A guide to

HVAC Building Services Calculations

Second edition

BSRIA Guide 30/2007
Supported by the DTI

CIBSE

BSRIA

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The authors have sought to incorporate the views of the steering group, but final editorial control of this document rested with BSRIA.

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PREFACE

This publication provides practical, easy to follow methodologies for a range of calculations used in the design of heating ventilating and air conditioning building services systems.

The calculation sheets are presented in five sections covering:

- Heating loads and plant
- Cooling loads and plant
- Water flow distribution systems
- Air flow distribution systems
- Acoustics for building services

The calculation sheets provide practical guidance including design watchpoints, design tips and rules of thumb, and are intended to aid the design process and reduce errors. The guidance is based primarily on data and procedures contained within the *CIBSE Guides*, together with other sources such as *Building Regulations*, with clear cross-referencing provided to data sources.

This publication is intended primarily to help junior design engineers, working within a structured and supervised training framework, by providing assistance in completing the basic calculations needed to define operating conditions for systems, size distribution systems and to specify required duties for plant and equipment. It is not the purpose of this guide to identify the most appropriate system for a particular application. Such decisions require knowledge, experience and analysis of the application.

This guidance is also not intended to be exhaustive or definitive. It will be necessary for users to exercise their own professional judgement, or obtain further advice from senior engineers within their organisation when deciding whether to abide by or depart from the guide. The calculation sheets are relevant to many design applications, but cannot be fully comprehensive or cover every possible design scenario. Every design project is different and has differing needs, and it is the professional duty of the responsible design engineer to consider fully all design requirements. Designers should exercise professional judgement to decide relevant factors and establish the most appropriate data sources and methodologies to use for a particular application.

Designers must be aware of their contractual obligations and ensure that these are met. Following this guidance - or any other guidance - does not preclude or imply compliance with those obligations. Similarly, it is the duty of the designer to ensure compliance with all relevant legislation and regulations.

It is hoped that design practices and individual designers will be encouraged to share knowledge and experience by extending and adding to the design watchpoints and design tips, and disseminating this work within their organisations. BSRIA would be pleased to receive any such contributions for incorporation into any future revisions of this publication to provide wider industry sharing of such knowledge.

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INTRODUCTION

BSRIA has been researching into the design process and design methodology in the building services industry since the mid 1990's. This has produced guidance on the use of engineering design margins[1], feedback to design[2] and quality control systems for detailed technical design[3]. The overall aim has been to develop systematic guidance for the industry that would contribute to greater consistency in design and to an overall raising of design standards.

The studies have involved considerable discussions with industrial partners on their current and future needs, and several visits to the design offices of a number of industrial contributors to the projects. A majority of those organisations consulted said that a lack of formal design guidance and inadequate recording of calculations was a major barrier to quality improvement in design. Many also felt that standardised formal procedures would help improve the quality of design outputs.

BSRIA's research also revealed that there is a lack of standardisation in design procedures, both between companies and between individuals. Many companies have developed their own design guidance and approaches to calculation procedures, leading to considerable diversity within the industry. This can make it difficult to cross-check work done by others, which could lead to differences in system design parameters and sizes, and even calculation and design errors. There are many specific examples of design errors and issues that should have been considered during design calculations and have led, (or could have led) to operational problems or subsequent litigation[4], including:

- Omission of HEPA filter resistance from fan-pressure calculations, requiring subsequent fan motor replacement which then required additional silencing
- Omission of duct sizes and flows from drawings, leading to incorrect sizes being installed
- Incorrect pipe and pump sizing for a constant temperature heating circuit, necessitating replacement of system distribution network
- No allowance for pipework expansion on a heating mains.

Although there is considerable design guidance and data available to inform the design process much of it is intended for use by experienced engineers, who have fulfilled a programme of education and training and have design experience. For example, while the design guides published by the Chartered Institution of Building Services Engineers (CIBSE)[5] provide essential design data for building services engineers, they are intended for use by experienced engineers, and therefore do not always show how to design in detail by giving every necessary calculation step. They also do not show how different calculation routines link together to build up the design process.

Research has also shown that many employers are currently finding it difficult to recruit design engineers with appropriate building services skills and experience, which necessitates recruiting and retraining engineers from other disciplines.[6] Output from building services courses is currently falling,[7] which implies there will be no short term improvement in this situation.

These recruits, with no building services training or experience, will require close supervision and considerable training which can place a heavy burden on company resources.

While there is no substitute for an appropriate quality control framework and adequate supervision by qualified senior staff, good training resources and technical support can provide an invaluable adjunct to company training provision.

Aim

As a result of all these factors many of the leading organisations involved in education and training in the building services industry, including BSRIA, CIBSE, ESTTL and HVCA and a number of industrial contributors embarked on this project to develop simple and clear guidance on building services calculation procedures that would be applicable across the industry.

Objectives

The resulting guidance is intended to be suitable as an in-company learning resource, in order to improve quality and communication within the design process. This should reduce the risk of design calculation errors and omissions, simplify the task of calculation checks and improve the overall efficiency of the design process.

A comprehensive review of current building services design practice and calculation procedures was carried out in consultation with the industry. This was closely linked to current industry design guides and reference material in order to develop this good practice guidance for building services calculation procedures, including:

- An overview of the building services design process;
- Flowcharts of key calculation sequences;
- Practical procedures and calculation sheets covering 30 key building services calculation design topics;
- Clear cross-referencing to the CIBSE Guide and other appropriate reference sources.

The calculation sheets provide an overview of each procedure, with guidance on design information, inputs and outputs, design tips and watchpoints and worked examples, to aid the design process and reduce errors. They are supplemented with illustrations and guidance on how to use appropriate tables, figures and design information correctly.

Intended users

This guidance is intended for practising building services design engineers, and will be particularly relevant to junior engineers and students on building services courses. Junior engineers would be expected to use it under supervision, (for example within a formal company training scheme) as part of their practical design work. Students can use it within the taught framework or industrial training component of their course, guided by course tutors as appropriate. The guidance should also encourage clear recording and referencing of calculation procedures which will aid quality assurance requirements and allow simpler and easier in-house checking of design work.

The guidance complements the CIBSE Guides, in particular Guide A covering design data, Guide B covering heating, ventilation and air conditioning, and Guide C covering reference data. It especially complements the CIBSE Concise Handbook[8] a companion volume showing the use and practical application of commonly used design data from other CIBSE Guides.

The Practical Guide to Building Services calculations also closely complements the BSRIA Guide: BG 4/2007 *Design Checks for HVAC – a quality control framework (Second edition)*[3]. This provides good practice guidance for building services technical procedures and design management, including design guidance sheets for 60 key design topics and check sheets that can be used in project quality assurance procedures.

New entrants to building services may find it helpful to read the overview information given in the BSRIA illustrated guides volumes 1 and 2.[9]

THE BUILDING SERVICES DESIGN PROCESS

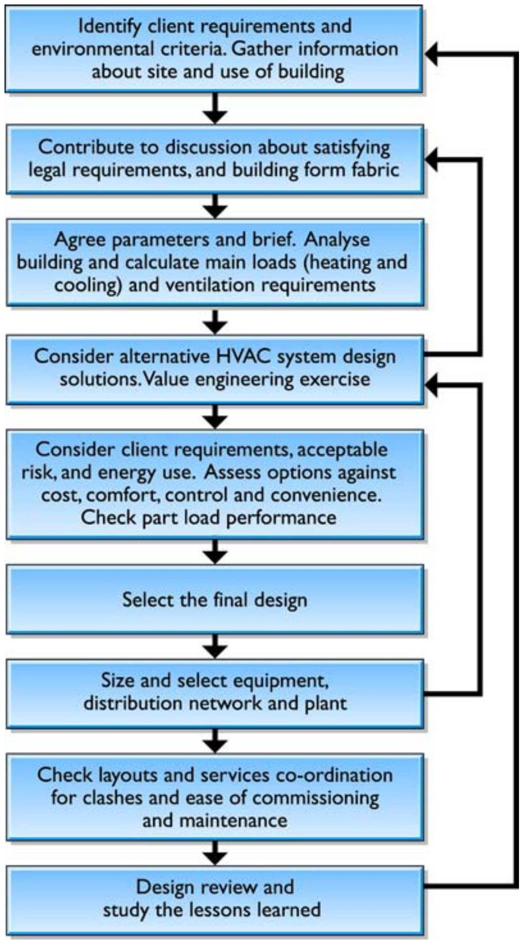
Calculation procedures are a necessary component of design but it is important to see them in the context of the whole design process. Decisions made as part of initial design and during the calculation procedures will affect system design, installation, operation and control.

The BSRIA publication *Design Checks for HVAC – a quality control framework (Second edition)*[3], provides a useful and relevant discussion of the building services design process. As part of this work, a detailed analysis of design procedures and tasks was carried out for building services design and a simple linear model of the building services design process derived was derived as shown. This gives a single design sequence, from statement of need, through problem analysis, synthesis and evaluation to final solution and enables design tasks to be clearly linked to both preceding and succeeding actions. Some primary feedback loops are shown, but in practice there are often feedback loops between all tasks and even within specific tasks.

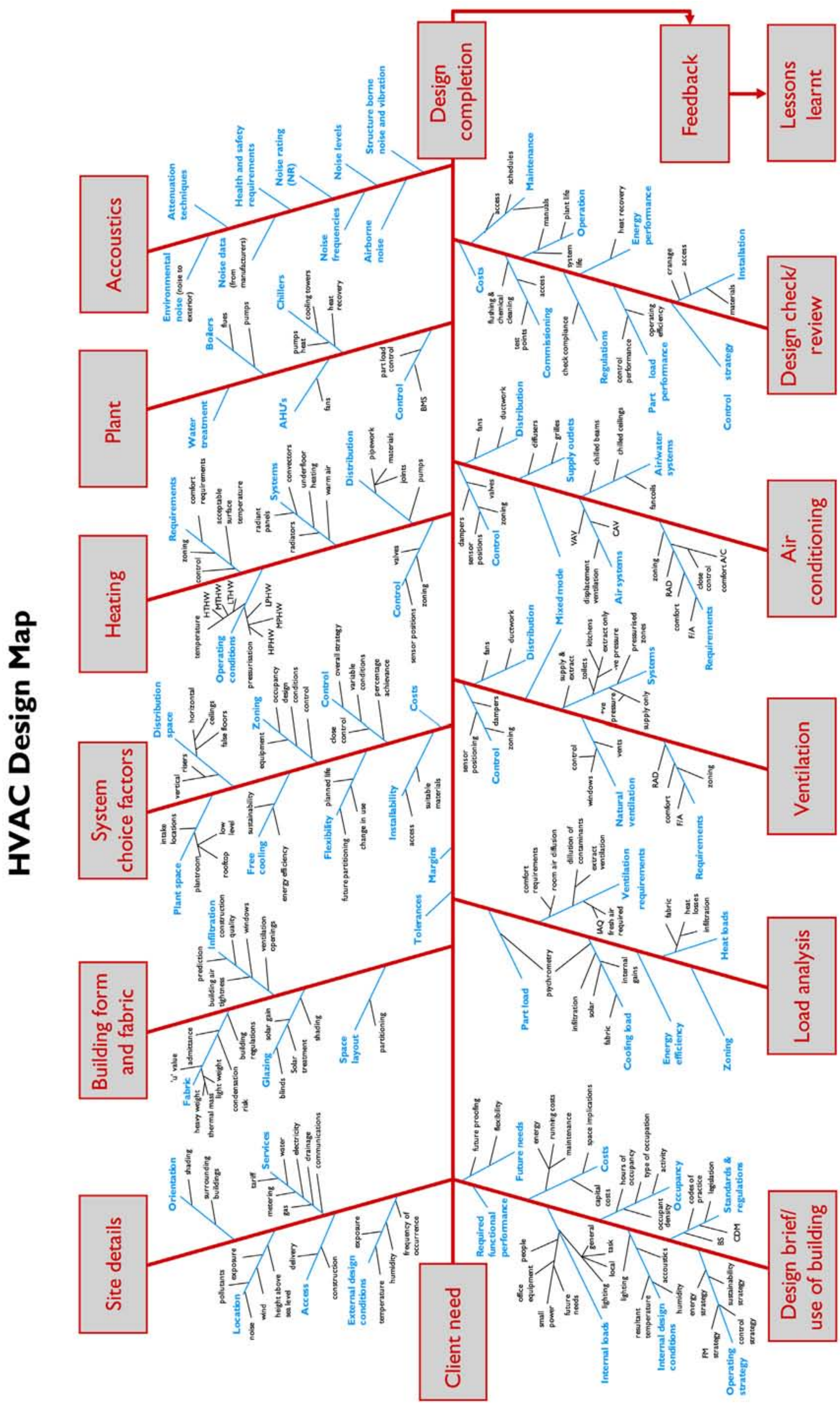
This work also mapped the building services design process, both as a sequence of design tasks and as a series of topics that make up the design process. This detailed map of the process is shown opposite. The map is shown as a linear view of design, (with iteration and intermediate feedback omitted) in the form of an Ishikawa or fishbone diagram. The process originates from the client's need on the left with various branches feeding into the main design line to eventually reach design completion and design feedback. The map may be of particular benefit to junior engineers as it will enable them to put their contribution to the whole design process in context. When engineers carry out load calculations or pipe sizing, it is easy to forget that this is part of a larger process with consequences for impact on future system installation, operation and control.

Note that CIBSE Guides B1 to B5 have been combined to form *Guide B – Heating, Ventilation, Air Conditioning and Refrigeration*. This publication provides references to both individual B guides and the combined B Guide where appropriate.

Figure 1: Simple example of a building services design process.



THE BUILDING SERVICES DESIGN PROCESS



OVERVIEW OF CALCULATION SHEETS

The calculation sheets are organised into five sections covering over 30 topics relevant to building services design:

Heating loads and plant

This section covers the key topics and calculations relevant to establishing heat loads for a space or building and sizing heating plant, covering infiltration, U values, heat loss, heating load, radiator sizing and boiler sizing. It explains how to use design data from different sources to establish heat losses and heating loads and explains the different components that make up plant loads.

Cooling loads and plant

This section covers the key topics and calculations relevant to establishing cooling loads for a space or building and sizing cooling plant, covering internal gains, external gains, cooling load, supply air temperature, cooler battery sizing and humidifier duty selection. It provides an overview of heat gains, explains maximum simultaneous loads and explains how to determine acceptable supply air temperatures and size plant components.

Water flow distribution systems

This section covers the key topics and calculations relevant to the sizing of water flow distribution systems, covering pipe sizing, system resistance, pump sizing and water system pressurisation. It explains how to read information from pipe sizing tables, how to work out pressure loss through pipe fittings, and how to determine the index run.

Air flow distribution systems

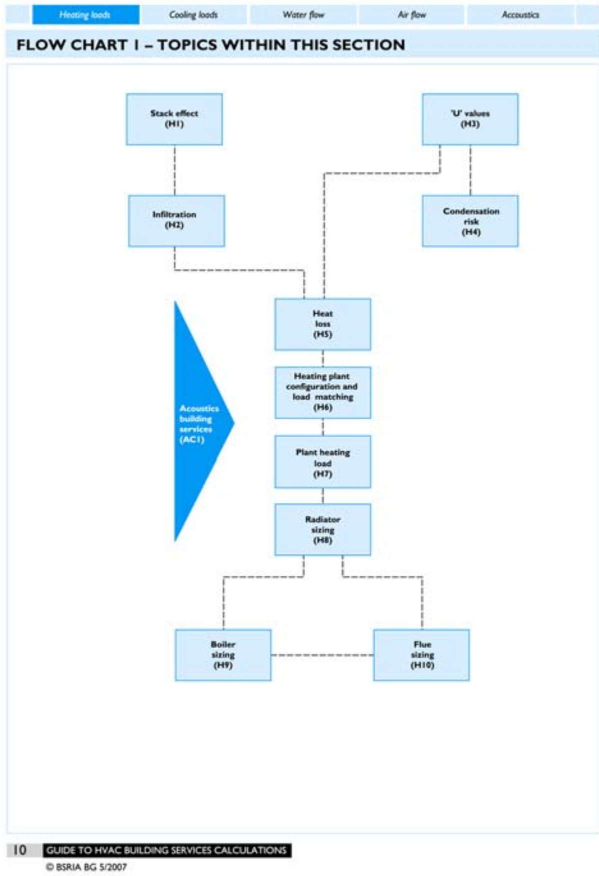
This section covers the key topics and calculations relevant to the sizing of air flow distribution systems, covering duct sizing, system resistance, fan sizing, grille and diffuser sizing, and space pressurisation. It explains how to read information from the CIBSE duct sizing chart, how to convert from circular to rectangular duct sizes, discusses practical selection of duct sizes to enable economic system installation, explains how to work out pressure loss through duct fittings, and how to apply corrections for air density changes.

Acoustics

This section shows how acoustics must be considered in building services design as most items of mechanical plant or equipment generate noise. This noise can be transmitted through the building to its occupants and outside the building to the external environment.

Calculation flowcharts are provided at the beginning of each section as shown opposite. These show the calculation procedures in that section and help to explain how different calculation routines link in sequence to build up the design process. This enables any one calculation sequence to be viewed in the context of the broader design process. Some other relevant design inputs and related processes are also shown for completeness, although they are not included in this current guidance as detailed calculation procedures.

Although the calculation procedures provided in this guide are grouped into four sections with calculation sequence flowcharts given for each section, during a real design process all the sections will inter-link. For example, emitter and boiler sizing will require consideration of pipe sizing, boiler sizing needs, details of heater batteries, duct sizing requires consideration of heating and cooling loads and ventilation requirements.



For each calculation topic the guidance provides the following information, as appropriate:

Overview

An overview of the calculation topic and procedure explaining what it is and where and when it is used to put it in context.

Design information required

This explains literally what you need to know to carry out a particular calculation, such as the design information necessary for a procedure, for related design decisions, system layouts or selection of equipment. This could include design data such as an internal design temperature or a mass flow rate, fluid type and temperature, and other design information such as duct material, insulation details and floor to ceiling heights.

Key design inputs

Key technical data (with units) essential for that particular calculation procedure such as mass flow rate, heating load, and limiting pressure drops.

Design outputs

The required design output from a particular calculation procedure which will be used to either inform future design, or to form part of the specification or design production, such as schedules of loads, schematic diagrams, system layout drawings with sizes and design data included, and schedules of equipment sizes and duties.

OVERVIEW OF CALCULATION SHEETS

Design approach
This provides guidance on the design approach to be considered during a calculation procedure and points to be aware of such as designing to minimise noise, the need to check that all of a system is under positive static pressure and the need to reduce corrosion risk.

Calculation procedure
This provides step-by-step procedural guidance, explaining the use of any charts or tables that are likely to be used.

Note: While the calculation procedures are as comprehensive as possible, no design guidance manual can be fully comprehensive for all design applications. It is the responsibility of the designer to add additional information as required by a particular project. Every design project is different and has differing needs and it is the responsibility of the design engineer to fully consider all design requirements

Example
One or more worked examples to illustrate the calculation procedure in detail.

Rule of thumb design data/ cross-check data
Relevant rule-of-thumb data which could be used (with caution) to provide reasonable data for use in design, such as selection of an acceptable pressure drop for use in pipe or duct sizing, or could be used to provide an approximate order of magnitude, a cross-check on a design output such as a watts per square metre, or watts per cubic metre check on a heating load.

References
Reference to relevant design information sources, such as *CIBSE Guides*, BSRIA publications, and *Building Regulations*.

See also:
Reference to other relevant calculation sheets in this guide.

Design tips
These provide practical design tips at the point where they are relevant during the explanation of the calculation procedure.

- **Design tip:** For example, the tips could include checking ceiling space available for ductwork distribution, checking both velocity and pressure drops are acceptable.

Design watchpoints
These provide guidance on things to watch out for or be aware of during the design process. An example is shown below.

DESIGN WATCHPOINTS

1. For example, the design watchpoints could include checking that the minimum fresh air requirement is always met, to cross-check computer outputs, to check noise levels are acceptable from selected grilles and diffusers, to ensure that duct dimensions selected are standard or readily available sizes.

Use of the guidance
Design calculations are part of the design process and therefore will form part of the project design file and records and be subject to standard in-company quality assurance (QA) and quality control (QC) procedures. As such they should always be properly recorded and checked. By clearly identifying required design inputs and design outputs in this guidance, and providing a clear methodology, users are encouraged to follow a good practice approach to design. Junior engineers would be expected to use this guidance within a framework of adequate supervision within their organisations, however the following notes highlight some good practice approaches to the use of design calculations.

Identify data sources
It is good practice to clearly record/cross-reference to data sources to enable input information to be adequately verified and to allow track-back of data if necessary. This is particularly important if changes occur in the design which necessitate reworking certain design calculations. Data used should be clearly identified as eg from a client brief (with date and design file reference), or from good practice sources such as the CIBSE Guides, BSRIA publications, British Standards etc. (again with precise details of the publication, date and exact source reference eg page number, table etc),

State assumptions
Where any assumptions are made in the calculation process because data is currently unknown these should be made overt, ie clearly noted as assumptions, and if necessary approved by a senior engineer. Assumptions made should always be reviewed at the end of any calculation process to check again that they were reasonable. If a calculation will need to be redone when more detailed information is provided (eg from a client, manufacturer etc) then this should be clearly noted.

Record calculations clearly
Design calculations should always be properly recorded and checked. Always ensure that all calculations are recorded in sufficient detail that they can be clearly followed by others. Be aware that if a problem arises on a project this could mean revisiting calculations several years after they were originally done.

Avoid margins without justification
Margins should never be added during a calculation process without an adequate reason for doing so and with the approval of a senior engineer. Excessive margins can result in system oversizing and poor operational performance and control. If any margins are used they should be clearly identified and a justification given for their use, which should be recorded in the design file. The use of margins should be reviewed at several stages during the design process to check their appropriateness and avoid any duplication or excess eg at the end of a calculation procedure, at design review stage etc.
(For more information on the use of margins in engineering design refer to *Design Checks for HVAC – A Quality Control Framework for Building Services Engineers*[3], topic sheet number 1 – Design Margins and CIBSE Research Report RR04, *Engineering Design Margins*[1].)

OVERVIEW OF CALCULATION TOPICS

Heating loads and plant

H1 Stack effect
H2 Infiltration
H3 U values
H4 Condensation risk
H5 Heat loss
H6 Plant heating load
H7 Heating plant configuration and load matching
H8 Radiator sizing
H9 Boiler sizing
H10 Flue sizing

Cooling loads and plant

C1 Internal heat gains
C2 External gains
C3 Cooling plant loads
C4 Ventilation – Outdoor air requirements
C5 Supply air quantity and condition
C6 Heating/cooling coil sizing
C7 Return air temperature effects on coil duty
C8 Humidifier duty
C9 Dehumidification

Water flow distribution systems

W1 Pipe sizing – General
W2 Pipe sizing – Straight lengths
W3 Pipe sizing – Pressure drop across fittings
W4 System resistance for pipework – Index run
W5 Pump sizing
W6 Control valve selection/sizing
W7 Water system pressurisation

Air flow distribution systems

A1 Duct sizing – General
A2 Duct sizing – Selecting a circular duct size
A3 Duct sizing – Circular to rectangular ducts
A4 Duct sizing – Pressure loss through fittings
A5 Duct system – Index run
A6 Fan sizing
A7 Grille and diffuser sizing
A8 Air density correction
A9 Pressurisation of spaces

Acoustics

AC1 Acoustics for building services

REFERENCES

1 Lawrence Race G, BSRIA, Parand F, BRE, *Engineering Design Margins*, CIBSE Research Report RR04 1997. Available free to CIBSE members at www.cibse.org.

2 Lawrence Race G, Pearson C & De Saulles T, *Feedback for Better Building Services Design*, AG 21/98, BSRIA 1998 ISBN 0 86022 520 8

3 Lawrence Race G, *Design Checks for HVAC – A Quality Control Framework (Second edition)*, BSRIA BG 4/2007. ISBN 978-0-86022-669-7

4 From information gathered for the publication *Design Checks for HVAC – A Quality Control Framework (Second edition)*, BSRIA BG 4/2007

5 CIBSE Design Guides, including Volumes: A *Environmental Design*, 2006, ISBN 1 903287 66 9; B *Heating, Ventilating, Air Conditioning and Refrigeration.*, ISBN 1 903287 58 8, C *Reference Data 2007,* ISBN 9 781903287 80 4

6 H Connor, S Dench, P Bates, *An Assessment of Skill Needs in Engineering*. DfEE Skills Dialogues SD2, February 2001.

7 Professor D Gann & Dr A Salter, *Interdisciplinary Skills for the Built Environment Professional*, Arup Foundation 1999.

8 CIBSE, *Concise Handbook*, 2003, ISBN 1 903287 44 8

9 De Saulles, T, *Illustrated Guide to Building Services,* 27/99, BSRIA 1999, ISBN 0 86022 543 3, and *Illustrated Guide to Electrical Building Services* AG 14/2001, BSRIA 2001, ISBN 0 86022 586 0

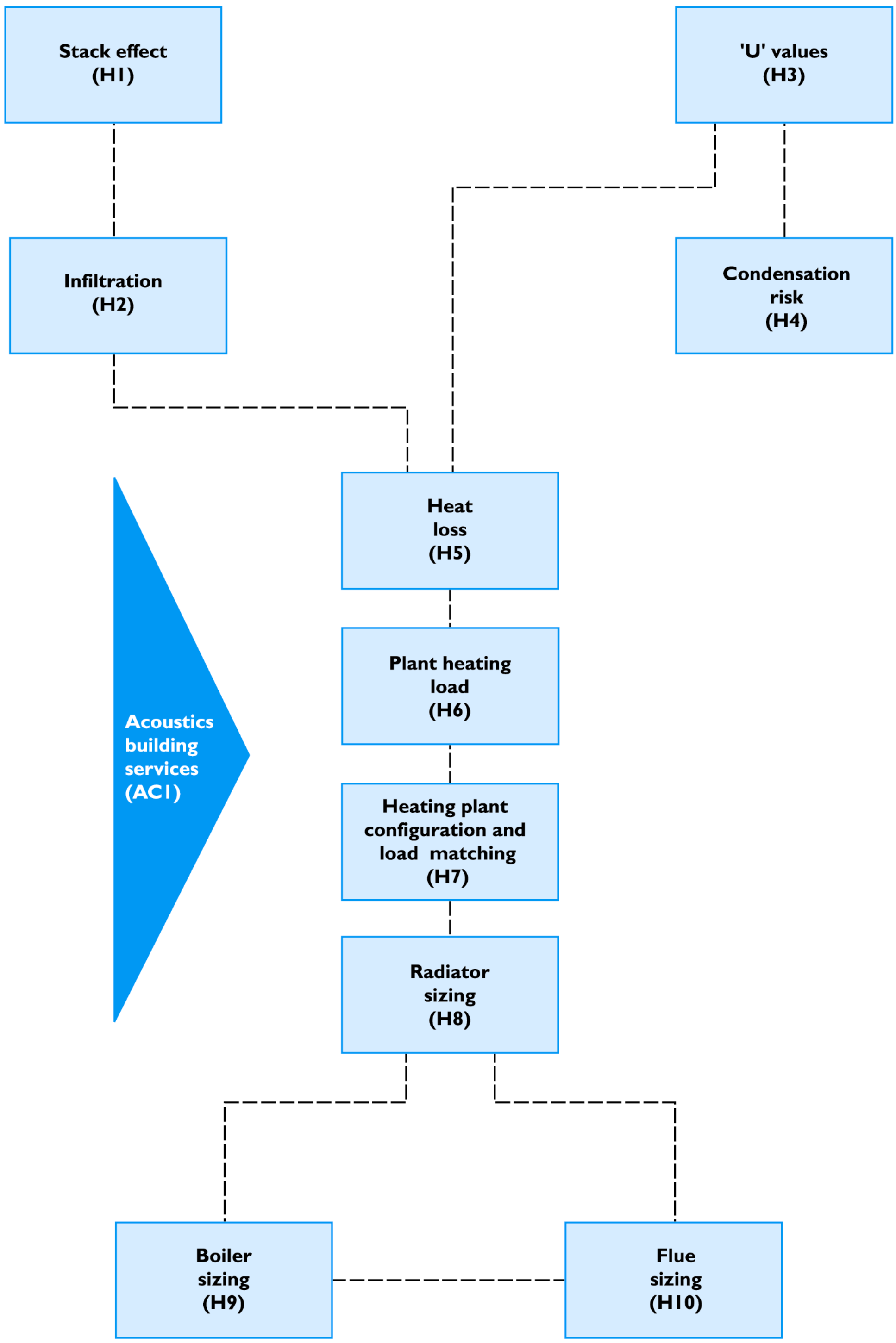
The following section contains ten building services engineering topic areas related to the design of heating systems, including heating loads and plant sizing.

The following two pages contain flow charts of the relevant design and calculation processes.

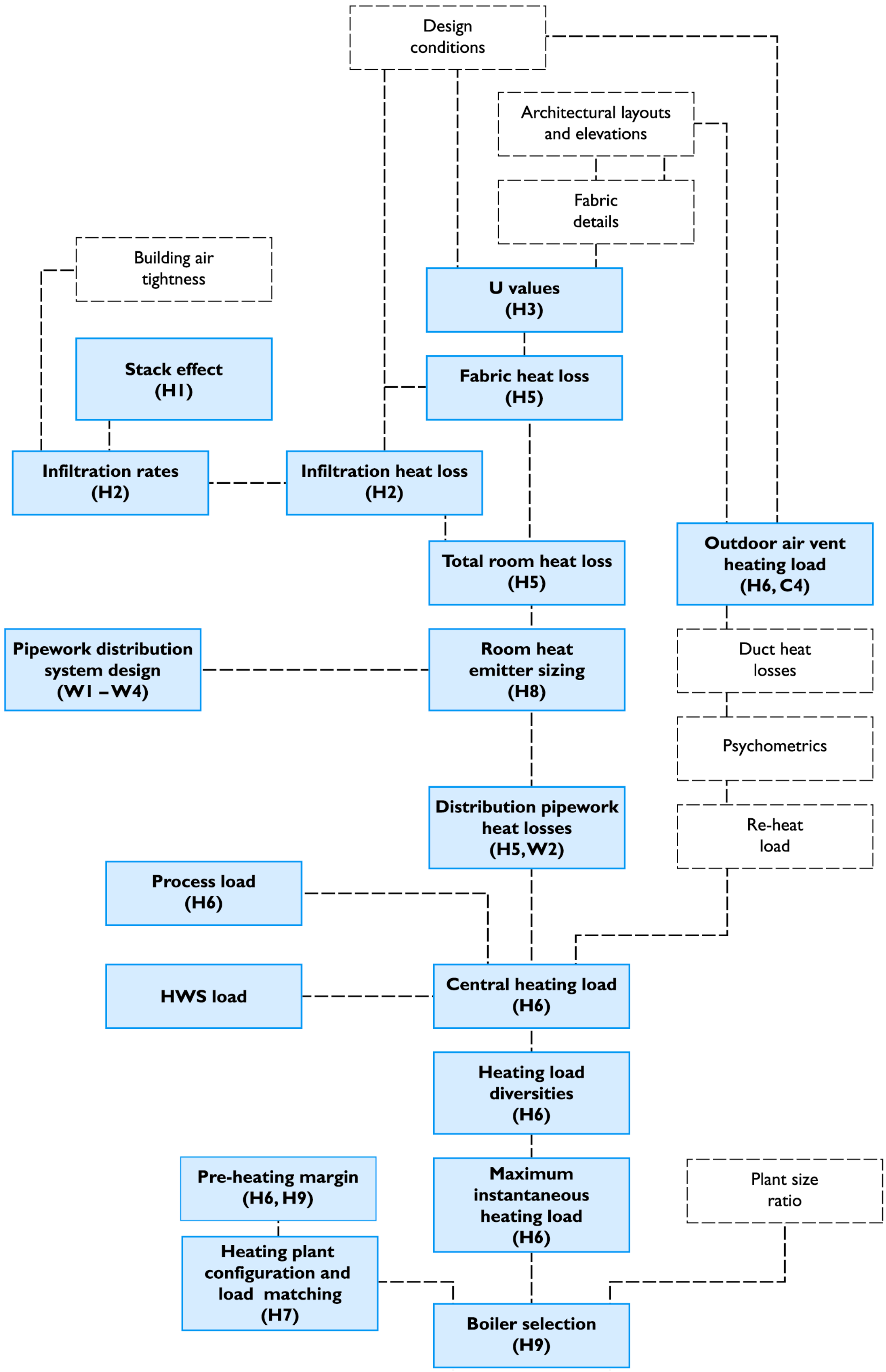
The first flow chart shows the ten topics within this section.

The second flow chart provides an overview of the process, showing some of the many related topics that need to be considered in the design of heating systems. The boxes highlighted in blue show an area that is fully or partially covered within one of the ten topic areas in this section, or in the rest of the guidance, with the appropriate reference numbers given.

FLOW CHART 1 – TOPICS WITHIN THIS SECTION



FLOW CHART 2 – OVERVIEW OF SYSTEM DESIGN PROCESS



This chart shows the design areas relevant to this design process. Where design areas are wholly or partially discussed in this document the relevant sheet references are given in brackets

H1 STACK EFFECT

Overview

Non-mechanical airflow through a building can occur due to both wind pressure imposed on a building and temperature differences between the inside and outside air.

Stack effect is a difference in pressure caused by a difference between inside and outside air temperature which gives different air densities, thereby causing vertical air movement.

In practice, wind pressures will modify stack effect (this aspect is not dealt with in this sheet). Further information is found in CIBSE AM 10 *Natural ventilation in non-domestic buildings*.

This pressure difference can be used to promote air movement, but will always be dependant on the difference in temperatures, and so may not be practicable for all ventilation applications.

To promote air movement through stack effect, there must be an air inlet point and an air outlet point, and the greater the vertical distance between the two the greater the stack effect.

The direction of air flow will depend on the temperature values. In other words, when the inside temperature is greater than the outside temperature, the resulting air flow will be upwards with air entering through the lower opening and exiting through the higher opening. If, however, the internal temperature should be lower than that outside, then the airflow would reverse, with air entering through the higher opening and leaving through the lower one.

The principle of stack effect can be used for daytime ventilation and also free cooling overnight. This is done by drawing cooler night time air through the building to reduce the internal temperature before occupancy the following morning. This can be very effective at liberating (after occupancy hours) the heat energy stored in the thermal mass of the building structure.

Another use is to limit internal temperature rise within a machine enclosure. Where internal gains are very high, a tall enclosure is constructed with vents or openings at high and low level. The airflow created by the stack effect reduces the internal temperatures to acceptable operating conditions for the machinery.

Standard calculations are available in chapter 4 of *CIBSE Guide A* for the estimation of airflow through simple building layouts. Additional information on wind pressure can also be found in chapter 4. For buildings that have a more complex arrangement of opening layouts, additional information can be found in the CIBSE publication *AM10 Natural ventilation in non-domestic buildings 2005*.

Design information required

Type, size and location of openings

The type and shape of the openings will have an effect on the airflow through them, and so needs to be accurately identified.

Key design inputs

- Inside and outside air temperatures (°C). The difference between inside and outside temperatures affects the difference in density and difference in pressure. The temperature difference is required as it causes the difference in pressure of the internal and external air masses which results in stack effect
- Height difference between inlet and outlet points (m). The greater the difference between the two openings, the greater the stack effect that can be achieved

Design outputs

- Ventilation strategy and specification including ventilation type, such as cross ventilation, single-sided ventilation; schedule of window types, actuators, method of control; and schedule of transfer grilles
- Analysis of predicted ventilation performance
- Requirements for solar shading, where appropriate
- Layout plan drawings showing air flow paths
- Control philosophy to be applied, where appropriate

Calculation approach

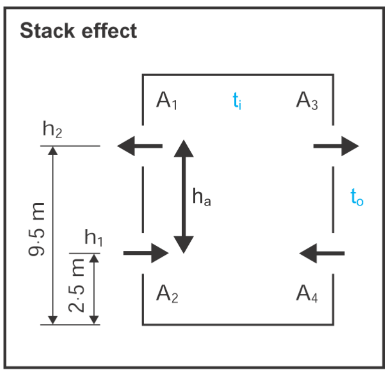
1. Select appropriate calculation according to the building layout
2. Identify the inside and outside air temperatures that are to be applied to the calculation
3. Identify the height difference between the inlet and outlet points (centre to centre)
4. Identify the type, size and shape of the opening, (some factors in the equation may vary according to this)
5. Enter values into equation to calculate the volume flow rate through the building.

Example

Calculate the rate of natural airflow due to temperature through the building described below.

Design data

The building has four openings for ventilation, two on each of the opposite sides, one at high level one at low level.



H1 STACK EFFECT

Where:

t_i = Mean inside temperature (°C)
t_o = Mean outside temperature (°C)
A_1, A_2, A_3, A_4 = Opening areas (m^2)
h_1, h_2 = heights above ground of centres of openings (m)
h_a = Difference between heights h_1 and h_2
(9·5 m – 2·5 m = 7 m)

Using equation:

$$Q_b = C_d \times A_b \times \left(\frac{2 \times \Delta t \times h_a g}{\bar{t} + 273} \right)^{0.5}$$

Where:

Q_b = volumetric flow-rate due to stack effect only (m^3/s)
C_d = discharge coefficient (value for a sharp opening is 0·61)
A_b = equivalent area for ventilation by stack effect only (m)
g = acceleration due to gravity (9·81 m/s^2)
$\bar{t}$ = mean of t_i and t_o (°C)
Δt = temperature difference between inside and outside
A_b = found from:

$$\frac{1}{A_b{}^2} = \frac{1}{(A_1 + A_3)^2} + \frac{1}{(A_2 + A_4)^2}$$

Area of openings:

$A_1 = 1\ m^2$
$A_2 = 0{\cdot}75\ m^2$
$A_3 = 1\ m^2$
$A_4 = 0{\cdot}75\ m^2$

Temperatures:

Summer
t_i = 22°C
t_o = 26°C

Therefore:

Δt = 26–22 = 4°C
$\bar{t}$ = (22 + 26)/2 = 24°C

Find A_b

$$\frac{1}{A_b{}^2} = \frac{1}{(1+1)^2} + \frac{1}{(0 \cdot 75 + 0 \cdot 75)^2}$$

$$\frac{1}{A_b{}^2} = \frac{1}{2^2} + \frac{1}{1 \cdot 5^2}$$

$$\frac{1}{A_b{}^2} = \frac{1}{4} + \frac{1}{2 \cdot 25}$$

$$\frac{1}{A_b{}^2} = 0 \cdot 25 + 0 \cdot 444 = 0 \cdot 694$$

$$\frac{1}{0 \cdot 694} = A_b{}^2$$

$$1 \cdot 44 = A_b{}^2$$

Therefore:

$$A_b = \sqrt{1 \cdot 44} = 1 \cdot 20 m^2$$

With all the variables found the flow rate can be calculated:

$$Q_b = 0 \cdot 61 \times 1 \cdot 2 \times \left(\frac{2 \times 4 \times 7 \times 9 \cdot 81}{24 + 273} \right)^{0.5}$$

$$Q_b = 0 \cdot 732 \times \left(\frac{549 \cdot 36}{297} \right)^{0.5}$$

$$Q_b = 0 \cdot 732 \times (1 \cdot 849)^{0.5}$$

Therefore:

$$Q_b = 0 \cdot 732 \times 1 \cdot 36 = 0 \cdot 995\ m^3/s$$

References

CIBSE Guide A, *Environmental Design*, 2006, ISBN 1 903287 66 9
CIBSE, *Natural Ventilation in Non-Domestic Buildings*, AM10, 2005, ISBN 1 903287 56 1
AIVC 1998, *TN 44 Numerical Data for Air Infiltration & Natural Ventilation Calculations,* ISBN 1946075972

See also:

Sheet H2 Infiltration
Sheet H5 Heat loss
Sheet C1 Internal heat gains
Sheet C2 External gains
Sheet C4 Ventilation – Outdoor air requirements
Sheet A8 Air density correction
Sheet A9 Pressurisation of spaces

DESIGN WATCHPOINTS

1. Be sure of the direction of airflow as it may change through the year as the outside temperature changes.
2. Make sure that airflow induced by stack effect does not cause problems with over- pressurising a space, or disturbing the design airflow patterns of ventilation and air conditioning systems.
3. Wind pressures acting on the building may nullify the pressure difference induced by stack effect.
4. Air paths or openings, provided to make use of airflow from the stack effect, might affect heat loss if they are not able to be closed.
5. Openings for stack effect airflow may represent a security risk if they are not satisfactorily secured.
6. Internal partitions and obstructions may lessen the effect by imposing greater resistance on the flow of air. Stack effect should ideally be limited to single zone areas.

ALPHABETICAL LIST