between the corner and standard offices. The main factor in decision making with regard to zone selection would therefore be expected to be the location of the zone, i.e. its orientation and the floor level. To illustrate more clearly the effect of location, the results are presented in Figure 3 where, for the sake of simplicity, if a user has chosen more than one standard room with the same orientation on the same floor only one selection has been counted.

As the number of respondents in this survey has been small, using the results for decision making with regard to zone selection should be treated with some degree of caution. For the same reason there are some discrepancies in selection of zones located on the third floor and top floor. While the south, east and west facing zones on the third floor have been given higher priority compared with the same zones located on the top floor, the south-east and south-west facing zones on the top floor have been judged to be more prone to overheating than similar zones on the third floor, presumably due to the perceived effect of the roof.

4.2 Simulations

In order to compare selections with actual results, simulations were performed using SERI-RES on a selection of zones to determine the hourly maximum temperatures reached and the number of hours when the zone temperature would be above 27°C. For each simulation two cases were considered; the base case using a constant infiltration rate of 0.2 air changes per hour and the nightime ventilation case which assumes that windows are open at night and that ventilation takes place at a rate determined by window opening and temperature difference. Simulations were performed using Copenhagen weather data for the months of May to September. Simulations were carried out for zones from East through South to West. Only the centre rooms on the east, south and west facades were simulated as it was assumed that the rooms on either side of the centre room would have the same, or very close, conditions. Similarly only rooms on the third and top floors were simulated since it was assumed that the third floor would be representative of all intermediate floors. Simulations were carried out on ten zones all together. Table 3 gives the total user selections corresponding to the simulated zones and, again, if a user has chosen more than one standard room with the same orientation on the same floor only one selection has been counted.

The results are presented in Table 4 which shows the computed figures, their order of critical priority and the months of occurrence. The hours above 27°C for the base case have not been included since the temperature was above 27°C for all occupied hours during the months of June, July and August for the zones simulated. It is immediately apparent from the table that, with the exception of the east zone, which is the worst case for each simulation condition, the criticality of a result and the month in which it occurs depends on the type of information being elicited as well as the zones for which simulations are conducted. The magnitudes of the results are also such that they would probably be unacceptable for all the cases considered and would result in further design decisions having to be made. It could be argued therefore that selection of any of the simulated zones would lead to the 'correct' design decision. It can be seen from Table 2 that all users have selected at least one of the simulated zones. How successful an individual user has been however depends on the questions asked i.e what simulation results are required. If the objective is to determine the 'worst' conditions then the East zone on the third floor has to be selected, this selection traps the worst values for the cases simulated. The reason why the east zone is the worst is probably due to the effect of the thermal mass of the building which is basically of heavyweight construction. A different result may be obtained for a lightweight building although this has not been confirmed by simulation.

Although only SERI-RES has been used in this study, results from EMPA and TNO-Bouw confirm the east zone as being the worst.

Table 5 illustrates the success of users in choosing the most critical zone only five out of seventeen being successful; approximately 30 %. If it is assumed that all east facing zones on intermediate floors would give a similar result then 6 users were successful; 35% of the total. The six users would have performed a total of 78 simulations.

5.0 Conclusions

Although results were available from only a small sample they confirm that different users are likely to select a wide range of different zones for assessment and that, as a consequence, different design decisions may be made. At an early design stage the building information is incomplete and designers (users) are only able to proceed on the basis of their previous experience and must select the minimum number of zones judged to include the most critical case.

It can be concluded that, unless obvious problem areas exist, eg South facing highly glazed space with high internal gains, or that the zones to be assessed are to answer specific questions, then users cannot select a single zone with any degree of reliability and must select a range of zones. The only advice that can be given is firstly that only experienced users should carry out assessments, secondly that accumulated experience needs to be obtained and 'handed down', and thirdly that simple selection techniques need, if possible, to be developed.

Although the results plotted in Figure 2 may be interpreted as providing a summary of the experience of different users selecting zones for a relatively simple and common building type they do not, according to the simulations, appear to be very successful. The comments from other members of the Subtask reprinted in Appendix 1 may provide some guidance.

Bearing in mind the disparity between the selections from the survey and the simulation results it is not possible to provide positive guidance on zone selection. To do this it would be necessary to carry out a range of simulations for buildings with a variety of different operating conditions and thermal characteristics.

Simple zone selection techniques need to be developed, tested and built in to computerised building assessment methods although it is unlikely, due to the complexity of the problem, that fixed rules ever be derived.The short term aim should be to improve the reliability of zone selection to reduce the amount of abortive work.

In the interim designers should aim to adopt a consistent, and documented, approach within their own organisations which will reduce the probability of gross errors occurring and should ensure that appropriate checking procedures are carried out. A body of real experience needs to be obtained.

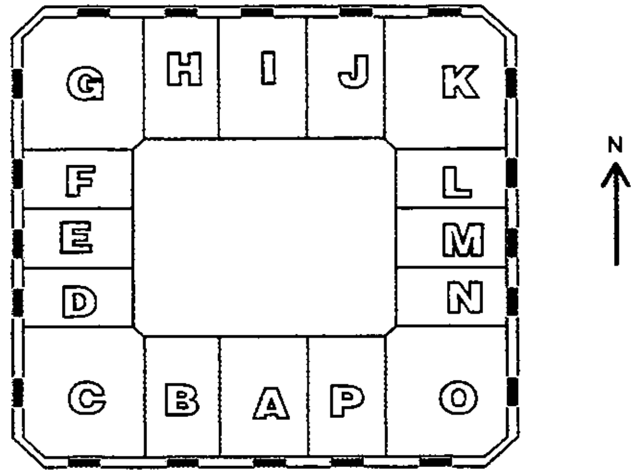


FIG 1
Basic Floor Plan

Office Type	Room	Floor	Orientation	User 1	User 2	User 3	User 4	User 5
Standard	A	3	S	*				*
Standard	A	5	S	*		*	*	*
Standard	A	1	S					
Standard	M	3	E					*
Standard	M	5	E			*		*
Standard	I	3	N					
Standard	I	5	N			*		
Standard	E	3	W					*
Standard	E	5	W			*		*
Corner	O	3	SE	*	*	*		
Corner	O	5	SE	*	*	*	*	
Corner	O	1	SE		*			
Corner	K	3	NE			*		
Corner	K	5	NE			*		
Corner	G	3	NW			*		
Corner	G	5	NW			*		
Corner	C	3	SW	*	*	*		
Corner	C	5	SW	*	*	*	*	
Corner	C	1	SW		*			

Table 1
Results from an initial five user survey carried out at TNO (ref IEA 21RN 262/92)
Zones in the above table are designated by combining the room letter with the floor number e.g zone A3

Floor	Zone	U 1	U 2	U 3	U 4	U 5	U 6	U 7	U 8	U 9	U 10	U 11	U 12	U 13	U 14	U 15	U 16	U 17
1	A	*			*			*					*					
1	C							*										
1	E							*										
1	M							*										
1	O	*											*					
3	A	*		*	*	*				*	*	*	*	*	*	*	*	*
3	B									*								
3	C	*	*			*				*			*	*			*	
3	D									*								
3	E	*				*				*	*	*	*	*	*	*	*	*
3	F									*								
3	G	*								*			*					
3	H									*								
3	I	*				*							*					
3	J									*								
3	K	*								*			*					
3	L						*			*								
3	M	*				*	*			*			*					
3	N						*			*								
3	O	*	*			*				*			*	*				
3	P									*						*		
4	A						*	*										
4	B						*											
4	C						*	*										
4	E							*										
4	M							*										
4	O						*	*										
4	P						*											
5	A	*			*	*	*	*					*	*		*	*	
5	B						*		*									
5	C		*	*		*	*	*	*		*			*			*	
5	D								*									
5	E					*		*						*		*	*	
5	G			*														
5	I					*												
5	K			*														
5	M				*	*		*										
5	O	*	*	*	*	*	*	*					*	*				
5	P						*									*		

U1 - U5 The users from the Netherland)
U6 - U8 The users from UK) Non IEA participants
U9 - U11 The users from Switzerland)

U12 Netherlands)
U13 Newcastle University)
U14 GZ) IEA participants
U15 BRE)
U16 Germany)
U17 PJ)

Table 2 Total selections by all users
* Shows selections

Room Orientation	Room .	1st Floor	2nd Floor	3rd Floor	4th Floor	5th Floor	Total select ions	%
S	A	4		13	2	10	29	23.0
S	B			1	1	2	4	3.2
S	P			2	1	2	5	4.0
SW	C	1		7	2	9	19	15.0
W	D			1		1	2	1.6
W	E	1		11	1	6	19	15.0
W	F			1			1	0.8
NW	G			3		1	4	3.2
N	H			1			1	0.8
N	I			3		1	4	3.2
N	J			1			1	0.8
NE	K			3		1	4	3.2
E	L			2			2	1.6
E	M	1		5	1	3	10	8.0
E	N			2			2	1.7
SE	O	2		6	2	9	19	15.0
	Total	9	0	62	10	45	126	100
	%	7.2	0	49.2	7.9	35.7	100	

Table 3 Distribution of all selections

The number of participants in this exercise was 17 as follows:
5 from UK
6 from Netherlands
5 from Switzerland
1 from Germany

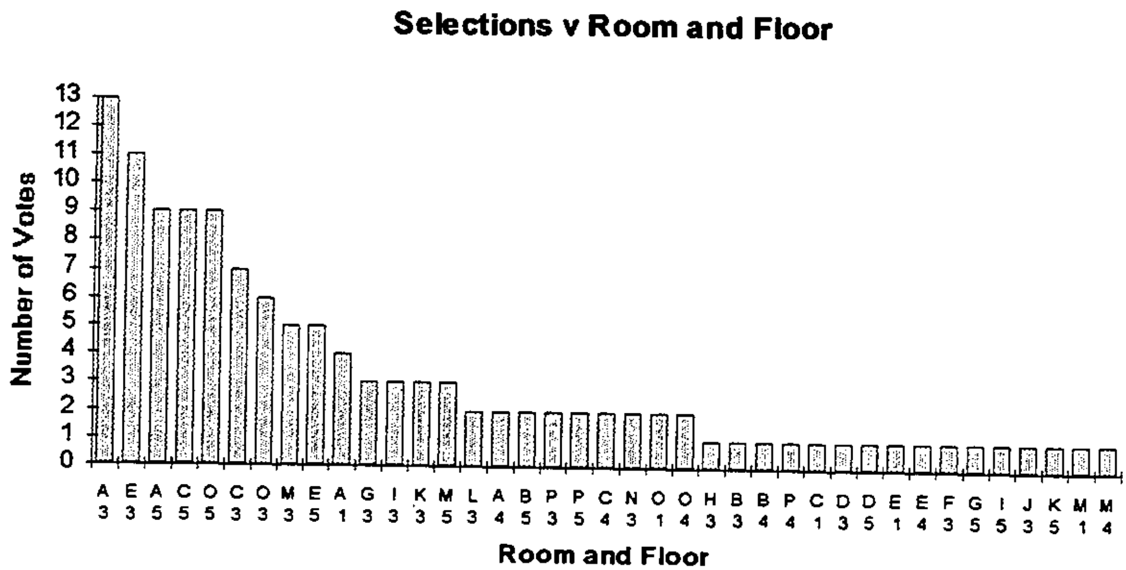


FIG 2 Distribution of all selections

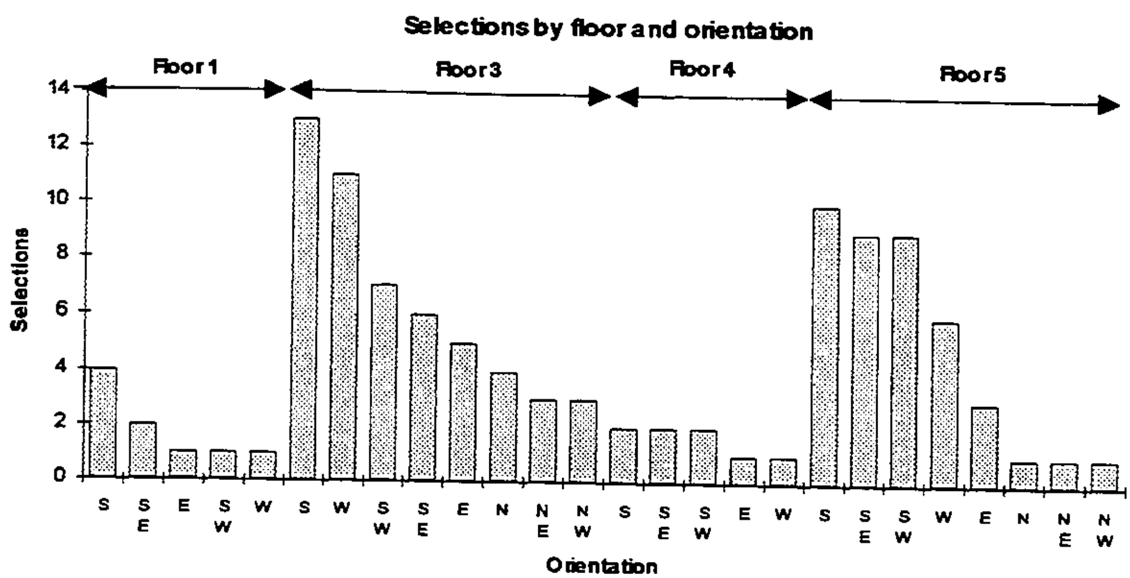


Fig 3 Distribution of selections according to orientation
(If a user voted for more than one room on the same orientation only one vote has been counted)

Room Orientation	Room .	3rd Floor	Top Floor
E	M	**5**	**3**
SE	O	**6**	**9**
S	A	**13**	**10**
SW	C	**7**	**9**
W	E	**11**	**6**

Table 3 Selections corresponding to simulated rooms

		Base Case		With Ventilation		With Ventilation	
Orientation	**Selections**	**Temp**	**Priority**	**Temp**	**Priority**	**Hours**	**Priority**
S-3	13	45.6	2 (Aug)	34.6	4 (Aug)	158	3 (Aug)
W-3	11	44.6	4 (June)	34.8	3 (June)	88	9 (June)
S-5	10	40.5	9 (Aug)	33.2	8 (Aug)	139	6(Aug)
SE-5	9	41.4	7 (June)	32.8	9 (June)	143	5 (Aug)
SW-5	9	39.9	10(June)	32.4	10 (June)	104	8 (Aug)
SW-3	7	42.7	6 (June)	33.4	7 (June)	117	7 (Aug)
SE-3	6	44.4	5 (June)	34.0	5 (June)	155	4 (Aug)
W-5	6	41.1	8 (June)	33.7	6(June)	73	10 (June)
E-3	5	50.0	1 (June)	36.3	1 (June)	176	1 (June)
E-5	3	45.4	3 (June)	34.8	2 (June)	175	2 (June)

Table 4 Comparison of selections with simulations

Floor	Zone	U 1	U 2	U 3	U 4	U 5	U 6	U 7	U 8	U 9	U 10	U 11	U 12	U 13	U 14	U 15	U 16	U 17
1	A	*			*			*					*					
1	C							*										
1	E							*										
1	M							*										
1	O	*											*					
3	A	*		*	*	*				*	*	*	*	*	*	*	*	*
3	B									*								
3	C	*	*			*				*			*	*			*	
3	D									*								
3	E	*				*				*	*	*	*	*	*	*	*	*
3	F									*								
3	G	*								*			*					
3	H									*								
3	I	*				*							*					
3	J									*								
3	K	*								*			*					
3	L						*			*								
3	M	*				*	*			*			*					
3	N						*			*								
3	O	*	*			*				*			*	*				
3	P									*						*		
4	A						*	*										
4	B						*											
4	C						*	*										
4	E							*										
4	M							*										
4	O						*	*										
4	P						*											
5	A	*			*	*	*	*					*	*		*	*	
5	B						*		*									
5	C		*	*		*	*	*	*		*			*			*	
5	D								*									
5	E					*		*						*		*	*	
5	G			*														
5	I					*												
5	K			*														
5	M				*	*		*										
5	O	*	*	*	*	*	*	*					*	*				
5	P						*									*		
Worst case chosen ?		Y	N	N	N	Y	Y	N	N	Y	N	N	Y	N	N	N	N	N

Table 5 Success of selections based on whether worst case has been chosen.

APPENDIX 1

Edited comments

1) Comments from Peter Verstraete(Belgium)

Rules for zoning are given in Section 6 of the PAMDOC vub-tm.010, Assessment of Overheating Risk in Office Buildings. A zoning procedure is given comprising the following steps:-

a) Divide the building into a minimal number of groups of similar rooms.
b) Select the group in which overheating is most likely to take place.
c) Select a room or rooms most representative of the selected group.
d) Model the representative room or rooms as one or several zones.

For each of the above steps the parameters to consider and the rules for making decisions are given.

2) Comments from Aad Wijsman(Netherlands)

The zoning depends on a range of design and operational criteria , however for a given building most of these criteria are fixed, for instance:

a). there are at the maximum 4 different orientations

b). the glazing type will be the same for E, S and W. Only N can be different from the other orientations

c). the influence of shading: by surrounding buildings the influence is small in summertime, by own building parts the influence is the same on one orientation

d). the occupation level and pattern will be the same for most spaces.

e) ventilation rate will be the same for most spaces.

f) building construction will be the same for most spaces.

g) dimensions of the spaces: Usually a maximum of 3-4 different spaces can be distinguished in an office building. Consider especially the influence of ground floor and top floor.

Further we should bear in mind, that the measures to control overheating will be for all/most zones the same.

Based on this information a zoning procedure should be developed, which leads to a maximum number of zones. By some sensitivity studies this (maximum) number can be reduced.

The PAMDOC should contain information about the aforementioned procedure.

3) Comments from Gerhard Zweifel(Switzerland)

For the overheating risk assessment as I understand it in my PAMDOC, which is something required by the authorities, it is not appropriate to look for the worst case in the building, although I could well imagine that for other, more economically based overheating risk assessments, this would be a way.

My proposal is (and this is a slight extension of what is in my current PAMDOC EMPA 0001):

1) Divide the building into the lowest possible number of areas with spaces of the same or nearly the same operation, and construction and with the same orientation.

2) Pick from these areas those with a ratio of more than 10% of the total building area (for which air conditioning is envisaged).

3) Pick from these areas all those with an orientation between SE and W.

If an area is equal to a space, take this space as a zone to be treated.

If an area consists of several spaces (the more frequent case), take the space most

representative of the area, as the zone to be treated.
4) Treat the remaining areas with orientations out of the sector defined above in the same way,

4) Extract from Blast 001 Pamdoc —Sonja Huther(Germany)

6.1.1 Modelled Zones

6.1.1.1 Description

There are supposed to be groups of similar offices but each group with different conditions.

1) Identify these groups and
2) Select groups with are judged to be most prone to overheating
3) Select one office from each group as typical of that expected to be most prone to overheating.

6.1.1.2 Parameter Definition List

Distinguish groups and zones according to the following criteria:
orientation / south, west
position in building / i.e. under roof, middle, etc.
internal loads
surface construction / i.e. low/heavy weight one, suspended ceiling, floor construction, ...
geometry, if it is widely different
(All offices are supposed to have some comfort requirements)

6.1.1.3 Define Zone

Prefer groups with south, southwest and west orientation
If there is a low weight roof, then take upper storey
If these is a heavy weight roof, then take middle storey
Prefer groups with highest internal loads
Prefer groups with most light weight surfaces (lw walls, suspended ceiling, lw double floor construction)
Calculate all different geometries.

6.1.1.4 Rationale

Neighbouring zones (in a group) are considered to have equal conditions and thus be
unmodelled
As experience shows south-west orientation is most prone to overheating
A lw roof is supposed to be more exposed than a middle floor as sunbeams can directly fall upon it. A hw roof is probably less exposed than a middle floor which is exposed to high internal loads
Peak temperatures in lw construction building will be higher.

6.1.1.5 Reference

User experience, IEA benchmark tests.

6.1.1.6 Quality Assurance

Simulate rejected zones also and compare their temperatures in ZONE GROUP LOADS.

6.1.1.7 Further Information

None

6.1.2 Adjacent Unmodelled Zones

6.1.2.1 Description

Conditions of adjacent Unmodelled zones are described by the choice of the WALL TYPE as set out in Manual page 379.

6.2 INTERZONAL COUPLING

As one single zone of a group of similar is selected, there will be similar adjacent zones . Nevertheless, if two zones of different groups are adjacent, this can be simulated as set out in the Manual. Air changes, i.e. for door openings, are not described here.

6.2.1 Interzonal Coupling : Airflow

6.2.1.1 Description

As set out in the Manual pages 353 and 195

6.2.2 Interzonal Coupling : Shortwave

6.2.2.1 Description

It is not possible to consider non-opaque interior surfaces within BLAST!

6.2.3 Interzonal Coupling : Conduction

6.2.3.1 Description

As set out in Manual page 454 INTERZONE SURFACES.

1 IEA 21 RN 262/92 , Overheating risk assessment in office buildings:
Building Thermal Performance Programs: Two-stage user tests.
Aad Wijsman TNO_Bouw, BBI Department, Leeghwaterstraat 5 PO box
29 , 2600 AA Delft.

PAPER 2

PRACTICAL WINDOW SYSTEM AND BUILDING SIMULATION PROGRAMS

Aad Wijsman
TNO-Bouw
BBI Department
Leeghwaterstraat 5
P.O. box 29
2600 AA Delft
Tel: 015 - 608608
Fax: 015 - 608432

Summary

TITLE	Practical window system and Building Simulation Programs.
REPORT NUMBER	IEA21RN312/93; February 8, 1993
INVESTIGATOR	A. Wijsman
ADDRESS	TNO-Bouw BBI-Department Leeghwaterstraat 5 P.O. box 29 2600 AA Delft

INTRODUCTION
The study of overheating risk in buildings uses computer programs that assess the thermal behaviour of the building. An important aspect of this is the translation from practical building to input data for the Building Simulation Program. One part of this process is the translation from practical window system to input data.

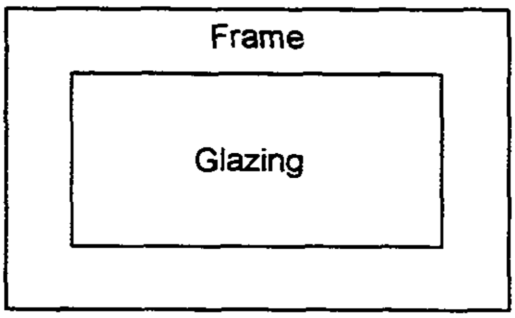


Figure 1 Window system

In a PAM (Performance Assessment Method) guidelines are given on how to handle the different elements of the building. The treatment of the window system is one aspect which requires careful consideration.

OBJECTIVES
The aim of this paper is to provide background information on window system modelling in order to improve the PAMs in this respect.

METHOD
Firstly a review is given of ways to treat the practical window system. The influence of the different ways of treatment on overheating results was then determined using the Dutch Building Simulation Program VA114. The office module used in these studies was a South facing module on the 3th floor of the specified IEA-21 Standard Office Building. The Dutch Base Case PAM was followed in all other respects.

RESULTS
The following aspects were considered:-

- Ways of modelling the window system
- The influence of way of modelling on overheating hours
- What to do when part of the window system information is missing.
- Information about window system treatment in the PAMs of the Subtask participants.

In addition the appendices provide information on:

- Rules to derive the characteristics of a window system from the characteristics of glazing and frame.
- Practical values for glazing-to-window area ratio
- The necessity of using the CF-value.
- The treatment of window system and shading by adjacent building elements.

CONCLUSIONS
In principle the different ways of modelling the window system

- glazing and frame separated or combined
- resistance network or U-, SF-, CF-value characterisation

give the same results. Only selfshading, when the window system lies deep in the facade, gives significantly different results.

It is important, that:-

- as well as U- and SF-value the CF-value is also used, especially for window systems with blinds, etc.
- the area and characterisation of the total window system is known

For the latter the right rules should be used to determine the characteristics of the total window system from area and characterisatics of both glazing and frame.

If no information about the glazing-to-window area ratio is available then guidelines (for instance a rule of thumb) should be available in the PAM.

If no characteristics of the frame are available then guidelines (for instance: assume frame has same properties as the wall) should be available in the PAM.

If there are not such guidelines in the PAM big deviations in the results can be expected (see figure 2a and b). Hard requirements on overheating hours (for instance the Dutch requirements: number of overheating hours above 28 C should not exceed 20 hours) are then without much sense.

Finally: the several PAMs developed in the framework of IEA-21 still suffer from a lack of some of this information. The PAMs should be extended with this information.

Fig. 2a: Influence of way of treatment.
Window system: double glazing, no blinds

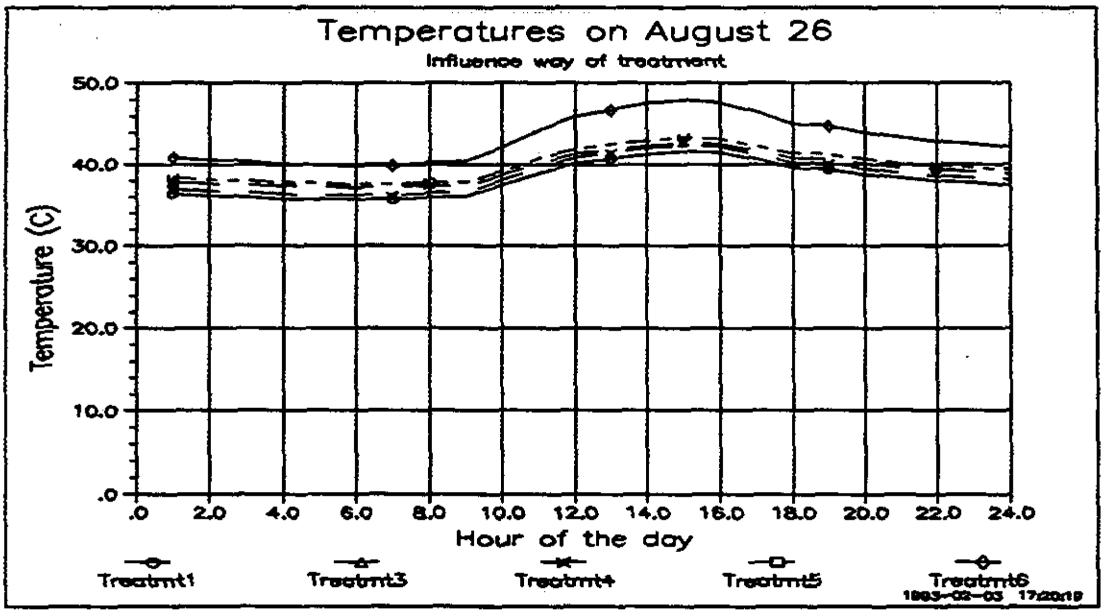
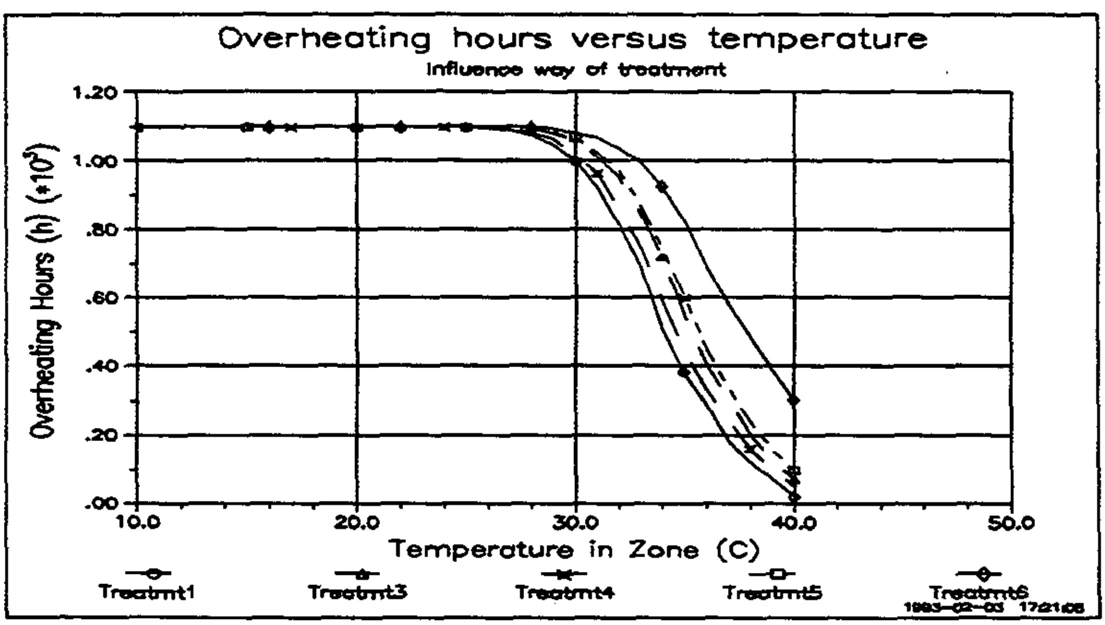


Fig. 2b: Influence of way of treatment on the Number of overheating hours during the entire summer period versus air temperature.
Window system: double glazing - no blinds



Practical window system and Building Simulation Programs

INTRODUCTION

Study of overheating risk in buildings is done with computer programs, that described the thermal behaviour of the building. An important aspect is the translation from practical building to input data for the Building Simulation Program. One detail in this process is the translation from practical window system to input data.

In a PAM (Performance Assessment Method) guidelines are given how to handle the several building aspects. The treatment of the window system is one of the aspects.

The aim of this paper is to give some more background information about window system modelling and so to come to improvement of the PAM's concerning the treatment of the window system.

Treated in this paper is:

- Way's to model the window system
- Influence of way of modelling on overheating hours
- How to handle if a part of the window system information is missing?
- Information about window system treatment in the PAM's of the several participants.

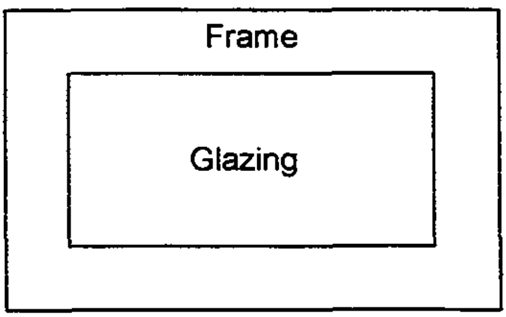


Figure 1 Window system

Moreover in appendices information is given about:

- Rules to derive the characteristics of a window system from the characteristics of glazing and frame.
- Practical values for glazing-to-window area ratio
- Necessity of using the CF-value.
- Treatment of window system and shading by own building parts.
- Information about window system treatment in the PAM's of the several participants.

The influence of the way of treatment of the window system on overheating results was determined with the Dutch Building Simulation Program VA114. The office module used was a South facing module on the 3th floor of the specified Standard Office Building [1]. The Dutch Base Case PAM [2] was followed for all other aspects.

WAY'S TO TREAT THE WINDOW SYSTEM

In general a window system consists of glazing and frame. Both parts with own characteristics and area.
The characteristics of glazing (and frame) can be available as:
1. resistance network with transmission of solar radiation and absorption of solar radiation in the panes
2. U-value, SF-value*) and CF-value*)
In principle the latter (U-value, SF-value and CF-value) can be derived from the former (resistance network).

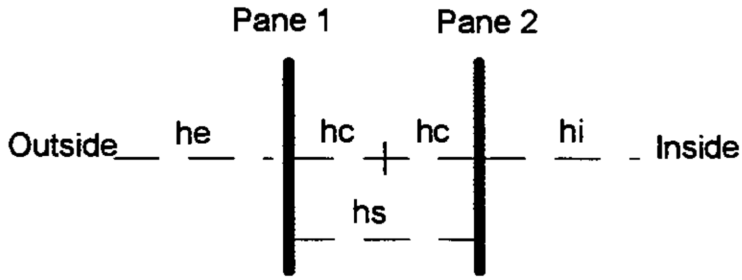


Figure 2: Example of resistance network

Symbols:
- he = external heat transfer coefficient
- hi = internal heat transfer coefficient
- hc = convective heat transfer coefficient
- hs = radiative heat transfer coefficient

The window system can be modelled as two separate parts (glazing and frame) or combined.So the following 3 way's of modelling can be distinguished:
1. model glazing and frame as separate parts and use the resistance network characterisation for each part
2. model glazing and frame as separate parts and use the 'U-, SF- and CF-value' characterisation for each part
3. model glazing and frame as combined window system and use the 'U-, SF- and CF-value' characterisation for the window system.

Definition:
- SF-value (Solar Factor)
  Part of incident solar radiation, that is transferred to the zone
- CF-value (Convection Factor)
  Solar heat is transferred to the zone by direct radia-tion, by convection and by longwave radiation. CF is the convective fraction.

INFLUENCE OF WAY OF MODELLING ON OVERHEATING HOURS

A comparison between the 3 way's of modelling is made:

1. two separate parts and resistance network for each part
2. two separate parts and U-, SF- and CF-value for each part
3. combined and U-, SF- and CF-value for window system.

The influence on overheating hours was determined with the Dutch Building Simulation Program VA114.
The Office Module used was a South facing module centered on the 3th floor of the specified Standard Office Building [1].
The Dutch Base Case PAM [2] was a guide for all other aspects beside the window system.
Information about assumptions made and input data used for this case can be found in [3].
In table 1 the properties of the window system used for method 1, 2 and 3 are given.
For this comparison it is assumed the front of the window system is in the same level as the front of the facade. So the window system does not lie deep in the facade.
The results are given in table 2 and figure 3.

Conclusion:
All three way's of modelling give very close results. So take the easiest way: area and characteristics U, SF and CF of overall window system.

Remark 1: Appendix C shows the necessity of using CF-value, especially for window systems with blinds.

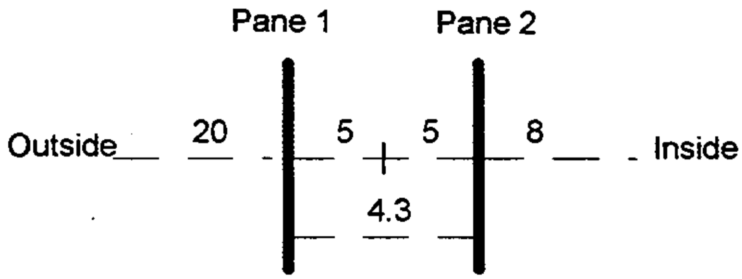
Remark 2: Appendix D shows that a small difference between method 1 (resp. 2) and method 3 occurs in case the window system lies deep (0.12 m) in the facade (so self shading is occuring). Neglecting the SF-value of the frame in calculating the SF-value of the window system for method 3 give closer results in this case.

Table 1: Properties of window system used

The window system has an area of 5.78 m^2. The glazing part is 3.99 m^2, the frame is 1.79 m^2. The type is double glazing with a wooden frame.

-Method 1: Separate treatment and resistance network

The glazing has an area of 3.99 m^2 (2.79 m x 1.43 m) and is modelled as resistance network with transmission by and absorption in the panes:



Absorption in first pane is 0.084 and in second pane is 0.066 of incident solar radiation. Transmission is 0.71. Visible transmission is 0.81.

The frame has an area of 1.79 m^2 and is modelled as a door construction. Material is Wood, thickness 0.115 m, conduc-tivity 0.23 W/mK, density 800 kg/m3 and specific heat 1880 J/kgK (U-value 1.5 W/m^2K). The absorption at the outer surface is 0.5.

-Method 2: Separate treatment and U-, SF- and CF-value.

The glazing has an area of 3.99 m^2 (2.79 m x 1.43 m) and is modelled with U, SF- and CF-value:

U-value	=	3.11	W/m2K
SF-value	=	0.763	W/m2K
CF-value	=	0.026	W/m2K

The frame has an area of 1.79 m^2 and is modelled with U-, SF- and CF-value:

U-value	=	1.5	W/m2K
SF-value	=	0.033	W/m2K
CF-value	=	0.0	W/m2K

-Method 3: Combined treatment and U-, SF- and CF-value.

The window system has an area of 5.78 m^2 (3.70 m x 1.56 m) and is modelled with U-, SF- and CF-value:

U-value	=	2.61	W/m2K
SF-value	=	0.537	W/m2K
CF-value	=	0.026	W/m2K

Table 2: Overheating hours versus temperature according to method 1, 2 and 3.
Number of hours above given temperature level.
<u>Window system:</u> Double glazing - no blinds
Window lies 0.00 m deep in the facade

Temperature Level in zone (in C)	Method 1: Separate, Network (in h)	Method 2: Separate, U, SF and CF (in h)	Method 3: Combined, U, SF and CF (in h)
24	1100	1100	1100
26	1100	1100	1100
28	1097	1097	1096
30	1062	1062	1062
32	959	957	958
34	731	724	729
36	455	448	454
38	260	253	257
40	118	114	121

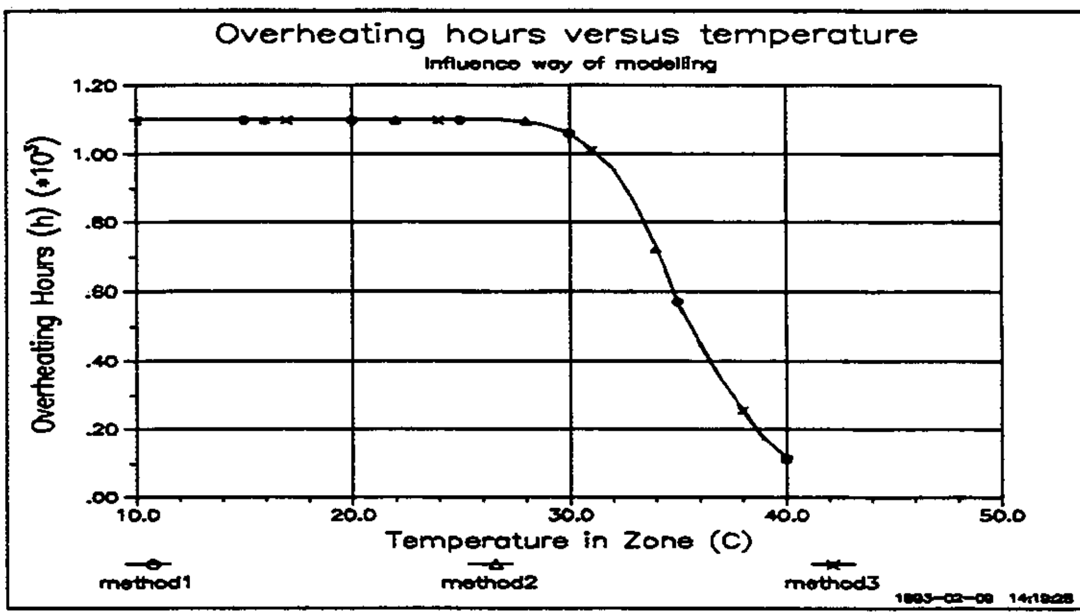


Figure 3: Overheating hours versus temperature according to method 1, 2 and 3.

HOW TO HANDLE IF A PART OF THE WINDOW SYSTEM INFORMATION IS MISSING?

The information of the window system, that is available is not complete in many cases.

Complete information consists of:
Characteristics and area of window system
or
Characteristics and area of both glazing and frame.

In the second case the characteristics of the window system can be determined from the individual information of the glazing and frame.

In this chapter with characteristics is meant:
- U-value
- SF-value (Solar Factor)
- CF-value (Convection Factor)

If only resistance network with transmission of solar radiation and absorption of solar radiation in the panes is available then determine the characteristics U, SF and CF from this information.

In table 3 for 6 cases it is given how to handle. For case 1 and 2 the information is complete, for the other cases not. The assumptions made in cases 3 - 6 will lead to differences in overheating hours.

The influences on overheating hours were determined with the Dutch Building Simulation Program VA114.

The results are given in table 4a and b resp. in figure 4a and b:

case 1 and 4 are close together; they only differ in area of the glazing resp. frame (given resp. rule of thumb).

case 3 and 5 are close together; they only differ in area of the glazing resp. frame.

case 1 and 3 (and also 4 and 5) differ because in the latter only the glazing is considered. The frame is considered to have the same characteristics as the opaque wall.

case 6 leads to much higher overheating hours than case 1, which is really unacceptable.

Conclusion:
Missing of information about the window system leads for case 3 - 5 to reasonable differences, for case 6 to unacceptable differences.

Table 3: Way's of treatment in case information about the window system is missing

1. If characteristics and area of window system are available then model window system by these characteristics and by that area.

2. If characteristics and area of both glazing and frame are available then derive from this information the charac-teristics and area of window system (use rules given in appendix A) and handle as 1.

But in many cases only a part of the information is available. So handle in a way, that is most applicable.

3. If only characteristics and area of glazing are available then use the glazing characteristics and the glazing area.
So it is assumed the frame has the same characteristics as the opaque wall the window system is in.

4. If area of window system and characteristics of glazing and frame are available then make an estimation of the area of glazing and frame (use rules given in appendix B) and handle as 2.

5. If area of window system and characteristics of glazing are available then make an estimation of the area of glazing and frame (use rules given in appendix B) and handle as 3.

NEVER use:

6. If area of window system and characteristics of glazing are available use area of window system and characteristics of glazing.

Table 4a: Overheating hours versus temperature.
Number of hours above given temperature level.
Window system: Double glazing - no blinds

Temperature Level in zone (in C)	Treatment 1 (in h)	Treatment 3 (in h)	Treatment 4 (in h)
24	1100	1100	1100
26	1099	1100	1100
28	1077	1098	1084
30	999	1065	1015
32	815	953	860
34	508	721	589
36	293	406	334
38	124	205	162
40	21	71	50

Table 4b: Overheating hours versus temperature.
Number of hours above given temperature level.
Window system: Double glazing - no blinds

Temperature Level in zone (in C)	Treatment 1 (in h)	Treatment 5 (in h)	Treatment 6 (in h)
24	1100	1100	1100
26	1099	1100	1100
28	1077	1099	1100
30	999	1068	1082
32	815	972	1038
34	508	747	926
36	293	450	690
38	124	245	487
40	21	100	305

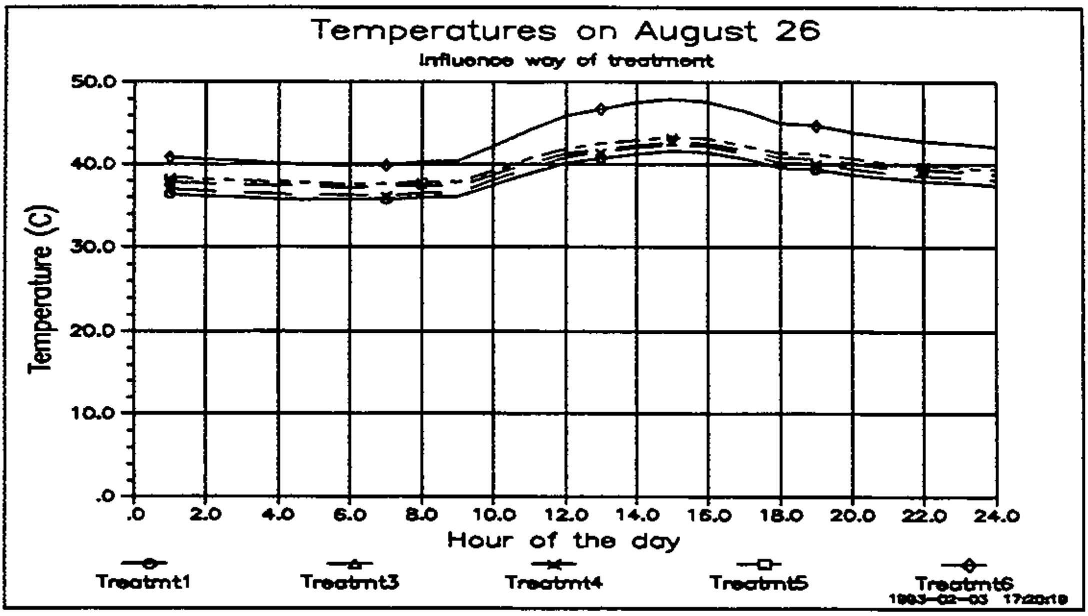


Fig. 4a: Air temperature on August 26, the hot summer day.
Influence way of treatment.
Window system: double glazing - no blinds

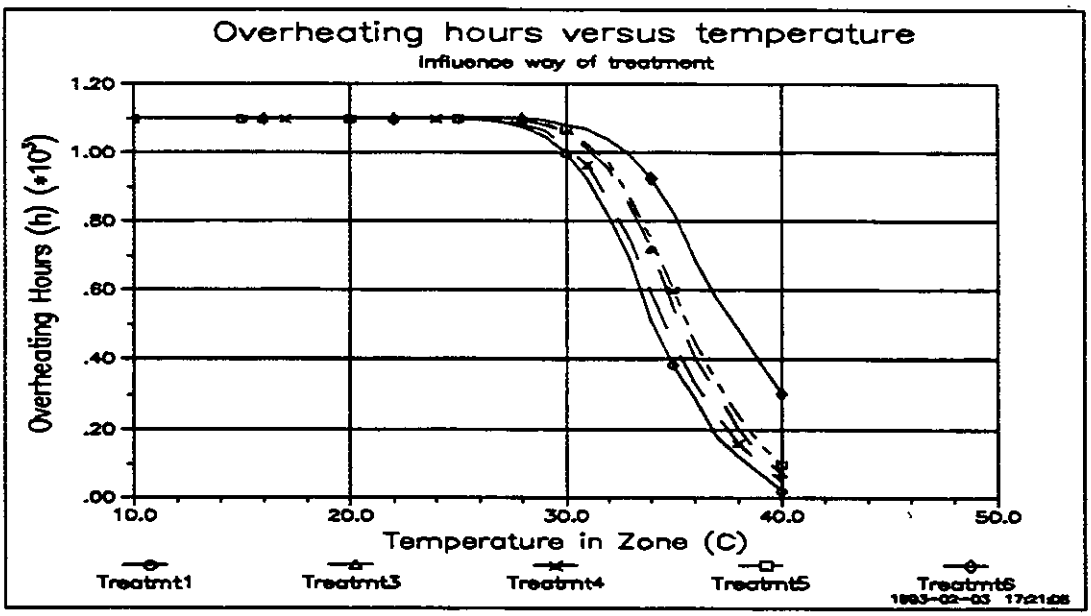


Fig. 4b: Number of overheating hours during the entire summer period versus air temperature.
Influence way of treatment.
Window system: double glazing - no blinds

Information about Window System treatment in the PAM's of the several participants.

The PAM's of the several participants of IEA-21 (version Autumn 1991) were studied with respect to the way the window system should be treated.

In Appendix E this information is given in detail.

To our opinion most of the PAM's are not complete, i.e. not all aspects are treated in the PAM's:
- area of window system, glazing and frame
- rule of thumb for glazing-to-window ratio
- characteristics of window system, glazing and frame
- rules to determine characteristics of window system from area and characteristics of glazing and frame
- using resistance network or U-, SF- and CF-value
- selfshading because the window system lies deep in the facade.
- etc.

And it should be treated.

Reason:
According to Dutch 'requirements' the number of overheating hours above 28 C should not exceed 20 hours (1% of working time). However the importance attached to this value is overrated: 19 is OK, 21 is not OK. Given the information in this paper a spread of 100 hours or more in the results can easily be get. So if no guidelines are given it has no sense to have such rigid require-ments.

Conclusion:
The PAM's should be extended with this information.

In principle the several way's of modelling the window system

- glazing and frame separated or combined
- resistance network or U-, SF-, CF-value characterisation

give the same results. Only selfshading because the window system lies deep in the facade can give some different results.

However it is important, that

- besides U- and SF-value also the CF-value is used, especially for window systems with blinds, etc.
- area and characterisation of the total window system is known

OR

- area and characterisation of both glazing and frame are known.

Use in the latter case the right rules to determine the characteristics of the total window system from the area and characterisation of both glazing and frame.

If no information about the glazing-to-window area ration is available then guidelines (for instance a rule of thumb) should be available.

If no characteristics of the frame are available then guidelines (for instance: assume frame has same properties as the wall) should be available.

If there are not such guidelines big deviations in the results can be expected. Hard requirements on overheating hours (for instance the Dutch requirements: number of overheating hours above 28 C should not exceed 20 hours) are then without much sense.

Finally: the several PAM's developed in the framework of IEA-21 still suffer from some of this information. They should be extended with this information.

LITERATURE

[1] IEA21RN183/91: G. Zweifel, November 1991
"Specification of the Office Building for PAMDOC Testing"

[2] IEA21RN261/92: A. Wijsman, July 1992
"Base Case PAM - TNO-Bouw-0001"

[3] IEA21RN265/92: A.Wijsman, September 1992
"Implementation of Base Case"

Appendix A: **Rules to derive the characteristics of a window system from the characteristics of glazing and frame.**

The characteristics of a window system can be derived from the characteristics from the two parts: glazing and frame.

Required is the glazing-to-window ratio R_{gw}, which is defined by:

$$R_{gw} = A_{glazing} / A_{window}$$

with

$A_{glazing}$ = area of glazing part
A_{window} = area of total window system

1. Model consisting of resistance/capacitance-network with absorption in the panes resp. on outer and inner surface.

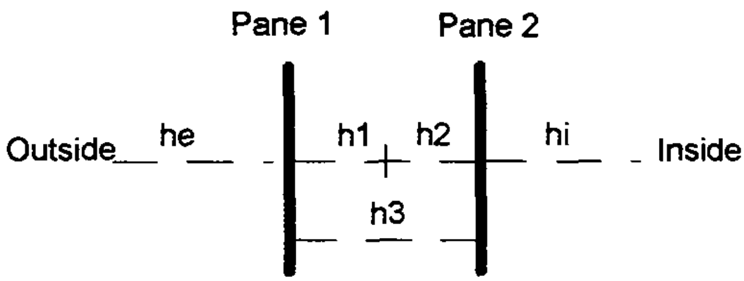


Figure A.1: Resistance network of window system

Rules:

$$U = R_{gw} * U_{glazing} + (1-R_{gw}) * U_{frame}$$

$$h_j = U / U_{glazing} * h_{glazing,j}$$

$$ABS_k = R_{gw} * ABS_{glazing,k}$$

$$TR = R_{gw} * TR_{glazing}$$

$$TRVI = R_{gw} * TRVI_{glazing}$$

with

U = U-value
h_j = heat transfer coefficient j (1/resistance)
ABS_k = absorption of solar radiation in pane k
TR = transmission for solar radiation
$TRVI$ = transmission for visible solar radiation (light transmittance)

R_{gw} = glazing-to-window area ratio

Remark:

For outer and inner 'pane' the absorption ABS should be increased by the absorption on outer resp. inner surface of frame:

$$ABS_e = R_{gw} * ABS_{glazing,e} + (1-R_{gw}) * ABS_{frame,e}$$

$$ABS_i = R_{gw} * ABS_{glazing,i} + (1-R_{gw}) * ABS_{frame,i}$$

2. Model with U-value, SF-value and CF-value.

Rules:

$$U = R_{gw} * U_{glazing} + (1-R_{gw}) * U_{frame}$$

$$SF = R_{gw} * SF_{glazing} + (1-R_{gw}) * SF_{frame}{}^{1)}$$

$$CF = CF_{glazing}{}^{2)}$$

$$TRVI = R_{gw} * TRVI_{glazing}$$

With

U = U-value
SF = Solar Factor*
CF = Convection Factor*
TRVI = transmission for visible solar radiation (light transmittance)
R_{gw} = glazing-to-window area ratio

Remarks:

1. SF_{frame} is almost 0.

2. This is based on $SF_{frame} = 0.0$

3. Some window models work with a Shading Coefficient SC. In that case the framework is included in that coefficient:

$$SC = R_{gw} * SC_{glazing}$$

---

* Definition:
- SF-value (Solar Factor)
Part of incident solar radiation, that is transferred to the zone:
Q_{in} = $SF * A_{window} * G_{sol}$
Q_{in} = solar heat transferred to zone
G_{sol} = incident solar radiation intensity
- CF-value (Convection Factor)
Solar heat is transferred to the zone by direct radiation, by convection and by longwave radiation. CF is the convective fraction:

CF	$=Q_{in,c}/Q_{in}$

Appendix B: Practical values for glazing to window area ratio.

The window system consists of two parts: the glazing and the framework. The glazing-to-window area ratio gives information about area's of both parts. The glazing-to-window area R_{gw} is defined by:

$$R_{gw} = A_{glazing} / A_{window}$$

with

$A_{glazing}$ = area of glazing part
A_{window} = area of total window system

Practical values for this glazing-to-window area ratio Rgw:

a. Parand (information from JP Hall)

$R_{gw} = 0.28*A_{window} + 0.37$	for $A_{window} < 1$ m2
$R_{gw} = 0.03*A_{window} + 0.64$	for 1 m2 $< A_{window} <$ 7 m2
R_{gw} = ...	for 7 m2 $< A_{window} <$ 12 m2
$R_{gw} = 1.0$	for 12 m2 $< A_{window}$

b. Sodagar (information from SERI-RES)

$R_{gw} = 0.85$	for domestic buildings
R_{gw} = calculated	for non-domestic buildings

c. Zweifel (information from specified Standard Office Building)

$R_{gw} = 0.69$ for A_{window} = 5.78 m2 (3*1.93 m2)

Remark: the window of the specified Standard Office Building (3 parts of 1.93 m2) agrees with the information of Parand.

Rule of thumb

From the information mentionned above a rule of thumb was derived:

Rule 1. The frame consists of an 0.10 m edge around the glazing

$$B_{glazing} = B - 0.20$$

$$H_{glazing} = H - 0.20$$

Rule 2. For a window with more than one partion (see fig. B.1)

$B_{glazing} = B - NB * 0.20$

$H_{glazing} = H - NH * 0.20$

With

NB = number of partions in width
NH = number of partions in height

The glazing-to-window area R_{gw} follows from:

$A_{glazing} = B_{glazing} * H_{glazing}$

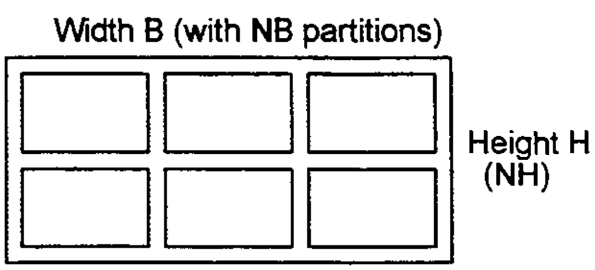
$A_{window} = B * H$

$R_{gw} = A_{glazing} / A_{window}$

with:

B = width of window
H = height of window

Figure B.1: Window with more than one partition



<u>Comparison rule of thumb with information from J.P Hall</u>
In figure B.2 the glazing-to-window area R_{gw} is given versus window area. A comparison is made between Hall and the rule of thumb. The window considered consists of <u>one partion</u>.

For the rule of thumb the aspect ratio (H/B) is assumed to be 1. For a aspect ratio of 0.5 the R_{gw}-values are about 0.02 lower than given in figure 2.

The rule of thumb comes very close to the practical data of Hall, especially for window area's lower than 1.5 m^2 or higher than 6 m^2. The biggest difference occurs at 3.5 m^2: 0.04
For a aspect ratio of 0.5 the methods will come still clooser.

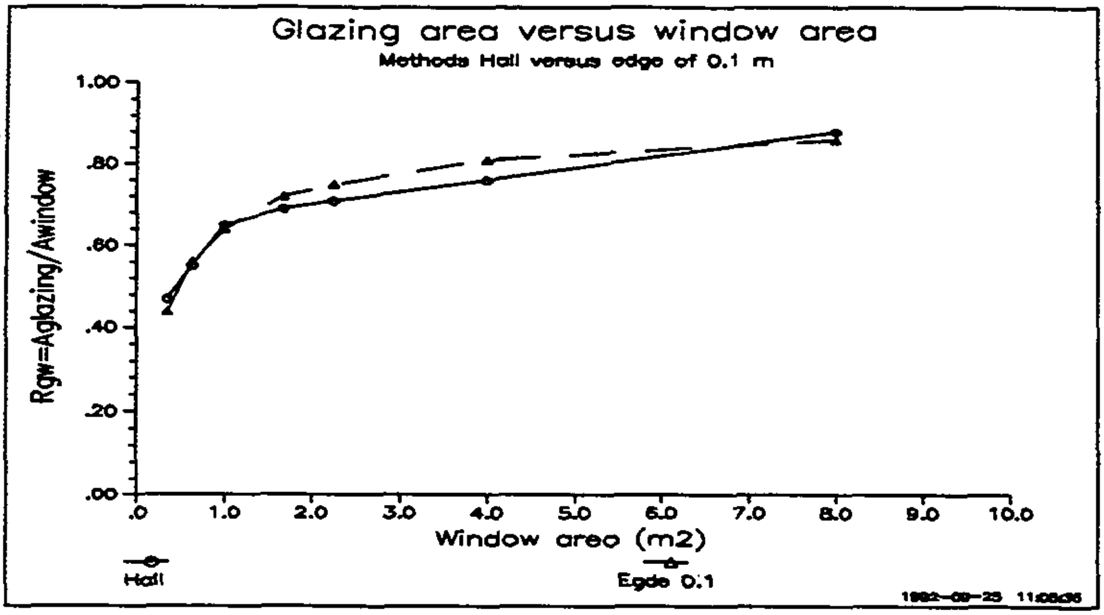


Figure B.2: Glazing-to-window ratio R_{gw} versus window area. Comparison rule
of thumb with information of J.P. Hall

For windows consisting of <u>more than one partition</u> the comparison can be made by taking the Hall-value at a window area A_{window}*, that is equal to:

A_{window}* = A_{window} / Number of partions

For instance:

B = 3.0 m^2
H = 2.0 m^2
NB = 3
NH = 2

Rule of thumb gives:

$A_{glazing}$ = (3.0 - 0.60) * (2.0 - 0.40) = 3.84 m^2
A_{window} = 3.0 * 2.0 = 6.0 m^2
R_{gw} = 0.64

Hall gives (see 6.0 m^2 / 6 = 1.0 m^2):

R_{gw} = 0.64

So a good agreement between rule of thumb and J.P. Hall.

Appendix C: Window system characterization by U, SF and CF. Necessity of using CF-value.

A window system is characterized by:
- U-value
- SF-value (Solar Factor)
- CF-value (Convection Factor)

In this appendix it is shown, that using only U and SF to characterize a window system can lead to an underestimation of the overheating problem. Especially for window systems with blinds.

The investigation was done by 3 calculations:
1. using resistance network with transmission of solar radiation and absorption of solar radiation by the panes/ by the blinds
2. using corresponding U- and SF-value.
3. using corresponding U-, SF- and CF-value.

The investigation was done with the Dutch Building Simulation Program VA114. The office module used was a South facing module on the 3th floor of the specified Standard Office Building [1]. The Dutch Base Case PAM [2] was followed for all other aspects.

Four window systems were investigated:
1. Double glazing without blinds
2. Double glazing with blinds on the outside
3. Double glazing with blinds in between the two panes
4. Double glazing with blinds on the inside

Figure C.1. shows the resistance network of a window system in general. Table C.1. contains the coefficients of the resistance network of the four window systems and the corresponding U-, SF- and CF-values.

Remark: for reasons of simplicity in this study only the glazing (characteristics and area) is considered. So frame is considered to have same characteristics as the wall component.

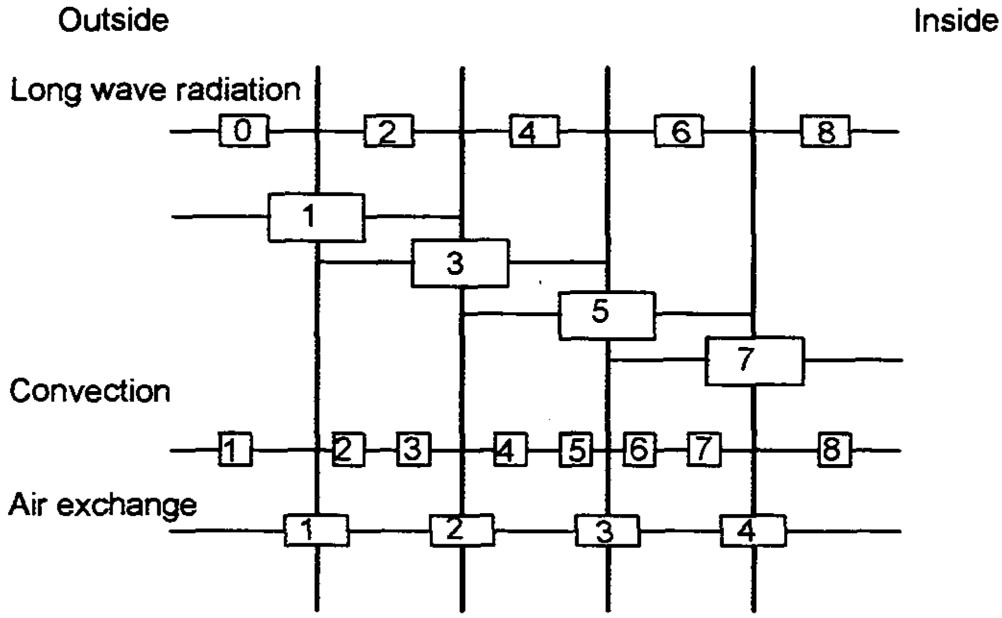
Results of the overheating calculations are given table C.2.A-D.

The use of the CF-value (method 3) brings the results much closer to the network results. For window systems with blinds, especial-ly those in between the panes and those inside, the use of the CF-value is necessary.

For the most sensitive window system (blinds inside) in figure C.2.A en B the temperature profile on a hot day and the overhea-ting hours versus temperature are given for the three methods.

Final remark:
The characteristics of the glazing systems used are constructed by ourselves. Good enough for this goal: to prove the necessity of the use of CF-value. The differences between the several window systems come on the second place (see fig. C.3.).

Figure C.1.General network of window system



From Figure C.2.:
- Difference in top temperature on the hot day between method 1 and 2 is 0.9 K, between method 1 and 3 only 0.1 K.
- Difference in overheating hours (level 36 C) between method 1 and 2 is 38 h, between method 1 and 3 only 2 h.

Final remark: if we look to the zone temperature method 3 comes very close to method 1, if we look however to the comfort tempe-rature, then method 3 gives a too low value (0.5 K) with respect of method 1. For method 2 this difference is even bigger (0.9 K)

Reason:
the use of an U ,SF (and CF) model supposes an one pane window with U-value 'U', a transmission SF and no absorp-tion of solar radiation in the pane. The so calculated pane temperature is too low and so the comfort temperature.

So for calculations on comfort temperature it is advised to use the network model for the window system.*

Conclusion:
The window system can be described by U, SF and CF. The with this method calculated zone temperatures are close to the temperatures calculated with a network

for the window system.

The use of CF is a necessity, especially for windows with blinds.

For calculations on the comfort temperature the U, SF, CF model gives a too low temperature. It is advised to use (if possible) the network description.

* In the year 1993 the VA114 Building Simulation Programme will get a better model for the U, SF, CF description of the window system. This new model (also one pane) takes absorption in the pane into account. The new model is tested and gives the right pane temperature at the zone side (and so the right comfort temperature in the zone) Extra input required for this model is the total transmission of the window system and the emissivity of the window system at the zone side.

Table C.1.: Network coefficients for 4 window systems

Coefficient	2 panes no blinds	2 panes blinds on outside	2 panes blinds in between	2 panes blinds on inside
<u>Long wave Radiation</u>				
hr_0	---	---	---	---
hr_1	---	---	---	---
hr_2	4.1	4.1	3.8	4.1
hr_3	---	---	0.9	---
hr_4	---	4.1	3.8	4.1
hr_5	---	---	---	---
hr_6	---	---	---	---
hr_7	---	---	---	---
hr_8	5.0	5.0	5.0	5.0
<u>Convection</u>				
hc_1	23.0	23.0	23.0	23.0
hc_2	3.0	3.0	3.0	3.0
hc_3	3.0	3.0	3.0	3.0
hc_4	---	3.0	3.0	3.0
hc_5	---	3.0	3.0	3.0
hc_6	---	---	---	---
hc_7	---	---	---	---
hc_8	3.0	3.0	3.0	3.0
<u>Air Exchange</u>				
hex_1	---	100.0	---	---
hex_2	---	---	100.0	---
hex_3	---	---	---	100.0
hex_4	---	---	---	---
<u>Absorption Coefficient</u>				
Abs_1	0.10	0.45	0.11	0.11
Abs_2	0.05	0.01	0.35	0.06
Abs_3	---	0.01	0.01	0.30
Abs_4	---	---	---	---
<u>Trans-mission</u>				
D_{sol}	0.71	0.11	0.11	0.11
D_{vis}	0.81	0.12	0.12	0.12
<u>Charact-eristics</u>				
U	2.88	2.18	2.49	2.54
SF	0.755	0.142	0.268	0.420
CF	0.022	0.084	0.221	0.447

Table C.2.A: Overheating hours versus temperature according to method 1, 2 and 3. Number of hours above given temperature level.
Window system: Double glazing - no blinds

Temperature Level in zone (in C)	Method 1: Network (in h)	Method 2: U and SF (in h)	Method 3: U, SF and CF (in h)
24	1100	1100	1100
26	1100	1100	1100
28	1099	1099	1099
30	1077	1077	1077
32	997	994	996
34	803	798	801
36	484	478	482
38	269	265	267
40	101	100	101

Table C.2.B: Overheating hours versus temperature according to method 1, 2 and 3. Number of hours above given temperature level.
Window system: Double glazing - blinds outside

Temperature Level in zone (in C)	Method 1: Network (in h)	Method 2: U and SF (in h)	Method 3: U, SF and CF (in h)
20	1100	1100	1100
22	1035	1033	1035
24	836	834	835
26	719	717	718
28	442	435	440
30	68	66	68
32	0	0	0
34	0	0	0
36	0	0	0

Table C.2.C: Overheating hours versus temperature according to method 1, 2 and 3. Number of hours above given temperature level.
Window system: Double glazing - blinds in between

Temperature Level in zone (in C)	Method 1: Network (in h)	Method 2: U and SF (in h)	Method 3: U, SF and CF (in h)
20	1100	1100	1100
22	1100	1100	1100
24	1071	1062	1066
26	880	864	873
28	746	723	738
30	445	419	429
32	147	122	143
34	7	3	5
36	0	0	0

Table C.2.D: Overheating hours versus temperature according to method 1, 2 and 3. Number of hours above given temperature level.
Window system: Double glazing - blinds inside

Temperature Level in zone (in C)	Method 1: Network (in h)	Method 2: U and SF (in h)	Method 3: U, SF and CF (in h)
20	1100	1100	1100
22	1100	1100	1100
24	1100	1100	1100
26	1088	1086	1085
28	1002	979	1001
30	828	787	826
32	566	502	558
34	287	235	283
36	96	58	94

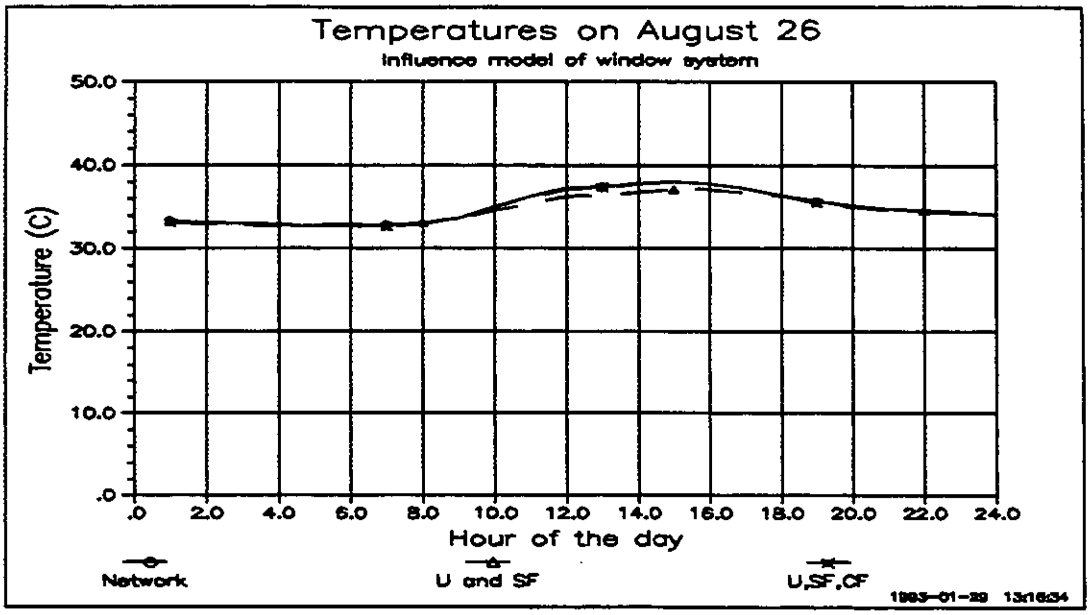


Figure C.2.a: Air temperature on August 26, the hot summer day.
Influence of window model.
Window system: double glazing - blinds inside.

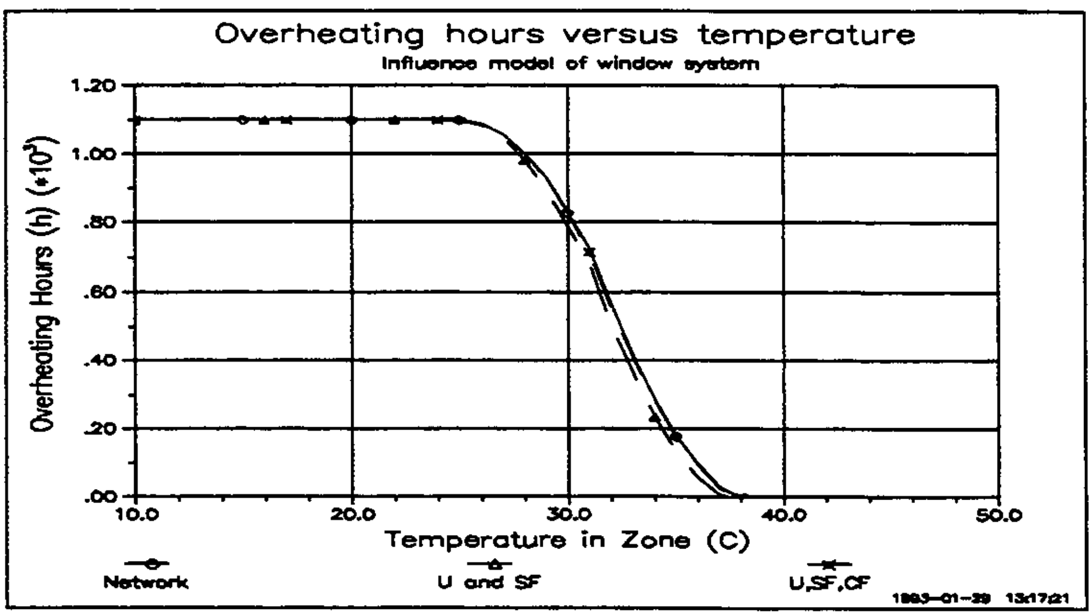


Figure C.2.b: Number of overheating hours during the entire summer period versus air temperature.
Influence of window model.
Window system: double glazing - blinds inside.

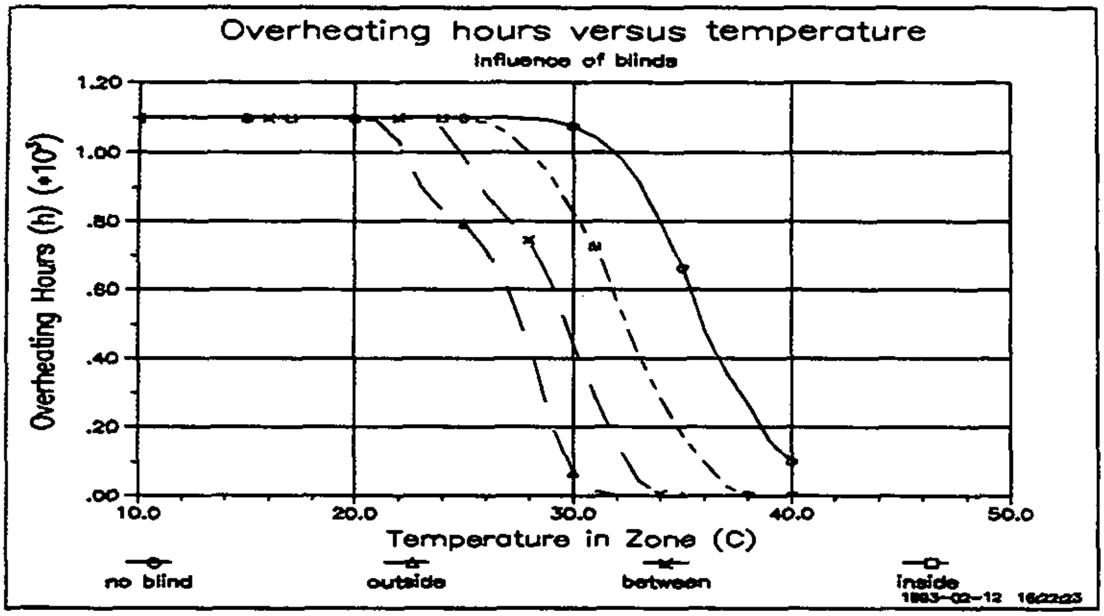


Figure C.3. : Number of overheating hours during the entire summer period versus air temperature.
Influence of type of blinds.

Appendix D: Way of modelling window system and shading because window system lies deep in the facade.

The window system can be modelled in three way's:

1. model glazing and frame as separate parts and use the resistance network characterisation for each part
2. model glazing and frame as separate parts and use the 'U-,SF- and CF-value' characterisation for each part
3. model glazing and frame as combined window system and use the 'U-, SF- and CF-value' characterisation for the window system.

The influence of these way's of modelling is determined with the Dutch Building Simulation Program VA114 for two cases:

A. the window system does not lie deep in the facade

B. the window system lies 0.12 m deep in the facade

In case B. self shading of the window system occurs.

The results of the calculations are given in table D.1a and b.

For case A the results are almost identical, for case B a small difference between method 1 (resp. 2) and method 3 occurs (see also figure D.1)

This difference is caused by the fact, that in VA114 the self shading (because the window system lies deep in the facade) happens at the edge of the 'window defined in VA114'. For model 1 (and 2) this is the edge of the glazing (3.99 m2) and for model 3 this is the edge of the window system (5.78 m2). For the smaller 'window' (3.99 m2) the effect of the shading is higher than for the larger 'window' (5.78 m2) (see figure D.2.). So the latter will have a higher number of overheating hours than the former (order of magnitude is 15 hours).

If the SF-value of the frame, in calculating the SF-value of the window system for method 3, is neglected (case 3^*) the results are again very close.

So the SF-value of the frame should be taken into account for case A and not for case B. And for the cases in between (for instance 0.04 m deep) something in between. So always for method 3 some uncertainity in the results is left.

To prevent underestimation of the overheating problem it is advised to take in all cases for model 3 the SF-value of the frame into account.

Table D.1a: Overheating hours versus temperature according to method 1, 2 and 3. Number of hours above given temperature level.
Window system: Double glazing - no blinds
Window lies 0.00 m deep in the facade

Temperature Level in zone (in C)	Method 1: Separate, Network (in h)	Method 2: Separate, U,SF and CF (in h)	Method 3: Combined, U,SF and CF (in h)
24	1100	1100	1100
26	1100	1100	1100
28	1097	1097	1096
30	1062	1062	1062
32	959	957	958
34	731	724	729
36	455	448	454
38	260	253	257
40	118	114	121

Table D.2b: Overheating hours versus temperature according to method 1, 3 and 3^*. Number of hours above given temperature level.
Window system: Double glazing - no blinds
Window lies 0.12 m deep in the facade

Temperature Level in zone (in C)	Method 1: Separate, Network (in h)	Method 3: Separate, U,SF and CF (in h)	Method $3^{*)}$: Combined, U,SF and CF (in h)
24	1100	1100	1100
26	1099	1100	1099
28	1078	1080	1077
30	1003	1009	999
32	824	840	815
34	517	548	508
36	297	317	293
38	127	144	124
40	21	35	21

Figure D.1: Overheating hours versus temperature according to method 1, 3 and 3*. Number of hours above given temperature level.
Window system: Double glazing - no blinds
Window lies 0.12 m deep in the facade

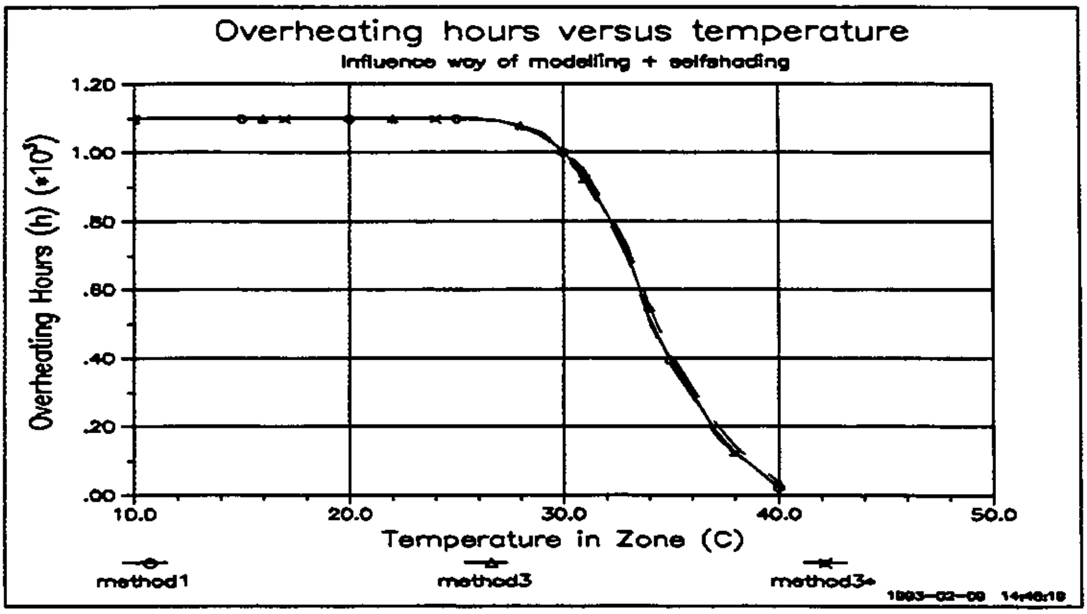
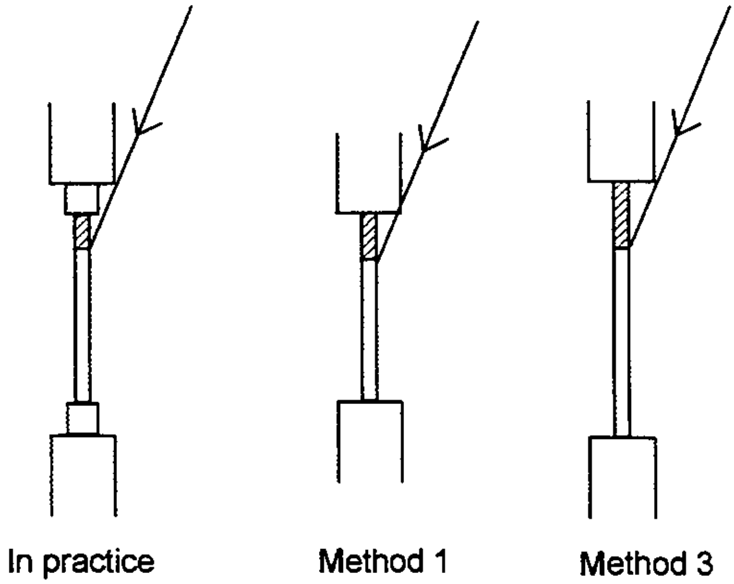


Figure D.2.: Shading because the window system lies deep in the facade happens at the edge of the 'window defined in VA114'. Situation in practice, for method 1 and for method 3.



<u>Appendix E:</u> Window treatment information in the PAMDOCs produced by Subtask participants.

The PAM's of the several participants (version autumn 1991) were studied with respect to the way the window system was treated.
In this appendix a review is given.

PAM's studied are:

1. EMPA	DOE-2	PAM October 1991
2. SORANE	TRNSYS	PAM March 1991
3. BRE	BREADMIT	PAM September 1991
4. NEWCASTLE	SERI-RES -	PAM September 1991
5. ROM	BLAST	PAM_0002 July 1991
6. TNO-BOUW	VA114	PAM September 1991

The information is given on the next pages.

Lines marked with '==>' means:
Conclusion/question from this information.

<u>Summary</u>

A review table is given on the next page. The '?' means: not known (not in PAM). This information should supplied be to the individual PAM's.

Remark: in the table their is TNO1 and TNO2 for both separate treatment (ST) and combined treatment (CT).

REVIEW TABLE

ASPECT	EMPA	SORANE	BRE	NEWCL	ROM	TNO1	TNO2
Treatment of glazing	ST	?	ST	CT	ST	ST	CT
+Framework						CT	
Model of glazing	U-SF	U-?	U-SF	U	U-TA	U-SF R-TA	U-SF R-TA
Model of Framework	SW-U	?/NA	?	SC	SW-U	SW-R	NA
Use of Database	G	?	?	NO	NO	G	NO
Non normal incidence solar	YES	?	?	YES	NO	NO	NO
Window deep in facade	YES	?	?	YES	YES	YES	YES

Explication of answers

General
Yes = taken into account
No = not taken into account
? = not known (not in PAM)

Treatment glazing+framework:
ST = Separate treatment
CT = Combined treatment

Model of glazing
: R-TA= Resist. network and Tr./Abs.
: U-TA= U-value and Transm./Absorbtion
: U-SF= U-value and SF-value
U-? = U-value and solar not known

Model of framework
NA = Not applicable
: SW-U = Separate wall; U-value
: SW-R = Separate wall; res./cap. nwrk
: CW-U = Combined with wallconstr.; U
: CW-R = Combined with wallconstr.; R

Use of database
: G = glazing only
GF = glazing + frame
G? = not known

1. EMPA - DOE-2 - PAM October 1991

7.1 Geometry

7.1.1 Description

Windows are defined as net glass area within a separate piece of exterior wall with the properties of the frame.

7.1.3 Assign Values

Windows - height and width: overall values including frame for exterior wall considered as frame; net glass values for WINDOW

7.1.4 Rationale

Height and Width of windows: glass values can be used for definition of windows, instead of using correction values for frame part.

==> So glazing and framework are treated SEPARATE.

7.4 Construction:

Layer by layer, thickness, density, specific heat and thermal conductance

==> Model used for wall is resistance/capacitance network

7.8 Window properties

7.8.1 Description

Choice of the best fitting glass type out of a library with the help of a table with number of glasses, transmission, reflection, visible transmission.

7.8.3 Assign Values

Number of panes : actual number

Glass-type-Code : transmittance and reflectance in Reference Manual table should meet actual values as close as possible.

Glass-conductance: entered value, corrected by outside film coefficient of 23 W/m2K should correspond to U-value in table mentioned above.

Vis-Trans : entered value should correspond to value "tau" in tables mentioned above.

==> Model used for glazing is U-value.

==> Is 'window lies deep in the facade' taken into account??

2. SORANE - TRNSYS - PAM March 1991

7.1 Geometry

The building geometry is defined for the BID program (the preprocessor for TYPE 56) by surfaces of walls and windows.

==> Treatment of glazing and frame separate/combined??
Window area = glazing + frame or glazing only??

7.4.3 Windows

U-value of glazing split up in Houtside,Uglass,Hinside
Absorbtance of the inside face (?) of window to short wave radiation.
Reflectance of the inner side of the window (?) to short wave radiation.

==> Model for glazing is U-value
==> Is 'window lies deep in the facade' taken into account??

3. BRE - BREADMIT - PAM September 1991

7.1 Geometry

7.1.2 Parameter Definition List
Percentage of wall area glazed.
7.1.3 Assign Values
Glazed areas should not include frame.

==> So glazing and framework are treated SEPARATE.
==> Framework is counted to wall construction or is not treated??

7.8 Window properties

7.8.1 Description
All glazed areas in a given wall are amalgamated together to give the area that is glazed in that surface. These are all assumed to have the same (or average) properties.
Model for glazing is U-value and (mean or alternating) solar gain factor.

==> Model for glazing is U-value and solar gain factor (SF-value?)

4. UNIVERSITY OF NEWCASTLE UPON TYNE - SERI-RES - PAM Sept. 1991

7.1 Geometry

7.1.1 Description

The design is described in terms of areas and heights and external surface orientations (6.1.1.2: Windows- the area of external glazing that bounds the space). Dimensions - length, height and width of window

==> Glazing and framework are treated COMBINED?

==> Window area is area of glazing + framework?

7.8 Window properties

7.8.1 Window Conduction

The combined thermal conduction of the glazing and the frame, including multiple layers of glazing, special coating and surface resistances.

Standard values: 5.4 for single glazing, 2.9 for double glazing.

==> Model for window is U-value.

7.8.2 Window Shading Coefficient

Shading Coefficient: fraction of total window area able to transmit solar radiation.

Standard values: 0.765 for single/double glazing (frame 0.85, net curtain 0.9). Exclusive shading devices.

7.8.3 Extinction Coefficient

Extinction coefficient of glazing material per unit thickness(mm).

Default value: 0.0197

7.8.4 Refractive index

Index of refraction of glazing material

Default value: 1.526

==> Model for window: exact calculation of transmission and absorption by glazing. Results in SF-value?. Correction SF-value with Shading Coefficient. Non-normal incidence taken into account.

5. ROM - BLAST - PAM_0002 July 1991

7.1 Geometry

7.1.1. Description

Windows are defined as net glass area within a separate piece of exterior wall with the properties of the frame.

==> So glazing and framework are treated SEPARATE

7.8 Window properties

7.8.1 Description

Window (pure glass area) were set into a frame material, which is defined as an external wall. Glass and frame material have same U-value as described in the building specifications.

7.8.3 Assign values

REVEAL = 0.12

==> Model for window is U-value; optical characteristics ??

==> Window lies deep in the wall taken into account.

6. TNO-BOUW - VA114 - PAM September 1991

7.1 Geometry

7.1.1 Description

Windows dimensions should be supplied.

==> Not specified what dimensions: glazing+frame or glazing only

==> Remark: both separate and combined treatment of glazing and framework is possible. Not given is what treatment to take for given glazing-to-window area ratio.

7.8 Window properties

7.8.1 Description

Each window construction must have its thermal properties specified. The name of the window construction and the presence of (controlled?) blinds must be specified. Properties come from a window database.

==> Database at moment only for glazed area, in future for both glazing and framework. Supply of properties other than from database is possible.

==> Model for glazing: both U-/SF-/CF-value and resistance network are possible.

==> Window lies deep in the facade can be taken into account

==> Non-normal incidence is not taken into account. SF-value for 45 incidence instead SF for normal incidence can be supplied.

PAPER 3

Natural ventilation by window opening

P. Jaboyedoff, C. Prudhomme

Natural ventilation by window opening

A study of the impact of different user assumptions on the results obtained by simulation of natural ventilation by window opening.

P. Jaboyedoff, C. Prudhomme
SORANE SA
Rte du Châtelard 52
CH-1018 LAUSANNE

1.0 Introduction

One of the techniques used to avoid overheating in buildings consists of providing ventilation by window opening. Modelling of natural ventilation by window opening and its effect on overheating reduction concerns more and more people involved in energy saving design, as it may help to avoid the use of active cooling systems.
The effect of window opening on the indoor temperature is due to additional air change with air from the outside. The results obtained by simulation of such a process are influenced by such parameters as:

- window opening strategy
- air change rate model
- related models for overheating control (blinds, ...)

This study aims to show how different hypotheses can affect the simulation.results. It is focused on the parameters directly related to the ventilation process.

2.0 Methodology

The process followed in this study consists in using different approaches, as implemented in different simulation programs or by different users of the same program, to demonstrate how different modelling and user assumptions can influence the results obtained in overheating risk assessment.

Window opening is simulated by programs using different methods, and may take into account different calculation procedures:

- Mode of aperture selection is either by means of a schedule or is based on temperature criteria.
- The opening can be performed by an on/off or progressive action
- The air change model when the window is opened can be a fixed value given as input, or a calculation based on temperature difference, DT, between zone and outdoor conditions
- The convective heat transfer coefficient is either a fixed value or is based on correlations, not usually taking into account the fact that a window is opened.

In order to determine the impact of different ventilation modelling representations, a flexible modelling environment has been developed.
Ventilation by window opening is difficult to represent by simulation as, in real naturally ventilated buildings, the user's behaviour is a key issue. In order to identify the impact of different user's strategies, some of these have been implemented in the model.

3.0 Modelling of ventilation by window opening

In order to grasp and identify the influence of these assumptions on the temperature prediction in an office module, a set of sub-models has been developed to facilitate simulations with different assumptions. These models have been implemented in TRNSYS 13.1. They consist of a movable blind control module, a window opening, and other related modules connected to the building module. This configuration enables one to simulate a number of combinations of window opening strategies and calculations.

The environment consists of specific modules such as:

- Movable blind simulation module based on zone temperature and radiation intensity level (Type 63)
- Window opening module allowing different strategies and models to be simulated (Type 62)

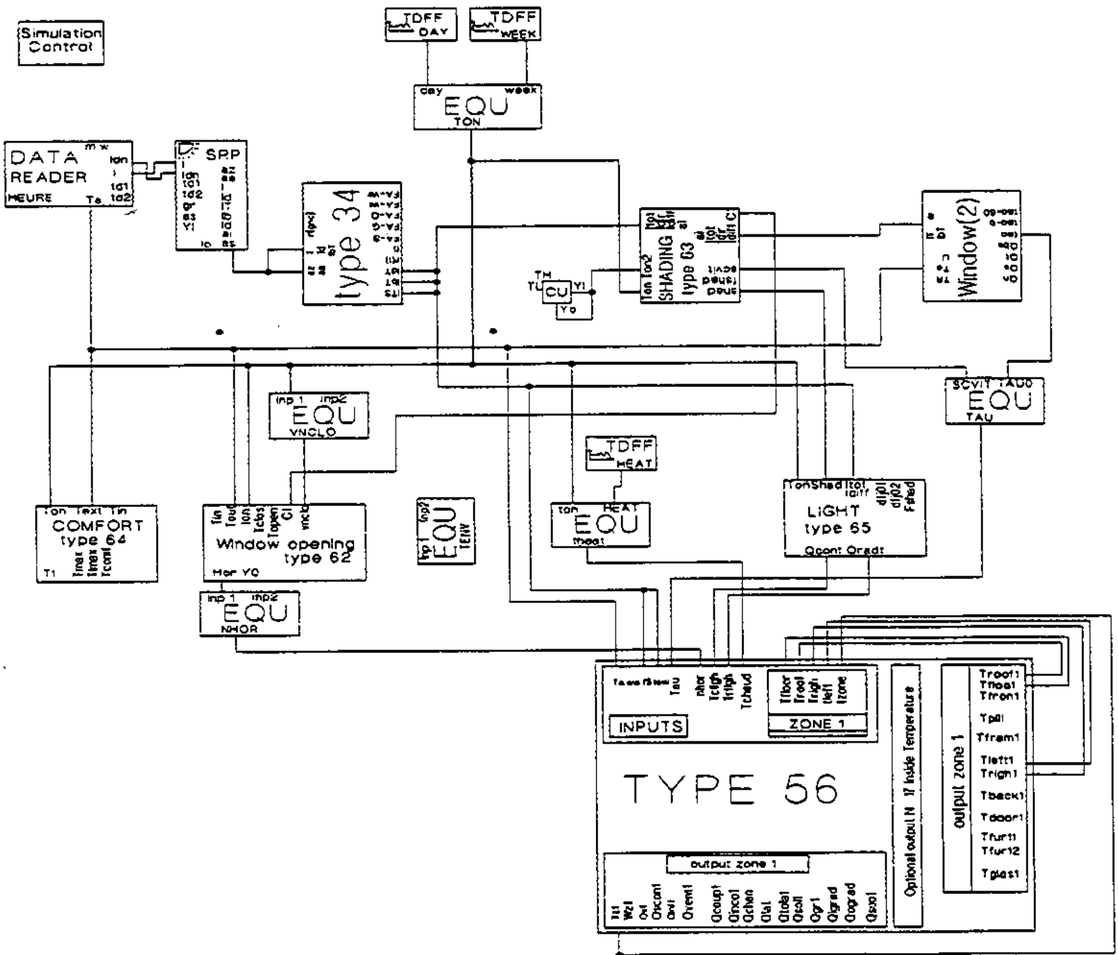


Figure 3.1: graphical representation of the TRNSYS simulation environment developed for this study

3.1 Blind operation

The blind operation follows the algorithm described on the figure 3.1.1 below. It is initially based on criteria for thermal comfort, and then on visual criteria (radiation intensity level)

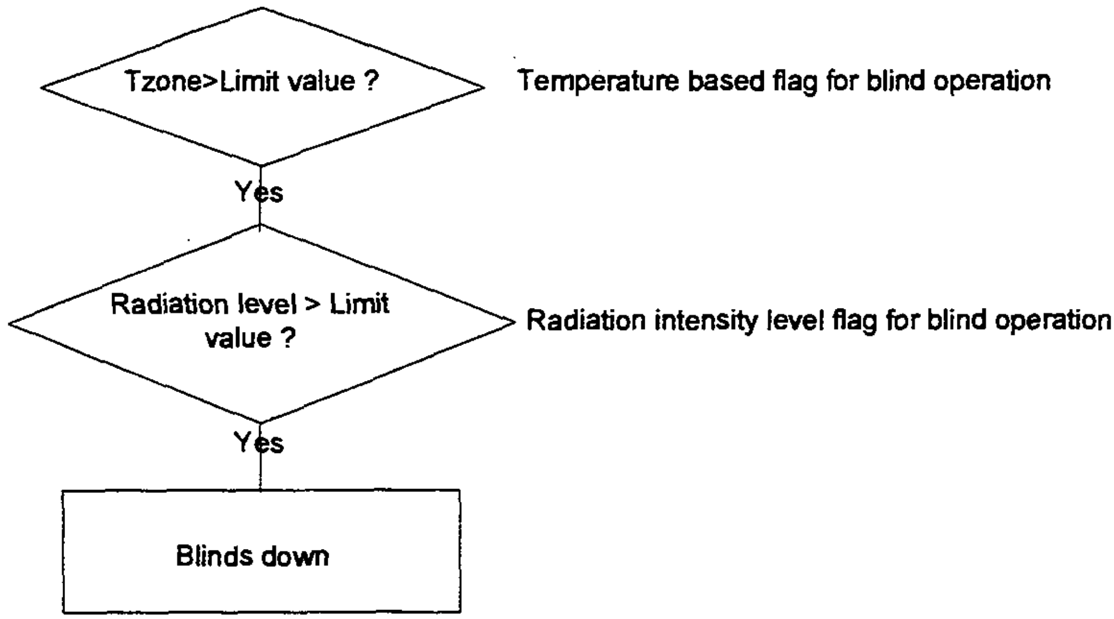


Figure 3.1.1: blinds operation conditions
The blinds have an adjustable shading coefficient (see item 7 of table 1)

3.2.Window opening strategy (MODE)

Four different modes have been implemented. They represent strategies that are likely to be applied by building users based on the given conditions. For example, because of the noise level, it may be impossible to open the window during the day, or due to security conditions, it may not be possible to keep the window opened at night, etc ...
The modes are as follows:

1. Window opening during the occupancy period only. (if the zone temperature is above a given value, and the outdoor air temperature is lower, then the window is opened)
2. Window opening during occupancy (as in 1.) and during night (as in 3.)
3. Window opening during night only (if at the end of the occupancy period, the zone temperature is higher than a given value (item 4 in table 1), and the outdoor air temperature is lower, then the window is left opened for the night in the same position as it was at the previous time step)
4. Window opening during night only (at the end of the occupancy period the window is opened for the night whatever the conditions are)

These modes corresponds to the item 1 in Table 1.

3.3.Window opening operation

Two models to describe how people operate windows have been considered:

1. The first consists of on/off behaviour. (figure 3.3.1), i.e. the people either open the window fully or keep it closed (item 2 in table 1)

ON/OFF (ouver = 1)

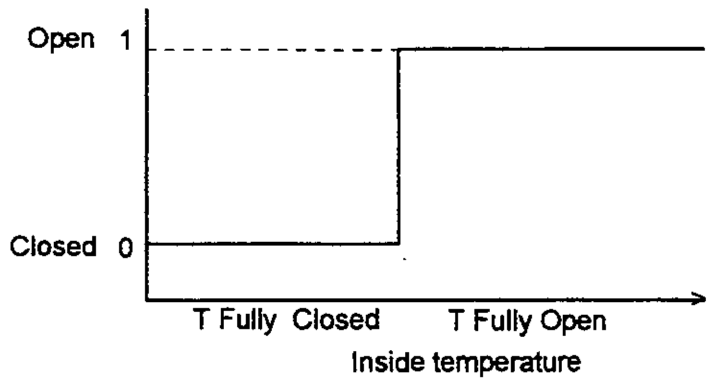


Figure 3.3.1

2. The second describes progressive opening behaviour (item 2 in table 1, figure 3.3.2), i.e. the people progressively open the window as a function of the zone temperature, which may also correspond to the averaged effect of opening the window completely for a shorter duration than the program time step.

PROPORTIONAL (ouver = 2)

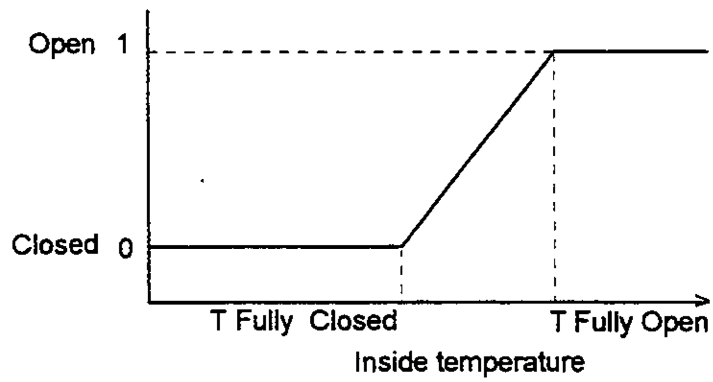


Figure 3.3.2

3.4.Air-change calculation

The calculation of the air-change rate between the zone and outside can be modelled following the two modes (corresponds to the item 3 in table 1).

1. The first is similar to what many existing programs use, that is the air-change rate is an input value given by the program's user.
2. The second is a calculation based on a discharge coefficient method.

$$N = \frac{Swin}{Vol} C \sqrt{\frac{2gh(Tz - Tout)Tout}{(Tz + Tout)Tz}} \left[h^{-1}\right]$$

Where:

Swin	1/2 opened window area	[m^2]
g	Gravity constant	[m^2/s]
h	1/2 window height	[m]
Vol	Zone volume	[m^3]
Tz	Zone temperature	[K]

Tout   Outdoor temperature   [K]

The effect of wind has not been taken into account. Only thermally driven air-change (stack effect) is modelled. It represents the worst case situation against overheating.

The discharge coefficient, (C), can be given different values for day and night (item 10, 11 in table 1) taking into account differences in the window operation (i.e. day-time -> vertical rotation axis, night time -> horizontal rotation axis).

It can also be modified in order to take into account the fact that the blinds are down and create additional pressure loss, reducing the value of the discharge coefficient (item 12 in table 1).

4.0 Case studies

The building office module used for the study is the same as for the base case study performed by the Subtask B participants. Its glazing area has been changed in order to show about the same overheating characteristics under two different climates. (Copenhagen, Rome).

Occupancy and gain schedules are as follows:

From Monday to Friday, 100 % from 8 to 12 hr, 50% from 12 to 14 hr, and 100 % from 14 to 18 hr.

Internal gains follow the same schedule, and amount to 10 W/m^2 including occupancy and appliances.

The base case has the following characteristics:

	Copenhagen	Rome
Glazing area:	4m^2	8.7m^2

The window shading coefficient (item 8 table 1) is set to 0.87 (double glazing)

Other conditions are the same for both climates, they are described in Table.1.

		Run conditions	
1	MODE (1=Day, 2=Day+night as 3, 3=Night if, 4=Night	Opening strategy (MODE)	3
2	OPEN (1=on/off, 2=progressive)	OPENING operation	2
3	CALCUL (1=N input, 2=N=f(Tzone-Tout)	Calculation of airchange (N	2
4	TNIG (min temp. at end of day for night opening as in	Min temp. for night openin	26
5	NHORIN (N value as input, as in OPEN = 1)	N airchange as input	-
6	NHORMX (max airchange rate)	Max air change rate	20
7	SHADBL (blind shading coefficient)	Blind shading coeff.	0.5
8	SHADWI (window shading coefficient)	Window shading coeff.	0.87
9	LIMSO (Min It level for blinds down [kJ/hr/m2])	Min solar rad for blinds	360
10	C1 (discharge coefficient daytime)	Discharge coeff. day time	0.6
11	C2 (discharge coefficient night time)	Discharge coeff. night time	0.25
12	ATTC (attenuation of discharge coefficient when blind	Attenuation by blinds [%]	30
13	HIN (kJ/m2/K)	Inside convective coeff. (k	10.8

Table 1: Conditions for the base case simulation

The base case corresponds to the run N°1, and is based on the conditions presented in Table 1. The window is opened during the night if the zone temperature is higher than 26 °C at the end of occupancy period, and the air change is calculated following the discharge coefficient method. The blind shading coefficient of 0.5 corresponds to an internal moveable venetian blind.

4.1.Influence of climate on opening strategies

Run n°1 (base case)

Window opening at night with conditional minimal temperature (26 °C) and indoor temperature greater than outdoor temperature.

In Copenhagen, this strategy operates correctly as, usually, the outdoor temperature at the end of the occupancy period is lower than the zone temperature. (see figure 5.1.C), In Rome (see figure 5.1.R), the outdoor temperature is still greater than the zone temperature at the end of the occupancy time and therefore the window remains closed most of the time.

Run n°2

In this case, the conditions are the same as for the Run n°1, but the window opening is scheduled every evening. The effect of this change in strategy has a very strong influence in the case of Copenhagen (see figure 5.2.C), as the relative number of hours above 27 °C is reduced from 22 % (see figure 5.1.C), to only 1 %. The difference obtained shows the importance of the assessment of the window operation strategies. In the case of Rome, the results show that by opening the window every night, the number of hours above 29 °C is reduced from 8 % (see figure 5.1.R), to 3 % (see figure 5.2.R). The influence is not as drastic as in the case of Copenhagen, but still changes the overheating rate.

Concluding remark: A ventilation strategy that seems to be applicable under one climate, may not be applicable in other locations.

4.2.Influence of internal convective heat transfer coefficient

Internal heat transfer coefficients are either given as input, in some programs, or computed by some internal correlations.

Run n°3

In order to determine the influence of the internal heat transfer coefficient on the building performance, it has been varied between 3 and 5.5 [W/m2/K].

The influence of this parameter change alone can be looked at by comparing the run n°3 (figures 5.3 C,R) against the runs n°2.

In the case of Copenhagen, the influence is very important, as the relative number of hours above 25 °C is reduced from 31 % down to 8 % only (see figure 5.3.C).

In the case of Rome, the relative duration above 27 °C is reduced from 59 % to 46 %.

Concluding remarks: The choice of the values of the heat transfer coefficient may seriously affect the results

4.3. Compounding parameter changes

When comparing the runs n°3 against the runs n°1, one has the compounded effect of two changes, a) opening window at night in accordance with a conditional opening schedule , b) an increased heat transfer coefficient.

The compound effect is then very important. In the case of Copenhagen, one has a reduction in overheating above 27 °C from 22 % of the occupancy duration (see figure 5.1. C) , to 0 % (see figure 5.3. C). The results obtained are in one case an overheating building (more than 20 % of the time above 27 °C), or in the other case a building without overheating problems. This may lead to different design decisions regarding mechanical cooling equipment to be made. In the case of Rome, even though less sensible, the trends are the same.

Concluding remark: in the case of heavy buildings, and when looking at compounded effect of parameter changes, one can, in some cases, arrive at different design decision.

4.4.Influence of the air change rate model

Many popular simulation programs do not allow one to compute the air change rate as a function of the temperature difference between the zone and the outside conditions. Also, conditional ventilation may not always be possible, and strategies such as using mechanical ventilation at night without cooling at a constant flow rate may be used.

Run n°4 (see figures 5.4 C, R), and n°5 (see figures 5.4 C, R)

In this case, the air change rate is given as input to the program. Unless specifically computed for some average temperature difference, the value is given on the basis of an assumption by the user. The effect of this choice is shown with the runs 4 and 5, where the air change rate has been estimated respectively at 3 [h^{-1}] , and at 15 [h^{-1}]. The difference between the run n°4 and 5 shows that the effect of such a parameter on the results is also very important.

When comparing run n°4 (N=3 [h^{-1}]) and run n° 2 (N=f(DT)), the difference is significant, whereas, when comparing case n° 5 and case n°2, the results are quite similar. The problem, is that the relative air change equation between case n° 5 and the case n°2 may be valid only in this case.

Concluding remark: It is recommended that for programs not able to compute the air change rate as a function of DT, one should conduct parametric studies, and give recommendations on the most appropriate value for different cases. An arbitrary choice of the value N can lead to substantial differences in the results.

5.0 Summary of the different runs performed

The simulation have been performed for each case on a 15 days period corresponding to the two last week of July for Copenhagen and Rome climate.

1. The hourly diagram on top of each page presents the pattern of the following variables:

TOUT	Outdoor temperature	[°C]
TZONE	Zone temperature	[°C]
NHOR	Air change rate	[h^{-1}]
OCCUP	Occupancy (0= unoccupied, 1= occupied)	[-]
SHADING	Indicates if the blinds are down (1), or not used (0)	[-]
Iin	Incoming radiation	[$kJ/h/m^2$]

2. The run conditions are summarised in a table as explained in table 1, and in section 3

3. A chart presents the relative number of hours during occupancy where the zone temperature is respectively higher than 25, 27, 29 [°C]

6. 0 Conclusions

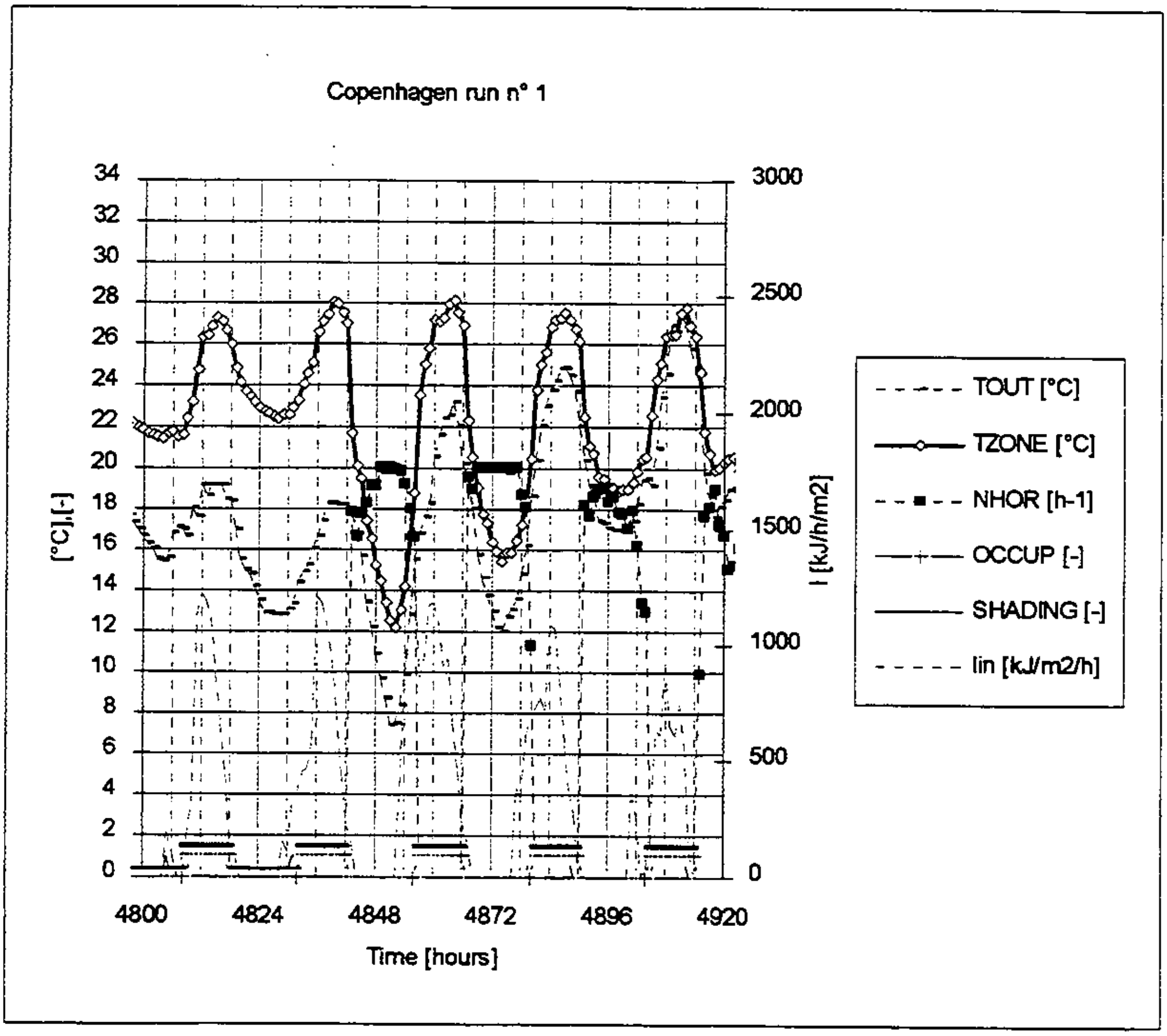
This study, has been restricted to simple ventilation by window opening, without considering effects such as wind pressure, stratification in the zone, correlation based heat transfer coefficients, nor other parameter variations such as blind shading factors, internal gains, etc....

It has been shown that, even with a restricted set of variables and all other parameters kept constant, the effect of variations introduced by a program user can lead to very different results.

The main reasons, arising from the investigation, are:

- Ventilation strategies may not be valid under different climate conditions
- Internal convective heat transfer coefficients have a significant effect on the overheating risk assessment
- When compounding the effect of multi-parameters variations, results may lead to different design decisions.
- Although providing the air change rate with opened windows as direct program input can lead to large errors it is nevertheless still in use with many programs.

There is a need for more detailed research in order to develop general algorithms for ventilation strategies, air change calculation and convective heat-transfer coefficients applicable to opened windows.



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	3
Opening operation	2
Calculation of air change (N)	2
Min temp. for night opening	26
N air change as input	-
Max air change rate	20
Blind shading coeff.	0.5
Window shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. day time	0.6
Discharge coeff. night time	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	10.8

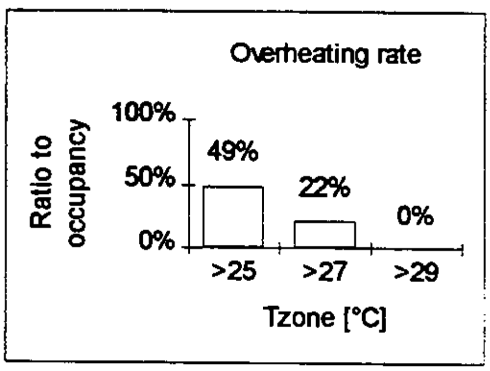
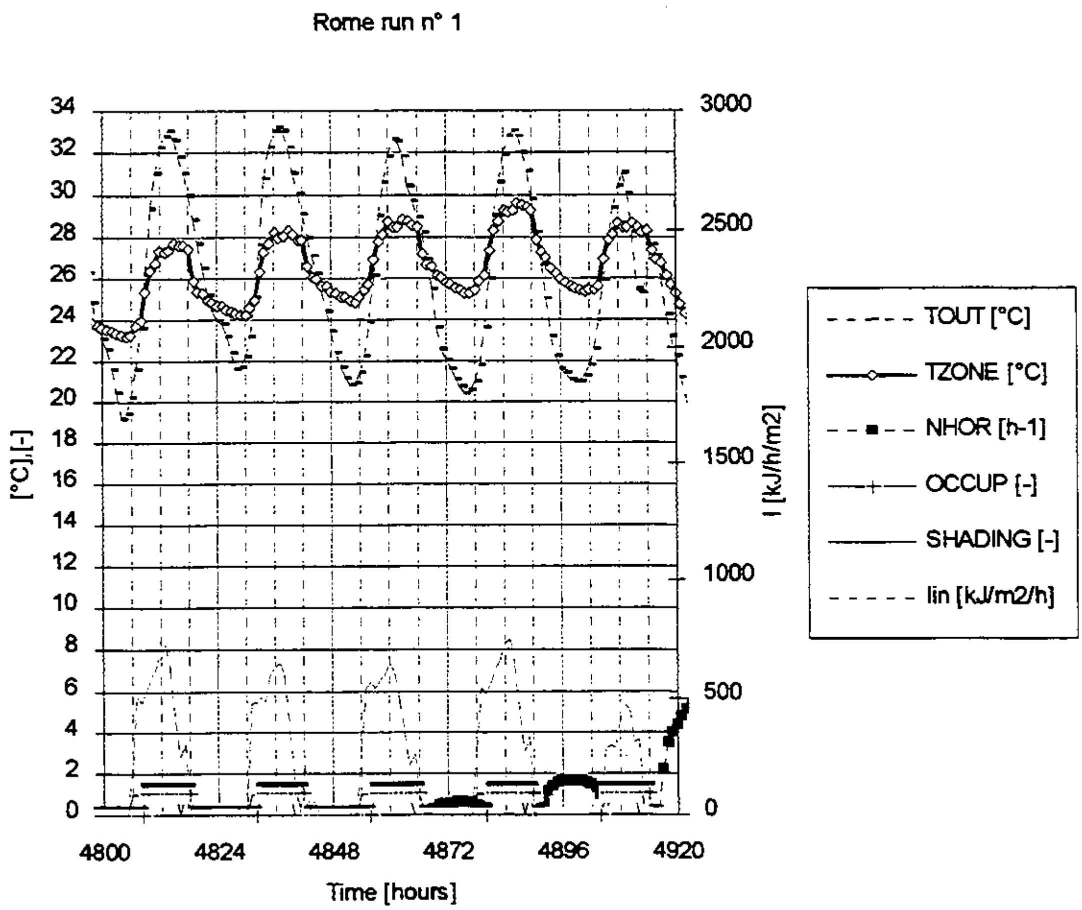


Figure 5.1 C



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	3
Opening operation	2
Calculation of airchange (N)	2
Min temp. for night opening	26
N airchange as input	-
Max air change rate	20
Blind shading coeff.	0.5
Windows shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. day time	0.6
Discharge coeff. night time	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	10.8

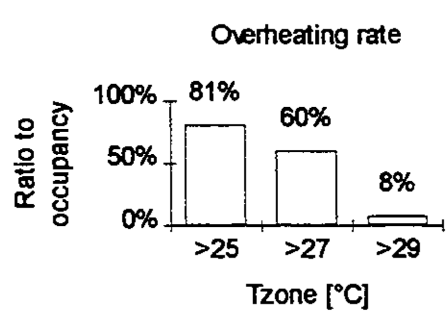
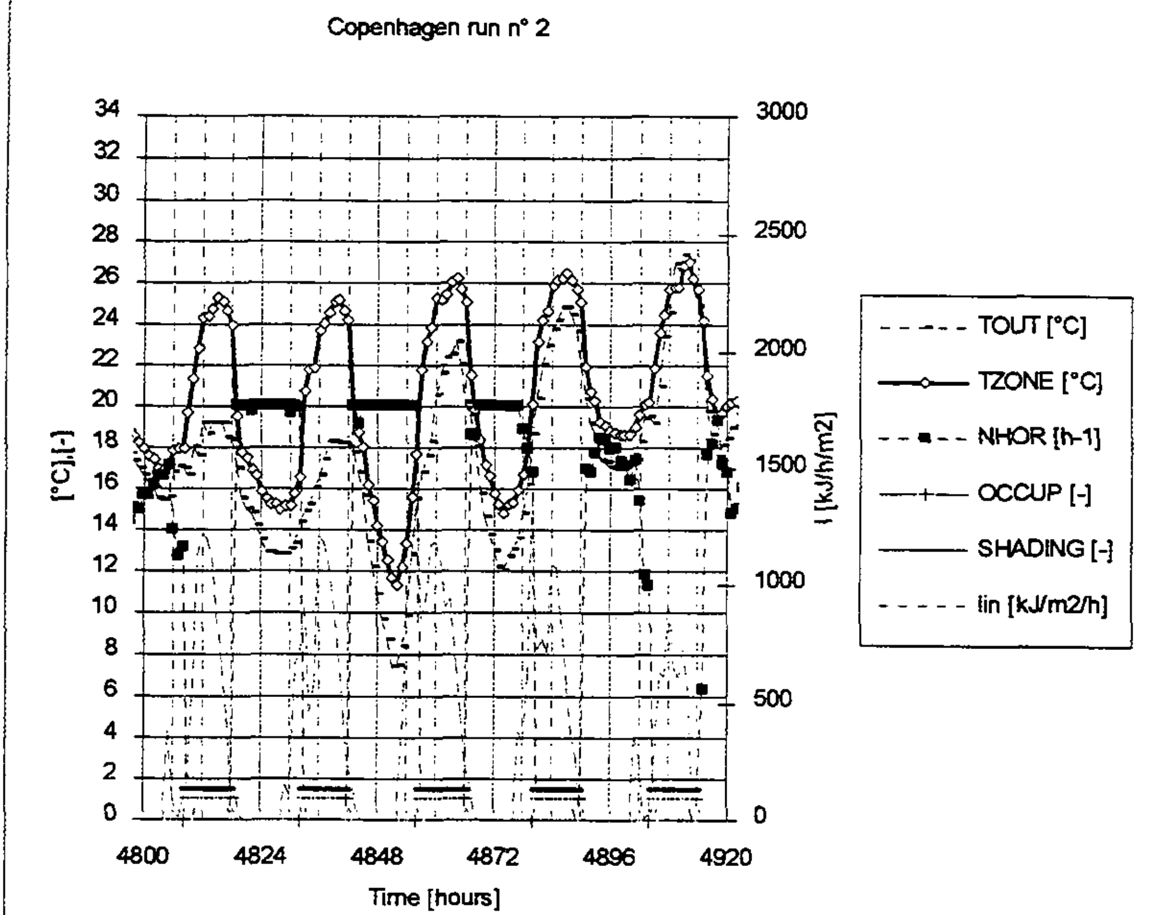


Figure 5.1 R



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	4
Opening operation	2
Calculation of airchange (N	2
Min temp. for night opening	26
N airchange as input	-
Max air change rate	20
Blind shading coeff.	0.5
Window shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. daytime	0.6
Discharge coeff. night time	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	10.8

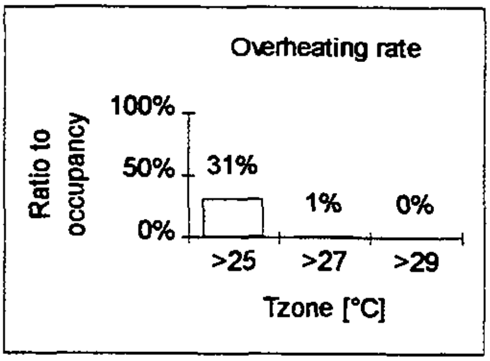
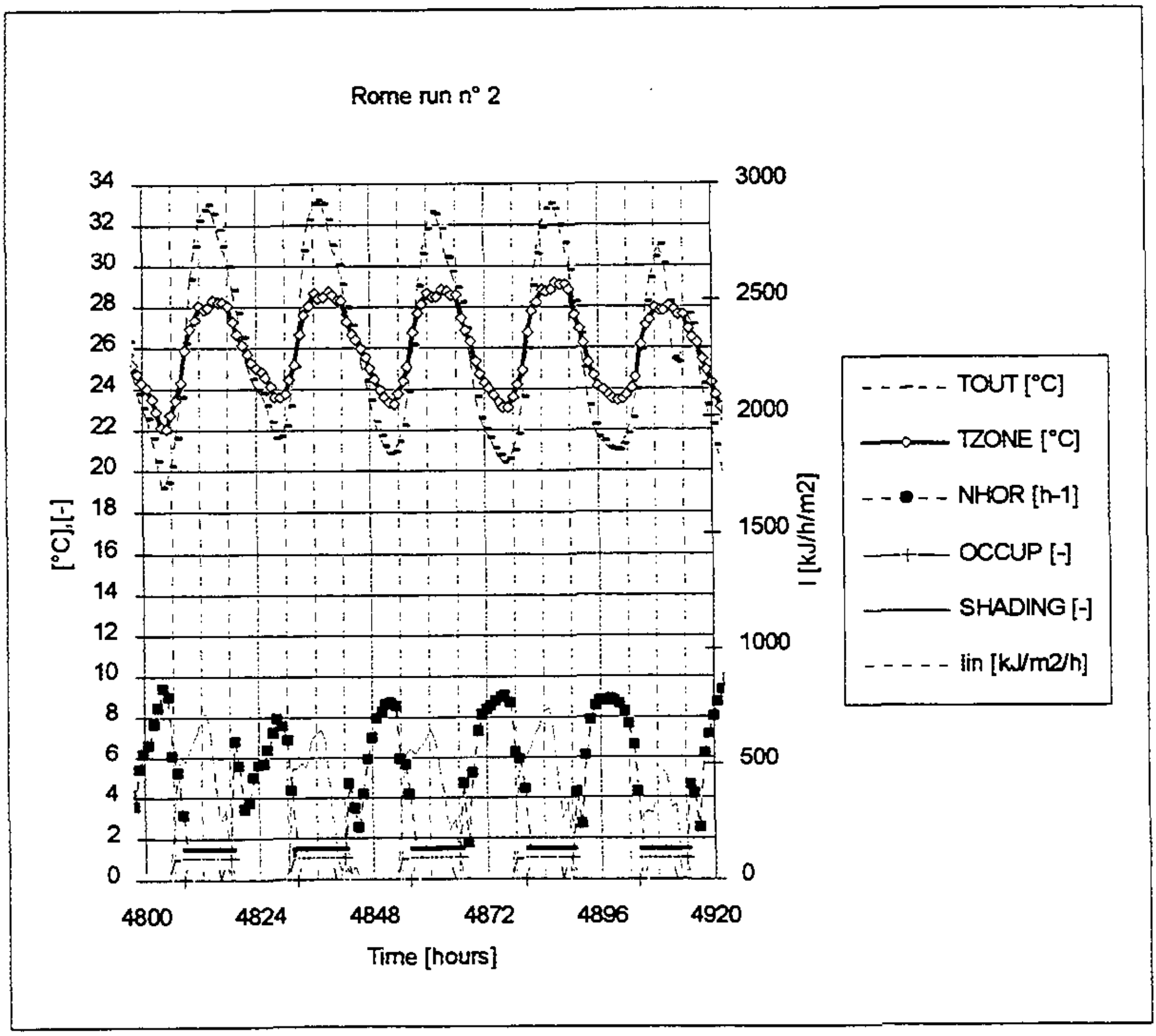


Figure 5.2 C



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	4
Opening operation	2
Calculation of air change (N)	2
Min temp. for night opening	26
N air change as input	-
Max air change rate	20
Blind shading coeff.	0.5
Window shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. day time	0.6
Discharge coeff. night time	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	10.8

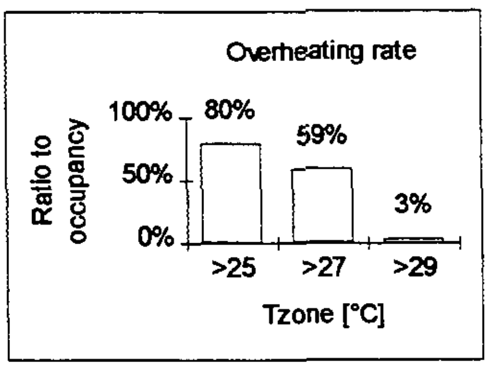
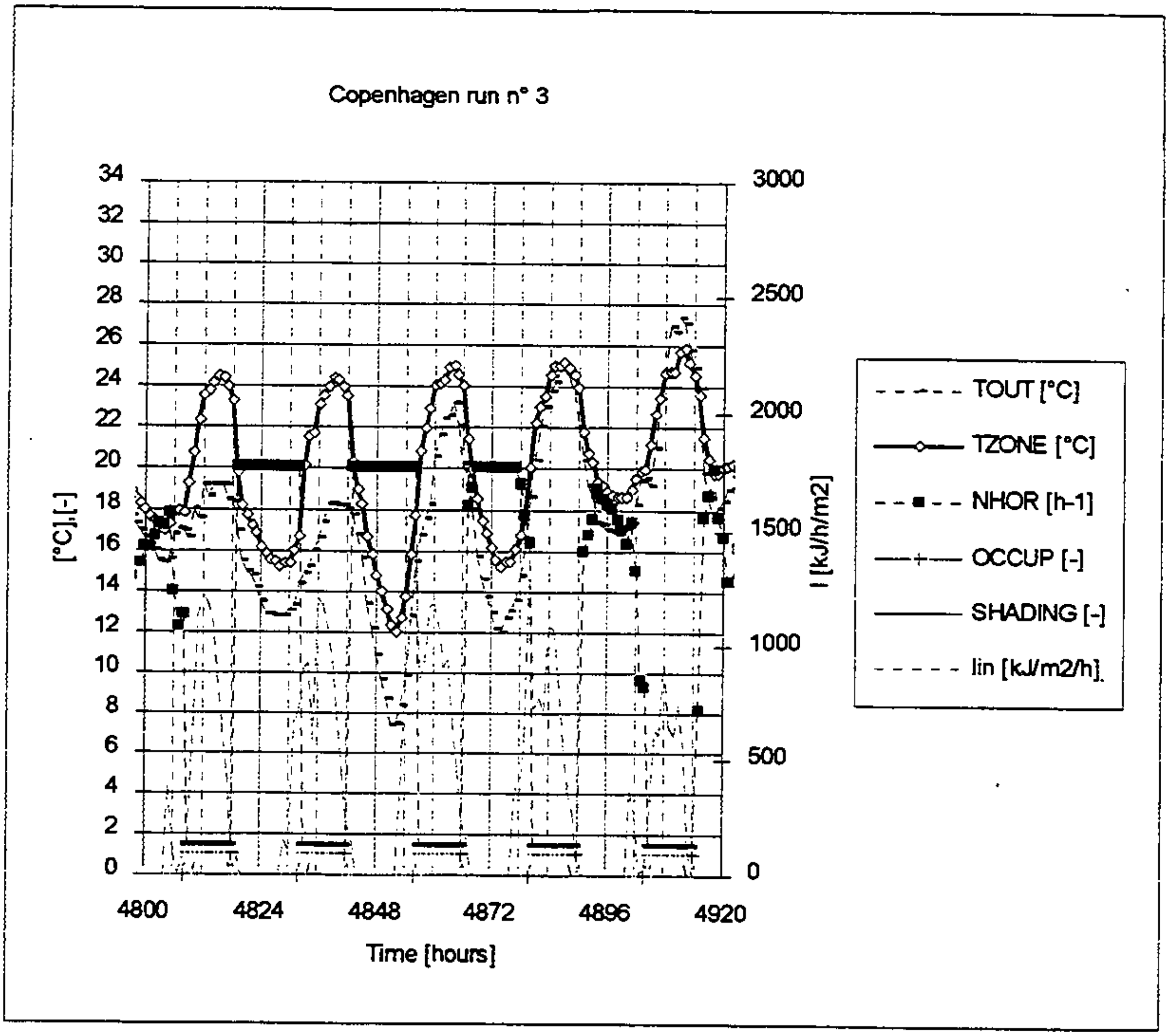


Figure 5.2 R



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	4
Opening operation	2
Calculation of airchange (N)	2
Min temp. for night opening	26
N airchange as input	-
Max air change rate	20
Blind shading coeff.	0.5
Window shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. day time	0.6
Discharge coeff. night time	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	20

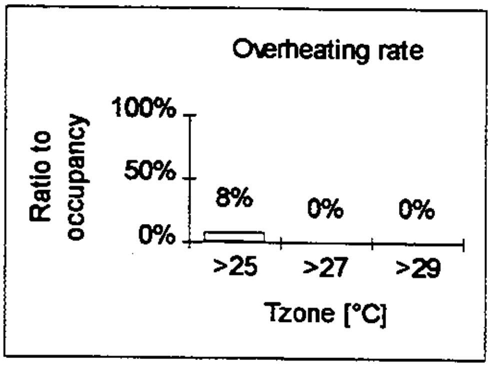
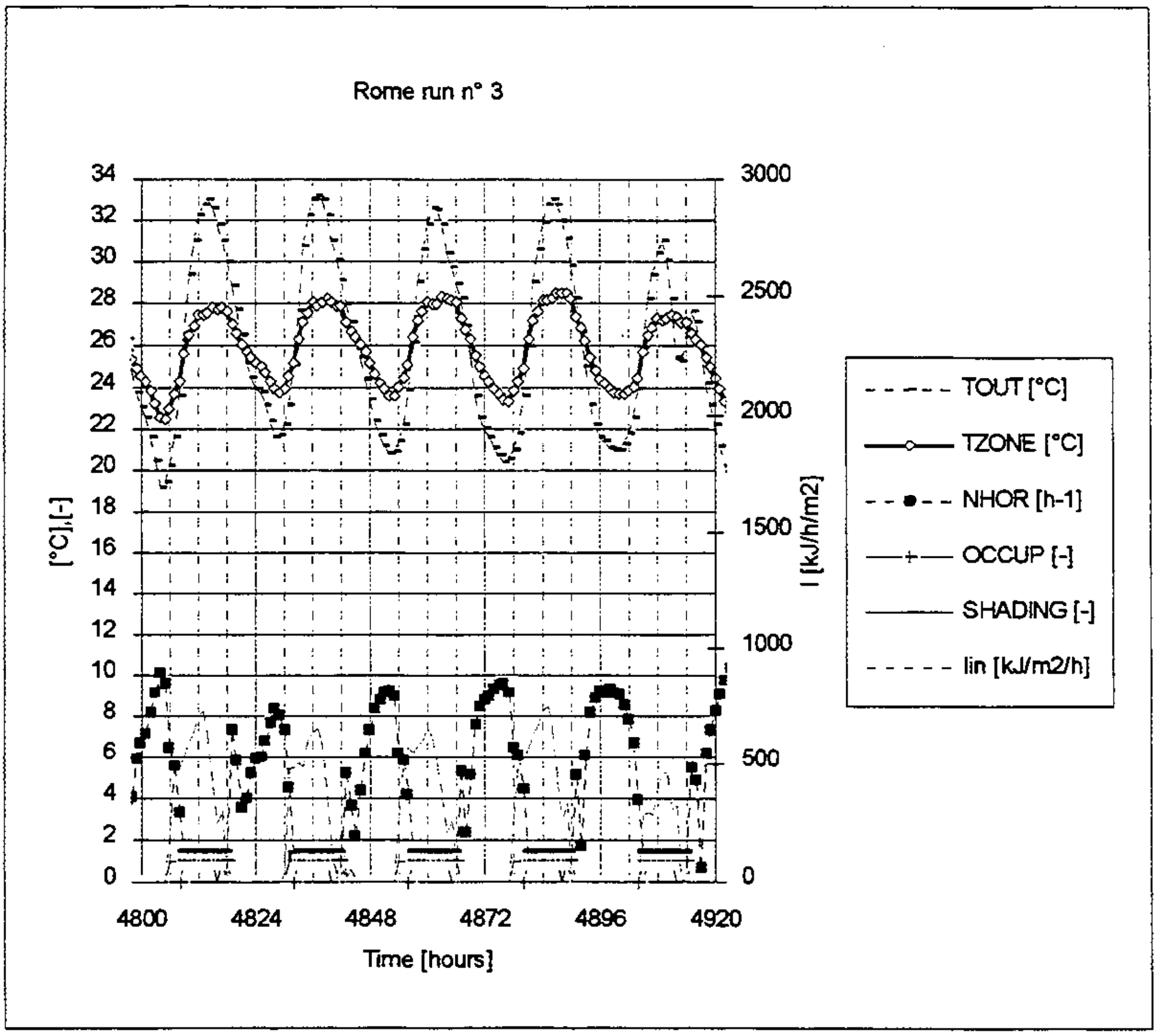


Figure 5.3 C



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	4
Opening operation	2
Calculation of airchange (N)	2
Min temp. for night opening	26
N airchange as input	-
Max air change rate	20
Blind shading coeff.	0.5
Windows shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. day time	0.6
Discharge coeff. night time	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	20

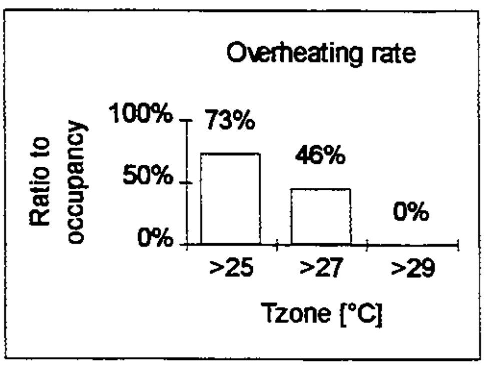
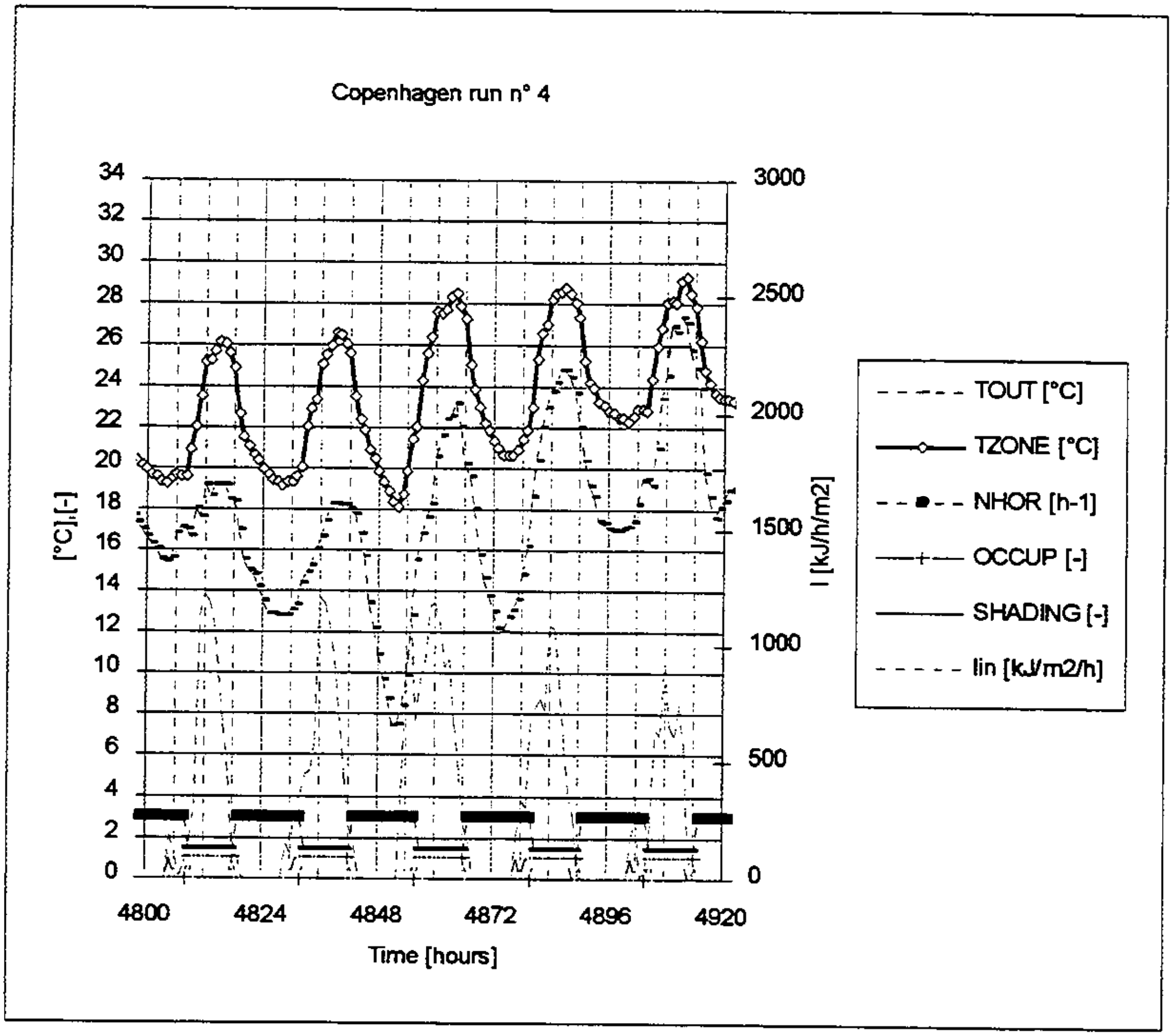


Figure 5.3 R



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	4
Opening operation	1
Calculation of airchange (N)	1
Min temp. for night opening	26
N airchange as input	3
Max air change rate	20
Blind shading coeff.	0.5
Windows shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. daytime	0.6
Discharge coeff. night time	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	10.8

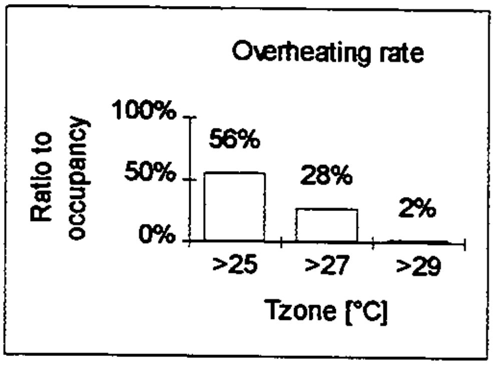
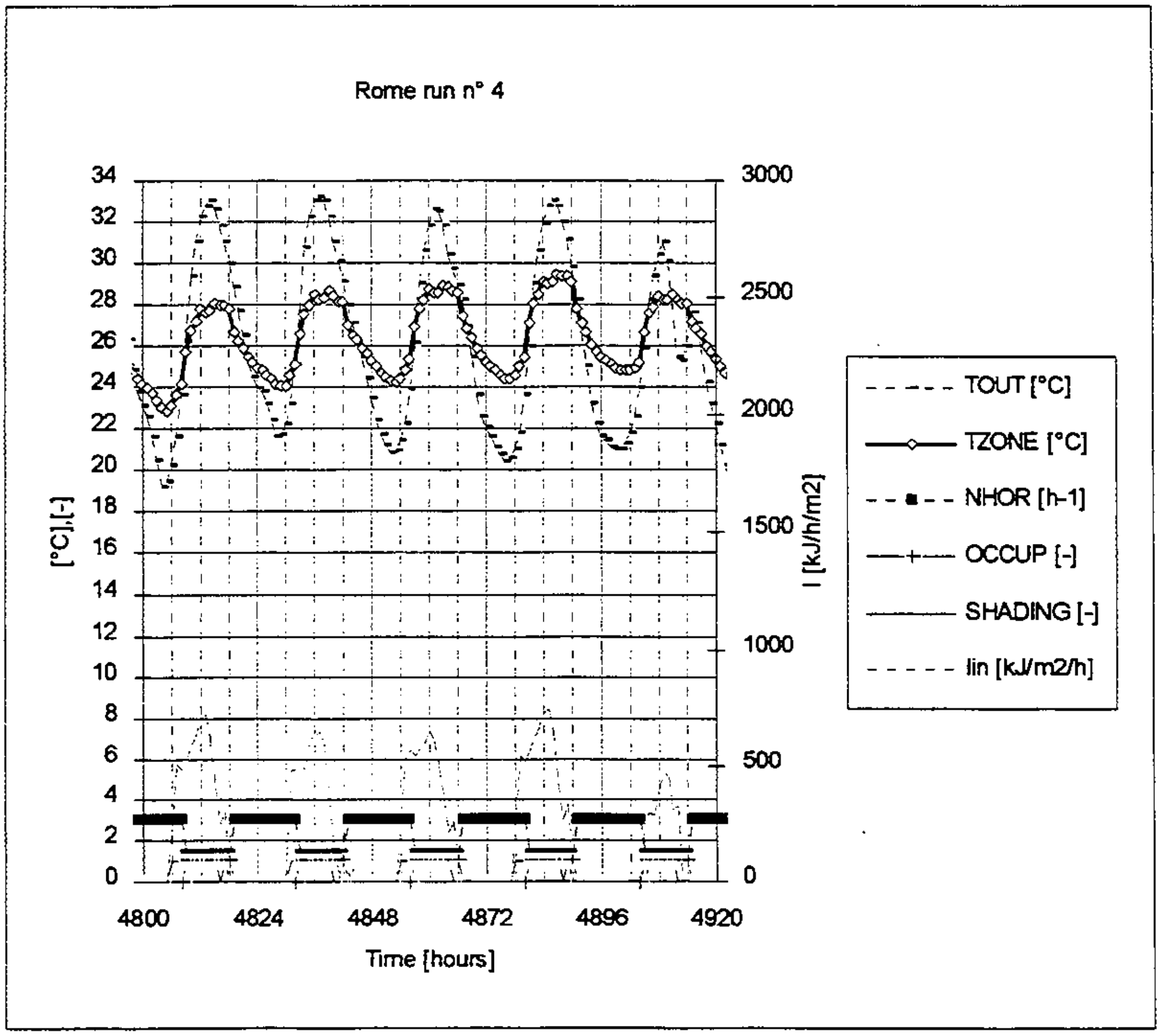


Figure 5.4 C



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	4
Opening operation	1
Calculation of airchange (N)	1
Min temp. for night opening	26
N airchange as input	3
Max air change rate	20
Blind shading coeff.	0.5
Windows shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. daytime	0.6
Discharge coeff. nighttime	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	10.8

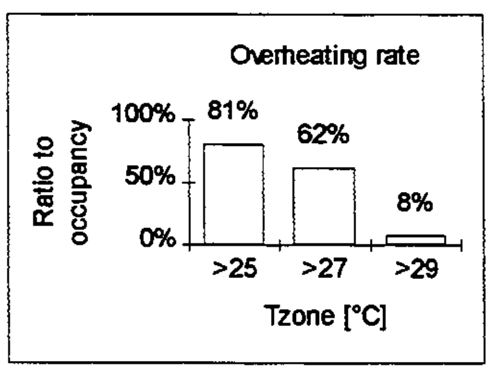
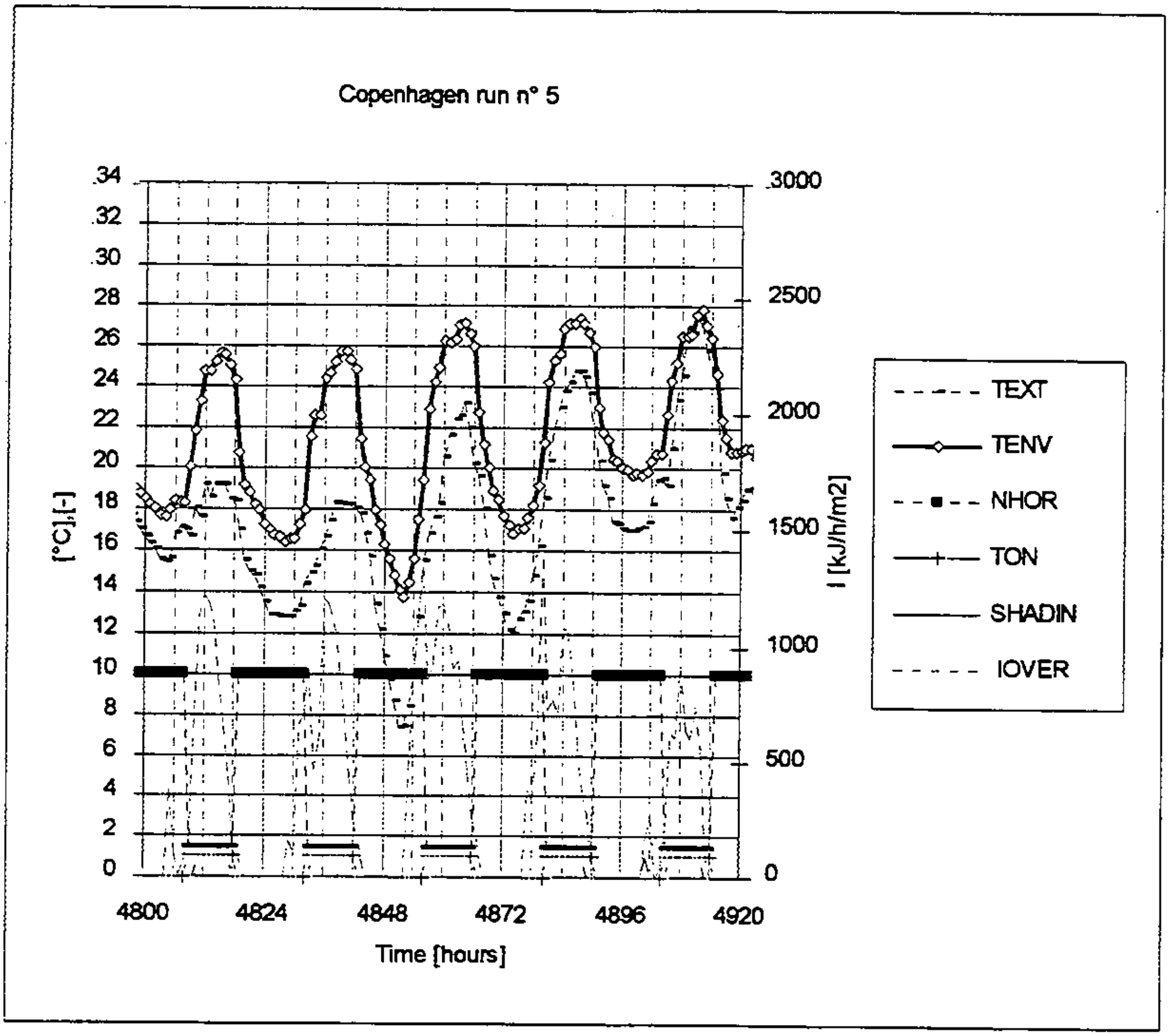


Figure 5.4 R



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	4
Opening operation	1
Calculation of airchange (N)	1
Min temp. for night opening	26
N airchange as input	10
Max air change rate	20
Blind shading coeff.	0.5
Windows shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. daytime	0.6
Discharge coeff. nighttime	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	10.8

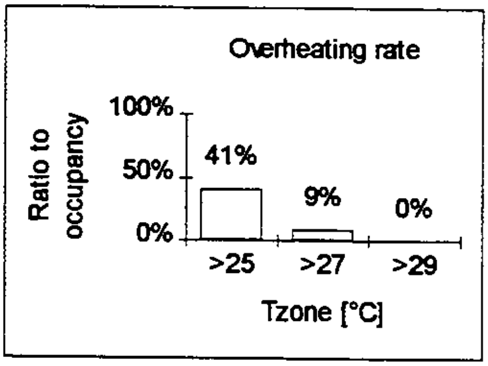
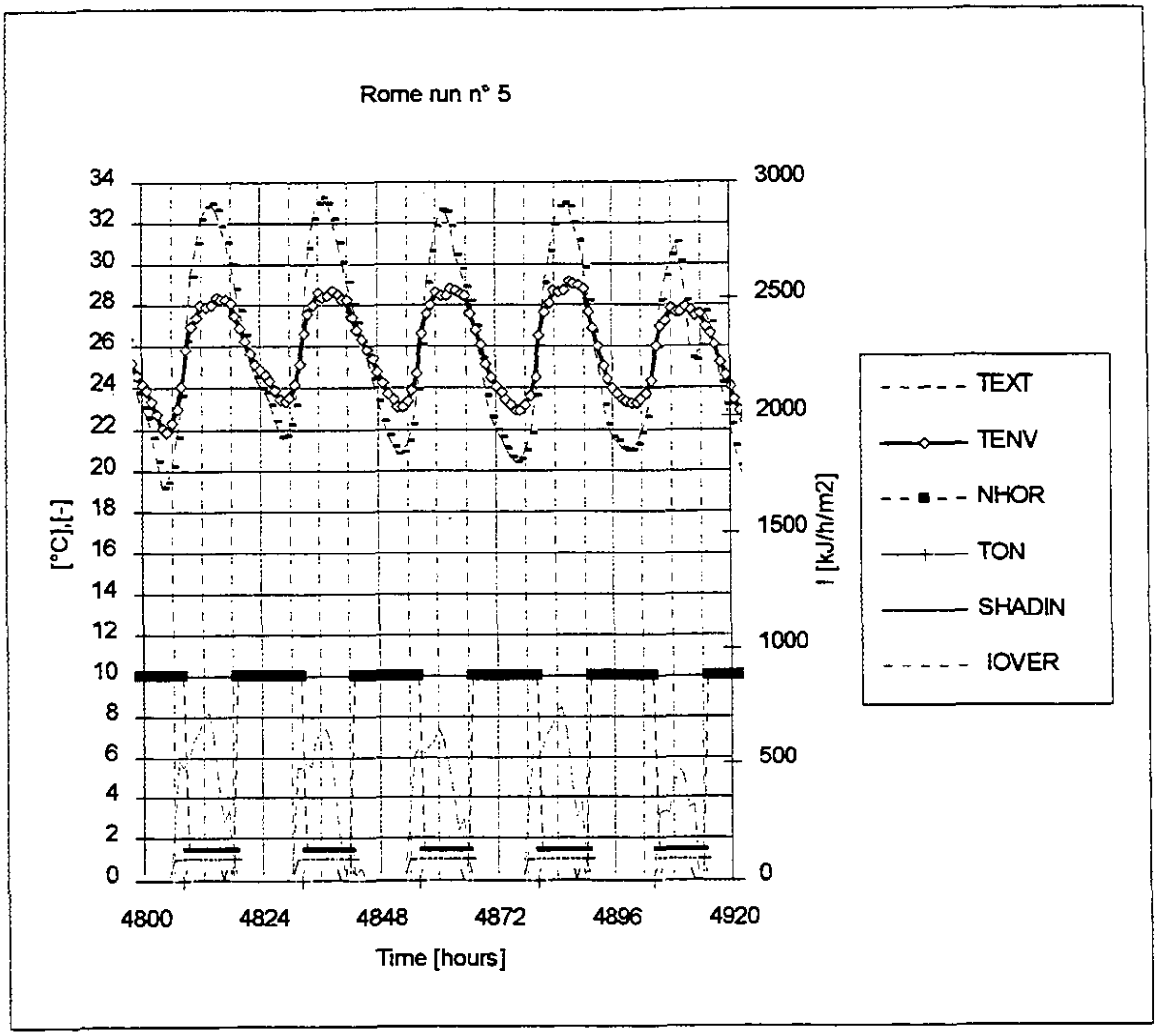


Figure 5.5 C



Run conditions (see explanations on table 1)	
Opening strategy (MODE)	4
Opening operation	1
Calculation of airchange (N	1
Min temp. for night opening	26
N airchange as input	10
Max air change rate	20
Blind shading coeff.	0.5
Window shading coeff.	0.87
Min solar rad for blinds	360
Discharge coeff. day time	0.6
Discharge coeff. night time	0.25
Attenuation by blinds [%]	30
Inside convective coeff. (kJ/m2/K	10.8

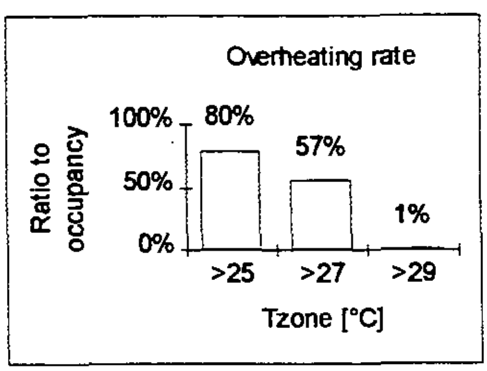


Figure 5.5 R

PAPER 4

SIMULATION ASPECTS OF CONTROL OF ARTIFICIAL LIGHTING IN CONNECTION WITH SHADING DEVICES

September 22 1993

Gerhard Zweifel
EMPA, Building Equipment Section
CH-8600 Duebendorf
Switzerland

1. Introduction

The aim of this report is to summarise the aspects of artificial lighting systems to be taken into account in building performance simulation. Emphasis is put on the conditions, when lighting is needed or used, i.e. the control, especially in connection with the use of shading devices. Other aspects are at least listed for completeness.

2. Description of Lighting Systems

2.1 Types

The different existing lighting systems can be distinguished by several qualities:
- Lighting type. Incandescent, fluorescent etc.
- Fixing: Suspended, recessed, task lights etc.
- Integration in ventilation system (non-vented, vented to return air, vented to supply and return air etc.)

2.2 Control

There are different ways for controlling the artificial lighting in a room:
- Automatic or manual control
- On/off switching, stepwise or continuous dimming
- Different criteria for automatic control (e.g. illumination, occupancy)
- Partition of a zone into subzones for control (e.g. perimeter and core)

3. Modelling

3.1 Types

For modelling in building simulation, artificial lighting systems are essentially a heat gain in the room or zone with a couple of parameters needed to describe the qualities mentioned above. These parameters are:
- The necessary illumination level for a particular use of a zone
- The installed electric power necessary to reach the targeted illumination level
- The parts of the heat gain appearing in form of radiation and convection
- The parts of heat gain appearing in the room or zone, in the return air and in adjacent rooms (ceiling void plenums e.g.)
- The relation between illumination and electric power consumption for part load conditions

A part of these parameters are - at least according to the experience of the author - very difficult to get information about, because they are not design parameters for the lighting manufacturers and therefore are partly not measured and/or calculated. Default values given in certain programs are helpful, but the user has little possibilities to judge these and therefore has to trust them.

3.2 Control

It is sensible to avoid unnecessary loads before cooling is provided in a building. One possibility for this is to switch off or reduce artificial lighting in a room when daylight provides enough illumination. Therefore it is essential for building simulation applications such as the overheating risk assessment, that the corresponding strategies can be calculated.

There are different levels of modelling lighting control. The simplest one is that the user has to define, e.g. by a schedule, when the lights are switched on and off. A stepwise control could be simulated in this way, too. This corresponds to an automatic control which occurs independent from any daylight or illumination level, or to the worst case of manual control, when the lights are switched on and left in operation unconsciously. A simulation of any further systems gets very tedious or inaccurate with this method.

A correct simulation of any automatic control taking into account the illumination level has to go in parallel with a daylight calculation, which is neither a simple and easy task, nor is it included in all programs. No further details about such a calculation are given here.

In the program DOE-2, the control can be calculated in the following way [1]: A zone can be partitioned into a maximum of 2 daylit and 1 non-daylit subzones by defining the two daylit fractions of the total zone floor area. If the sum is lower than 1, the rest of the zone will be non-daylit, which means, the lights in this part will be operated according to the definition, independently from daylighting. For each of the two daylit subzones, a reference point can be specified by its 3 room coordinates, and assigned an illumination level setpoint and a control type (continuous or stepwise with a number of steps). The program will calculate the illumination level at the reference points due to daylighting, and determine the electric power of the artificial light in each subzone such that the illumination level is never below the setpoint.. In the case of continuous dimming it will be exactly the setpoint, with step control normally more. For continuous dimming, a relationship between the part load ratio of the illumination and the power consumption can be specified. The whole calculation is only done when the lights are allowed to be on by a schedule.

A similar method is used in SERI RES [2], but without the possibility of dividing into subzones. Also there is no specification of a reference point, which probably means that either a fixed point (e.g. the centre of the room) or an average value for the whole room is used.

In VA 114 [3] a method is used, where a (definable) part of the lighting load is continuously on (simulating the lighting in the core zone) and the rest (simulating the lighting in the perimeter zone) is switched (on/off) according to the natural illumination in the centre of the room. The natural illumination in the centre of the room is calculated based on an equation, containing the ratio of window area of the facade area, the solar radiation on the window and the visible transmission factor of the window system. Switching on and off happens for different, definable illumination levels. So automatic control and manual control by ideal (on 600 lux, off 600 lux) and non-ideal (on 600 lux, off 100'000 lux) users can be simulated.

The correct simulation of manually controlled lights is even more complicated. The two extreme cases of a very unaware user and an ideal user can be covered by the methods for automatic control described above. In DOE-2 there is an additional possibility for defining a control probability for the consideration of a non-ideal user. Random numbers will be used to switch like the automatic control, but only in the specified percentage of the cases. There is a possibility of the same philosophy in

SERI-RES. There are two reasons for a recommendation not to use these possibilities e.g. in an overheating risk assessment:
- The results will not be the same for different runs with equal input parameters
Non-ideal behaviour of the occupants should result rather in discomfort than in increased energy consumption.
Simplified methods have to be used in programs without daylighting possibilities. E.g. it can be assumed, that on sunny days with a reasonable operation of the shading devices (e.g. avoid direct radiation to penetrate), no artificial lighting will be needed in a perimeter zone of e.g. 5 m from the exterior wall.

4. Connection to Window and Shading Devices

4.1 Problem

With a daylighting calculation, the connection to the treatment of windows and especially of shading devices is given due to the fact, that these may have an effect on the illumination and therefore on the use of artificial lights.
In DOE-2, for the daylighting calculation in connection with exterior blinds there are some important parameters describing the latter. One operation parameter is the criterion, when the blinds are to be closed. In DOE-2, the value of the direct solar radiation at the inner surface of the window is used for this. The threshold is an input parameter. For overheating risk assessments, EMPA recommends to put 0 for this parameter, which means, that the blinds are always closed when direct radiation exists. A visible transmission value for the blinds has to be specified in the form of a schedule, i.e. time dependent. This depends on the type of blind as well as on the operation (e.g. slat angle which can be varied).
VA114 can also take blinds into account by defining the visible transmission fraction of the window system with blinds.
This input need leads to a big uncertainty, because very few data are available about the effects of exterior blinds on the transmission of visible light. It was only by a study carried out in the frame of this project in Switzerland, that some reasonably sufficient data, based on measurements, could be provided for this.

4.2 Performed Studies

The influence of the illumination level for the control of the artificial lights on the lighting energy use and on the indoor temperatures was analysed in the frame of the Office Case Study of Annex 21 and is reported in [4].
The aim of the Swiss study [5] was to estimate the values to be used in the visible transmission schedules used in DOE-2 when simulating blinds of different types and with slats at different angles. Parametric runs with DOE-2.1D with variable reduction factors were compared to results from measurements made many years ago [6].
Two types of blinds were considered in the measuring campaign: so-called "Rafflamellen" blinds and metallic blinds painted in white, grey, brown or grey outside and black inside (Fig. 1). The slat angle positions were 0° (horizontal), 30°, 45°, 60° and 90° (practically closed). The ratio of distance between slats to slat width is 0.85, i.e. 68:80 for the "Rafflamellen" blinds and 76:90 for the metal ones.
Sets of days were selected from the real weather tape for the simulation, which had similar overcast conditions as those existing during the various measurement periods.

For each blind type and each slat position, a set of parametric runs were made with DOE-2.1D and varying values for the visible shading factor or reduction factor (R) used in the schedule to simulate the reduction of illuminance due to the blinds. This was repeated until a satisfactory value for R was obtained giving calculated daylight factors which agreed with measurements, for all five slat positions and for all five types of blind.

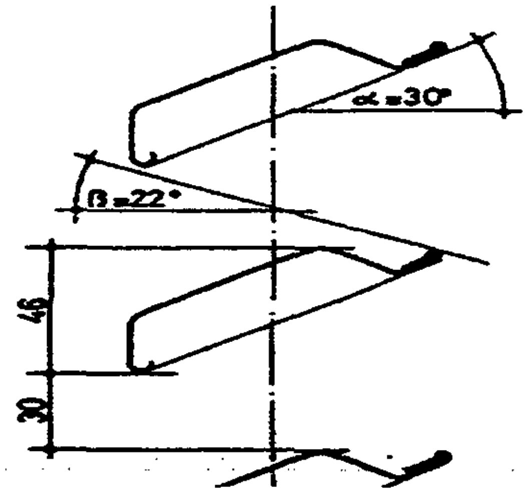


Fig. 1: Metal blind with slats at 30°

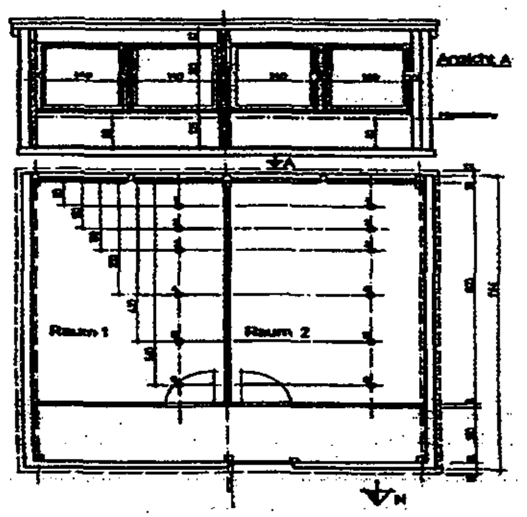


Fig 2: Test cabin used

Measurements only existed for **overcast** conditions. Measurements made at the Lawrence Berkeley Laboratory (LBL), USA, for grey venetian blinds at different angles in a scale model test cell under real clear sky and sun conditions in September, were used to compare the effect of blinds on the daylight factors under clear sky conditions. The test cell was simulated with Superlite to obtain some kind of indication. Similar reduction ratios were obtained for clear sky and overcast conditions. Therefore the overcast results will be used for clear sky conditions.

The best estimated values for the reduction factors (R) for DOE-2 are given in table 1 along with the corresponding calculated daylight factors (DF) for a reference point near the window (1.8 m) and another about 2/3 of the depth of the space (4.2 m) when the slats are horizontal or at 30°. Mean values for R and DF are given for other slat angles. From the daylight factors, estimated interior illuminance values can be obtained near the window and towards the back of the space for different required exterior illuminances.

Blind type		Near window (1.8 m)		Rear of space (4.2 m)		Overall		
	Slat angle	Reduct^{n} Factor	Daylight Factor*	Reduct^{n} Factor	Daylight Factor*	Reduct^{n} Factor	Daylight Factor* win	rear
no blind*			6.65-7.52		1.92-2.06			
White Rafflamellen:								
alpha	0	**0.45**	2.29	**0.33**	1.03	**0.42**	2.13	1.32
	30	**0.22**	1.12	**0.18**	0.56	**0.21**	1.07	0.66
	45					**0.15**	0.76	0.47
	60					**0.09**	0.46	0.28
	90					**0.027**		
White metal blind:								
alpha:	0	**0.44**	2.23	**0.36**	1.13	**0.41**	2.03	1.25
	30	**0.22**	1.12	**0.2**	0.63	**0.21**	1.07	0.66
	45					**0.15**	0.76	0.47
	60					**0.08**	0.41	0.25
	90					**0.002**		
Light grey metal:								
alpha:	0	**0.34**	1.72	**0.25**	0.78	**0.31**	1.57	0.97
	30	**0.11**	0.56	**0.10**	0.31	**0.10**	0.51	0.31
	45					**0.07**	0.36	0.22
	60					**0.045**	0.23	0.14
	90					**0.001**		
Brown metal:								
alpha:	0	**0.3**	1.52	**0.21**	0.66	**0.27**	1.37	0.85
	30					**0.07**	0.36	0.22
	45					**0.04**	0.20	0.13
	60					**0.025**	0.12	0.077
Light grey outside black inside:								
alpha:	0	**0.38**	1.94	**0.31**	0.97	**0.37**	1.88	1.16
	45					**0.06**	0.31	0.19

* measured values of daylight factors for exterior illuminations of about 10'000 and 44'000 lux

Table 1: Reduction factors for illuminance, to be used in DOE-2 inputs, and corresponding calculated daylight factors for different blinds with various slat angles for overcast conditions.

In this study the strategy was that no direct sunlight can enter the space and that only diffuse and reflected sunlight from the slats reaches the interior. The solar angles determine the required blind slat angles to prevent direct radiation from penetrating into the space (e.g. for the studied blinds, a slat angle of 30° prevents direct penetration of solar radiation with a solar angle above 22° (Fig. 1).
The most general way of description was found by defining a function which describes the visible blind transmission (reduction) factor as a function of the solar angle δ, which is defined according to figure 3.
The function is:

$$R = 0.08952 + 0.2158 * \tan\delta + 0.2031 * (\tan\delta)^2$$

It was built into DOE-2 in form of a 'functional input'.

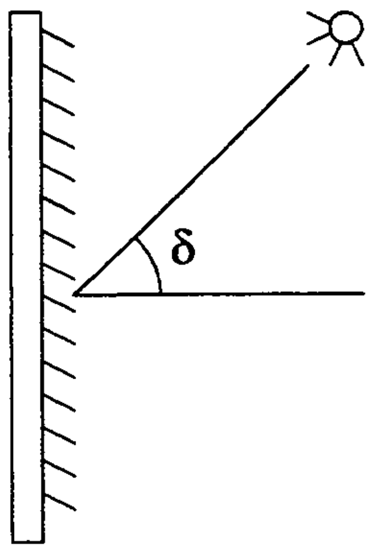


Fig. 3: Definition of the solar angle δ

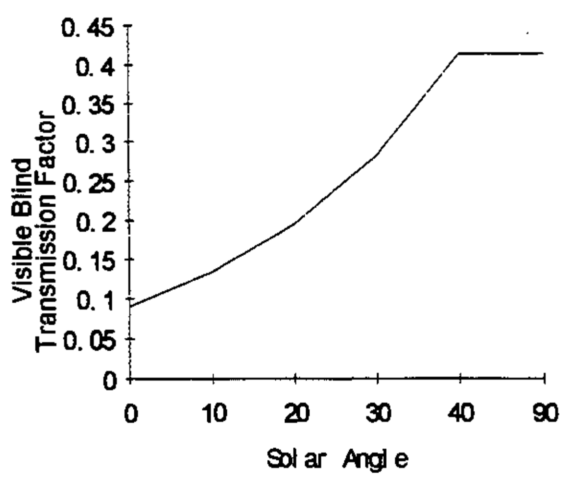


Fig. 4: Reduction factor as a function of the solar angle δ

A simplified representation of the dependency of slat angle and reduction factors from the solar altitude is given in table 2. The values for R_{1win}, R_{1rear}, R_2, R_3, R_4 can be obtained from table 1 for the blind in question.
The required slat positions according to the time of year (solar position) were established, using the solar paths for Zürich in order to define appropriate schedules. But these are orientation dependent and therefore the more general way with the function mentioned above was preferred.

Solar Altitude h		Reduction Factor	Slat Angle
"Rafflamellen"	Metal Blind		
h > 40°	h > 40°	R_{1win}, R_{1rear}	0°
40 > h > 23°	40 > h > 22°	R_2	30°
23 > h > 11°	22 > h > 10°	R_3	45°
11 > h > 0°	10 > h > 0°	R_4	60°

Table 2: Visible blind transmission (reduction) factors and slat angles for different solar altitudes

5. Need for Further Studies

Similar illuminance measurements with blinds should be made under clear sky conditions.
The reflection of sunlight on the blind slats is a rather complicated procedure and should be studied more in detail.
Additional studies could perhaps lead to rules of thumb for use with programs without daylighting capabilities, giving e.g. information on the need for artificial lighting in the perimeter zone depending on the solar radiation on the window, the transmission factor and the needed illumination level.

6. References

[1] DOE-2.1D Supplement
[2] Contribution from Behzad Sodagar, University of Newcastle upon Tyne
[3] Contribution from Aad Wijsman, TNO-BOUW, Delft
[4] Aad Wijsman: 'Influence of Some Assumptions Made During Implementation of the Base Case' (IEA21RN223/92)
[5] Nicole Hopkirk: 'Estimation of Illumination Reduction Factors for Simulation of Blinds with DOE-2' (IEA21RN234/92)
[6] W. Geiger et al: 'Untersuchungen über wärme-, licht- wind- und schalltechnisches Verhalten von Sonnen- und Wetterschutzanlagen', 1979

PAPER 5

THE INTERPRETATION OF OVERHEATING RISK

B.Warren and B Sodagar
University of Newcastle upon Tyne (UK)
August 1993

General

The cross comparisons of the 'overheating' PAMDOCSs which were undertaken as part of the evaluation process highlighted a number of issues meriting further consideration. Of particular importance was the fact that different users may interpret what is meant by overheating in different ways. This results in the use of a number of different overheating criteria against which simulation program outputs are compared to determine whether or not a problem exists. Since, even when using the same input data, different programs produce different numerical results the application of different ways of interpreting these results is likely to confuse the issue even further. The problem is not unknown within the research community and limited simulation studies have been carried out to investigate the effects of applying the different criteria to specific tasks for example those of Cohen, Munro and Ruyssevelt.(Ref 1)

The judgement as to whether a building is likely to experience unacceptable overheating depends on:

- the program input, such as weather data and incidental gains,
- the program itself
- the way in which the program output is interpreted, the overheating criterion which is related to the perception of discomfort.

Although different users may prefer to adopt a particular criterion for their own particular reasons it may, in any case, be desirable to specify different criteria to deal with specific design priorities. These could be, for example, to deal with particular building types, such as factories or schools, or perhaps to satisfy legal requirements. Only the interpretation of the program output is considered here.

Currently there is no definitive interpretation of what is meant by overheating in relation to thermal comfort. A summary of the current position, a private communication from Nigel Oseland (BRE) is appended.(Appendix1)

The criteria

A total of five different criteria were identified from the PAMDOCs produced in the work of the Subtask but it is likely that others are also used. It is also likely that different criteria are used for different building types; in the UK for example that used in the Passive Solar Program for housing is different from that described in Design Note 17 for school buildings. All the criteria are based on exceeding a limiting temperature further qualified by a measure of the time during the occupied period for which it is exceeded. The simplest criterion took no account of the extent to which the temperature was exceeded whilst the most complex criterion was based on the product of excess temperature and time. Limiting temperatures ranged from 25 to 28°C and time periods could be based on hours or days. Only one of the criteria, that used in The Netherlands (Dutch 1), made reference to humidity. The criteria are described as follows:-

1)Passive Solar Programme (PSP)

That used in the UK Passive Solar Programme states that temperatures over 27°C should not occur for more than 3% of the working hours in a year.

2)Dutch 1

That used in The Netherlands indicates that there should be no more than 5% of working hours with a temperature greater than 25°C for 60% relative humidity.

3)Dutch 2
Indicates that there should be no more than 1% of working hours with a temperature greater than 28°C

4)Swiss
The product of hours x temperature in excess of a defined level is used. The defined level is taken as 24°C up to a daily maximum ambient temperature of 12°C and 28°C when the daily maximum ambient temperature exceeds 20°C with linear variation between these limits. The criterion is that 30 kelvin hours per year must not be exceeded.

5)DN 17
Used by the UK, Design Note 17 (DN17), for the design of school buildings. In this criterion the number of days in the year for which the indoor temperature exceeds 27°C is determined. If the resultant temperature exceeds 27°C for no more than 10 days during the summer then this is considered to be a reasonable predictive risk.

Temperatures used

It is worth noting that not all programs output temperatures of the same type; for example SERI-RES uses a temperature which is a mix of mean radiant and air temperature but which is not one of the common forms such as resultant or environmental temperature. Temperatures used in the overheating criteria may not therefore necessarily match those from the programs.

Investigation of the problem

In order to obtain some information on the effects of using different overheating criteria an investigation was carried out for the BRE by Eppel and Lomas (Ref 2) using three programs, SERI-RES, ESP and HTB2 in conjunction with five different criteria. The programs and criteria were used to assess overheating for an existing house design with four different areas of south facing glazing. This enabled an assessment to be made of design differences, in terms of glazed area, which would result from using the different criteria. The fact that a house design was used rather than, say, an office design was not of crucial importance since the objective was to assess whether the different criteria would lead to different design decisions.
Fig 1 is an example of the results obtained using one program, SERI-RES. The fraction of the overheating limit obtained for each of five different criteria was plotted against the percentage of the designed window area for the Linford house (Passive Solar Programme) using Kew weather data. It can be seen that the application of different criteria results in the prediction of different allowable window areas if overheating is to be avoided. The approximate areas are shown in Table 1.
Additional work has been carried out by Wijsman (TNO-BOUW) (Ref 3) to compare the five overheating definitions. From the definitions a table of overheating hours corresponding to the zone temperature was obtained (Table 2). For the DN17

criterion the assumption was made that during the 10 days the excess number of hours could be anywhere between 1 and 7 hours per day so an average of 4 hours was taken leading to 40 hours over the 10 day period. It was not possible to include the Swiss criterion which is based on Kelvin Hours.

The values from Table 1 give the relationship shown in Fig. 1. indicating that perhaps the four criteria could possibly be replaced by a linear relationship connecting zone temperature and hours exceeded.

The Dutch use two criteria to take into account the fact that the the shape and slope of the plot of overheating hours against zone temperature depends on the building and system configuration. This is indicated in Fig. 3. In Fig 3(a) the Dutch 1 criterion is the limiting factor and in 3(b) the limiting factor is the Dutch 2 criterion. For the case considered by Eppel and Lomas the Dutch 1 criterion would be the limiting factor giving an allowable window area of 56% of the design value.

Discussion

The results clearly show that the use of different criteria can lead to different design decisions suggesting that some standardisation of approach is needed if performance assessment methods are to be put on a more consistent basis. Of the criteria tested in the investigation it is not possible to select the most appropriate without further work. It is likely that a number of different criteria may be required which would take into account the requirements of different building types and activities and the types of outputs of the programs currently in general use.There is a possible connection between the criteria which relate temperature with the number of hours above that temperature which requires further investigation. Bland (Ref 4) suggests some of the desirable properties of an appropriate assessment measure with which to compare competing designs or to provide a rating of an existing building and suggests, for overheating, a function of the form $(T-T_0)^2$ + **constant**. This work needs to be extended. A fully documented set of criteria needs to be produced with a description of their applicability and limitations so that designers and clients are fully conversent with the consequences of their use.For a given application different design decisions may be made, or different levels of comfort achieved, depending on the combinations of program and overheating criteria used. On the assumption that different programs will continue to be used amongst the international design community then, at least, some rationalisation of criteria is required to ensure consistency of use for different aplications. It is unlikely that a single criterion will meet all requirements.It is proposed that initially a programme of work be carried out to thoroughly document the different criteria and test their use for different applications taking into account the implications for thermal comfort and energy use. This would enable designers to choose, from a range of criteria, those best suited to the solution of particular design problems. In parallel with this work further investigations on the lines suggested by Bland should be carried out.

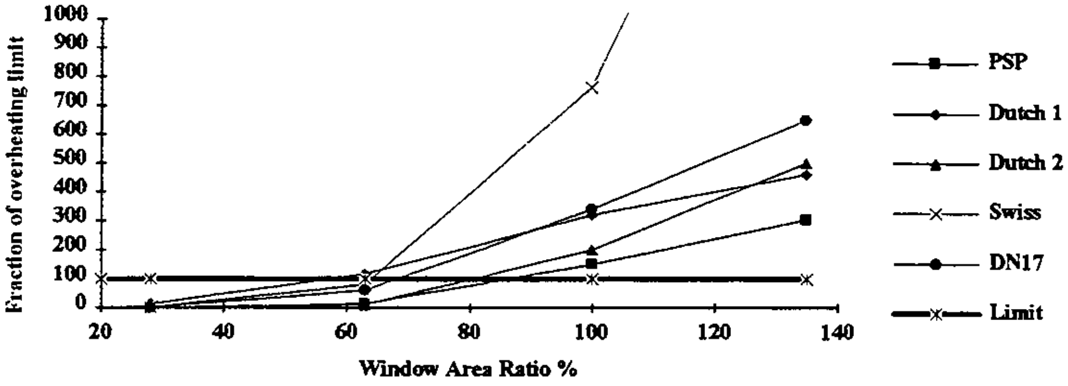


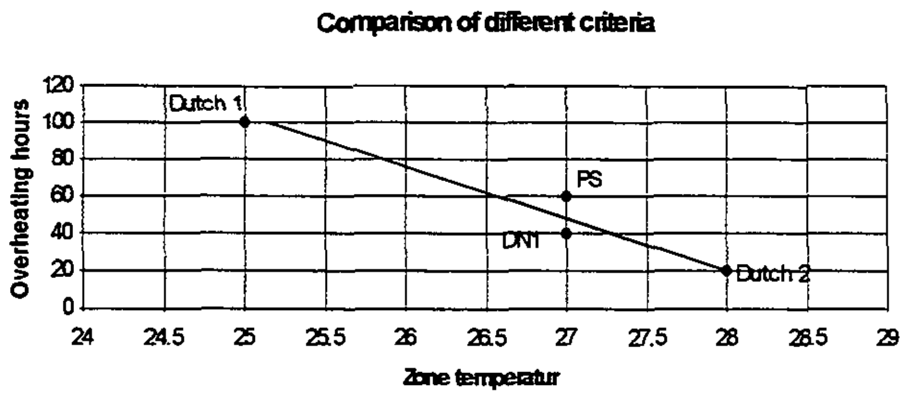
Fig. 1

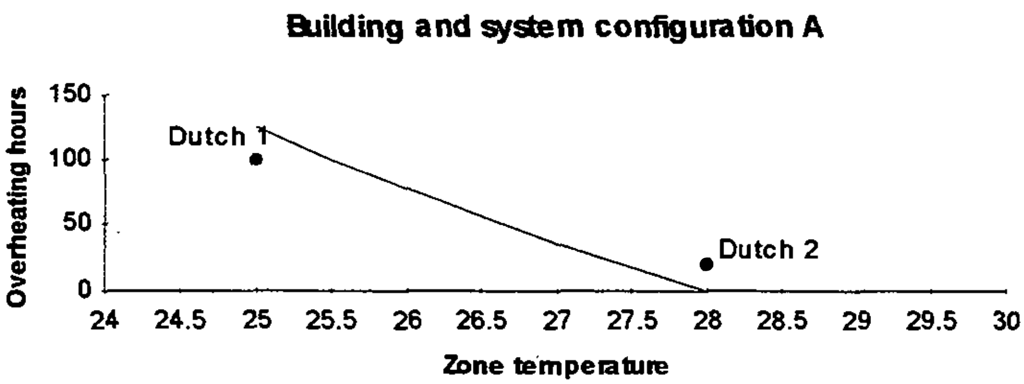
Criterion	Allowable Window Area % of Design
PSP	85
Dutch 1	56
Dutch 2	80
Swiss	64
DN 17	68

Table 1 Design changes resulting from the use of different overheating criteria

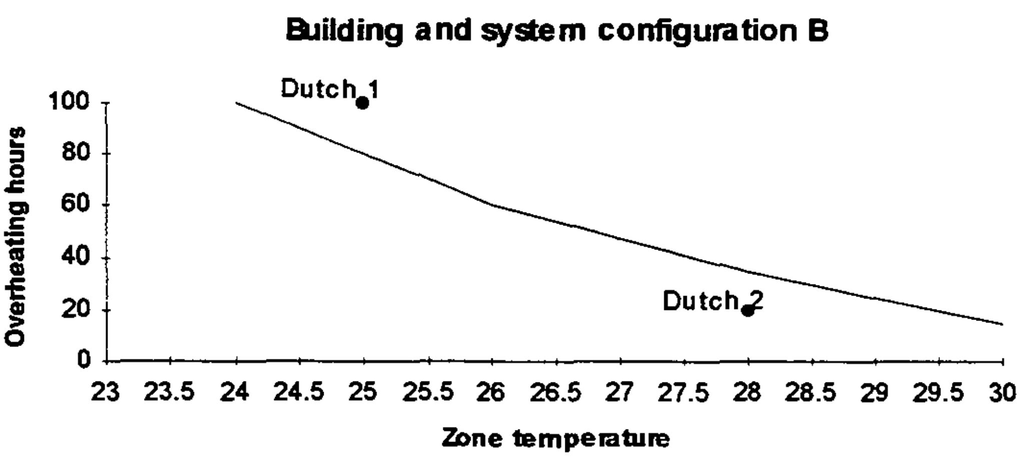
Criterion	Zone Temperature	Overheating Hours
PSP	27	60
Dutch 1	25	100
Dutch 2	28	20
DN 17	27	40

Table 2 Values of zone temperature and overheating hours.





(a) Dutch 1 limiting criterion.



(b) Dutch 2 limiting criterion.

Fig. 3 Use of different Dutch criteria.

References

1) R. R. Cohen, D. K. Munro and P. A. Ruyssevelt ; Halcrow Gilbert Associates Ltd., Burderop Park, Swindon SN4 0QD, UK :'Overheating Criteria for Non Air Conditioned Buildings'; CIBSE National Conference 1993.

2) IEA 21 RN 235/92; H. Eppel and K. J. Lomas ; 'Comparison of Alternative Criteria for Assessing Overheating in Buildings'.

3) A Wijsman ; TNO-BOUW; private communication.

4) IEA 21 RN 352/93; B. H. Bland; 'Proposed Method for Calculating Thermal Discomfort'.

Summer thermal comfort criteria in naturally ventilated buildings
Nigel Oseland, Building Research Establishment.

1. Current Standards and Guidelines

Cohen (1993[a], 1993[b]) adequately summarises the comfort and overheating criteria in the various national guidelines and standards. CIBSE (1986) suggest that 27°C is the temperature at which occupants may consider themselves "uncomfortably hot" and therefore defines overheating as an environmental temperature over 27°C for more than 2½% of the yar. *Design Note 17* (DoES, 1981) which provides guidelines for the conservation of fuel in educational buildings recommends a design temperature of 23±4°C and recommends that the temperature should not exceed 27°C during normal working hours but an excess for 10 days during summer is a reasonable predictive risk.

ISO (1993) is a standard *method* based on Fanger's *PMV* model. However, temperatures of 24.5±1.5°C would be considered comfortable (10% dissatisfied) for sedentary activity (1.2 met), summer clothing (0.5 clo), and 50% RH. Recently, discrepancies between reported and predicted thermal sensation in the field during winter has been attributed to excluding an extra 0.15 clo from chair insulation (Fanger, 1993). If the chair clo is added to typical summer clothing (0.5+0.15=0.65 clo) then the optimum design temperature becomes 23.5±2°C. Coincidentally, Oseland (1993) found that people considered themselves "hot" at a mean temperature of 25.4°C in homes.

ASHRAE-55 recommends designing internal environments which satisfy at least 80% of the occupants, whereas *ISO 7730* recommends the percentage dissatisfied is lower than 10%. Using *ISO 7730* to recalculate the range of temperatures for 20% dissatisfied produces an optimum of 24.5±3°C for 0.5 clo and 23.5±3.5°C for 0.65 clo (i.e. a maximum of 27-27.5°C).

The main design index used in the above guidelines is the operative (i.e. dry resultant or globe) temperature. Whilst operative temperature is a combination of air temperature and mean radiant temperature it ignores air velocity. Other indices like *ET**, which was used in *ASHRAE-55* until 1992, include air velocity. *ISO 7730* provides an extra equation to calculate draught risk but, like the other guidelines, does not consider the beneficial cooling effect due to forced air velocity. This may be why current guidelines and standards appear to recommend fairly low temperatures for upper comfort limits.

SCANVAC (1991) split their guidelines on the indoor environment into three "quality classes". In order to meet the top classification, individual control of both temperature and airflow must be provided.

2. Studies in naturally ventilated buildings

There have been several studies which indicate differences in the comfort temperatures required in air-conditioned (AC) and naturally ventilated (NV) buildings. In his classic study, Humphreys (1978) plotted the neutral (i.e. comfortable) temperatures (t_ψ) of AC and NV buildings against the mean monthly outdoor temperature ($\bar{t}_o$). He found that the t_ψ of NV buildings correlated well with ($\bar{t}_o$) (r=0.97). Humphreys concluded that people adapt to their surrounding environment conditions and proposed that the indoor temperature of an NV building should "shadow" the outdoor temperature. He suggested that t_ψ could be found using $t_\psi = 11.9 + 0.534\,\bar{t}_o$.

Using Humphreys' equation, a typical British summer mean monthly outdoor temperature of 17.5°C would produce an indoor design temperature of 21.2°C. No upper limit would be set as it is assumed people will adapt their behaviour, clothing or in the long term physiology to compensate for temperature drifts.

Auliciems (1989) reanalysed Humphreys' work including extra data from Australia and proposed that design temperatures in both AC and NV buildings could be determined using a combination of mean monthly indoor t_i and outdoor temperatures, i.e. $t_\psi = 0.48\bar{t}_i + 0.14\bar{t}_o + 9.22$ or alternatively based on the $\bar{t}_o$ alone, i.e. $t_\psi = 17.6 + 0.31\bar{t}_o$. Thus, for $\bar{t}_o$ of 17.5 the optimum design temperature is 23.0°C, which is 2°C, higher than predicted by Humphreys.

In a comparison of NV and AC buildings in Thailand, Busch (1992) found that for the NV buildings the neutral temperature was 27.4°C, but the upper limit (20% dissatisfied) was as high as 31°C. In a European study by Berglund and Gonzalez (1978), a maximum temperature of 27.2°C was acceptable to more than 80% of the subjects in typical summer clothing. De Dear (1993) explains that the difference between required temperatures in NV and AC buildings, in his own studies, is probably because occupants of NV buildings are more tolerant of diurnal and seasonal variation in room temperature whereas the occupants of AC buildings have higher expectations of the internal environment.

In contrast, other European work has suggested that increased temperatures (>25°C) will affect health, i.e. increase SBS symptoms and in extreme cases cause heat stress, and possibly reduce work productivity.

3. Comfort and acceptability

Thermal comfort researchers mix up expressions like comfort, thermal sensation, preferance, acceptability, and satisfaction. Indeed thermal comfort standards are based on studies conducted using the *ASHRAE Thermal Sensation Scale*; The psychological notion of comfort is not actually considered. It is therefore probable that the temperature tolerance in thermally acceptable buildings is much wider than that required for comfort. Indeed, Brager (1993) found that if "slightly uncomfortable" is considered acceptable the 98% of the occupants in San Francisco offices considered their environment acceptable. Designing for an acceptable building wil therefore raise the upper design limits for NV buildings. More research is required on defining the limits of, for example, comfortable to satisfactory to acceptable to tolerable internal environment. Alternatively, the limits could be set by more objective measures such as productivity, health, energy conservation, or economics.

4. Conclusions

Most standards and guidelines recommend upper summer temperatures of 27°C. The design criteria for comfort and acceptability differ; designing for acceptability rather than comfort enables a higher upper temperature limit. the occupants of naturally ventilated buildings appear to have a greater tolerance of temperature drifts than those in air-conditioned buildings. Indeed, people in free-running buildings may adapt to their environment (across seasons as well as geographical climate). More work is required on temperature requirements for comfort, health, economics, productivity, energy conservation, and acceptability, satisfaction etc.

5. References

ASHRAE (1992) *ANSI/ASHRAE-55, Thermal Environmental Conditions for Human Occupancy.* Atlanta: ASHRAE.

Auliciems, A (1989) Thermal Comfort. In N.C. Ruck (ed) *Building Design and Human Performance.* New York: Van Nostrans Reinhold.

Berglund, L.G. and Gonzalez, R.R. (1978) Application to acceptable temperature drifts to built environment as a mode of energy conservation. *ASHRAE Transactions, 84*(1), 110-121.

Brager, G.S. (1993) A comparison of methods for assessing thermal sensation and acceptability in the field. Presented at *Thermal Comfort: Past, Present and Future.* Garston: BRE.

Busch, J.F. (1992) A tale of two populations: thermal comfort in air-conditioned and naturally ventilated offices in Thailand. *Energy and Buildings, 18,* 235-249.

CIBSE (1986) *CIBSE Guide, Volume A Design Data.* London: CIBSE.

Cohen, R.R., Munro, D.K. and Ruyssevelt, P.A. (1993[a]) Over-heating criteria for non-air-conditioned buildings. Proceedings of *CIBSE National Conference.* London: CIBSE

Cohen, R.R. (1993[b]) A comforting future. *Building Services, 15* (9), 35-36.

De Dear, R. (1993) Outdoor climatic influences on indoor thermal comfort requirements. Presented at *Thermal comfort: Past, Present and Future.* Garston: BRE.

DoES, Department of Education and Science (1981) *Design Note 17, "Guidelines for Environmental Design and Fuel, Conservation in Eductional Buildings.* London: HMSO.

Fanger, P.O. (1993) How to apply models predicting thermal sensation and discomfort in practice. Presented at *Thermal Comfort: Past, Present and Future.* Garston: BRE

Humphreys, M.A. (1978) Outdoor temperatures and comfort indoors. *Building research and Practice, 6*(2), 92-105.

ISO (1993) *Moderate Thermal Environments - Determination of the PMV and PPD Indices and Specification of the Conditions for Thermal Comfort, ISO 7730.* Geneva: International Organisation for Standardization.

Oseland, N.A. (1993) Predicted and reported thermal sensation votes in UK homes. Submitted to *EDRA's 25th Annual Conference.* Also *PD263/93.*

SCANVAC (1991) *Classified Indoor Climate Systems.* Stockholm: the Swedish Indoor Climate Institute.

PAPER 6

SIMULATION ASPECTS OF SUSPENDED CEILING

December 1, 1993

Aad Wijsman
TNO-Bouw
BBI Department
Leeghwaterstraat 5
P.O. box 29
2600 AA Delft
Tel: 015 - 608608
Fax: 015 - 608432

1 INTRODUCTION

The aim of this report is to summarise those aspects of suspended ceilings to be taken into account in Building Thermal Performance simulation.

2.DESCRIPTION OF SUSPENDED CEILING

The ceiling of a room (e.g. an office module) and the floor of the upper room is formed by one and the same construction, e.g. a concrete slab. For visual and acoustic reasons an extra construction layer (plasterboard, perforated metal sheets (very acoustic!), etc.) is provided below this construction. Between the concrete slab and this extra layer there is an air gap (the plenum). This construction is called a suspended ceiling.
A disadvantage of such a suspended ceiling is the shielding of the mass of the concrete slab. During summer time this leads to higher zone temperatures or to higher cooling peak loads.
In practice this disadvantage can be avoided by making the suspended ceiling partly open (15-20% open). Air exchange between zone and plenum couples the zone to the mass of the slab. The visual and acoustic advantages are maintained using this construction.
Lighting fittings may be incorporated into the suspended ceiling.

Figure 1 is a schematic illustration of an office module with a suspended ceiling.

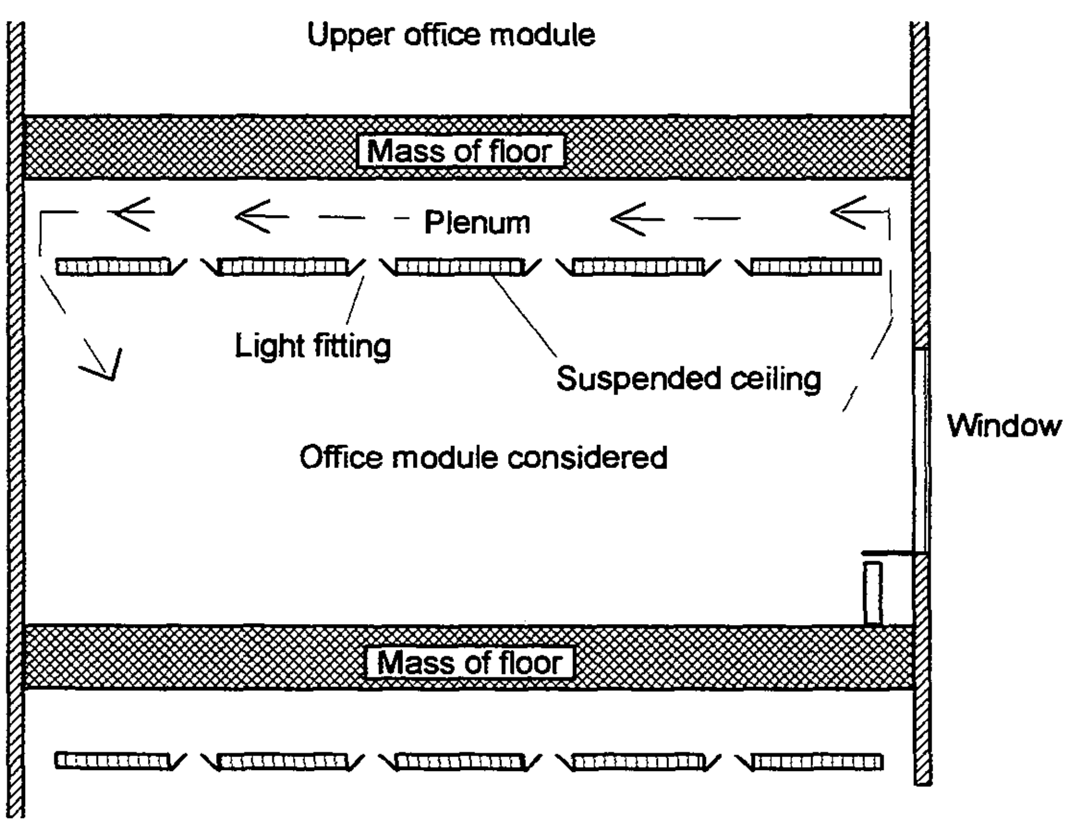


Figure 1: Office Modules with suspended ceiling

2.1 Airflow through the plenum

In practice the following 5 cases can occur:

1. The suspended ceiling is closed; there is no air exchange between zone and plenum.
2. The suspended ceiling is partly open; there is only air exchange between the zone and the plenum due to buoyancy when the temperature in the zone is higher than the temperature in the plenum (so-called conditional airflow).
3. As 2., but with continuous airflow through the plenum, independent of zone and plenum temperature, caused by other air movement patterns. (for instance caused by cold window, heating element, etc) within the zone.
4. Exhaust ventilation air is removed mechanically through the plenum. In this case a large part of the convective heat from artificial lighting is removed directly.
5. The plenum is ventilated with ambient air during night operation.

2.2 Control

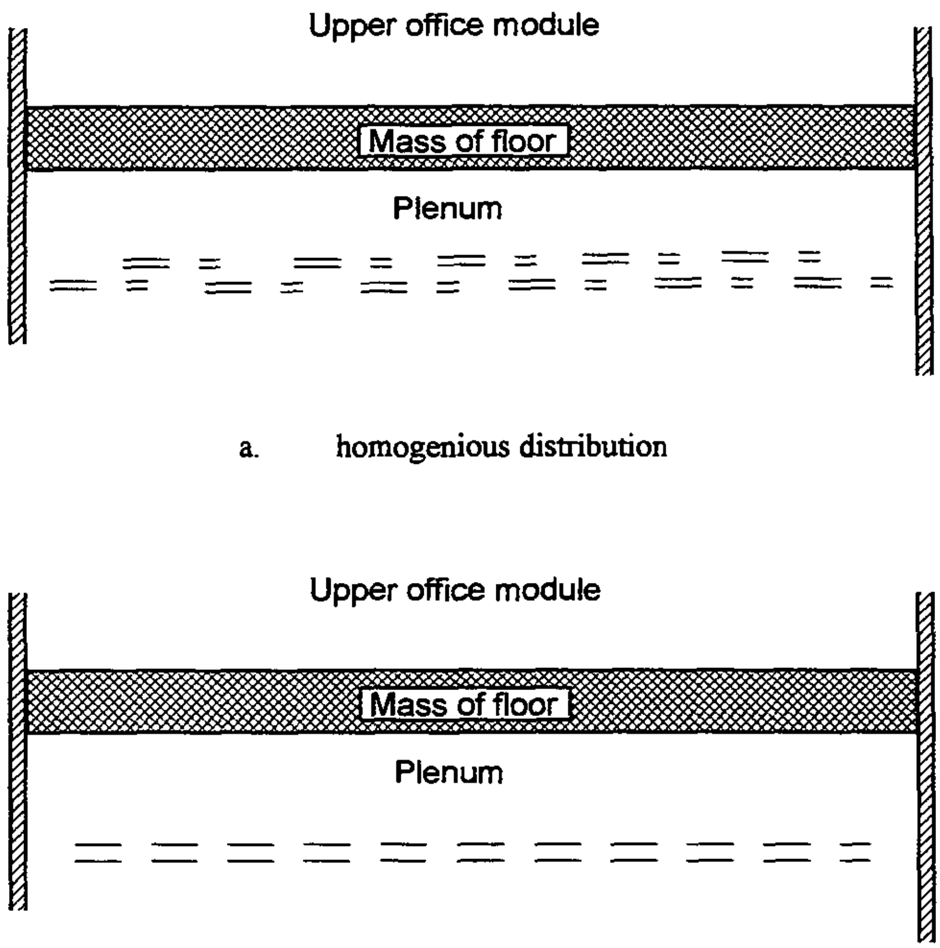
The airflow through the plenum is not controlled, but in practice combinations of the above 5 cases can occur (dependent on control of the mechanical ventilation system).
For instance: during day operation the exhaust mechanical ventilation is removed by the plenum (case 4), during night operation there is no mechanical ventilation and conditional airflow (case 2) or continuous airflow (case 3) occurs.
There can therefore be a switch from one case to another.

3 SIMULATION OF THE SUSPENDED CEILING

3.1 Information requirement

For the simulation of the suspended ceiling information is required concerning:

- the airflow that occurs in cases 2 and 3. Is this airflow constant or dependent on temperature difference between zone and plenum? Is it dependent on what percentage of the ceiling is open and the position of openings?(see figure 2)
- what proportion of the lighting heat dissipation becomes available to the plenum and what to the zone? What is the proportion of radiative and convective dissipation? Do these factors depend on plenum air movement?
- what is the convective heat transfer between the ceiling construction and the airflow through that construction?
- what is the infiltration rate of the plenum? Negligible with respect to the zone or of the same order?
- etc.



a. homogenious distribution

b. only near the side walls

Figure 2: Position of openings in the suspended ceiling

3.2 Control

As mentionned under 2.2 there is no control of the airflow through the plenum. However the airflow can switch because of mechanical ventilation control. Also a combined situation can occur, for instance exhaust mechanical ventilation is removed by the plenum (case 5), but with an airflow that is of the same order as the flow by boyancy (case 2) or by other airmovements (case 3).

It is important to know how this situation is handled by the program? Only one case at the time or a combination of both cases?

3.3 One- or two-zones approach

Many building thermal performance programs work with 'Center Wall-to-Center Wall' dimensions for the zone geometry and with constructions that have 'zero-thickness'.
The suspended ceiling construction can have a thickness up to 0.5 m so is not negligible with respect to the total zone height of about 3 m.

There are two basic approaches to the simulation:-
A. Treat the Office Module with suspended ceiling as 1 zone; the suspended ceiling with the floor above being considered as one construction.
B. Treat the Office Module with suspended ceiling as 2 zones; the air gap, bounded by the floor at the top and the suspended ceiling at the bottom being treated as a separate zone.
Method A neglects the thickness of the suspended ceiling construction, method B does not.
Both methods are discussed in Appendix A. See also [1]

3.4 Approach by the different programs

Ideally the information outlined in 3.1, 3.2 and 3.3 should be given but it is unlikely that it will all be available. With regard to 3.3 in general the simulation programs should have the ability to model a ventilated construction with a heat source in that construction (method A - one zone approach) or multizones with interzonal airflow (method B - two zone approach).

The approaches used by VA114, DOE-2, SERIRES, ESP and TRNSYS are as follows:-

VA114(Contribution by A. Wijsman, TNO-Bouw)
The program VA114 can handle both the one-zone and the two-zone approach.
One-zone approach
The air exchange between zone and plenum for conditional airflow (case 2) and continuous airflow (case 3) is supposed to be constant and given by user input. It is independent of the actual temperature difference between zone and plenum. For the cases 4 and 5 the airflows are given by user input.
The lighting heat dissipation is partly convective and partly radiative. The radiated heat is all available to the zone. The convective heat is also all available to the zone except for the case where exhaust mechanical ventilation air is removed through the plenum (case 4). In this case the fraction removed by the exhaust air is provided by the user the remainder being available to the zone.
The convective heat transfer between ceiling construction and airflow through the construction is described by a coefficient that is fixed in the program and is equal to the coefficient in the case without airflow.
The program handles no combined situations. The conditional airflow because of buoyancy (case 2) and the continuous airflow because of other air movements in the zone (case 3) occur only if there is no removal of exhaust mechanical ventilation air (case 4) and no ventilation with ambient air (case 5).

Two-zone approach
In this case the plenum is the second zone.
The continuous airflow by other air movements within the zone (case 3) can be simulated by interzonal airflow provided by the user.
The removal of exhaust mechanical ventilation air can be simulated by considering supply air to zone 1 and exhaust air from zone 2. This causes an extra interzonal airflow from zone 1 to zone 2.
It is clear that the program can now handle combined situations (for instance case 3 and case 4).
The infiltration rate of both zones can be given by user input, so may be different or the same.
The radiative part of the lighting dissipation becomes available to zone 1 and the convective part to zone 2.
The convective heat transfer coeffient at each surface of a zone can be given including zone 2, the plenum.
Remark: VA114 has the capability to calculate the infiltration and interzonal airflows. So with this two-zone approach the airflow through the plenum can also be calculated.

SERI-RES (Contribution by B. Sodagar, Univ. of Newcastle)
Modelling suspended ceiling using SERI-RES is exactly the same as using VA114. A suspended ceiling may be modelled as either part of the structure (treating the Office Module with suspended ceiling as 1 zone) or as a separate zone (treating the Office Module with suspended ceiling plenum as 2 zones).

DOE-2 (Contribution by G. Zweifel, EMPA)
This program can handle both the one-zone and the two-zone approach. Since there is no possibility for a natural interzonal convective coupling, some of the cases are treated in a simplified way.
For the closed suspended ceiling (case 1) both the one-zone and the two-zone approach are possible. With the one-zone approach, the air gap has to be defined as a layer which forms part of the ceiling construction. A heat resistance has to be defined for this layer. Recommended values are partly (for certain gap thicknesses) available in standards and other documents. With the two-zone approach the plenum is defined as a complete zone which can have all features like windows, people, infiltration, etc. This applies also to the ventilated plenum case (case 5).
The partly open suspended ceilings (case 2 and 3) cannot be simulated correctly in DOE-2. In this case the user is advised to neglect the suspended ceiling, in order to take into account the thermal mass of the concrete slab, if the opening area is more than 10% of the total area. This number is given in the Swiss cooling load standard (SIA 382/2) and is based on a Dutch study.
For case 4, the two-zone approach is used and the air flow direction is defined by putting the plenum's zone-name under 'PLENUM-NAMES' in the system definition. The return air defined in the system definition is then automatically led through the plenum. There can be several under one system, as well as conditioned zones. In that case the air of all defined conditioned zones is led through all defined plenums of one system. The load

from the lights can be distributed between the conditioned zone, the plenum and the return air, and also the radiative / convective split in both zones. If the information is not available then default values are used which depend on the chosen lighting type.
Combinations of the different cases are possible, as can be seen from the description above.

ESP (Contribution by D. Bloomfield, BRE)

ESP makes no special allowance for suspended ceilings and gives no guidance. However, it does have the capability to take into account heat generated in a construction (e.g. floor, ceiling), so the single zone approach is possible. The two-zone approach can also be used. The user has to specify all values. e.g. radiant/convective split of lighting energy outputs, interzonal (fixed) airflow.

TRNSYS and other programs

No information has been provided on **TRNSYS** or any other programs.

4.0 STUDIES RELATING TO SUSPENDED CEILINGS

At TNO-Bouw a study was performed on the influence of the suspended ceiling on the Overheating of an Office Module [1] and some preliminary work was carried out on the one-zone and two-zone approach.

4.1Study on the influence of the suspended ceiling on the Overheating of a Office Module.

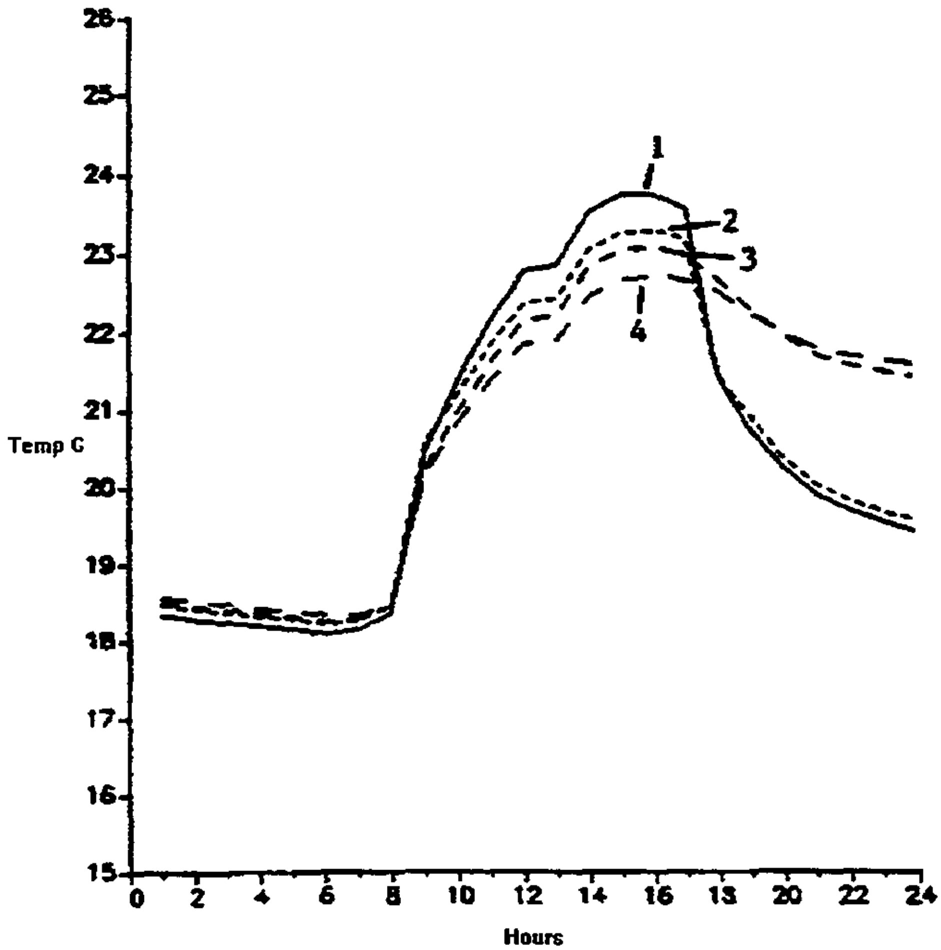
This study followed the one-zone approach.
For a 'standard' module four situations were compared:

1. A suspended ceiling, that is thermally closed (no airflow)
2. A suspended ceiling, that is thermally open. Airflow occurs in the case when the temperature in the zone is higher than the temperature in the plenum (so-called conditional airflow)
3. A suspended ceiling, that is thermally open. There is continuous airflow through the plenum because of other air movement patterns in the zone.
4. No suspended ceiling.

The example in figure 3 shows the influence on zone temperature for a specific day.
Comment on figure 3: the installation has the capability of providing nightly cooling. Its operation starts if, during night time operation, (after 17.00 h) the zone temperature is higher than 23 C. For this specific day the nightly cooling comes into operation for cases 1 and 2 but not for cases 3 and 4. This accounts for the very different zone temperatures during the evening.

In this study the following effects were investigated:

- the magnitude of the airflow through the plenum
- the magnitude of the casual gains
- the effect of temperature control in the zone
- the presence of nightly cooling



(1)-Suspended ceiling, thermally closed-no airflow-
(2)-Suspended ceiling, thermally open - airflow when zone temp. > plenum temp.-
(3)-Suspended ceiling, thermally open - continuous airflow through plenum.--
(4)-No suspended ceiling

Figure 3: Influence of the thermally open ceiling

4.2 Preliminary work on the one-zone and the two-zone approach.

A comparison between the one-zone and the two-zone approach was made for the case with continuous airflow through the plenum (case 3). The comparison was done for the same 'standard' module as used for [2] (including nightly cooling).

In figure 4 the results are given for 3 simulations:

1. One-zone approach
2. Two-zone approach, convective part of lighting becomes available in the plenum (zone 2).
3. Two-zone approach, convective part of lighting is also available in zone 1.

Simulations 1 and 3 give same results, simulation 2 has less overheating hours in the zone (about 70 h). It is clear that the distribution of the convective part of the lighting energy between the zones is important. The question remains: what model provides the best approach to practice ?

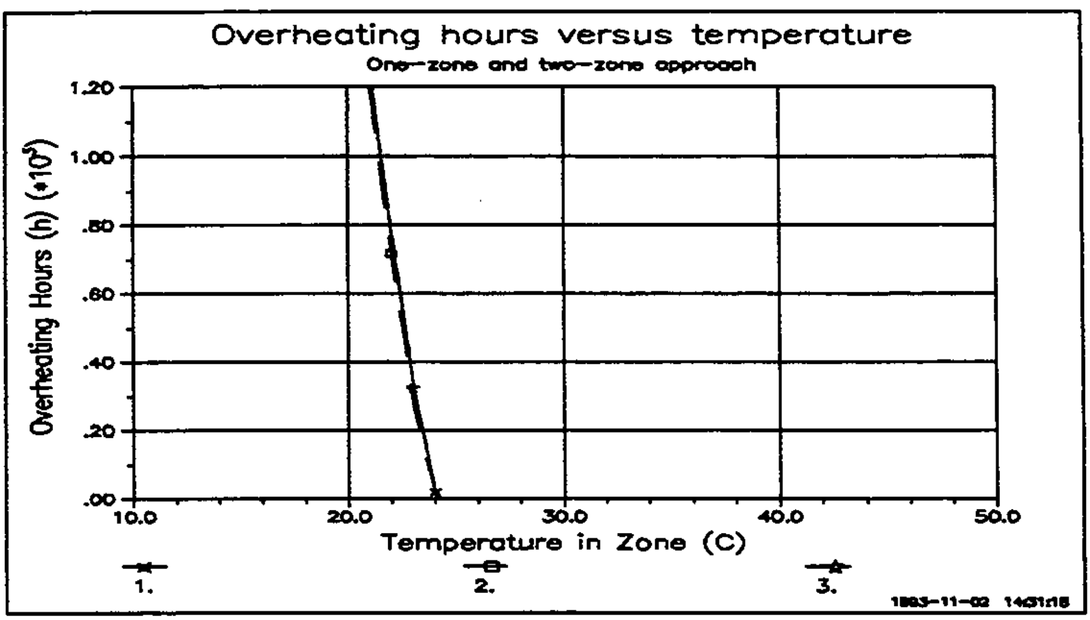


Figure 4: Comparison of the one-zone and two-zone approaches.
(See text for explanation number 1-3)

5.0 THE NEED FOR FURTHER STUDIES

The one-zone and two-zone approaches to the problem of simulating suspended ceilings has been investigated for several cases. Further investigation of the effects of using these methods should be carried out for all the cases.

Also the effect of given airflow through the plenum instead of calculated airflow should be investigated.

The results from these further studies will lead to guidelines as to how to simulate the suspended ceiling in an appropriate way.

6. REFERENCES

[1] A. Wijsman: 'Prework to come to PAM for suspended ceiling', October 1991.

[2] A. Wijsman and W. Plokker: 'Gevoeligheidsstudie Thermisch Open plafond (Sensitivity study on Thermal Open Suspended Ceiling)', June 1990.

APPENDIX A: One or two zone approach to the simulation of suspended ceilings.

Many Building Thermal Performance programs work with 'Center Wall-to-Center Wall' dimensions for the zone geometry and with constructions that have 'zero-thickness'.
The suspended ceiling construction can have a thickness up to 0.5 m, so are far from negligible with respect to the total zone height of about 3 m.
Two different methods of simulation are as follows:

A. Treat the Office Module with suspended ceiling as 1 zone, the suspended ceiling with floor above being considered as one construction.

B. Treat the Office Module with suspended ceiling as 2 zones; the air gap, bounded by the floor at the top and the suspended ceiling at the bottom, is treated as a separate zone.

Method A neglects the thickness of the suspended ceiling construction, method B does not.

Both methods are now discussed in more detail.

A. Treat the Office Module with suspended ceiling as 1 zone; the suspended ceiling with floor above is considered as one construction.

Figure A.1 shows the configuration.

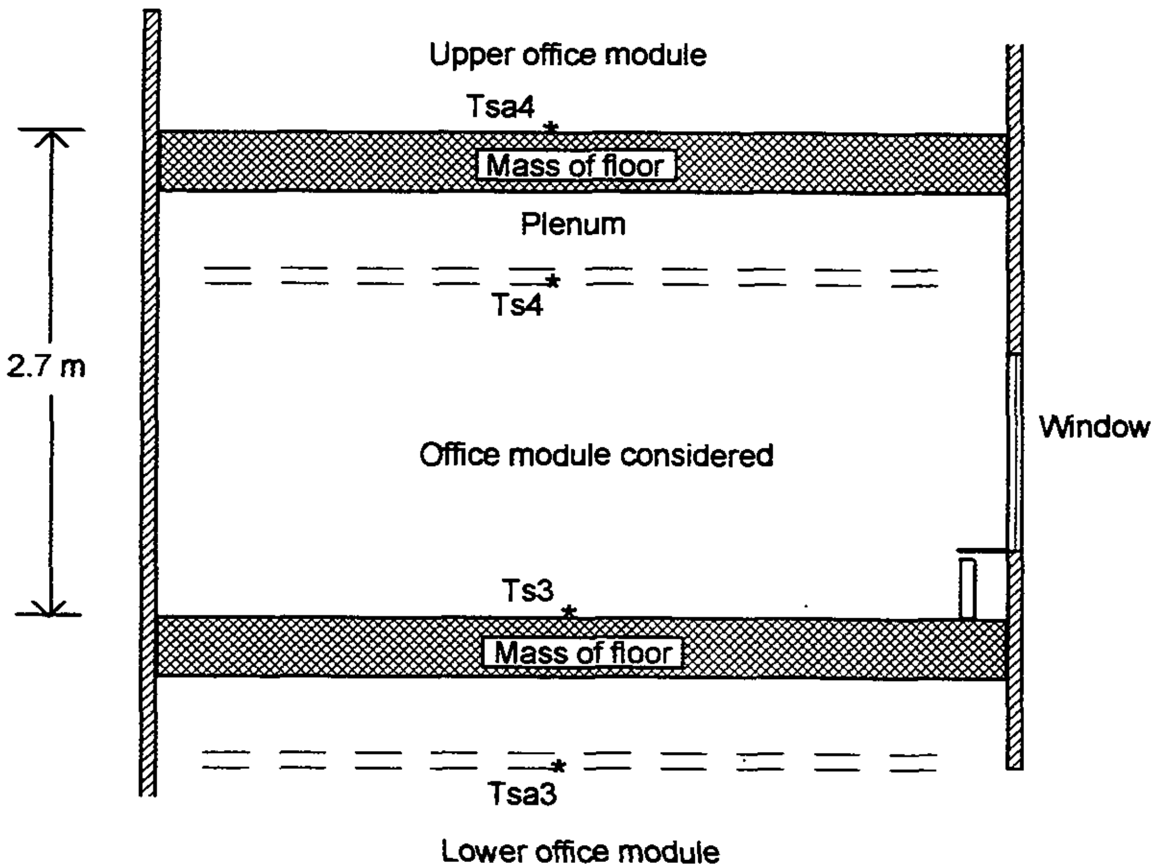


Figure A.1: Office Modules with suspended ceiling - method A

NB All construction thicknesses are taken as zero.

Further information.

Suspended ceiling: one zone

1. Zone height = 2.70 m

2. Adjacent Unmodelled Zones: Tsa3 = Ts4
Tsa4 = Ts3

Means: floor coupled to ceiling

3. Infiltration : simple
FV = f(Vw) = FVA+FVB*Vw+FVC*Vw**2
VENTN(1,0) = ambient to zone = FV*VOLUME/3600
VENTN(0,1) = zone to ambient = VENTN(1,0)

4. Mechanical ventilation:
MVENTI = air supply to zone = Input,i
MVENTO = air removal from zone = Input,o

5. Air flow through Suspended Ceiling:

```
            MSUSPC = 0.0
            IF (Thermal open ceiling) THEN
                  IF ((Continuous flow).OR.(Tair,zone.GT.Tair,plenum)) THEN
                        MSUSPC = Input
            ENDIF
      ENDIF
      IF (Ventilated with ambient air) THEN
            MSUSPC = Input
      ENDIF
      IF (Exhaust air removed by plenum) THEN
            MSUSPC = MVENTO
      ENDIF
```

6. Constructions
all vertical wall constructions as given
ceiling : concrete slab-air gap-plasterboard
floor : plasterboard-air gap-concrete slab

Ventilated ceiling is a special construction, which can be handled by VA114. Four ways of ventilation are possible:

1. IOPLF = 1 : Air flow through plenum if (Tzone.GT.Tplenum)
2. IOPLF = 2 : Continuous air flow through plenum.
3. IPLEN = 1 : Exhaust air removal by plenum
4. IVNTB = 1 : Ventilation of plenum with ambient air

No air flow if IOPLF=IPLEN=IVNTB=0

For amount of air flowing through plenum MSUSPC see 5.

7. Casual gains

Persons = Input ; Convective part = 0.5

Equipment = Input ; Convective part = 0.5

Lighting = Input ; Convective part = 0.5

IF (Exhaust air removed by plenum) THEN

Convective part of Lighting is removed by exhaust air

ELSE

Convective part of Lighting becomes available to zone air

ENDIF

8. Installation

Installation in zone as projected.

B. Treat the Office Module with suspended ceiling as 2 zones; the air gap, bounded by the floor at the top and the suspended ceiling at the bottom, is treated as a separate zone.

Figure A.2 shows the configuration.

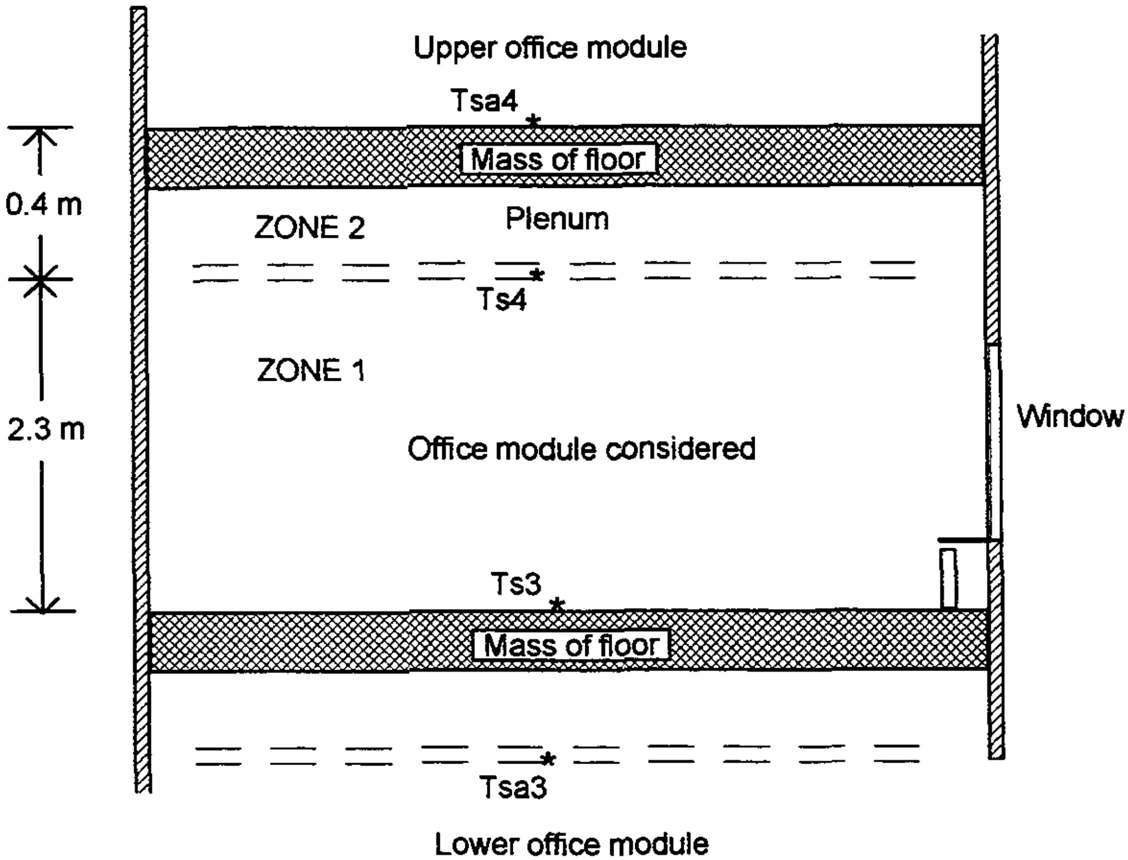


Figure A.2: Office Modules with suspended ceiling - method B.

NB all constructions are supposed to have 'zero-thickness'

Further information.

Suspended ceiling: two zones

1 Zone height zone1 = 2.30 m; zone2 = 0.40 m

2 Adjacent Unmodelled Zones: Tsa3 = Ts4
Tsa4 = Ts3
Means: Floor1 coupled to ceiling 2

3 Infiltration : simple FV = f(Vw) = FVA+FVB*Vw+FVC*Vw**2
Same for both zones

```
        VENTN(1,0) = ambient to zone1 = FV*VOLUME1/3600
        VENTN(0,1) = zone1 to ambient= VENTN(1,0)
        VENTN(2,0) = ambient to zone2 = FV*VOLUME2/3600
        VENTN(0,2) = zone2 to ambient = VENTN(2,0)
```

4 Mechanical ventilation: MVENTI = air supply to zone
MVENTO = air removal from zone

```
    IF (Exhaust air removed by plenum) THEN
        Zone 1          MVENTI1 = Input,i; MVENTO1 = 0.0
        Zone 2          MVENTI2 = 0.0    ; MVENTO2 = Input,o
    ELSE
        Zone 1          MVENTI1 = Input,i; MVENTO1 = Input,o
        Zone 2          MVENTI2= 0.0     ; MVENTO2= 0.0
    ENDIF
```

5 Interzonal air flow: VENTN(2,1) = zone1 to zone2
VENTN(1,2) = zone2 to zone1

```
    VENTN(2,1) = 0.0
    IF (Thermal open ceiling) THEN
        IF ((Continuous flow).OR.(Tair,zone.GT.Tair,plenum)) THEN
            VENTN(2,1) = Input
        ENDIF
    ENDIF
    VENTN(1,2) = VENTN(2,1)
    IF (Exhaust air removed by plenum) THEN
        Program adjusts VENTN(1,2) and VENTN(2,1)
    ENDIF
```

6 Constructions

Zone1

all vertical wall constructions as given
ceiling : plasterboard
floor : concrete slab

Zone2

all vertical wall constructions (opaque) the same as zone1
ceiling : concrete slab
floor : plasterboard

7 Casual gains

Zone1

Persons = Input ; Convective part = 0.5
Equipment = Input ; Convective part = 0.5
Lighting = Input (= radiative part of Lighting);
Convective part = 0.0

Zone2

Persons = 0.0 ; Convective part = 0.0
Equipment = 0.0 ; Convective part = 0.0
Lighting = Input (=convective part of Lighting);
Convective part = 1.0

Remark: the convective part of Lighting becomes available in zone2 (the plenum).

8 Installation

Zone1

Installation in zone as projected.

Zone2

No installation

Printed in the UK by HMSO Basildon 111693/2/8391349 150 1/95 CRC Supplied