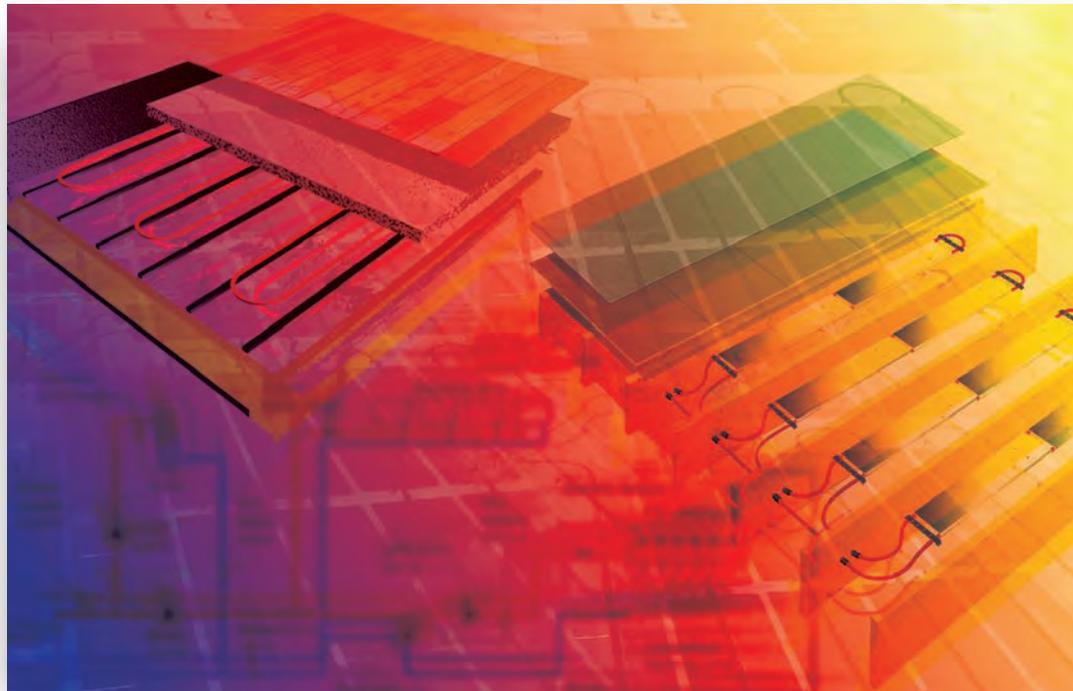


Underfloor Heating and Cooling



By Reginald Brown



ACKNOWLEDGEMENTS

BSRIA would like to thank the Underfloor Heating Manufacturers Association (UHMA) for their support. The project was organised on behalf of UHMA by the following member companies:

Rod Hickmott, Maincor (Fundraising)
Mike Lamb, Warmafloor (Technical co-ordination).

The project was undertaken by BSRIA with the assistance of a project steering group drawn from representatives of the following companies who provided BSRIA staff with technical assistance and supported the publication of this guide:

Continental Underfloor Heating
Danfoss Randall Ltd
Emmeti Ltd
Maincor Ltd
Rehau Ltd
Underfloor Warehouse Ltd
Uponor Housing Solutions Ltd
Warmafloor (GB) Ltd
Wavin UK.

Acknowledgement is also given to the following organisations for their assistance in providing technical information and commenting on draft publications:

AECOM
Hampshire County Council
Hoare Lea
National House-Building Council
WSP.

BSRIA would also like to thank John Sands who authored the original BSRIA publication AG 12/2001: *Underfloor Heating Systems – The Designers Guide* and provided initial input to this guide.

This publication has been designed and produced by Ruth Radburn and Alex Goddard.

BSRIA is grateful for the use of photographs and illustrations. The use of such photographs does not in any way imply endorsement of the products shown.

Every opportunity has been taken to incorporate the views of the contributors, but final editorial control of this document rests with BSRIA.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means electronic or mechanical including photocopying, recording or otherwise without prior written permission of the publisher.

CONTENTS

1	INTRODUCTION	1
1.1	Purpose of this guide	1
1.2	The format of this guide	1
2	PRINCIPLES	3
2.1	Thermal comfort	3
2.2	Heat emitters	3
2.3	Spatial temperature profile	4
2.4	Benefits of underfloor heating	6
3	UNDERFLOOR TECHNOLOGY	8
3.1	Systems	8
3.2	Floor structures	17
3.3	Applications	23
3.4	Underfloor cooling	25
4	SYSTEM DESIGN	27
4.1	Allocation of responsibilities	27
4.2	Provision of information	28
4.3	Design standards	29
4.4	Design criteria	30
4.5	Heat loss calculations	31
4.6	System sizing for heating	34
4.7	System sizing for cooling	40
4.8	System water flow rate	42
4.9	System water pressure drop	42
4.10	Layout	42
4.11	Control	43
4.12	Warranties and guarantees	45
4.13	Costs	46
5	DISTRIBUTION AND CONTROL	48
5.1	Hydronic underfloor heating control	48
5.2	Heating and cooling integration	57
5.3	Electric underfloor systems	60
5.4	Summary	62
6	ENERGY SOURCES	63
6.1	Conventional boilers	63
6.2	Biomass boilers	64
6.3	Heat pumps	66
6.4	Combined heat and power plant	73
6.5	Wind turbines	74
6.6	Solar collectors	74
6.7	Summary	76

CONTENTS

7	FLOOR FINISHES	77
7.1	Surfaced concrete and screed	77
7.2	Masonry finishes over concrete and screed	78
7.3	Masonry finishes over floating or suspended floors	79
7.4	Thermoplastic tubes	79
7.5	Impact flooring	79
7.6	Carpet and underlay	80
7.7	Wood and laminate flooring	81
7.8	Effect of floor finishes on thermal performance	82
8	INSTALLATION AND MAINTENANCE	83
8.1	Design issues	83
8.2	Installation process	87
8.3	Commissioning, balancing and start-up	91
8.4	Handover	92
8.5	Maintenance	92
8.6	Thermographic surveys	93
	REFERENCES	115

APPENDICES

APPENDIX A:	EXAMPLE CALCULATIONS	94
APPENDIX B:	CHECKLISTS	98
APPENDIX C:	2010 BUILDING REGULATIONS	112
APPENDIX D:	ESTIMATING COOLING CAPACITY	113

TABLES

Table 1: Comparison of underfloor heating with other systems	7
Table 2: Comparison of underfloor heating pipes	12
Table 3: Recommended insulation value below underfloor heating (from <i>BS EN 1264-4:2009</i>)	14
Table 4: Types of insulation	15
Table 5: Applicability of underfloor heating	23
Table 6: Specific applications and benefits of underfloor heating and cooling	24
Table 7: Applications not usually suitable for underfloor heating	25
Table 8: Potential applications of underfloor cooling	26
Table 9: Performance table showing heat outputs to <i>BS EN 164</i> for 16mm OD PE-X/PE-RT underfloor heating pipes embedded within 75mm floor screed (50mm screed thickness above pipe) – floor covering resistance of 0.00 m ² K/W	39
Table 10: Control elements associated with underfloor heating systems	52
Table 11: Application of optimum start and night set-back	57
Table 12: Typical properties of biomass fuel	65
Table 13: Example variation of ground-source heat pump COP with temperature	67
Table 14: Maximum extraction rates for buried ground coils	69
Table 15: Recommended maximum length for different pipe sizes	70
Table 16: Maximum extraction rates for close loop boreholes	70
Table 17: Summary of potential low carbon heat sources for underfloor heating	76
Table 18: Design criteria at an external temperature of 5°C	94
Table 19: U-values for various construction elements	94
Table 20: Heat losses (excluding floor loss)	95
Table 21: Required heat output values	95
Table 22: Pipe spacing at 45°C	96
Table 23: Pipe spacing at 45°C and 40°C	97
Table 24: Water flow rate	97

FIGURES

Figure 1: Ideal temperature profile	5
Figure 2: Profile for underfloor heating	5
Figure 3: Profile for radiators	5
Figure 4: Profile for convector heating	5
Figure 5: Typical screeded floor construction	18
Figure 6: Typical floating floor construction	19
Figure 7: Floating floor with spreader plates	19
Figure 8: Pipe in insulation covered by screed	20
Figure 9: Typical intermediate/suspended floor construction	20
Figure 10: Pipe laid on insulation material set between joists	21
Figure 11: Suspended floor system with quilt and spreader plates	21
Figure 12: Heating pipe integrated within floor panel	22
Figure 13: Underfloor heating for raised access floor system	23
Figure 14: Annual hours exceeding an outdoor temperature	25
Figure 15: Simplified product-specific sizing chart	37
Figure 16: Simplified product-specific sizing chart for cooling	41
Figure 17: Typical schematic for a domestic underfloor heating system	44
Figure 18: Typical schematic for a commercial underfloor heating system	44
Figure 19: Historical pipework circuit arrangement	49
Figure 20: Modular heating manifolds	50
Figure 21: Schematic of two-port manifold	50
Figure 22: Typical pre-assembled two-port thermostatic manifolds with integral pump	51
Figure 23: Underfloor heating circuit control	53
Figure 24: Principle of weather-compensated flow temperature	54
Figure 25: Underfloor heating circuit with weather compensation control	54
Figure 26: Domestic central heating	56
Figure 27: Passive cooling with ground-source heat pump (internal circulation pumps)	58
Figure 28: Passive cooling with ground-source heat pump (external circulation pumps)	58
Figure 29: Underfloor cooling for a boiler-fed system	59
Figure 30: Cooling system controls	60
Figure 31: Mains voltage electric floor heating	61
Figure 32: An integrated biomass boiler and fuel delivery system	64
Figure 33: Closed cycle vapour compression heat pump	67
Figure 34: Horizontally laid coils	69
Figure 35: Flat-plate solar collector	75
Figure 36: Additional rug placed over carpet	82
Figure 37: Example of a flushing bypass	90
Figure 38: Colour thermographic image of an underfloor heating installation	93

I INTRODUCTION

I.1 PURPOSE OF THIS GUIDE

In 2001 BSRIA was asked by the underfloor heating industry to provide technical guides to help promote the understanding and application of underfloor heating. While underfloor heating systems that used the latest materials were seen as innovative and having enormous potential, there was little appreciation by building services designers of the technological and design issues. As a result BSRIA publications AG 12/2001: *Underfloor Heating Systems – The Designers Guide* and AG 13/2001: *Underfloor Heating Systems- An Assessment Standard for Installations* were published. It is now time to review this and this guide replaces the previous BSRIA publications.

The objective of the guides was to familiarise building services designers with the basics of the technology, and to make them better able to select and apply the most suitable options. For other construction professionals such as architects, structural engineers, quantity surveyors and contractors the guides would help them appreciate the services issues and their relationship with other aspects of the building project.

The guides would also be helpful for those professionals, such as facilities managers, who are not directly involved in the design and construction aspects of a project but are interested in the operational performance of underfloor heating, and non-technical people, such as clients and end-users who might be considering such systems.

This revised guide reflects the advances in the technology, design methods and applications that have taken place in the last ten years, including the growth in cooling applications and the integration of renewable energy into many underfloor heating schemes.

It should enable building services designers to familiarise themselves with the key issues surrounding the design of modern underfloor heating and cooling systems, assess whether those systems would be appropriate for their applications, and initiate the design process.

I.2 THE FORMAT OF THIS GUIDE

This guide is organised into the following sections:

Principles - Discusses the essential principles of thermal comfort and the underlying reasons for differences in performance between conventional and underfloor heating solutions.

Underfloor technology – Describes the typical components of underfloor heating and cooling systems.

System design – Outlines the design process and explains where underfloor heating and cooling systems differ from conventional systems. Explains the calculation methods based on manufacturers' information produced in accordance with *BS EN 1264 Part 3*^[1] (with worked examples) and introduces good design practice. Some of the technical issues are explored in more detail in later sections.

Distribution and control – Examines controls and control strategies in more depth.

Note that the schematics provided in this document are intended to explain the principles of operation discussed in the text. They do not necessarily show all the components (strainers, vents, pressurisation systems, expansion vessels, and safety valves) that are required for a complete system.

Energy sources – Discusses the various sources of heat and cold that may be attached to the underfloor system including both conventional boiler and chiller plant and renewable heating and cooling options.

Floor finishes – Compares different floor finishes in respect of their appropriateness for underfloor heating and cites the relevant standards.

Installation and maintenance - Highlights good practice to help avoid installation problems on site. Provides useful guidance for other members of the professional team with respect to the interfaces between disciplines.

The checklists in Appendix B are available as a download from the BSRIA website.