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Contents

1 Introduction

1.1 Background and aim of the research project

The protection of safety and health of their citizens is a major reason for governments to draw up laws, rules and regulations for the built environment. In the course of time other points of departure, such as utility, energy economy, sustainability and economic motives have come to play a part. For these subjects technical requirements are formulated and the regulations procedures have been laid down in laws for checking building plans against the requirements and issuing the building permits. The procedures usually continue through the construction period until the building is completed, inspections in the building phase ensuring the building for which the building permit has been issued is also really being built according to the plan.

This report is the result of an international research project into the systems of building regulations, implementation and control and the systems of technical requirements in the following eight European countries: the Netherlands, England, France, Germany, Sweden, Norway, Belgium and Denmark. The research project was focused on the technical requirements for dwellings and systems that ensure that these requirements are met.

The project was initiated and financed by the Dutch ministry of Housing, Physical Planning and Environment. The first motive to commission the project was to generate ideas and arguments that could contribute to the discussion within the Discussion platform Building Regulations (*OverlegPlatfom Bouwregelgeving)* concerning the future development of the Dutch system of building regulations. This discussion platform consists of representatives of organisations in the building sector (including local authority building control) and has been established by the secretary of state of the ministry of Housing, Physical Planning and Environment. The main function of the platform is to advise the secretary of state of Housing about changes in the building regulations to ensure that they are broadly accepted in the building sector.

1.2 Research questions

The general aim of the project was further specified by the research group, in consultation with the Ministry of Spatial Planning, Housing and the Environment and the Discussion platform Building Regulations to the following research questions:

I *How do the Dutch building regulations relate to the regulatory systems of other European countries?*

The following assessment criteria are used to compare the regulatory systems:

- the scope of government responsibility (quality aspects, control procedures,

control tasks);
- the effectiveness of the regulatory systems (to what level are the goals of the regulatory system realised); and
- the efficiency of the regulatory systems (which is the administrative and financial burden for citizens, companies and governments).

II *Are the systems of building control in the European countries converging or diverging?*

III *What are the interesting elements of the regulatory systems of the different countries that contribute to effective and efficient building control and could be the ingredients for a uniform system of building control in Europe in the future?*

These questions gave direction to the whole project and are explicitly worked out in the final chapters of the two parts (see section 1.3.1) of the report, where the conclusions are formulated.

1.3 Subjects

1.3.1 Two parts

The content of the comparative study was further determined by a selection of subjects of the building regulations. A first distinction has been made between the comparison of the regulatory systems on one hand, and the comparison of the content and level of technical requirements for some selected subjects. We have split these two major subjects into two books:
- Building regulations in Europe, Part I, A comparison of the systems of building control in eight European countries (HUPS 23).
- Building regulations in Europe, Part II, A comparison of technical requirements in eight European countries (this book – HUPS 24).

1.3.2 Subjects in Part I: Systems of building control

The focus in the project lies on the technical requirements for houses and the systems for implementation of the requirements. A central instrument to assure implementation is the building permit procedure, which in all the countries is carried out by local authorities. The permit procedures are the starting point for the analysis of the systems of building control. For which categories of buildings does a permit have to be obtained and what kind of checks does who carry out? For most building projects some form of planning control also has to be carried out. The report sometimes refers to planning control, to give it a place in the procedures for building, but this is not worked out in detail.

The systems of building control in the eight European countries were analysed and described according to the following structure:

- *Regulatory framework*
- *Permit procedures*
  - Categories of buildings
  - Description of the procedures
  - Planning issues (zoning, aesthetics, etc.)
  - Sanctions for non-compliance
- *Building control*
  - Roles and responsibilities
  - Municipal departments
  - Private building control organisations
  - Fees
- *Technical requirements*
  - Regulatory framework
  - Formulation
  - Subjects
  - References, guidance and EC Directives
  - Certification

The systems of building control in the eight countries are described according to the above structure.

1.3.3 Subjects in Part II: Technical requirements

The subjects of the technical requirements to be compared were selected because of policy discussions in the Netherlands about the necessity and the level of the requirements. The selected subjects are the following:

- *Stairways and ramps*
  - Bridging changes of levels
  - Staircase
  - Ramp
- *Fire resistance and escape*
  - Strength of structure in case of fire
  - Limitation of fire development
  - Limitation of spread of fire
  - Further limitation of spread of fire
  - Limitation of development of smoke
  - Limitation of spread of smoke
  - Escape inside smoke compartment
  - Escape routes
  - Design of escape routes
- *Prevention of burglary*
  - Entrance of a building (lock)
  - Prevention of burglary
- *Sound insulation between rooms and between dwellings in residential buildings*

  - Protection against noise from installations
  - Sound insulation between spaces within one building unit
  - Sound insulation between spaces of different units in one building
- *Limitation of the use of noxious materials and penetration of dangerous substances from the soil*
  - Limitation of the use of noxious materials
  - Limitation of the penetration of noxious substances or radiation from the soil
- *Daylight*
- *Accessibility*
  - Accessibility sector
  - Free passage
  - Accessibility
- *Dimensions of rooms*
  - Habitable area
  - Habitable room

1.4 Research method

A lot of background information and documentation had already been collected in previous research projects. In the first place the material we gathered was restructured and updated. Specific topics were further investigated. The various country monographs were sent to our contacts to update the data. We would like to thank the contact persons in the eight countries for providing us with the necessary information.

In 1999 the Department of the Environment, Transport and the Regions of the United Kingdom conducted research in to both statutory regulations and financial incentives for housing quality in eight European countries are described. This study was published in 2001 in two parts in the OTB Housing and urban policy studies (nos. 15 and 16): *The control and promotion of housing quality in Europe* (Part I Country monographs and Part II Comparative analyses). The comparative DETR study of the control and promotion of quality in housing in Europe has served as a reference for the comparison of the subjects and levels of technical requirements of this project.

A considerable part of the research activities in this part of the research was contracted out to the University of Liverpool. Linda Sheridan (Senior Tutor at the School of Architecture and Building Engineering) has been involved in the writing of the DETR-report that was the starting point of this part of the research. This applies especially to Part II of the report (comparison of the technical requirements). The OTB Research Institute for Housing, Urban and Mobility Studies has taken the lead in Part I of the research report.

The research project has been carried out between mid 2000 and spring 2002.

1.5 Structure of this book

This book contains three chapters in which the approach (Chapter 1), the systems of formulation and global contents of the sets of technical requirements (Chapter 2) and the observations and conclusions of the comparison (Chapter 3) are described. The actual detailed comparison of the requirements of the selected subjects are described in seven appendices. These subjects are: Stairways and ramps (Appendix 1), Fire safety and escape (Appendix 2), Prevention of burglary (Appendix 3), Noise (Appendix 4), Noxious materials and substances from the ground (Appendix 5), Daylight (Appendix 6), Accessibility (Appendix 7) and Dimensions of habitable space and habitable rooms (Appendix 8).

2 Formulations and subjects of technical building regulations

2.1 Introduction

There are considerable variations in the technical building regulations of the eight European countries studied. This chapter attempts to summarise both the approach (formulation of requirements) and scope (subjects) of the regulations in each country. This is essentially an approximation, for it is impossible to make a fully reliable set of observations without detailed reading and analysis that far exceeds the scope of this project. Nonetheless, the attempt does demonstrate differences in the systems of the eight countries.

Section 2.2 deals with the formulations of the regulations. Section 2.3 presents a comparison of the subjects of the regulations.

2.2 Formulations of technical building regulations

2.2.1 Different approaches

The formulation of technical requirements have been discussed for many years. For instance, the Building Research Station of the Department of the Environment in England conducted comparative analyses of building control from 1969-74 (Atkinson, 1974; Cibula, 1971; Cibula, 1970; Daldy, 1969; Honey, 1970). Daldy demonstrates that the move away from specifications towards functional requirements started over 30 years ago, offering a clear explanation of specifications, functional requirements, and performance standards, together with the use of deemed-to-satisfy clauses, codes of practice, the system of agrément, and information for guidance.

In 1978 the Nordic Committee on Building Regulations developed a five-level model of technical requirements (NKB, 1978). Almost 20 years later, Bowen compared this with the structure of the first version of the Dutch Building Decree (Bowen, 1997). The different components of the Nordic five level model are elaborated in Table 2.1. The table accommodates variations in the terms used by different commentators.

The first three levels elaborate the objectives. Level one is a broad statement of what the building regulations are intended to provide, for instance: safety, health, energy conservation, accessibility, and protection of the environment. More unusually, they might provide safeguards against loss of amenity, or protect other property. Level two is a qualitative objective, specific to one aspect of the target performance, for instance: the building should be designed to provide opportunities to escape in case of fire. Level three is typically a qualitative or descriptive requirement, but in some countries, or for some aspects of performance, the operative requirements include quantitative requirements, for instance: an escape route should lead directly to open

Table 2.1 Nordic five level system

Level	Type of component	Description
Level 1	Objectives/Goal	The goal addresses the essential interests of the community at large with respect to the built environment, and/or the needs of the user-consumer.
Level 2	Functional statement/Functional requirement	Requirement specific to a building or building element, which addresses one of the specific aspects of the performance required to achieve the stated goal.
Level 3	Performance requirements/Operative requirement	Actual requirement, in terms of performance criteria or expanded functional description.
Level 4	Performance-based methods/Verification	Instructions or guidelines for verification of performance.
Level 5	Deemed-to-satisfy/Examples of acceptable solutions	Supplements to the regulations with examples of solutions deemed to satisfy the requirements.

air (qualitative), and/or the distance between the door to a dwelling and a protected stairway should be no more than 15 m (quantitative).

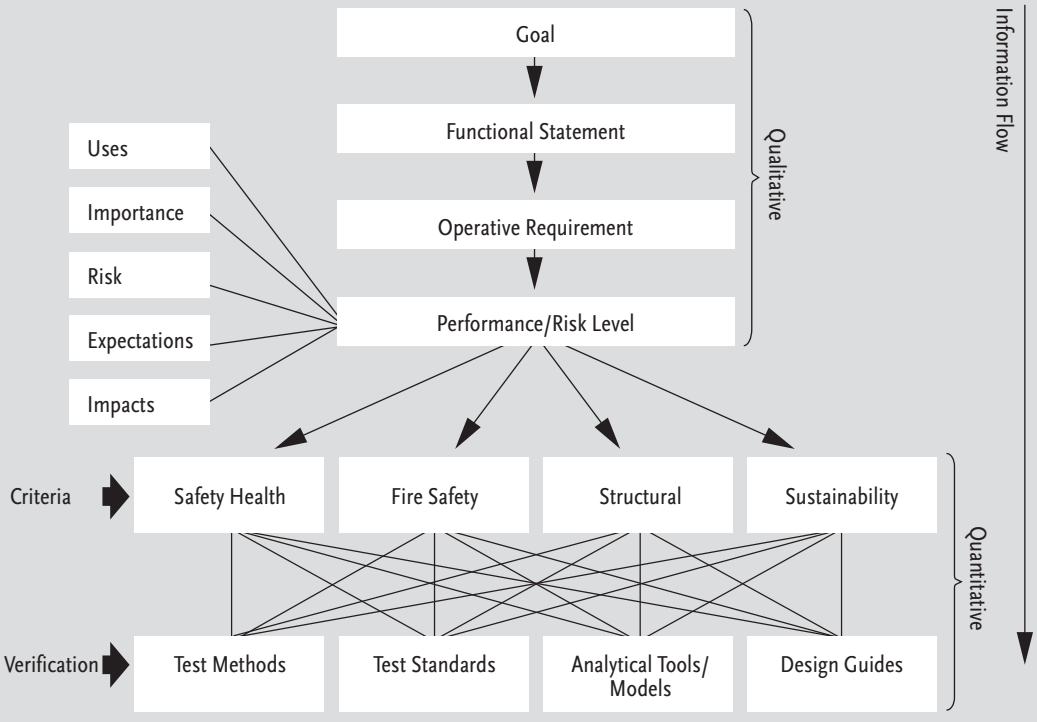
The last two levels both deal with the interpretation of the objectives and requirements in practice. Level four identifies methods to verify compliance, for instance: distances on escape routes should be measured by way of the shortest route ignoring walls, partitions, fittings. Level five offers examples of compliance, for instance: a diagram showing requirements for means of escape for different corridor configurations. Often, level five is given in a supplement to the regulations, with examples of solutions deemed to satisfy the requirements (Bowen, 1997). The last two levels are sometimes combined because compliance with a given prescriptive solution is just one of several possible methods of verification (Foliente, 2000).

The CIB Taskgroup 37 'Performance based building regulatory systems' is developing an internationally accepted model for performance based requirements (see Figure 2.1). It moves on from the Nordic five level system, introducing a 'Performance risk level', which determines the application of requirements, and a further level of 'criteria'[1] which proposes four categories of objectives: health and safety, fire safety, structure, and sustainability. It also combines levels four and five into a single verification level, which includes design guides as well as testing or modelling techniques, but does not specifically mention examples of acceptable solutions.

We have attempted to use this model to analyse the formulation of requirements in different countries. Some countries, including the Netherlands, have consciously attempted to follow such a model. Others have devised their own performance-based systems. Others continue to use traditional systems. We found the analysis difficult, even for those countries that have adopted some form of performance-based system, firstly because commentators vary in their understanding of these terms, and secondly because there is incon-

1 The word 'criteria' is more usually associated with forms of verification; 'themes' or 'subject categories' might be a more appropriate expression.

Figure 2.1 Performance system model CIB-TG 37



Source: www.icbo.org/Code_Talk/Performance_Codes/CIBTG/performance-system-model-diagram

sistency within the specific systems of regulations in the countries used for different subjects.

As other commentators have pointed out (Scholten, 2001; Beller *et al*., 2001) the term 'performance requirement' is interpreted in different ways. Although it is understood by CIB to mean the qualitative formulation of requirements or goals, as opposed to prescriptive regulations with mandatory design solutions, some countries understand it to constitute a description of desired levels of performance.

The countries studied use a broad variation of systems and formulations of the requirements. The numerous combinations include:

- generalised 'functional' requirements in combination with 'deemed-to-satisfy' practical design solutions;
- generalised 'functional' requirements with design guidance, or reference to external sources of design guidance;
- 'prescriptive' requirements with reference to solutions; and
- quantitative 'performance' requirements without reference to practical design solutions.

It should be noted that planning and building control are separated in England and Wales, and Sweden, but are combined in Belgium, Denmark, France, Germany, the Netherlands and Norway.

2.2.2 Building Decree, The Netherlands

The formulation of regulations in the Building Decree is the result of the Action Programme for deregulation. Briefly, the criteria for regulations are as follows:

- a regulation must be legally explicit and equitable;
- a regulation must be unambiguous and thereby measurable and verifiable;
- a regulation should present only a minimal restriction on freedom and innovation in design.[2]

The Building Decree conforms in some ways to the CIB-TG 37 model, but it is not consistent across subjects in the nature of each component.

The goal is given in the title: "Decree of 7th August 2001 providing for the establishment of regulations relating to the building of constructions from the point of view of safety, health, functionality, energy economy and the environment (Building Decree)". These goals are interpreted in five themes, which are different from the four criteria in the CIB-TG 37 model: safety includes fire safety and structure, health is separated from safety, functionality is introduced, and instead of a single theme of sustainability, there are separate chapters for energy economy and the environment.

The 'performance risk level' is accounted for in three ways:

- separation of requirements for new building and minimum levels of requirements for existing buildings;[3]
- identification of application of requirements with regard to 'user functions';
- identification of application of requirements with regard to certain sizes or occupancies of user functions.

These are complemented by an introductory chapter of 'definitions'.

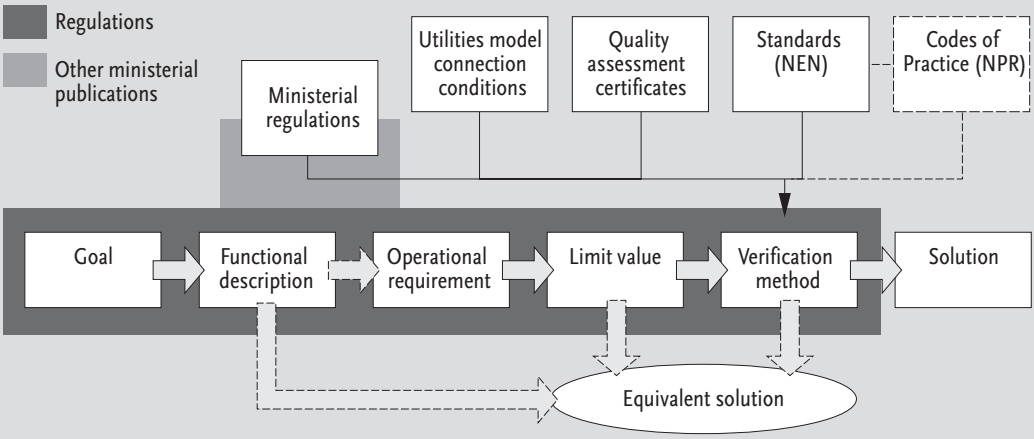
The technical regulations are expressed in numerous performance requirements. Each performance requirement comprises:

- a functional statement, which expresses the intention of the performance requirement;
- operative requirements which elaborate the practical implications of the

2 The concept of design freedom has been discussed more in the Netherlands than in any of the other countries studied. One result is the use of quite abstract terms. For instance, the Building Decree uses the term 'habitable room' instead of living room or bedroom, and describes a habitable room with appliances to prepare food, rather than a 'kitchen'.

3 In the case of alteration or renovation projects, the Building Decree gives the municipal executive (the Mayor and Aldermen) the power to grant exemptions. This power is intended for cases in which the requirements, which were developed for new building, are considered too onerous. The requirements for existing buildings specify the extent of this power and minimum levels which apply in the case of exemptions from the levels of requirements for new building.

Figure 2.2 Formulation of the Dutch Building decree



functional description, often including:

- a limit value, which indicates the minimum level of performance that must be attained;
- a determination/verification method, usually by reference to a standard of the Dutch Standardisation Institute (NEN) or a Ministerial Regulation.

For services, the determination method is often a reference to the utility companies' model connection conditions. The explanatory notes to the Building Decree also refer to certificates declaring the quality of materials or products, 'Kwaliteitsverklaring', which may be used to prove that they meet the levels of performance required by the Decree. The Ministry of Housing, Physical Planning and Environment lists product certificates and agrément certificates, which it recognises as relating to one or more clauses of the Building Decree. Quality certificates are a form of verification which is not noted in the CIB-TG 37 model.

Apart from the national standards, the Building Decree does not accord any special status to design guidance that is not under the direct control of the Ministry. Thus, whereas the first version of the Building Decree made frequent reference to advisory codes of practice (NPRs), there is only a single reference in the latest revision.[4]

A designer who uses such guidance must check whether it meets the functional and operative requirements.

The Building Decree does not offer examples of acceptable solutions. Its formulation, using performance requirements, is intended to allow a high degree of design freedom. The Decree allows 'equivalent solutions' if a proposal does not meet one or more operative requirements, perhaps due to particular characteristics of the site, or the use of innovative materials or construction techniques. In such cases, the developer must demonstrate that the proposed solution meets the intention of the functional requirement and the

4 Explanatory notes to Building Decree: Article 3.15 refers to NPR 5071.

level of performance described by the limit value or determination method. In practice, although the formulation of the Building Decree appears relatively liberal, there are numerous examples of prescription, such as limitations on dimensions of stairways, to which it would be difficult to propose equivalent solutions.

The formulation of the Dutch Building Decree and its relationship to other documents is described in Figure 2.2. As noted earlier, the Decree no longer refers directly to NPRs, but they are widely used in practice.

2.2.3 Building Regulations, England and Wales

In England and Wales, the structure of the Building Act, the Building Regulations, and the associated advisory Approved Documents is relatively clear, in terms of a hierarchy of components, similar to the CIB-TG 37 model. However, there are some inconsistencies between different subjects, which are partly the result of a rolling programme of review and amendment, but also reflect the nature of the subjects.

The Building Act 1984 is the enabling legislation for the Building Regulations 2000.[5] It gives the Secretary of State powers to make regulations for the purpose of: "*a) securing the health, safety, welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings; b) furthering the conservation of fuel and power; c) preventing waste, undue consumption, misuse or contamination of water.*"

These goals are formulated differently from the criteria of the CIB-TG 37 model, and add the concept of 'welfare and convenience'.

Schedule 1 to the Building Regulations sets out functional requirements, grouped in themes, termed 'Parts'. For instance, Part B is Fire safety and comprises five functional requirements: B1 Means of warning and escape; B2 Internal fire spread (linings); B3 Internal fire spread (structure); B4 External fire spread; and B5 Access and facilities for the fire service. Each functional requirement is brief, for instance:

B1 Means of warning and escape: "*The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate means of escape in case of fire from the building to a place of safety outside the building capable of being safely and effectively used at all material times.*"

Approved Documents (*ADs*) are issued for each of the themes, which elaborate the requirements, discuss the underlying issues, and describe strategies that can be used to comply with the functional requirements. Some *ADs* are introduced by clarifications perfaced by the statement: "*In the Secretary of*

5 The Building Regulations 2000 replaced the Building Regulations 1991 (as amended), but many of the associated Approved Documents date from the 1990s.

State's view, the requirements of [X] will be met if …" The information in the *ADs* does not have mandatory status, but for the majority of residential work, it is treated as such in practice in order to avoid delays.

The *ADs* include:

- guidance on operative strategies and tactics (advisory equivalent to operative requirements);
- and various forms of verification:
  - description of methods of measurement and verification, often by reference to British Standards;
  - direct examples of acceptable solutions, often by means of diagrams or tables of minimum or maximum dimensions or other values; or
  - references to external design guidance.

The guidance describes appropriate criteria for the interpretation of the functional requirements and represents acceptable solutions. Building control bodies can also accept alternative strategies and tactics, provided the developer demonstrates that they comply with the functional standards. An increasingly common example of this is fire engineering solutions in buildings other than dwellings.

The 'performance risk level' is accounted for in two ways. Firstly, Schedule 1 to the Building Regulations states limits on application. For instance,

"Requirement B3(3) does not apply to material alterations to any prison provided under section 33 of the Prisons Act 1952."

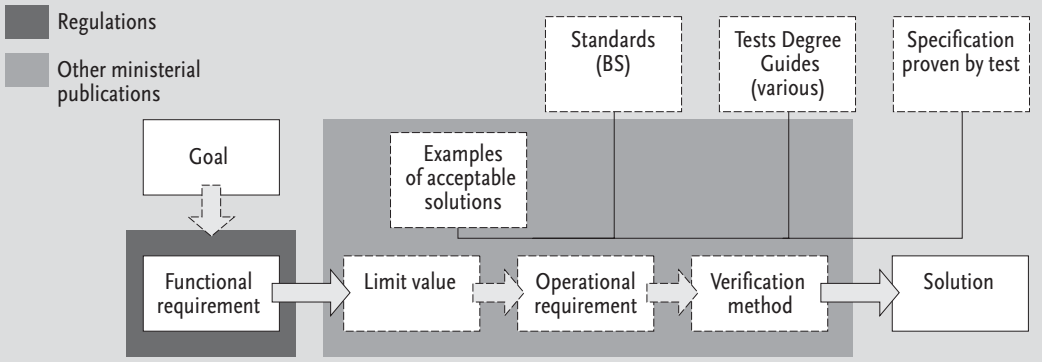
Secondly, most of the *ADs* provide further guidance on diffing levels of requirements. For instance, the fire safety AD, has differing requirements for dwellings and buildings other than dwellings, and amongst those, for different purpose groups. Requirements vary according to height or size of buildings. For instance, it differentiates requirements for dwellings with a floor less than or more than 4.5 m above ground level.

Often, *ADs* offer a variety of ways of complying with requirements, for instance, Approved Document B Fire Safety: Appendix A: Performance of materials and structures offers options for materials, products or structure:

"*a) to accord with a specification proven by test;*
b) to be assessed by test against appropriate standards or design guides such as Building Research Establishment (BRE) reports;
c) to conform to tables given in the Approved Documents; or
d) to be designed in accordance with a British Standard or Eurocode."

Despite this relatively clear structure, the expression of requirements varies between subjects. For some subjects the options for compliance are inherently very limited, such as provision for H1 Cesspool, Septic tanks, and Settlement tanks. ADH sets out detailed strategies, including dimensions, and the alternative of following a British Standard code of practice.

Figure 2.3 Formulation of the Building Regulations in England and Wales



The relationship of the Building Regulations, Approved Documents, and other documents is described in Figure 2.3.

There have been some significant changes to the application and requirements of the Building Regulations in recent years, including the extension of accessibility requirements to housing (1999), and provisions applying to existing housing in the revised requirements for the Conservation of Fuel and Power (2001), which include controls on replacement windows and heating systems. Other amendments have reviewed the underlying approaches to safety issues or have sought to remove matters which do not relate to health and safety. For example, structural design calculations no longer consider deflection or deformation unless they would impair the stability of another building.

With the shift to functional requirements and the rolling programme of revisions, the Approved Documents are becoming more discursive and easier to understand. Each amendment incorporates explanations of the reasoning underlying the requirements and a discussion of the strategies employed. There is also improved co-ordination of the various parts.

The operative requirements quoted in the comparative analyses throughout this book are taken from the Approved Documents, as this reflects common usage, but it should be remembered that they are advisory.

2.2.4 The other countries

This summary of the formulation of requirements is supplementary to the original brief of the research. Apart from the Netherlands and England and Wales, the authors are not confident of their findings. However, the following summaries offer an indication of the formulation of requirements in the other countries.

Belgium: National and regional legislation

Unlike many other countries, Belgium has not reformulated traditional building regulations as performance requirements, and does not resemble the CIB-TG 37 model. The reason for this may be political, given Belgium's federal nature, without uniformity of technical regulations, on either a national or

regional basis. The clearest control is the national legislation for fire safety, which is arranged in terms of risk classes related to fire-fighting equipment, and does not apply to single family houses. Most of the requirements are written in a prescriptive manner.

In Wallonie, the development code, (*Code Wallon de l'Aménagement du Territoire, de l'Urbanisme et du Patrimoine, CWATUP*) enables the regional government to issue regulations on acoustic qualities. In practice, the acoustic performance of buildings in Wallonie relies on the implementation of national standards, which are occasionally tested in court cases. The development code also includes self-contained specifications for accessibility, and requirements for thermal insulation and ventilation which include values, but also refer to performance levels to be set by the ministry. Other basic habitability legislation includes specifications for the size of dwellings, and the size of windows.

Denmark: *Bygningsreglement* and *Bygningsreglement for småhuse*

In Denmark, the Building Act 1993 is implemented in the Building Regulations and the Building Regulations for Small Dwellings. There is no clear statement of *goals* in the Building Regulations; presumably this is given in the Building Act.

There is some resemblance to the CIB-TG 37 model, but the distinction between functional statements, operative requirements, and guidance is inconsistent. Mostly, both sets of building regulations use mandatory functional statements, accompanied by optional interpretations (the advisory equivalent to operative requirements). For instance, the functional requirement:

"Workrooms must receive sufficient daylight for them to be well lighted",

is accompanied by a margin note

"The supply of daylight will normally be sufficient when the window area in the case of side light corresponds to 10 per cent of the floor area or, in the case of roof light, to at least 7 per cent of the floor area.".

Some of the interpretations comprise references to standards and codes of practice. However, there are also numerous specifications, for instance:

"Escape lighting shall give at least 1 lux on the floors along escape routes…"

Many methods of measurement and verification are given within the document, or its appendices, but there are also numerous references national standards. The Building Regulations include examples of constructions that meet the fire safety requirements, but this appears to be the only instance of such examples of acceptable solutions.

The 'performance risk level' is partly acknowledged in the separate volumes for small houses and other buildings. Also, some subjects in the Building Regulations have differing requirements related to the use of buildings.

The arrangement of themes is quite different from the criteria of the CIB-

TG 37 model, with many more headings: arrangement of buildings (including accessibility) design and construction (including structural design); fire safety; resistance to moisture; thermal insulation; sound; heat-producing appliances and chimneys; indoor climate; services; farm buildings and wind turbines.

France: *Code de la Construction et de l'Habitation*

In France, only the more recent regulations, such as those for acoustic performance, are written as performance requirements, and despite a hierarchy of regulation and guidance there is little resemblance to the CIB-TG 37 model.

The building and housing code (*Code de la Construction et de l'Habitation, CCH*) comprises legislative articles and regulatory articles. There is no overall statement of goals. The legislative articles allow regulations to be made by Decrees of the Council of State, identify the subject of regulations, and specify the application of requirements. Some legislative articles refer to Laws (*lois*).

The regulatory articles are a mixture of specifications (such as minimum floor area and volume, and sanitary provision), and performance requirements (such as acoustic insulation, and energy efficient provision of heating and hot water). The first section of the regulations is a group of general requirements which is a mixture of a list of rules, with no statement of objectives, and performance requirements for safety. These are followed by more recent performance requirements, for access for disabled people, thermal performance, and acoustic performance.

Some regulations refer to one or more decrees (*décrets*), but others (such as the requirements for resistance to damp, and for guarding of windows and balconies) make no reference to any secondary legislation. Many regulations require implementing orders (*arrêtés*) to be made to set levels of requirements, but for some subjects (such as thermal performance) operative requirements are to be included in the same implementing order as verification methods.

Some decrees (such as those for accessibility) are self-contained, detailed specifications of *operational requirements*, but for some subjects (such as fire safety), details are given in implementing orders. Interpretations of detail are often given in ministerial circulars (*circulaires*), but these are not referred to in the CCH, decrees, or implementing orders.

Implementing orders refer to French national standards (*Normes Françaises, NFs*), but in practice the verification of many subjects also relies on unified technical guides (*Documents Techniques Unifiés, DTUs*), and for non-traditional technologies, to technical commentaries on experimental methods (*Appréciations techniques d'expérimentation, ATEX*) published by CSTB (*Centre Scientifique Technique du Bâtiment*).

The CIB-TG 37 model assumes a permit approval process, but in France building permits mostly refer to planning issues rather than technical con-

struction requirements. The project developer (*maître de l'ouvrage*) is responsible for conformity to the technical requirements of the *CCH*. There is a statutory framework of insurance, established by the *Code Civil*, which includes a mandatory 10-year liability under which the Architect and contractors are each responsible for building defects. This liability, and the associated requirements of the insurance providers, act as a mechanism to ensure conformity with the technical requirements. Verification of safety subjects is often by reference to DTUs and ATEXs. If a national standard or DTU is cited in a construction contract, it must be complied with.

Germany: *Hessische Bauordnung*, Hesse

In Hesse, the Building Ordinance (*HBO*) is mostly written as performance requirements, but it has only limited resemblance to the CIB-TG 37 model, and it is inconsistent in its formulation. There is no overall statement of goals.

The *HBO* requirements were re-formulated, with effect from 2002, as brief functional statements, indeed there are no further explicit requirements for some subjects (such as "sufficient sound insulation"). However, some subjects (such as fire protection and fire walls) include operative requirements and specifications.

Although the criteria of the CIB-TG37 model are included, the subjects of the *HBO* are grouped according to both issues and parts of the building. For instance, the section on roofs contains fire safety and other safety requirements. The range of subjects is wider, including accessibility. There is no indication of the means of verification, but it is implicit that reference should be made to national standards (*DIN*s). Performance risk level is reflected in the building classifications, given in both the text and annexes.

Norway: *Tekniske forskrifter til plan- og bygningsloven*

The provisions of the Planning and Building Act of 14 June 1985 No. 77 are implemented in the Technical Regulations (*Tekniske forskrifter til plan- og bygningsloven*).

Since 1997 Norway has systematically adopted performance requirements, and the structure of the Technical Regulations and accompanying guidelines is broadly similar to the CIB-TG 37 model. The Technical Regulations comprise functional statements. The Guidelines to the regulations (*REN veiledning til teknisk forskrift*) are the advisory equivalent to operative requirements, but detailed interpretation relies on the Norwegian Building Research Institute's (*Byggforsk*) series of planning and technical information leaflets. The Guidelines refer to national standards (*Norsk Standard, NS*), but the *Byggforsk* leaflets are commonly understood as acceptable solutions, and in practice constitute the main source of verification.

The subjects are grouped differently from the criteria of the CIB-TG 37

model: personal and material safety, environment and health, installations, and usability. Performance risk level is considered in terms of occupancy, and the classification of buildings for fire risk.

It should be noted that the operative requirements quoted in the comparative analyses throughout this book are taken from the Guidelines and the *Byggforsk* leaflets, as this reflects common usage, but it should be remembered that they are advisory.

Sweden: Building Regulations

In Sweden, the Building Regulations implement provisions of the Planning and Building Act (1987: 10). There is no overall statement of goals in the Building Regulations, but presumably these are given in the Act.

The Building Regulations comprise mandatory provisions, which are mostly functional statements, and advisory 'general recommendations'. Most of the mandatory provisions are performance requirements (such as design for accessibility), but some include specifications or operative requirements (such as ceiling heights, and periods of fire resistance).

The subjects are grouped differently from the criteria of the CIB-TG 37 model: design (which addresses ceiling heights, accessibility, and spaces for services); fire safety; hygiene, health and environment; noise; safety; and energy efficiency. The Building Regulations do not include requirements for structural design, which are given in the Design Regulations.

General recommendations variously include examples of provision satisfying mandatory requirements (the advisory equivalent to operative requirements), references to various means of verification (including Swedish Standards and other sources), and definition of terms and clarifications of the meaning of mandatory requirements. The Building Regulations approve alternative methods and design solutions set out in European Standards adopted as Swedish Standards (SS-EN), and in European Prestandards (SS-ENV). General recommendations may also contain certain explanatory or editorial information. Although the general recommendations are advisory they may represent minimum standards in practice.[6] Performance risk level is considered in terms of occupancy, and the classification of buildings for fire risk.

6 For instance, given the performance requirements for accessibility a turning circle smaller than the general recommendation is unacceptable because of the current size of wheelchairs. Hypothetically, wheelchairs may be improved reducing the need for a turning circle of this size and developers or builders would then be obliged to demonstrate to the authorities that new improved wheelchairs are in common use, and thus room dimensions can be reduced.

2.2.5 Conclusion

The formulation of technical regulations varies between the countries studied. Apart from Belgium, there is a general trend towards performance-based requirements, but the concept of performance requirements is interpreted differently and in most of the countries the technical regulations include specifications.

There is a common pattern of verification by reference to national standards, but some countries also refer to other sources. The practical implementation of technical regulations often relies on guidance that are not cited in regulations. The grouping of subjects is different, in all cases, from the criteria of the CIB-TG 37 model.

Despite the intentions underlying the revision of the Dutch Building Decree, England and Wales offers clearer distinctions between functional requirements and guidance, and conforms more closely to a performance-based model.

2.3 Identification of technical subjects in building regulations

2.3.1 Approach

The comparative analysis was based on of a limited range of topics, selected by Ministry of Spatial Planning, Housing and the Environment, for which we identified the relevant legislation. We have additionally attempted to describe the full range of technical subjects that are addressed in each country, and to compare this with the scope of the Dutch Building Decree.

The accessibility of regulations is in itself an interesting issue. One must first identify the relevant documents and then find the subjects within those documents. This proved problematic, due to the difficulty of identifying regulations in Belgium and, to a lesser extent, France because building regulations comprise numerous items of legislation and it is difficult to find relevant items on-line. In contrast, Denmark, England and Wales, Germany (Hesse), the Netherlands, Norway and Sweden issue clearly identifiable sets of building regulations, which are published on-line. Electronic publication makes it easy to search for subjects.

Denmark publishes two documents, one specifically for houses, the other for larger buildings including blocks of flats. England and Wales issues 15 documents, the regulations themselves and 14 *Approved Documents*, each elaborating one of the themes of the building regulations. Norway produces two documents, the technical building regulations and an associated guide. Germany (Hesse), the Netherlands, and Sweden each publish a single document

that identifies the subjects of control but are reliant, to varying degrees, on national standards for details of compliance.

Belgium has a much more confusing system, with federal legislation and regional controls specific to Wallonie, Flanders, or Brussels.[7] We could not find a compendium of Belgian legislation. Although federal legislation is published on the *Moniteur Belge* website, the search engine is difficult to use and some of the on-line legislation is incomplete. Also, it is difficult to identify relevant documents because federal legislation is titled by date and the secondary descriptive title is often not mentioned, while revisions are titled by the date of the revision. There are no regional building codes, but Wallonie has both a *Code Wallon de l'amenagement du Territoire, de l'Urbanisme et du Patrimoine (CWATUP)* which includes ennabling legislation and specific requirements for certain topics, and a fitness standard, *Critères de Salubrité des Logements* which is a condition of renting or subsidy. Although *CWATUP* is primarily planning legislation, it addresses issues that are usually the subject of building regulations.

In France the national Code of building and housing identifies the subjects of control and the date of associated decrees. However, detailed requirements are elaborated in a further body of implementing orders and ministerial guidance. The research organisation *CSTB* assembles construction legislation in a compendium which simplifies the process of identifying subjects of legislation, but the compendium is very expensive. Individual items of legislation are published on various websites, including the official government journal, but it is a slow process to identify all the relevant legislation.

Access to national standards is restricted in each country, because standards institutions are self-funding and rely on sales of standards, whether in hard copy or electronic form. Apart from a few standards that were essential to understanding requirements, such as the acoustics *normes* in Belgium, the analysis has been compiled without reference to national standards.

See table 2.2 for an overview of primary sources.

2.3.2 Objectives of the requirements

Each country has some building regulations concerning safety (including structural stability, fire safety), health (sanitation), energy conservation, accessibility for people with disabilities, and environmental control (noise protection, daylighting, ventilation). However, the regulations for certain topics may be nothing more than ennabling legislation (Belgium (Wallonie)) or general performance requirements (Germany (Hesse), Sweden), which then

7 This analysis does not consider Flanders or Brussels, but please see Part I (HUPS 23) for details of their systems of building control.

Table 2.2 Primary sources

	English translation of titles	Primary sources	Revision
Belgium			
Federal		Legislation relevant to the subjects studied comprised:	1997
	Royal implementing order setting basic standards for the prevention of fire and explosion in new buildings.	*Arrêté royal (AR) du 07-07-1994 fixant les normes de base en matière de prévention contre l'incendie et l'explosion, auxquelles les bâtiments nouveaux doivent satisfaire;* modified by *AR du 19-12-1997.*	
Wallonie	Wallon Code for the Development of Land, Town Planning, and Heritage.	*Code Wallon de l'Aménagement du Territoire, de l'Urbanisme et du Patrimoine (AERW du 14 mai 1984;* last amended *AGW du 10 juin 1999).*	1999
	Fitness criteria for housing.	*Critères de Salubrité des Logements: 11 fevrier 1999 Arrêté du Gouvernement wallon déterminant les critères de salubrité, le caractère améliorable ou non des logements ainsi que les critères minimaux d'octroi de subventions.*	1999
Flanders		Flanders was not included in this study.	
Brussels		Brussels was not included in this study.	
Denmark	Building Regulations, Ministry of Construction and Housing.	*Bygningsreglement By- og Boligministeriet.*	1995
	Building Regulations for Small Dwellings.	*Bygningsreglement for småhuse BR-S 98.*	1998
England and Wales	*The Building Regulations* and *Approved Documents A-H, J-N.*		2000 various
France	Construction and Housing Code: Laws, Regulations (Decrees of the Council of State).	*Code de la Construction et de l'Habitation: Partie Législative [Lois]; Partie Réglementaire (Décrets en Conseil d'Etat).*	various
	Associated decrees, implementing orders, and ministerial circulars.	Associated *décrets, arrêtés, circulaires,* published in *Recueil des Eléments utiles à l'Exécution des Projets et Marchés de Bâtiments en France (REEF).* Various items of legislation were used for the comparative analysis, too numerous to list here.	various
	Minimum fitness standards.	Also *Normes minimales d'habitabilité (annexe 1 de l'arrêté du 30 décembre 1987).*	1987
Germany			
Hesse	Building Ordinance of the state of Hesse.	*Hessische Bauordnung.*	2002
Netherlands	Building Decree.	*Bouwbesluit.*	2001
Norway	Technical regulations of the Planning and Building Code.	*Tekniske forskrifter til plan- og bygningsloven.*	1997
	Guidebook to the technical regulations.	*REN veiledning til teknisk forskrift til plan- og bygningsloven.*	1997
Sweden	Boverket's Building Regulations.	Boverkets Byggregler (BBR-94: 3) BFS 1993: 57.	1997

rely on the implementation of national standards.

The Dutch Building Decree identifies five main objectives: safety, health, utility, energy conservation and environmental protection, but only gives requirements for the first four. The objective 'environmental protection' was introduced with the conversion of the Building Decree in 2003, to provide a

Table 2.3a Belgium – Wallonie: Headings in primary sources

English translation of headings	Headings in original language	Location
WALLON CODE FOR THE DEVELOPMENT OF LAND, TOWN PLANNING AND HERITAGE	**CODE WALLON DE L'AMENAGEMENT DU TERRITOIRE, DE L'URBANISME ET DU PATRIMOINE (CWATUP)**	
Regional regulations for urban development	**Des règlements régionaux d'urbanisme**	Titre IV Des règle ments d'urbanisme: Chapitre Ier Des règlements régionaux d'urbanisme: Art. 76.
Article 76 allows the Wallon government to formulate legislation concerning:		
Fitness, conservation, stability and beauty of buildings, installations, and their surroundings; safety, particularly protection from fire and predictable natural risks.	*Salubrité, conservation, solidité et beauté des constructions, des installations et de leurs abords; sécurité - protection contre l'incendie et les risques naturels prévisibles.*	Para 1°
Conservation, fitness, safety, viability, beauty of road system, its access and surroundings.	*La conservation, la salubrité, la sécurité, la viabilité et la beauté de la voirie, de ses accès et de ses abords.*	Para 2°
Servicing of buildings ... supply of water, gas, electricity, heating, tele-communications, rubbish collection.	*La desserte des immeubles ... distributions d'eau, de gaz, d'électricité, de chauffage, de télé-communications et l'enlèvement des immondices.*	Para 3°
Thermal qualities. Acoustic qualities. Energy efficiency and energy conservation.	*La qualité thermique et acoustique des constructions, les économies d'énergie et la récupération des énergies.*	Para 5°
Accessibility for people with reduced mobility.	*L'accessibilité et l'usage des espaces et bâtiments ou parties de bâtiments ouverts au public ou à usage collectif, par les personnes à mobilité réduite.*	Para 6°
NB No headings are given in CWATUP: the following is a summary of the specific technical requirements:		
General regulations applicable to protected areas in some towns	**Du règlement général sur les bâtisses applicable aux zones protégées de certaines communes en matière d'urbanisme**	CHAPITRE XVII
Width of streets. Facades – width, height, materials, side and rear facades. Roofs – pitch, materials. Courtyards and gardens. Ground treatments. Ducts, cables. Street furniture. Commercial ground floors. Car parking.	*Largeur des rues etc. Facades. Toitures. Zones de cours et jardins. Traitement du sol. Conduites, câbles et canalisations. Mobilier urbain. Rez-de-chaussée commerciaux. Parcage des véhicules.*	Art. 394 - 402
Thermal insulation and ventilation of buildings	**Isolation thermique et ventilation des bâtiments**	CHAPITRE XVIIbis. - AERW du 29 février 1984
Housing: global thermal insulation values or energy demand for heating per m2 floor area; thermal transmission values of walls. Office and school buildings. Work to existing buildings.	*Niveau d'isolation thermique globale (valeur k) ou besoins en énergie de chauffage par mètre carré de plancher. Valeurs pour les coefficients de transmission thermique des parois. Immeubles de bureaux et les bâtiments scolaires. Bâtiments existants.*	Art. 407 – 411

English translation of headings	Headings in original language	Location
Air changes. Refurbishment, including replacement of window frames or external doors: air inlets. Office and school buildings: mechanical extract for toilets.	Renouvellement d'air. Immeubles destinés au logement qui font l'objet de transformation ... prescriptions relatives aux entrées d'air. Immeubles de bureaux, bâtiments scolaires: locaux sanitaires: extraction mécanique.	Art. 412
Accessibility and use by people with reduced mobility, of spaces and buildings or parts of buildings open to the public or for collective use	**Règlement général sur les bâtisses relatif à l'accessibilité et à l'usage des espaces et bâtiments ou parties de bâtiments ouverts au public ou à usage collectif par les personnes à mobilité réduite**	CWATUP Chapitre XVIIter. -AGW du 25 février 1999, article 1er
Car parking spaces. Access routes. Landings. Projections. External and internal doorways. Circulation spaces. Stairways. Access to lifts and areas. Lifts, platform lifts. Ticket booths. Information system. Postboxes. Telephones. Toilets, bathrooms, showers, changing rooms, Fixed seating, bedrooms available to the public. Pavements, circulation routes.	*Parkings. Voie d'accès. Paliers de repos. Objets saillants. Portes extérieures et intérieures. Sas, couloirs, dégagements. Cage d'escalier. Niveaux des locaux et les ascenseurs éventuels. Acenseur ou élévateur à plate-forme. Locaux à guichets. Système d'information. Boîtes aux lettres. Téléphones. Cabine W.C. Salles de bain, douches, cabines de déshabillage, sièges fixes, chambres mises à la disposition du public. Trottoirs, espaces et mobilier.*	Art. 415
Building in rural sites	**Règlement général sur les bâtisses en site rural**	CHAPITRE XVII quater–
Signs and billboards	**Règlement général d'urbanisme relatif aux enseignes et aux dispositifs de publicité**	CHAPITRE XVII quinquies
Fitness standards for housing	**Criteres de salubrite des logements**	
Ceiling heights (fitness standards, requirements for adaptations, rehabilitation, refurbishment or acquisition, new-build standards). Useful area. Habitable rooms. Habitable area of dwelling, useful area of dwelling, useful area of building, area of glazed bays, floor area.	*Hauteur sous-plafond (salubrité; adaptation, réhabilitation, restructuration, acquisition; construction). Superficie utile. Pièce d'habitation. Superficie habitable du logement, superficie utile du logement, superficie utile du bâtiment, surface des baies vitrées, superficie de plancher.*	Article 1e r 1° - 8°
Stability of exterior envelope and load-bearing structure. Stability of non-structural elements. Damp-proofing. Electric and gas installations. Ventilation. Natural lighting. Sanitary equipment. WC compartment. Heating installations. Structure and dimensions. Volume, dimensions, layout, exits. Minimum habitable area. Circulation on ground floor, stairways.	*Stabilité de l'enveloppe extérieure et de la structure portante. Stabilité des composants non structurels. Étanchéité. Installations électriques et de gaz. Ventilation. Éclairage naturel. quipement sanitaire. Local où est situé le W-C. É Installation de chauffage. Structure et dimension. Volume, dimensions, agencement ou dégagements. Superficies minimales habitables. Circulation au niveau des sols et des escaliers.*	Annexe I

Table 2.3b Belgium: example of federal legislation

English translation of headings	Headings in original language	Location
Implementing order establishing minimum standards for prevention of fire and explosion, for new buildings.	Arrêté royal du 7 juillet 1994 fixant les normes de base en matière de prévention contre l'incendie et l'explosion, auxquelles les bâtiments nouveaux doivent satisfaire.	
Terminology	**Terminologie**	Annexe 1
General. Terminology concerning reaction to fire. Terminology concerning heating and air-handling equipment.	Définitions générales. Définitions relative à la réaction au feu. Terminologie relative aux équipments thermiques et aérauliques.	
Low buildings. Medium buildings. High buildings	**Bâtiments bas. Bâtiments moyens Bâtiments élevés**	Annexes 2 – 4
Annexes 2-4 for low, medium and high buildings, are similar, although the wording and order of requirements varies a little. The following entry identifies the common requirements and those peculiar to medium and high buildings.		
Layout and access routes.	Implantation et chemins d'accès.	
Requirements concerning some construction elements.	Préscriptions relatives à certains éléments de construction.	
Division into compartments. Evacuation of compartments. Number of exits. Exits.	*Division en compartiments. Evacuation des compartiments. Nombre de sorties. Les sorties.*	
Also: Medium, high buildings:	Bâtiments moyens, élevés:	
Roofs.	*Toitures.*	
Requirements concerning the construction of buildings and evacuation spaces.	Préscriptions relatives à la construction des bâtiments et des espaces d'évacuation.	
Penetration of partitions. Structural elements. Vertical partitions and interior doors. Ceilings and false ceilings. Façades.	*Traversées des parois. Eléments structuraux. Parois verticales et portes intérieures. Plafonds et faux-plafonds. Façades.*	
Also: Medium, high buildings:	Bâtiments moyens, élevés :	
Compartments. Internal stairwells. Exterior stairwells. Escape routes and passageways. Markings.	*Compartiments. Cages d'escaliers intérieures. Cages d'escaliers extérieures. Chemins d'evacuation et coursives. Signalisation.*	
Requirements concerning the construction of some rooms and service spaces.	Préscriptions relatives à la construction de certains locaux et éspaces techniques.	
Services rooms and spaces. General. Boiler rooms and ancillary spaces. Electricity transformer rooms. Rubbish shutes. Shafts containing pipes. Car parking spaces. Rooms. Commercial complex. Shared kitchens.	*Locaux et espaces techniques. Généralités. Chaufferies et leurs dépendances. Locaux de transormation de l'électricité. Evacuation des ordures. Gaines contenant des canalisations. Parkings. Salles. Ensemble commercial. Cuisines collectives.*	
Equipment for buildings.	Equipment des immeubles.	
Lifts and goods lifts. Paternosters, container transporters and automatic goods lifts. Electrical equipment: low voltage, driving force, lighting, warning signals. Installations supplied by combustible gas and distributed by pipework. Air-handling equipment. Systems for announcements, warning, and alarm, and means to extinguish fire.	*Ascenseurs et monte-charge. Paternosters, transportuers à conteneurs et monte-charges à chargement et déchargement automatiques. Installations électriques de basse tension, de force motrice, d'éclairage et de signalisation. Installations alimentées en gaz combustible et distribué par canalisations. Installations aérauliques. Annonce, alerte, alarme et moyens d'exstinction des incendie.*	
Also: Medium, tall buildings:	Bâtiments moyens, élevés :	
Escalators. Hydraulic lifts.	*Escaliers mécaniques. Ascensuers hydrauliques.*	
Reaction of materials to fire	**Réaction au feu des matériaux**	Annexe 5
Definition. Test methods. Classification of materials. Partitions. Stairs. Rubbish chutes. Façades. Roofs.	Definition. Methodes d'essai. Classement des matériaux. Parois des locaux. Escaliers. Vide-ordures. Façades. Toitures.	

basis for the development of specific requirements in the coming years. There is a project running for the development of the so called 'Material Based Environment Profile' (*MMG: Materiaalgebonden Milieu-profiel*). As in the other countries, such general objectives give only a vague indication of the scope of requirements.

The following analysis addresses only the technical subjects, rather than sections that deal with the building control system. Also it does not consider any sections about characteristics of building materials or workmanship.

2.3.3 Structure of the sets of requirements

In Denmark, England and Wales, France, Germany (Hesse), Netherlands, Norway, and Sweden, each of the primary sources is structured into sections with sub-headings. Broadly, there are three methods of classification, which are often used in combination:

- Objectives (fire safety, hygiene, health, energy conservation, accessibility, etc.).
- Strategies to achieve objectives (ventilation, thermal insulation, etc.).
- Parts of buildings (elements of construction - walls, floors and ceilings, roofs; areas in the building – circulation routes, habitable areas, etc.).

Additionally, sub-sections may be specific to dwellings, or to other types of buildings. Some countries also use 'General' headings, which disguise a variety of requirements.

The structure of regulatory documents in Belgium is very different, with both regional and federal requirements. We have not identified any single source listing the relevant legislation. In Wallonie, *CWATUP* is particularly difficult to navigate because it lacks sub-headings, and in order to describe the contents it was necessary to devise a brief summary. *Critères de Salubrité des Logements* is a much simpler document, but also lacks sub-headings. The only item of federal legislation studied, for fire safety, is structured around a three-part classification of buildings (see Tables 2.3a and 2.3b).

Denmark has two sets of building regulations, one of which is relevant to blocks of flats, the other one deals only with small houses. The classification of subjects mixes issues and parts of buildings. Some sub-sections on fire safety are related to building function (see Tables 2.4a and 2.4b).

In England and Wales, the *Approved Document*s are each based on one of the subjects identified in a Schedule to the Regulations, and each subject comprises one or more functional requirements. The structure of *ADs* varies, reflecting the differing revisions over time and the nature of the subjects. Some are sub-divided on the basis of the functional requirements, but others are organised by means of compliance which encompass more than one functional requirement. Some sub-sections on fire safety are related to building function (see Table 2.5).

Table 2.4a Denmark: Headings in primary sources

English translation of headings	Headings in original language	Location
BUILDING REGULATIONS	**I. BYGNINGSREGLEMENT**	
Regulations for buildings	**Bebyggelsesregulerende bestemmelser**	Kapitel 2 [Part 2]
General.	Generelt.	2.1 – 2.8
General criteria.	Generelle kriterier.	
Area of the plot.	Grundens størrelse.	
Distances to road, boundary etc.	Afstandsforhold.	
Height and number of storeys.	Højde og etageantal.	
Building floor area.	Etageareal.	
Recreation areas.	De ubebyggede arealer.	
Regulations for garages, carports, outhouses and other small buildings.	Bebyggelsesregulerende bestemmelser for garager, carporte, udhuse og lignende mindre bygninger.	
Regulations for small buildings max 10 m².	Bebyggelsesregulerende bestemmelser for småbygninger på højst 10 m².	
Calculation of area of the building	**Beregning af bebyggelsens omfang**	Kapitel 3 [Part 3]
Calculation of plot ratio.	Beregning af bebyggelsesprocent.	3.1 – 3.5
Calculation of area of the plot.	Beregning af grundstykkets areal.	
Calculation of building floor area.	Beregning af bebyggelsens etageareal.	
Calculation of heights.	Beregning af højdeforhold.	
Calculation of distances to road, boundary etc.	Beregning af afstandsforhold.	
Arrangement of buildings	**Bygningers indretning**	Kapitel 4 [Part 4]
General.	Generelt.	4.1 – 4.4
Access conditions:	Adgangsforhold	
Corridors and ramps, stairs, guard and handrails.	*Gange og ramper, trapper, værn og håndlister m.v.*	
Domestic buildings:	Beboelsesbygninger.	
Arrangement of the dwelling, habitable rooms and kitchens, sanitary accommodation, corridor widths, door widths, balconies.	*Boligens indretning, beboelsesrum og køkkener, bade- og wc-rum, dørbredder, gangbredder, altaner.*	
Other buildings than domestic buildings.	Andre bygninger end beboelsesbygninger.	
Design and construction	**Konstruktive bestemmelser**	Kapitel 5 [Part 5]
Performance of building works	Udførelse af bygnings-konstruktionerne:	5.1 – 5.5
General, design of structures.	*Generelt, dimensionering af konstruktioner.*	
Glass areas and glass constructions.	Glaspartier, glasflader og glaskonstruktioner.	
Playground equipment etc.	Legepladsredskaber m.v.	
Access for disabled persons to constructions and installations.	Handicaptilgængelig indretning af konstruktioner og anlæg.	
Building site.	Byggepladsen.	

English translation of headings	Headings in original language	Location
Fire safety General. Definitions. Distance from boundaries. Fire walls and fire-division walls. Escape routes. Rescue facilities. Structural requirements. Multi-storey housing.Fire compartments, fire divisions, etc., escape routes, rescue facilities. Hotels etc. Nursing institutions. Assembly rooms. Classrooms. Day-care institutions. Shops and similar sales premises. Office premises etc. One-storey industrial and storage buildings. Car parks. Farm buildings.	**Brandforhold** Generelt. Brandtekniske begreber. Afstandsforhold. Brandvægge og brandsektionsvægge. Flugtveje. Redningsforhold. Konstruktive forhold. Etageboligbyggeri. Brandceller og brandsektioner m.v., flugtveje, redningsforhold. Hoteller m.v. Plejeinstitutioner. Forsamlingslokaler. Undervisningslokaler. Daginstitutioner. Butikker og lignende salgslokaler. Kontorlokaler m.v. Industri- og lagerbygninger i 1 etage.Garageanlæg. Avls- og driftsbygninger.	Kapitel 6 [Chapter 6] 6.1 – 6.18
Resistance to moisture General. Surface water and drainage. Climate envelope. Wet rooms.	**Fugtisolering** Generelt. Overfladevand og dræning. Klimaskærm. Vådrum.	Kapitel 7 [Chapter 7] 7.1 – 7.4
Thermal insulation General. U-values for construction elements. Maximum permissible heat loss. Maximum thermal energy required for heating and ventilation per year. General, domestic builidngs, non-domestic buildings. Minimum permissible thermal insulation.	**Varmeisolering** Generelt. U-værdier for bygningsdele. Varmetabsramme. Energirammer. Generelt, energiramme for boliger, energiramme for andre bygninger. Mindste varmeisolering.	Kapitel 8 [Chapter 8] 8.1 – 8.5
Resistance to the passage of sound General. Domestic buildings, hotels, nursing institutions, etc. Airborne sound insulation, impact sound pressure level, reverberation time, noise level. Buildings for ducational purposes. Day-care institutions.	**Lydforhold** Generelt. Beboelsesbygninger, hoteller, plejeinstitutioner m.v.Lluftlydisolation, trinlydniveau, efterklangstid, støjniveau. Bygninger til undervisningsformål. Daginstitutioner.	Kapitel 9 [Chapter 9] 9.1 – 9.4
Heat producing appliances and chimneys General. Fireplaces and solid fuel stoves. Central heating boilers, oil burners, etc. Large central heating boilers. Straw-fired boilers. Heat producing appliances for commercial use. Connection to chimney. Chimneys and flue pipes.	**Ildsteder og skorstene** Generelle krav til ildsteder. Særlige krav til pejse og brændeovne. Krav til centralvarmekedler, oliebrændere m.v. Særlige krav til store centralvarmekedler. Særlige krav til halmfyringsanlæg. Tilslutning til skorsten. Krav til skorstene og røgrør.	Kapitel 10 [Chapter 10] 10.1–10.8
Indoor climate General. Ventilation. General, residential buildings, buildings other than dwellings. Contamination from building materials – general, formaldehyde, asbestos, mineral wool, fly ash and clinker from coal firing. Other contaminants Nitrogen oxides, radon, other contaminants from the subsoil. Temperature.	**Indeklima** Generelt. Ventilation. Generelt, beboelsesbygninger, andre bygninger end beboelsesbygninger. Forureninger fra byggematerialer. Generelt, formaldehyd, asbest, mineraluld, flyveaske og slagger fra kulfyring. Forureninger i øvrigt Kvælstofilter, radon, anden forurening fra undergrund. Temperatur.	Kapitel 11 [Chapter 11] 11.1 – 11.5
Services General. Heating, hot water and cooling systems. Ventilation systems. Water installations. Drainage installations. Waste disposal installations. Lifts. Antennas. Lighting installations.	**Installationer** Generelt. Varme-, varmtvands- og køleanlæg. Ventilationsanlæg. Vandinstallationer. Afløbsinstallationer. Renovationsanlæg. Elevatorer. Antenner. Belysningsanlæg. Tekniske hjælpemidler for handicappede.	Kapitel 12 [Chapter 12] 12.1 – 12.9
Farm buildings and similar, and wind turbines General. Heights and distances. Construction elements. Fire safety. Drainage.	**Avls- og driftsbygninger og vindmøller** Generelt. Bygningshøjder - og afstande. Bygningskonstruktioner. Brandforhold. Afløbsforhold	Kapitel 13 [Chapter 13] 13.1 – 13.5

Table 2.4b Denmark: Headings in primary sources

English translation of headings	Headings in original language	Location
BUILDING REGULATIONS FOR SMALL DWELLINGS	**II. BYGNINGSREGLEMENT FOR SMÅHUSE**	
Regulations for buildings General. Area of the plot. Plot ratio. Height and number of floors. Distances to road, boundary etc. Area of the building. Measurements of heights and distances. Height and distance in relation to road, boundaries with neighbouring properties and paths. Supplementary provisions on heights and distances. Parking areas.	**Bebyggelsesregulerende bestemmelser** Generelt. Grundstørrelse. Bebyggelsesprocent.Højde og etageantal. Afstandsforhold. Bebyggelsens omfang. Måling af højder og afstande. Bebyggelsens højde og afstand i forhold til vej, naboskel og sti. Supplerende bestemmelser om bebyggelsens højde og afstandsforhold Parkeringsarealer.	Kapitel 2 [Part 2] 2.1 – 2.10
Arrangement of houses General. Access conditions. Guards and handrails. Habitable rooms and kitchens. Rescue facilities. Sanitary accommodation. Widths of doors and corridors.	**Boligens indretning** Generelt. Adgangsforhold. Værn. Beboelsesrum og køkken. Redningsåbninger. Bade- og wc-rum. Dør- og gangbredder.	3 3.1 – 3.7
Structures, fire protection and building site General. Loadbearing structures. Fire protection. Resistance to passage of sound. Roofs. Wet rooms. The building site.	**Konstruktioner, brandforhold og byggepladsen** Generelt. Bærende konstruktioner. Brandforhold. Lydforhold. Tage. Vådrum. Byggepladsen.	4 4.1 – 4.7
Thermal insulation General. U-values for construction elements. Maximum heat loss. Maximum heat consumption. Minimum thermal insulation.	**Varmeisolering** Generelt. U-værdier for bygningsdele. Varmetabsramme. Energiramme. Mindste varmeisolering.	5 5.1 – 5.5
Indoor climate General. Ventilation. Air change. Contamination from building materials – General, Formaldehyde, asbestos, mineral wool, fly ash and clinker from coal firing. Other contaminants – Nitrogen oxides, radon, other contaminants from below ground.	**Indeklima** Generelt. Ventilation. Luftskiftets størrelse. Forureninger fra byggematerialer. Generelt. Formaldehyd, asbest, mineraluld, flyveaske og slagger fra kulfyring. Forureninger i øvrigt. Kvælstofilter, radon, anden forurening fra undergrund.	6 6.1 – 6.5
Services General. Heating and hot water systems. Ventilation systems. Water installations. Drainage installations. Waste disposal installations.	**Installationer** Generelt. Varme- og varmtvand-sanlæg. Ventilationssystemer. Vandinstallationer. Afløbsinstallationer. Renovationsanlæg.	7 7.1 – 7.6
Heat-producing appliances and chimneys Heat-producing appliances. Aire for combustion. Connection to chimney. Chimney and flue pipes. Distances to combustible materials. Straw thatched roofs etc.	**Ildsteder og skorstene** Ildsteder. Luft til forbrænding. Tilslutning til skorsten. Skorstene og røgrør. Afstande til brændbart materiale. Stråtag eller anden tag-dækning som ikke er brandmæssigt egnet klasse T tagdækning, supplerende bestemmelser.	8 8.1 – 8.6
Joined single-family houses General. Site. Supplementary provisions: heights and distances; access conditons, guards and handrails, habitable rooms and kitchens, fire protection, resistance to passage of sound, thermal insulation, indoor climate, services. Playground equipment.	**Sammenbyggede enfamiliehuse** Generelt. Det ubebyggede areal. Supplerende bestemmelser: bebyggelsens højder og afstande, adgangsforhold, værn, beboelsesrum og køkken, brandforhold, lydforhold, varmeisolering, indeklima, installationer. Legepladsredskaber.	9 9-1 – 9.12
Holiday cottages Garages, carports, outhouses and similar small buildings. Small buildings of max. 10 m². Allotment huts.	**Sommerhuse** Garager, carporte, udhuse og lignende mindre bygninger. Småbygninger på højst 10 m². Kolonihavehus.	10 – 13

In France it is possible to identify the subjects of regulation, which are specified in the national *Code de la Construction et de l'Habitation (CCH),* but it is difficult to find a complete family tree of the implementing orders which elaborate the *CCH*. The headings and sub-headings in the *CCH* are a mixture of general provisions and objectives, but some are not particularly informative. There are no further sub-headings in the Articles, so it would be necessary to summarise the content of each paragraph of each article to understand the scope of the regulations in detail. The legislative articles are the basis of the regulatory articles. Only the regulatory articles relevant to buildings (rather than roadways or neighbouring land) are included in the following analysis (see Tables 2.6a and 2.6b).

The least helpful headings are in Germany (Hesse) where there are no sub-headings but headings may encompass several different types of concerns. Some sections of the building ordinance are structured around parts of buildings, rather than objectives; other sections are less specific. For instance, Paragraph 43, entitled 'Dwellings' is almost a random list of subjects, addressing provision of separate entrances to dwellings in mixed use buildings; provision for barrier-free access; ventilation of kitchens, storage for prams and bikes, and provision of a bath or shower and toilet (see Table 2.7).

In the Netherlands, most of the headings and sub-headings clearly identify the subject and objectives, which are elaborated in one or more articles (see Tables 2.8).

In Norway, the headings and sub-headings are fairly explicit, with some further sub-sub-headings (see Tables 2.9).

In Sweden, there are four levels of sub-headings. The third level includes objectives, parts of buildings, definitions, or requirements for specific applications. For example, sub-heading 3.12 Access comprises: 3:121-3:126 access for wheelchairs, general; access to buildings; entrances and circulation spaces; lifts and other lifting devices; doors; non-residential premises (see Tables 2.10a and 2.10b).

Table 2.5 England and Wales: Headings in primary sources

Headings in original language	Location
APPROVED DOCUMENT A: STRUCTURE (2000)	
Loading. Ground movement.	A1 - A2
Sizes of structural elements for certain residential buildings and other small buildings of traditional construction. Basic requirements for stability. Sizes of certain timber floor ceiling and roof members in single family houses. Thickness of walls in certain small buildings. Proportions for masonry chimneys above the roof surface. Strip foundations for plain concrete. External wall cladding. Re-covering of roofs. Codes, standards and references.	Sections 1, 1A – 1E, 2 - 4
Disproportionate collapse.	A3
Reducing the sensitivity of the building to disproportionate collapse in the event of an accident.	Section 5
APPROVED DOCUMENT B: FIRE SAFETY (2002)	
Means of warning and escape.	B1
Fire alarm and fire detection systems. Dwelling houses. Flats and maisonettes. Design for horizontal escape– buildings other than dwellings. Design for vertical escape – buildings other than dwellings. General provisions common to buildings other than dwelling houses.	Sections 1 – 6
Internal fire spread (linings).	B2
Wall and ceiling linings.	Section 7
Internal fire spread (structure).	B3
Load bearing elements of structure. Compartmentation. Concealed spaces (cavities). Protection of openings and fire stopping. Special provisions for car parks and shopping complexes.	Section 8 – 12
External fire spread.	B4
Construction of external walls. Space separation. Roof coverings.	Section 13 – 15
Access and facilities for the fire service.	B5
Fire Mains. Vehicle access. Access to buildings for fire fighting personnel. Venting of heat and smoke from basements.	Sections 16 – 19
APPROVED DOCUMENT C: SITE PREPARATION AND RESISTANCE TO MOISTURE (2000)	
Preparation of site. Dangerous and offensive substances. Subsoil drainage. Resistance to weather and ground moisture.	C1 – C4
Site preparation and site drainage: normal site preparation, organic material, site drainage. Contaminants: signs of contaminants, gaseous contaminants – radon, landfill gas and methane. Floors next to the ground: ground supported floors, suspended timber floors, suspended concrete floors. Walls. Claddings for external walls and roofs.	Sections 1 – 5
APPROVED DOCUMENT D: TOXIC SUBSTANCES (2000)	
Cavity insulation.	D1
Acceptable level of performance, urea-formaldehyde (UF) foam.	
APPROVED DOCUMENT E: RESISTANCE TO THE PASSAGE OF SOUND (2003)	
Protection against sound from other parts of the building and adjoining buildings. Protection against sound within a dwelling-house etc. Reverberation in the common internal parts of buildings containing flats or rooms for residential purposes. Acoustic conditions in schools.	E1 – E4
Performance. Pre-completion testing. Separating walls and associated flanking constructions for new buildings. Separating floors and associated flanking constructions for new buildings. Dwelling-houses and flats formed by material change of use. Internal walls and floors for new buildings. Rooms for residential purposes. Reverberation in the common internal parts of buildings containing flats or rooms for residential purposes. Acoustic conditions in schools.	Sections 0 – 8

Headings in original language	Location
APPROVED DOCUMENT F: VENTILATION (2000)	
Means of ventilation.	F1
Domestic buildings. Non-domestic buildings.	Sections 1 - 2
Condensation in roofs.	F2
Roofs with a pitch of 15° or more (pitched roofs). Roofs with a pitch of less than 15° and those where ceiling follows the pitch of the roof.	Sections 1 - 2
APPROVED DOCUMENT G: HYGIENE (2000)	
Sanitary conveniences and washing facilities. Bathrooms.	G1 – G2, Sect. 1– 4
Hot water storage.	G3
Systems up to 500 litres and 45 kW. Systems over 500 litres or 45 kW.	Sections 3 - 4
APPROVED DOCUMENT H: DRAINAGE AND WASTE DISPOSAL (2002)	*AD H* (2002)
Also: Sewers Protocol.	
Sanitary pipework and drainage.	H1
Sanitary pipework. Foul drainage.	Sections 1 – 2
Cesspools and tanks – capacity, siting, design and construction, alternative approach.	H2
Rainwater drainage.	H3
Gutters and rainwater pipes. Rainwater drainage.	Sections 1 - 2
Solid waste storage – domestic developments, non-domestic developments.	H4
APPROVED DOCUMENT J: COMBUSTION APPLIANCES AND FUEL STORAGE SYSTEMS (2002)	
Air supply. Discharge of products of combustion. Protection of building. Provision of information. Protection of liquid fuel storage systems. Protection against pollution.	J1-J6
General guidance. Provisions which apply generally to combustion installations. Appliances burning solid fuel. Gas burning appliances. Oil burning appliances. Liquid fuel storage and supply.	Sections 0 – 5
APPROVED DOCUMENT K: PROTECTION FROM FALLING, COLLISION AND IMPACT (2000)	
Stairs, ladders and ramps. Protection from falling. Vehicle barriers and loading bays. Protection from collision with open windows, skylights and ventilators. Protection against impact from and trapping by doors.	K1 – K5
Stairs and ladders. Ramps. Guards and barriers. Protection from collision. Protection against impact.	Sections 1 – 5
APPROVED DOCUMENT L1: CONSERVATION OF FUEL AND POWER IN DWELLINGS (2002)	
General. Design and construction. Work on existing dwellings.	Sections 0 - 2
APPROVED DOCUMENT L2: CONSERVATION OF FUEL AND POWER IN BUILDINGS OTHER THAN DWELLINGS (2002)	
General. Design. Construction. Providing information. Work on existing buildings.	Sections 0 – 4
APPROVED DOCUMENT M: ACCESS AND FACILITIES FOR DISABLED PEOPLE (2000)	
Interpretation. Access and Use. Sanitary conveniences. Audience or spectator seating.	M1 – M4
Buildings other than dwellings.	Sections 1 – 5
Dwellings: Means of access to and into the dwelling. Circulation within the entrance storey of the dwelling. Accessible switches and socket outlets in the dwelling. Passenger lifts & common stairs in blocks of flats. WC provision in the entrance storey of the dwelling.	Sections 6 - 10
APPROVED DOCUMENT N: GLAZING - SAFETY IN RELATION TO IMPACT, OPENING AND CLEANING (2000)	
Protection against impact.	N1, Section 1
Manifestation of glazing.	N2, Section 2
Safe opening and closing of windows, skylights and ventilators.	N3, Section 3
Safe access for cleaning windows etc.	N4, Section 4

Table 2.6a France: Headings in primary sources (legislative articles)

English translation of headings	Headings in original language	Location
CONSTRUCTION AND HOUSING CODE (Legislative section)	**CODE DE LA CONSTRUCTION ET DE L'HABITATION (Partie Legislative)**	
General provisions: Construction of buildings	**Dispositions générales: Construction des bâtiments**	LIVRE I [BOOK I]: TITRE I [TITLE I]
General rules	**Règles générales**	Chap. I
Provisions applicable to all buildings.	Dispositions applicables à tous les bâtiments.	Section I Arts. L111-1 - L111-3
General provisions applicable to residential buildings.	Dispositions générales applicables aux bâtiments d'habitation.	Section II
General construction rules. General rules for subdivision of buildings.	*Règles générales de construction. Règles générales de division.*	Sous-sections I - II Arts. L111-4 - L. 111-6-2
Disabled people.	Personnes handicapées.	Section III Arts. L111-7 - L111-8-4
Thermal characteristics.	Caractéristiques thermiques.	Section IV Arts. L111-9 - L111-10
Acoustic characteristics.	Caractéristiques acoustiques.	Section V Arts. L111-11 - L111-11-2
Special provisions	**Dispositions spéciale**	Chap. II
Construction at the edge of roadways and railways. Underground surveys and works. Party walls. View. Transmitters. Buildings near a wartime beach or magazine. Building near forests. Nuisance caused by specified activities. Protection against xylophagous insects.	Constructions en bordure de voie. Sondages et travaux souterrains. Servitudes de mitoyenneté. Servitudes en vue. Antennes émettrices. Constructions autour d'une plage de guerre ou d'une poudrerie. Constructions à proximité des forêts. Nuisances dues à certaines activités. Protection contre les insectes xylophages.	Sections I - IX Arts. L112-1 - L112-17
Safety and protection of buildings	**Sécurité et protection des immeubles**	**Titre II**
	Dispositions de sécurité relatives aux immeubles de grande hauteur.	Chap. II Arts. L122-1 - L122-2
Protection from risk of fire and panic in buildings open to the public.	Protection contre les risques d'incendie et de panique dans les immeubles recevant du public.	Chap. III Arts. L123-1 - L123-3
Adaptation of buildings in times of war.	Adaptation des constructions au temps de guerre.	Chap. IV Art. L124-1
Safety of specified equipment in buildings.	Sécurité de certains équipements immeubles par destination.	Chap. V
Safety of lifts. Safety of automatic garage doors.	*Sécurité des ascenseurs. Sécurité des portes automatiques de garage.*	Section I - II L125-1 - L125-5
Permission for police to enter common parts of residential buildings.	Intervention de la police et de la gendarmerie dans les immeubles à usages d'habitation.	Chap. VI Art. L126-1
Surveillance of buildings.	Gardiennage ou surveillance des immeubles.	Chap. VII Art. L127-1
Heating and maintenance of buildings	**Chauffage et ravalement des immeubles**	**Titre III**
Heating of buildings.	Chauffage des immeubles.	Chap. I Arts. L131-1 - L131-6
Maintenance of façades.	Ravalement des immeubles.	Chap. II Arts. L132-1 - L132-5
Control of termites.	Lutte contre les termites.	Chap. III Arts. L133-1 à L133-3

Table 2.6b France: Headings in primary sources (regulatory articles)

English translation of headings	Headings in original language	Location
CONSTRUCTION AND HOUSING CODE (Regulatory section - Council of State Decrees)	**CODE DE LA CONSTRUCTION ET DE L'HABITATION (Partie Réglementaire - Décrets en Conseil d'Etat)**	
General provisions: Construction of buildings	**Dispositions générales: Construction des bâtiments**	LIVRE I [BOOK I]: TITRE I [TITLE I]
General rules	**Règles générales**	Chap. I
General provisions for residential buildings.	Dispositions générales applicables aux bâtiments d'habitation.	Section II Arts. R111-1 - R111-17
Disabled people.	Personnes handicapées.	Section III
Provisions for new multi-family residential buildings.	*Dispositions applicables aux bâtiments d'habitations collectifs neufs.*	Sous-section I Arts. R111-18 - R111-18-4
Provisions for construction, creation or modification of establishments or installations open to the public.	*Dispositions applicables lors de la construction, de la création ou de la modification d'établissements recevant du public ou d'installations ouvertes au public.*	Sous-section II Arts. R111-19 - R111-19-3
Thermal characteristics.	Caractéristiques thermiques.	Section IV Arts. R111-20 - R111-21
Acoustic characteristics.	Caractéristiques acoustiques.	Section V Arts. R111-23-1 - R111-23-3
Special provisions	**Dispositions spéciales**	Chap. II
Special provisions for prevention of risk from earthquakes.	Dispositions spéciales relatives à la prévention du risque sismique.	Section I Art. R112-1
Safety and protection from fire	**Sécurité et protection contre l'incendie**	TITRE II
Protection from fire – classification of materials	Protection contre l'incendie - Classification des matériaux.	Chap. I Arts. R121-1 - R121-13
Safety in very tall buildings.	Dispositions de sécurité relatives aux immeubles de grande hauteur.	Chap. II
Definitions. Location, conditions of use, safety principles. Interministerial technical committee. Duties of occupation. Implementation of controls.	*Définitions et classifications. Emplacement, conditions d'utilisation, principes de sécurité. Commission technique interministérielle. Obligations relatives à l'occupation des locaux. Mesures de contrôle.*	Sections 1-V Arts. R122-1 – R122-29

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English translation of headings	Headings in original language	Location
Protection from risk of fire and panic in buildings open to the public.	Protection contre les risques d'incendie et de panique dans les immeubles recevant du public.	Chap. III Arts. R123-1 – R123-55
Definition, application of safety rules. Classification.	*Définition et application des règles de sécurité. Classement des établissements.*	Sections I - IV Arts. R123-2 - R123-21
Adaptation of buildings in times of war.	Adaptation des constructions pour le temps de guerre.	Chap. IV Art. R124-1
Safety of specified equipment in buildings.	Sécurité de certains équipements d'immeubles par destination.	Chap. V
Safety of automatic garage doors.	Sécurité des portes automatiques de garage.	Section II Arts. R125-3-1 - R125-5
Protection from natural risks or mining.	Protection contre les risques naturels ou miniers.	Chap. VI Art. R126-1
Supervision of specified residential buildings.	Gardiennage ou surveillance de certains immeubles d'habitation.	Chap. VII Arts. R127-1 - R127-7
Heating and maintenance of buildings	**Chauffage et ravalement des immeubles**	TITRE III
Heating of buildings.	Chauffage des immeubles.	Chap. I
Recording and sharing of charges in shared buildigns. Charges for hot water in shared buildings. Heating installations. Maximum temperature in heating systems.	*Equipement et répartition des frais dans les immeubles collectifs. Frais d'eau chaude dans les immeubles collectifs. Régulation des installations de chauffage. Limitation de la température de chauffage.*	Sections I – IV, Arts. R131-1 - R131-24
Maintenance of façades.	Ravalement des immeubles.	Chap. II Art. R132-1
Control of termites.	Lutte contre les termites.	Chap. III Arts. R133-1 - R133-2

Table 2.6c France: example of an implementing order

English translation of headings	Headings in original language	Location
IMPLEMENTING ORDER CONCERNING PROTECTION FROM FIRE IN RESIDENTIAL BUILDINGS	**ARRETE DU 31 JANVIER 1986 RELATIF A LA PROTECTION CONTRE L'INCENDIE DES BATIMENTS D'HABITATION**	
General, and classification of residential buildings	**Generalites et classement des batiments d'habitation**	TITRE I
Application of requirements. Classification of materials and elements of construction.	Généralités.	Chap. I Art. 1 – 2
Classification of residential buildings. Access ways for fire-fighting.	Classement des bâtiments d'habitation. Voies échelles, voies engins.	Chap. II Art 3-4
Structure and envelope of residential buildings	**Structures et enveloppe des batiments d'habitation**	TITRE II
Structure.	Structure.	Chap. I
Vertical load-bearing elements. Floors.	*Eléments porteurs verticaux. Planchers.*	Sections 1 - 2 Arts. 5 - 6
Envelope.	Enveloppe.	Chap. II
Vertical stepping of buildings. Walls. Storerooms or cellars. Facades, surface finishes of facades, facades incorporating openings, facades without openings. Roof coverings.	*Recoupement vertical des bâtiments. Parois. Celliers ou caves. Façades, revêtements des façades, façades comportant des ouvertures, façades ne comportant pas d'ouvertures. Couvertures.*	Sections 1 - 5 Arts. 7 - 15
Insulation of internal walls.	Isolation des parois par l'intérieur.	Chap. III Art. 16
Escape routes	**Degagements**	TITRE III
Stairways.	Escaliers	Chap. I
Walls of stairways on facades. Walls of stairways not located on facades. Treads, flights, and landings. Surfaces in stairwells. Connection of stair and underground spaces. Characteristics of stairwells.	*Parois des cages d'escalier situées en façades. Parois des cages d'escaliers non situées en façade. Marches, volées et paliers de l'escalier. Revêtements de la cage d'escalier. Communication de l'escalier avec le sous-sol. Caractéristiques des cages d'escalier.*	Sections 1 - 6 Arts. 18 – 29
Protected horizontal circulation routes.	Circulations horizontales protégées.	Chap. II
Open air and smoke protected horizontal circulation routes.	*Circulations horizontales à 'l'air libre', à 'l'abri des fumées'.*	Sections1 - 2 Arts. 30 - 38
Protected escape routes linking a protected stairway and a protected horizontal circulation route.	Dégagements protégés, associant un escalier protégé et une circulation horizontale protégée.	Chap. III
Protected escape routes for Category 3B dwellings. Protected escape routes for Category 4 dwellings.	*Dégagements protégés des habitations de la troisième famille B. Dégagements protégés des habitations de la quatrième famille.*	Sections 1 - 2 Arts. 39 – 43

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English translation of headings	Headings in original language	Location
Pipes and ducts	**Conduits et gaines**	TITRE IV
General requirements.	Prescriptions générales.	Chap. I
Definitions, general. Pipes and ducts passing between different storeys. Pipes and ducts penetrating walls which are required to be fire resistant.	*Définitions et généralités. Conduits et gaines mettant en communication des niveaux différents. Conduits et gaines traversant des murs pour lesquels sont exigées des propriétés de résistance au feu.*	Sections 1 - 3 Art. 44 – 49
Gas ducts and pipes.	Gaines et conduites montantes de gaz.	Chap. II
Special requirements. Places for installation of gas-fired appliances for space heating and hot water.	*Prescriptions particulières. Locaux exclusivement réservés à l'installation d'appareils à gaz pour le chauffage et la production d'eau chaude.*	Sections I - 2 Art. 50 – 57
Other ducts.	Autres gaines.	Chap. III
Risers for electricity. Ventilation pipes and circuits. Refuse chutes.	Gaines pour colonnes montantes 'électricité'. Conduits et circuits de ventilation. Vide-ordures.	Arts. 58 - 64
Special requirements for foyers	**Dispositions particulieres applicables aux logements-foyers**	TITRE V, Chaps. I – IV, Arts. 65 - 76
Car parks	**Parcs de stationnement**	TITRE VI, Chaps. I – V, Arts. 77 – 96
Miscellaneous requirements	**Dispositions diverses**	TITRE VII
Lifts. Dry risers. Pedestrian circulation.	*Ascenseurs. Colonnes sèches. Circulation des piétons.*	Sections 1 – 3, Arts. 97 - 99

Table 2.7 Germany (Hesse): Headings in primary sources

English translation of headings	Headings in original language	Location
BUILDING ORDINANCE OF THE STATE OF HESSE	**HESSISCHE BAUORDNUNG**	
	Das Grundstück und seine Bebauung	Zweiter Teil [Part 2]
Development of property and land Development of building plots. Entrances and approach roads. Areas and distances. Distances from adjoining properties. Open space. Children's playgrounds.	Bebauung der Grundstücke. Zugänge und Zufahrten auf den Grundstücken. Abstands-flächen und Abstände. Übernahme der Abstandsflächen und Abstände auf Nach-bargrundstücke, Grundstücksteilung. Grundstücksfreiflächen, Kinderspielplätze.	§ 4 – 8
General requirements for the execution of construction Organisation. Building site. Stability. Protection against harmful influences. Fire protection. Thermal protection, noise control, vibration protection. Road safety.	**Allgemeine Anforderungen an die Bauausführung** Gestaltung. Baustelle. Standsicherheit. Schutz gegen schädliche Einflüsse. Brandschutz. Wärmeschutz, Schallschutz, Erschütterungsschutz. Verkehrssicherheit.	Dritter Teil [Part 3] Erster Abschnitt [Section 1] § 9 – 15
Walls, floors and ceilings, roofs Structural walls, external walls, columns, supports. Partitions. Fire walls. Floors and ceilings. Roofs.	**Wände, Decken, Dächer** Tragende Wände, Außenwände, Pfeiler, Stützen. Trennwände. Brandwände. Decken. Dächer.	Dritter Abschnitt [Section 3] § 25 – 29
Circulation and emergency routes, guardings, lifts Stairs. Essential stairways and exits. Essential corridors. Lifts. Windows, doors, and cellar light wells. Guardings, parapet walls, railings.	**Verkehrs- und Rettungswege, Umwehrungen, Aufzüge** Treppen. Notwendige Treppenräume und Ausgänge. Notwendige Flure und Gänge. Aufzüge. Fenster, Türen, Kellerlichtschächte. Umwehrungen, Brüstungen, Geländer.	Vierter Abschnitt [Section 4] § 30 – 35
Technical installations Pipes, ventilation systems, service shafts, ducts. Boilers, heating and fuel supply plants, combustion appliances. Water supply installations. Waste water and rainwater installations. Introduction of waste water into small sewage treatment plants or containers. Spaces for waste containers.	**Haustechnische Anlagen** Leitungen, Lüftungs-anlagen, Installationsschächte, Installations-kanäle. Feuerungsanlagen, Wärme- und Brennstoffversorgungsanlagen, ortsfeste Verbrennungsmotoren. Wasserversorgungs-anlagen. Anlagen für Abwasser und Nieder-schlagswasser. Einleitung der Abwasser in Kleinkläranlagen oder Behälter. Standflächen und Aufstellräume für Abfallbehältnisse.	Fünfter Abschnitt [Section 5] § 36 – 41
Habitable rooms and dwellings Habitable rooms. Dwellings.	**Aufenthaltsräume und Wohnungen** Aufenthaltsräume. Wohnungen.	Sechster Abschnitt [Section 6] § 42 – 43
Special installations Garages, car parking bays, parking areas for bicycles. Structural facilities and areas of special types or use. Barrier-free building.	**Besondere Anlagen** Garagen, Stellplätze für Kraftfahrzeuge, Abstellplätze für Fahrräder. Bauliche Anlagen und Räume besonderer Art oder Nutzung. Barrierefreies Bauen.	Siebter Abschnitt [Section 7] § 44 – 46

Table 2.8 The Netherlands: Headings in primary sources

English translation of headings	Headings in original language	Location
BUILDING DECREE	**BOUWBESLUIT**	
Safety	**Voorschriften uit het oogpunt van veiligheid**	Chapter 2
General strength of the building construction. Stability in the event of fire. Floor partition.	Algemene sterkte van de bouwconstructie. Sterkte bij brand. Vloerafscheiding.	Headings 2.1-2.3
Bridging differences in height. Staircases. Ramps.	Overbrugging van hoogteverschillen. Trap. Hellingbaan.	Heading 2.4-2.6
Electricity supply and emergency power supply. Lighting. Gas supply.	Elektriciteits- en noodstroomvoorziening. Verlichting. Gasvoorziening.	Headings 2.7-2.9
Moveable construction components.	Beweegbare constructie-onderdelen.	Heading 2.10
Limiting the risk of fire. Limiting the development of fire. Limiting the spread of fire. Further limiting the spread of fire. Limiting smoke formation. Limiting the spread of smoke. Escaping from a smoke compartment. Smoke-free escape routes. Design of smoke-free escape routes. Prevention and restriction of accidents in the event of a fire. Fighting ires. Large fire compartments. Tall and underground buildings.	Beperking van het ontstaan van een brandgevaarlijke situatie. Beperking van ontwikkeling van brand. Beperking van uitbreiding van brand. Verdere beperking van uitbreiding van brand. Beperking van ontstaan van rook. Beperking van verspreiding van rook. Vluchten binnen een rookcompartiment en een subbrandcompartiment. Rookvrije vluchtroutes. Inrichting van rookvrije vluchtroutes. Voorkoming en beperking van ongevallen bij brand. Bestrijding van brand. Grote brandcompartimenten. Hoge en ondergrondse gebouwen.	Heading 2.11-2.23
Access to a construction. Resistance to burglaries.	Toegang van een gebouw. Inbraakwerendheid.	Heading 2.24-2.25
Health	**Voorschriften uit het oogpunt van gezondheid**	Chapter 3
Protection against external noise. Protection against noise from installations. Soundproofing between habitable rooms in one user function. Restriction of resonance. Soundproofing between rooms with different user functions (new buildings).	Bescherming tegen geluid van buiten. Bescherming tegen geluid van installaties. Geluidwering tussen verblijfsruimten van één gebruiksfunctie. Beperking van galm. nieuwbouw. Geluidwering tussen ruimten van andere gebruiksfuncties.	Headings 3.1-3.5
Protection against damp from outdoors. Protection against damp from inside. Drainage of waste water and faeces. Drainage of rainwater.	Wering van vocht van buiten. Wering van vocht van binnen. Afvoer van afvalwater en fecaliën. Afvoer van hemelwater nieuwbouw.	Headings 3.6-3.9

English translation of headings	Headings in original language	Location
Ventilation in habitable area, habitable room, toilet and bathroom. Airing facility. Ventilation in other rooms. Supply of combustion air. Removal of smoke.	Luchtverversing van een verblijfsgebied, verblijfsruimte, toiletruimte en badruimte. Spuivoorziening. Luchtverversing van overige ruimten. Toevoer van verbrandingslucht. Afvoer van rook.	Headings 3.10-3.14
Restriction of the use of hazardous materials. Restriction of possible penetration of hazardous substances or radiation from the ground.	Beperking van de toepassing van schadelijke materialen. Beperking van het kunnen binnendringen van uit de grond afkomstige schadelijke stoffen of straling.	Headings 3.15-3.16
Protection against vermin. Drinking water facility. Hot water facility. Daylight.	Bescherming tegen ratten en muizen. Drinkwatervoorziening. Warmwatervoorziening. Daglicht.	Headings 3.17-3.20
Utility	**Voorschriften uit het oogpunt van bruikbaarheid**	Chapter 4
Surface area of standing place [for caravan].	Oppervlakte van de standplaats.	Heading 4.1
Accessibility sector. Free passage. Accessibility.	Toegankelijkheidssector. Vrije doorgang. Bereikbaarheid.	Headings 4.2-4.2
Habitable areas. Habitable rooms. Toilet. Bathroom. Changing room. Shared storage room for household refuse. Bicycle storage room. Meter room.	Verblijfsgebied. Verblijfsruimte. Toiletruimte. Badruimte. Kleedruimte. Gemeenschappelijke opslagruimte voor huishoudelijk afval. Stallingsruimte voor fietsen. Meetruimte.	Headings 4.5-4.12
Lift shaft. Lift machinery room.	Liftschacht. Liftmachineruimte.	Headings 4.13-4.14
Installation space for a sink, installation space for a cooking appliance. Installation space for a fireplace. Installation space for a hot water appliance.	Opstelplaats voor een aanrecht en opstelplaats voor een kooktoestel. Opstelplaats voor een stooktoestel. Opstelplaats voor een warmwatertoestel.	Headings 4.15-4.17
Swimming pool.	Bassin.	Heading 4.18
Energy conservation	**Voorschriften uit het oogpunt van energiezuinigheid**	Chapter 5
Heat insulation. Restriction of air permeability. Energy performance.	Thermische isolatie. Beperking van luchtdoorlatendheid. Energieprestatie.	Headings 5.1-5.3
Environmental protection	**Voorschriften uit het oogpunt van milieu**	Chapter 6
Although provision is made for the regulation of environmental protection issues, none are as yet included in the Building Decree.		

Table 2.9 Norway: Headings in primary sources

English translation of headings	Headings in original language	Location
TECHNICAL REGULATIONS OF THE PLANNING AND BUILDING CODE	**TEKNISKE FORSKRIFTER TIL PLAN- OG BYGNINGSLOVEN**	
Personal and material safety	**Personlig og materiell sikkerhet**	Kap. VII [Chapter VII]
Personal and material safety.	Personlig og materiell sikkerhet.	§ 7-1
Safety in case of fire.	Sikkerhet ved brann.	§ 7-2
Documentation in case of fire. Hazard classes and fire classes. Load-bearing capacity and stability in case of fire. Ignition, development and spread of fire and smoke. Preparations for fire fighting. Spread of fire between construction works. Escape of persons. Arrangements for rescue and fire-fighting personnel.	*Dokumentasjon. Risikoklasser og brannklasser. Bæreevne og stabilitet ved brann. Antennelse, utvikling og spredning av brann og røyk. Tilrettelegging for slokking av brann. Brannspredning mellom byggverk. Rømning av personer. Tilrettelegging for rednings- og slokkemannskap.*	§ 7-21 - 7-28
Location and load-bearing capacity.	Plassering og bæreevne.	§ 7-3
Reliability classes for construction works. Safety against actions of nature (slides, flooding, waves and wind). Structural safety.	*Pålitelighetsklasser for byggverk. Sikkerhet mot naturpåkjenninger. Konstruksjonssikkerhet.*	§ 7-31 - 7-33
Safety in use.	Sikkerhet i bruk.	§ 7-4
Layout, size and design. Outdoor areas. Burn injuries. Injuries from electrical sources. Objects falling from construction works. Movable parts of construction works. Saunas and freezer compartments. Safety against drowning.	*Planløsning, størrelse og utforming. Uteareales. Forbrenningsskader. Skader fra elektriske kilder. Nedfall fra byggverk. Bevegelige deler av byggverk. Badstue og fryserom. Sikkerhet mot drukning.*	§ 7-41 – 7-48
Environment and health	**Miljø og helse**	Kap. VIII [Chapter VIII]
Environment and health.	Miljø og helse.	§ 8-1
Use of energy.	Energibruk.	§ 8-2
Energy and power. Air tightness. Materials favourable to energy and the environment.	*Energi og effekt. Tetthet. Energi og miljøvennlige materialer.*	§ 8-21 – 8-2
Indoor climate.	Innemiljø.	§ 8-3
Air quality. Contamination. Ventilation. Light. Indoor thermal climate. Moisture. Cleaning prior to taking the building in use.	*Luftkvalitet. Forurensninger. Ventilasjon. Lys. Termisk inneklima. Fukt. Rengjøring før bygning tas i bruk.*	§ 8-32 – 8-38
Building acoustics and vibrations.	Lydforhold.	§ 8-4
Protection against noise. Protection against vibrations.	*Beskyttelse mot støy. Beskyttelse mot vibrasjoner.*	§ 8-42 – 8-43
Outdoor environment.	Ytre miljø.	§ 8-5
Energy conditions. Limitation of effluents. Contamination in the ground.	*Energiforhold. Begrensning av utslipp. Forurensning i grunnen.*	§ 8-51 – 8-53
Operation, maintenance and cleaning.	Drift, vedlikehold og renhold.	§ 8-6
Operation. Maintenance. Cleanability and cleaning.	*Drift. Vedlikehold. Rengjørbarhet og rengjøring.*	§ 8-61 – 8-63

English translation of headings	Headings in original language	Location
Installations	**Installasjoner**	Kap. IX [Chapter IX]
Installations.	Installasjoner.	§ 9-1
Heating plants.	Varmeanlegg.	§ 9-2
Furnace plants. Electrical heating plants. Heating plants connected to district heating. Central heating plants.	*Fyringsanlegg. Elektriske varmeanlegg. Varmeanlegg tilknyttet fjernvarme. Sentralvarmeanlegg.*	§ 9-21 – 9-24
Ventilation plants.	Ventilasjonsanlegg.	§ 9-3
Design of ventilation plants. Arrangements for operation of ventilation plant.	*Utførelse av ventilasjonsanlegg. Tilrettelegging for drift av ventilasjonsanlegg.*	§ 9-31 – 9-32
Refrigeration plants and heat pumps.	Kuldeanlegg og varmepumper.	§ 9-4
Execution of refrigeration plants and heat pumps. Machine rooms, cooling and freezing rooms.	*Utførelse av kuldeanlegg og varmepumper. Maskinrom, kjøle- og fryserom.*	§ 9-41 – 9-42
Sanitary plants.	Sanitæranlegg.	§ 9-5
Water supply. Sewage.	*Vannforsyning. Avløp.*	§ 9-51 – 9-52
Lifting devices.	Løfteinnretning.	§ 9-6
Field of application for rules concerning lifting devices. Administrative provisions for lifting devices. Technical provisions for lifting devices - lifts; lift shafts; machine and pulley rooms; stairlifts and lifting platforms; escalators and passenger conveyors.	*Virkeområde for regler om løfteinnretninger. Administrative bestemmelser for løfteinnretninger. Tekniske bestemmelser for løfteinnretninger – heis, heissjakt, maskin- og tauskiverom, trappeheis og løfteplattform, rulletrapp og rullende fortau.*	§ 9-61 – 9-63
Electrical installations.	Elektriske installasjoner.	§ 9-7
Usability	**Brukbarhet**	Chapter X
General requirements for usability.	Generelle krav til brukbarhet.	§ 10-1
General requirements for outdoor areas.	Generelle krav til utearealer.	§ 10-2
Access to buildings.	*Atkomst til bygning.*	§ 10-21
Layout.	Planløsning.	§ 10-3
Layout and size. Toilets, wardrobes etc. Lighting and open view. Sheds and storage spaces. Source separation and waste storage. Fixed interior fittings. Movable building components.	*Planløsning og størrelse. Toaletter, garderobe mv. Belysning og utsyn. Boder og oppbevaringsplass. Kilde-sortering og avfallsoppbevaring. Fast innredning. Bevegelige bygningsdeler.*	§ 10-31 – 10-37
Technical aids [Accessibility].	Tekniske hjelpemidler.	§ 10-4
Requirements for lifts. Induction loop systems for hearing aids. Operating buttons, signs etc.	*Krav om heis. Teleslynge. Manøverknapper, skilt e.l..*	§ 10-41 – 10-43
Communication routes.	Kommunikasjonsveier.	§ 10-5
Stairs. Ramps.	*Trapp. Rampe.*	§ 10-51 – 10-52
Aspects of emergency planning.	Beredskapshensyn.	§ 10-6
Air raid shelters. Chimneys in dwellings.	*Tilfluktsrom. Skorstein i boliger.*	§ 10-61 – 10-62

Table 2.10a Sweden: Headings in primary sources

English translation of headings	Headings in original language	Location
BOVERKET BUILDING REGULATIONS	**BOVERKETS BYGGREGLER**	
Design	**Utformning**	**3**
General.	Allmänt.	3:1
Room height. Access.	*Rumshöjd. Tillgänglighet.*	3:11 – 3:12
Dwellings.	Bostäder.	3:2
Design of dwellings. Accessibility of rooms. Supplementary housing facilities.	*Bostadsutformning. Rummens tillgänglighet. Bostadskomplement.*	3:21 – 3.23
Plant rooms and service rooms.	Drift- och skötsel-utrymmen.	3:3
General. Spaces for building services and equipment. Refuse storage rooms etc.	*Allmänt. Utrymme för installationer och utrustning. Avfallsutrymme m.m.*	3:31 – 3.33
Mechanical resistance and stability	**Bärförmåga, stadga och beständighet**	**4**
Safety in case of fire	**Brandskydd**	**5**
General.	Allmänt.	5:1
Principal requirements. Documentation. Design by calculation. Control of design for escape.	*Alternativ utformning. Dokumentation. Analytisk dimensionering. Kontroll av utrymningsdimensionering.*	5:11 – 5:14
Fire resistance classes and other conditions.	Brandtekniska klasser och övriga förutsättningar.	5:2
Buildings. Elements of structure, materials, claddings and surface finishes. Other general conditions. Certain premises and activities.	*Byggnad. Byggnadsdel, material, beklädnad och ytskikt. Övriga allmänna förutsättningar. Vissa lokaler och verksamheter.*	5:21 – 5:24
Escape in the event of fire.	Utrymning vid brand.	5:3
General. Separation from other escape routes. Travel distance. Access. Equipment. Design conditions. Special conditions.	*Allmänt. Avskiljande från andra utrymningsvägar. Gångavstånd. Framkomlighet. Utrustning. Dimensionerande förutsättningar. Särskilda förutsättningar.*	5:31 - 5:37
Protection against the outbreak of fire.	Skydd mot uppkomst av brand.	5:4
General. Heat producing appliances. Flues for solid or liquid fuel. Flues for gaseous fuels. Subsidiary flues and lining tubes. Special conditions.	*Allmänt. Eldstad. Rök- och avgaskanal. Uppvärmning med varmluft. Särskilda förutsättningar.*	5:41 - 5:46
Protection against the spread of fire inside a fire compartment.	Skydd mot brandspridning inom brandcell.	5:5
Requirements regarding materials, surface finishes and claddings.	*Materialkrav, ytskikt och beklädnad.*	5:51
Protection against the spread of fire and fire gases between fire compartments.	Skydd mot brand- och brandgasspridning mellan brandceller.	5:6
Division into fire compartments. Fire resistance class of elements of structure separating fire compartments. External walls and windows. Attics and ceiling voids. Air handling installations. The production of heat. Special conditions.	*Brandcellsindelning. Brand-teknisk klass på brandcellsskiljande byggnadsdel. Yttervägg och fönster. Vinds- och undertaks-utrymmen. Luftbehandlingsinstallation. Pannrum. Särskilda förutsättningar.*	5:61 - 5:67

English translation of headings	Headings in original language	Location
Protection against the spread of fire between buildings.	Skydd mot brandspridning mellan byggnader.	5:7
General. Design depending on the distance between buildings. Compartmentation of large buildings. Fire walls. Roof covering.	*Allmänt. Utformning beroende på avstånd mellan byggnader. Sektionering av stora byggnader. Brandvägg. Taktäckning.*	5:71 - 5:75
Loadbearing capacity in the event of fire.	Bärförmåga vid brand.	5:8
General. Design by classification. Design based on a model of a natural fire sequence.	*Allmänt. Dimensionering genom klassificering. Dimensionering baserad på modell av naturlig brandförlopp.*	5:81 - 5:83
Fire fighting facilities.	Anordning för brandsläckning.	5:9
Access routes for the rescue service. Fire gas ventilation. Equipment for manual fire fighting. Access for the rescue service.	*Tillträdesväg för räddningstjänsten. Brandgasventilation. Anordningar för manuell brandsläckning. Åtkomlighet för räddningstjänsten.*	5:91 - 5:94
Hygiene, health and the environment	**Hygien, hälsa och miljö**	**6**
General.	Allmänt.	6:1
Air.	Luft.	6:2
Quality of air supplied to a building. Quality of indoor air. Ventilation. Building services.	*Luftkvalitet till byggnad. Luftkvalitet i byggnad. Ventilation. Installationer.*	6:21 - 6:24
Light.	Ljus.	6:3
Daylight and sunlight. Lighting.	*Dagsljus och solljus. Belysning.*	6:31 – 6:32
Temperature.	Temperatur.	6:4
Indoor thermal environment. Heat output requirement.	*Termiskt rumsklimat. Värmeeffektbehov.*	6:41 – 6:42
Moisture.	Fukt.	6:5
General. Surface and subsoil drainage. Buildings.	*Allmänt. Markavvattning och dränering. Byggnad.*	6:51 – 6:53
Water supply and drainage.	Tappvatten och avloppsvatten.	6:6
Water supply. Drainage.	*Tappvatten. Avloppsvatten.*	6:61 - 6:62
Discharges to the environment.	Utsläpp till omgivningen.	6:7
General. Contaminated air. Products of combustion.	*Allmänt. Förorenad luft. Förbränningsgaser.*	6:71 - 6:73
Protection against noise	**Bullerskydd**	**7**
General.	Allmänt.	7:1
Sound insulation. Sound level. Reverberation time. Check measurements.	*Ljudisolering. Ljudtrycksnivå. Kontrollmätning.*	7:11 - 7:14
Dwellings.	Bostäder.	7.2
Nonresidential premises.	Lokaler.	7:3

Table 2.10b Sweden: Headings in primary sources

English translation of headings	Headings in original language	Location
Safety in use	**Säkerhet vid användning**	**8**
General.	Allmänt.	8:1
Protection against falls.	Skydd mot fall.	8:2
Lighting. Surfaces intended to be walked on. Major differences in level. Access and safety fittings on roofs.	*Belysning. Yta avsedd att beträdas. Större nivåskillnad. Tillträdes- och skyddsanordning på tak.*	8:21 - 8:24
Protection against injuries due to collisions, trapping or tripping.	Skydd mot skador genom sammanstötning, klämning eller snubbling.	8:3
Buildings or parts of buildings. Equipment capable of movement and associated spaces.	*Byggnad eller del av byggnad. Rörlig anordning med tillhörande utrymme.*	8:31 - 8:32
Reference to Decree (1993:1598) *on lifts and certain other mechanically operated devices.*		
Protection against burns.	Skydd mot brännskador.	8:4
Hot surfaces in buildings or building services. Temperature of hot water.	*Heta delar av byggnad eller installation. Varmvattentemperatur.*	8:41 - 8:42
Protection against explosions.	Skydd mot explosioner.	
Buildings. Heating installations.	*Byggnad. Värmeinstallation m.m.*	8:5
Protection against drowning.	Skydd mot drunkning.	8:51 - 8:52
Pools and similar which are intended for bathing or swimming. Other pools, containers, manholes and similar.	*Bassäng o.d. som är avsedd för bad eller simning. Annan bassäng, behållare, brunn o.d.*	8:6 8:61 - 8:62
Protection against being locked in.	Skydd mot instängning.	8:7
Doors and locks.	*Dörr och lås.*	8:71
Protection against poisoning.	Skydd mot förgiftning.	8:8
Protection against electric shocks.	Skydd mot elstötar och elchocker.	8.9
Energy economy and heat retention	**Energihushållning och värmeisolering**	**9**
General.	Allmänt	9:1
Limitation of heat losses.	Begränsning av värmeförluster.	9:2
The building envelope. Ventilation. Production and distribution of heat.	*Klimatskärm. Ventilation. Värmeproduktion och värmedistribution.*	9:21 -9:23
Efficient use of heat.	Effektiv värmeanvändning.	9:3
Efficient use of electricity.	Effektiv elanvändning.	9:4

2.3.4 Scope of subjects

The headings and sub-headings have been used to compile a comparison of subjects based on the themes in the Dutch Building Decree (see Tables 2.11). The requirements in other countries have been arranged as much as possible under these themes.

Unfortunately, the headings and sub-headings are not necessarily revealing. The varying levels of detail that can be understood from the headings means that it is not possible to state with confidence that a certain subject is not included in one country's requirements. For example, it appears that the safety of lifts is not addressed in England and Wales, but that is simply because they appear at a lower level of sub-sub-headings in the Fire Safety regulations. Sometimes topics appear more than once, and a detailed reading

Table 2.11 Subjects that appear not to be addressed in the Building Decree

Safety	
Antennas, transmitters	Denmark (not small houses), France
Outdoor areas/play	Denmark, Germany (Hesse), Norway
Glazing	England and Wales, Sweden
Safe window cleaning	England and Wales, Germany (Hesse)
Safety of automatic garage doors	France
Safety against actions of nature: earthquakes, natural risks, mining / slides, flooding, waves and wind	France, Norway
Safe working on roofs	Germany (Hesse), Sweden
Devices to stop fall of snow and ice from roofs to roads	Germany (Hesse)
Layout, size, design	Norway
Burns	Norway, Sweden
Objects falling from construction works	Norway
Drowning	Norway, Sweden
Being locked in	Norway, Sweden
Trapping/tripping	Sweden
Explosions (heating installations)	Sweden
Poisoning	Sweden
Health	
Indoor climate/air supply	Denmark, Norway, Sweden
Outdoor areas/play	Denmark, Germany (Hesse), Norway
Heating/temperature	Denmark, France, Germany (Hesse), Norway, Sweden
Termites/xylophagous insects	France
Utility	
Lighting	Germany (Hesse), Norway, Sweden
View	France, Norway
Ducts, pipes/spaces for building services and equipment	Germany (Hesse), Sweden
Water flow rate	Sweden
Energy	
Lighting installations/conservation of power/efficient use of electricity	Denmark (not small dwellings), England and Wales, Sweden
Environmental protection	
Recycling/source separation	Denmark, Norway, Sweden
Water metering	Germany (Hesse)
Materials favourable to energy and the environment	Norway
Limitation of effluents	Norway

was needed to discern to which theme they belonged.

Sometimes regulations appear unique due to the particular expression of the headings. For instance, many countries have provisions to guard against explosions, but only Sweden uses the word explosion in the headings and sub-headings studied. Also, some countries use classifications that can only be deciphered by reading the text. For instance, in Sweden the 'Safety in use' section includes the heading 'Equipment capable of movement and associated spaces'. It deals with lifts. This section demonstrates a further difficulty in using a survey of headings, for it consists only of a general recommendation referring to

Table 2.12 Subjects which appear to be addressed only by the Building Decree

Safety	Lighting
	Access, resistance to burglaries
Utility	Standing place [for caravans used as permanent dwellings]
	Free passage [dimensions of circulation other than accessibility]
	Toilet; bathroom (size)
	Meter room
	Installation spaces: sink, cooking appliance, fireplace, hot water appliance

the *Decree (1993: 1598) on lifts and certain other mechanically operated devices*. It would be necessary to go through each source in detail in order to identify subjects which are dealt with by similar references to other legislation.

Given these qualifications, a few observations are possible. The Dutch Building Decree groups requirements in four themes: safety, health, utility, energy conservation. Each of the other countries also has requirements which can be grouped under the first four themes. The Building Decree also identifies a fifth theme, environmental protection. It does not yet include any requirements for this theme, but some other countries do. There are also some subjects addressed by other countries that cannot be categorised within the themes of the Building Decree.

It appears that a few of the domestic subjects in the Building Decree are not addressed by other countries (see Table 2.11).

Navigation tables reveal that most of the requirements for safety lighting, apart from emergency lighting, and those for swimming pools do not apply to housing. The guidance to the Building Decree does not explain why there is particular concern for the adequacy of hard standing spaces for residential caravans, which appear not to be subject to building regulations in the other countries. The requirement for free passage, in terms of the height of circulation spaces, reflects the height of the Dutch population and is located alongside accessibility requirements for wheelchair users. The requirement for a meter room is often interpreted as a requirement for an enclosed hallway, rather than an entirely open plan. The requirements for installation spaces for sinks and appliances may seem archaic, but are part of a concern in the Netherlands for space standards which contribute to the sustainability of housing. Conversely, there are subjects in other countries that do not appear to be addressed by the Building Decree, under each of the headings.

There are a great many Safety issues that are not addressed by the Netherlands, but the majority of these are only addressed by one or two of the countries studied (see Table 2.11).

Requirements, such as safety against actions of nature, reflect characteristics of climate and it may be that they are addressed in legislation other than building regulations. It is difficult to understand why so few countries consider the safety of glazing, or safe window cleaning, but it is possible that these topics are covered in the text, without reference in headings. Overall, the Scandinavian countries appear to control many more aspects of safety than other countries, but this is misleading in a couple of ways. Norway appears to be unusual in referring to 'Layout, size, and design' under Safety but the sec-

tion covers issues that in other countries are dealt with under different headings, such as utility. As noted earlier, Sweden is not alone in concern for explosions, but appears to be so simply because it is the only country to use the word 'Explosions' as a heading or sub-heading. The most notable genuine differences are the requirements for protection against injuries due to trapping or tripping, against burns, against drowning, against being locked in, and against poisoning, which are only found in Norway and Sweden.

There are far fewer differences under the theme of health (see Table 2.11).

Although the Netherlands seems to differ from the Scandinavian countries in not controlling indoor climate, it is difficult to understand the extent of the differences without reading the requirements in detail. However, it clearly does not have requirements for the quality of air supply. The apparent lack of requirements for comfort temperatures is misleading, because comfort temperatures are included in calculations of energy performance.

There are also only a few differences under the theme of utility (see Table 2.11)

Although the Netherlands has requirements for lighting that are related to safety, it does not consider lighting under the heading of utility. The Building Decree does not deal with either of the aspects of view that are addressed in France (privacy) and Norway (indirect daylighting), but this might be covered by planning regulations. A detailed reading is required to understand that some of the German requirements for ducts are dealt with under health; it is more difficult to detect whether the Swedish concern for access to services is covered. It is almost certain that Sweden is unique in controlling the rate of water flow from taps.

There is much greater similarity in headings under the energy theme, but unlike the Netherlands, a few countries consider the efficient use of electricity for lighting or other purposes (see Table 2.11).

The most recent aspect of building regulations is environmental protection. The Building Decree does not address recycling, unlike the Scandinavian countries. Although it has basic requirements for the provision of water supply, it does not require metering of the supply. However, it is possible that the provision of water meters is dealt with in other legislation (as in England and Wales) or codes of practice. Norway is clearly unusual in relating embodied energy to energy performance in use, under the heading of materials favourable to energy and the environment. Its limitations on effluents are more commonplace, and in the Building Decree are dealt with under health headings of 'Dispersal of smoke' and 'Disposal of waste water', in local Building Codes, and by the Environmental Management Act (see Table 2.11).

There are also some subjects that cannot be categorised within the themes of the Building Decree, because it only addresses buildings, rather than sites, locations, or management in use. This contrasts with *CWATUP* in Belgium (Wallonie), and the building regulations in Denmark, Germany (Hesse), and

Table 2.13 Issues outside the themes of the Building Decree

Urban qualities	Belgium (Wallonie)
Use of site	Belgium (Wallonie), Denmark, Germany (Hesse), Norway
Building sites	Denmark (small dwellings), Germany (Hesse)
Car parking, garages	Belgium, France, Germany (Hesse)
Maintenance of facades, operation, maintenance and cleaning	France, Norway, Sweden
Emergency planning	France, Norway
Supervision of specified residential buildings; permission for police to enter common parts of residential buildings; nuisance caused by specified activities; party walls; charges for heating and hot water in communal buildings	France
Road safety	Germany (Hesse)

Norway, which include planning issues of development of sites, such as the height of buildings or distances from boundaries. In England, the Netherlands, and Sweden such issues may be dealt with in planning legislation. France is alone in regulating charging for services, but this is because the *CCH* deals with the management and subsidy of housing as well as construction (see Table 2.13).

A full listing of the headings found in the technical regulations of each country is given in Tables 2.14 a-f.

Table 2.14a Subjects identified in primary sources: Safety

Subjects	**Belgium** (Wallonie) CWATUP	**Belgium** (Wallonie) Critères de Salubrité	**Belgium** (federal) Federal legislation	**Denmark** BRegs	**Denmark** BRegs Small dwellegs	**England & Wales**	**France**	**Germany** (Hesse)	**Netherlands**	**Norway**	**Sweden**
Fire			X	X	X	X	X	X	X	X	X
Structure/mechanical resistance and stability/load bearing capacity		X		X	X	X		X	X	X	X
Changes in level/falling/stairs/ramps/guardings		*				X		X	X	X	X
Moveable construction components/collision, impact						X		*	X	X	X
Electricity supply		X							X	X	X
Gas supply		X						*	X		
Lighting			Not known						X		
Access, resistance to burglaries									X		
Safety of lifts							X		*		*
Antennas, transmitters				X			X				
Outdoor areas/play					*			X		X	
Glazing						X					*
Safe window cleaning						X		*			
Safety of automatic garage doors							X				
Safety against actions of nature: earthquakes, natural risks, mining/slides, flooding, waves and wind							X			X	
Safe working on roofs/surfaces intended to be walked on								*			X
Devices to stop fall of snow and ice from roofs to roads								*			
Layout, size, design										X	
Burns										X	X
Objects falling from construction works										X	
Drowning										X	X
Being locked in										*	X
Trapping/tripping											X
Explosions (heating installations)											X
Poisoning											X

Key: X identified in heading, sub-heading or summary.
* subjects included under different heading.
NB. Absence of X or * does not guarantee absence of requirements.

Table2.14b Subjects identified in primary sources: Health

	Belgium (Wallonie)		**Belgium** (federal)	**Denmark**		**England & Wales**	**France**	**Germany** (Hesse)	**Netherlands**	**Norway**	**Sweden**
Subjects	CWATUP	Critères de Salubrité	Federal legislation	BRegs	BRegs Small dwellegs						
Noise				X		X	X	X	X	X	X
Damp/moisture		X		X		X		*	X	X	X
Drainage of waste water and faeces/sanitary equipment/hygiene		X		X	X	X		X	X	X	X
Drainage of rainwater				X	X			X	X	*	*
Ventilation	X	X		X	X	X		X	X	X	X
Combustion air/removal of smoke				X	X	X			X	X	X
Hazardous materials						X		*	X	X	*
Vermin								*	X		
Drinking water supply			Not known	X	X			X	X		X
Hot water facility				X	X				X		X
Daylight		X						*	X	X	X
Waste disposal				X	X			X	*	X	X
Indoor climate/air supply				X	X					X	X
Heating/temperature				X	X		X	X		X	X
Termites/xylophagous insects							X				

Key: X identified in heading, sub-heading or summary.

* subjects included under different heading.

NB. Absence of X or * does not guarantee absence of requirements.

Table 2.14c Subjects identified in primary sources: Utility

Subjects	**Belgium** (Wallonie) CWATUP	**Belgium** (Wallonie) Critères de Salubrité	**Belgium** (federal) Federal legislation	**Denmark** BRegs	**Denmark** BRegs Small dwellegs	**England & Wales**	**France**	**Germany** (Hesse)	**Netherlands**	**Norway**	**Sweden**
Standing place [for caravan]									X		
Accessibility	X			*	*	X	X	*	X	X	X
Free passage (dimensions of circulation other than accessibility)		X							X		
Habitable area, rooms (size)		X		*	*		*		X	X	
Habitable area, rooms (ceiling height)		X		*	*			*	X	X	
Toilet. Bathroom (size)									X		
Storage – refuse								X	X	X	X
Storage – bicycles								*	X	X	X
Meter room									X		
Lift shaft, lift machinery room				X	X			X	X	X	*
Installation spaces: sink, cooking appliance, fireplace, hot water appliance										X	
Swimming pool (for therapy)									X		
Lighting								*		X	X
View							X			X	
Ducts, pipes/spaces for building services and equipment								X			X
Water flow rate											*

Key: X identified in heading, sub-heading or summary.
* subjects included under different heading.
NB. Absence of X or * does not guarantee absence of requirements.

Table 2.14d Subjects identified in primary sources: Energy conservation

	Belgium (Wallonie)		**Belgium** (federal)	**Denmark**		**England & Wales**	**France**	**Germany** (Hesse)	**Netherlands**	**Norway**	**Sweden**
Subjects	CWATUP	Critères de Salubrité	Federal legislation	BRegs	BRegs Small dwellegs						
Heat insulation/thermal insulation/conservation of fuel	X		Not known	X	X	X	X	X	X	X	X
Restriction of air permeability						*			X	X	X
Energy performance	X			X	X	*			X	X	X
Lighting installations/conservation of power/efficient use of electricity				X		X					X

Key: X identified in heading, sub-heading or summary.
* subjects included under different heading.
NB. Absence of X or * does not guarantee absence of requirements.

Table 2.14e Subjects identified in primary sources: Environmental Protection

	Belgium (Wallonie)		**Belgium** (federal)	**Denmark**		**England & Wales**	**France**	**Germany** (Hesse)	**Netherlands**	**Norway**	**Sweden**
Subjects	CWATUP	Critères de Salubrité	Federal legislation	BRegs	BRegs Small dwellegs						
Recycling/source separation			Not known	*	*					X	*
Water metering								*			
Materials favourable to energy and the environment.										X	
Limitation of effluents										X	

Key: X identified in heading, sub-heading or summary.
* subjects included under different heading.
NB. Absence of X or * does not guarantee absence of requirements.

Table 2.14f Subjects identified in primary sources: Themes not found in the Dutch Building Decree

	Belgium (Wallonie)		**Belgium** (federal)	**Denmark**		**England & Wales**	**France**	**Germany** (Hesse)	**Netherlands**	**Norway**	**Sweden**
Subjects	CWATUP	Critères de Salubrité	Federal legislation	BRegs	BRegs Small dwellegs						
Urban qualities	X										
Use of site	X			X				X		X	
Building sites					X			X			
Car parking, garages			X				X	X			
Maintenance of facades, operation, maintenance and cleaning			Not known				X			X	X
Emergency planning							X			X	
Supervision of specified residential buildings							X				
Permission for police to enter common parts of residential buildings							X				
Nuisance caused by specified activities							X				
Party walls							X				
Charges for heating and hot water in communal buildings							X				
Road safety								X			

Key: X identified in heading, sub-heading or summary.
* subjects included under different heading.
NB. Absence of X or * does not guarantee absence of requirements.

2.4 Conclusions

A study of headings and sub-headings is an unreliable way to understand the scope of building regulations, due to differences in both the structure of regulations and in the wording of headings. A common structuring of themes would represent a useful step towards harmonisation, but would be difficult to achieve. The most critical decision would be the highest level of headings. The structure might reflect the Essential Requirements of the Construction Products Directive:

- Structure
- Fire
- Environment
- Safety
- Noise
- Energy.

However, this does not easily accommodate issues of utility, amenity, or social inclusion. Also, it would not necessarily promote sustainable design to

locate issues such as ventilation in an environment section, separate from energy. A simpler common structure would combine all the topics under three headings:

- Safety: Structure, fire and explosion, changes of level, openings.
- Environment: Energy performance, air quality, electricity, water, noise, recycling.
- Amenity: Accessibility, space standards, provision of facilities and equipment.

Alternatively, it might be more practical to structure regulations around the building process:

- Site: Groundworks, foundations, sewers, drainage, site aspects of grey-water recycling, rainwater collection, service connections.
- Envelope: Structural design of super-structure; fire resistance of structure, external spread of flame; damp proofing, insulation; windows, external doors.
- Services: Water, gas, electricity supply and distribution; heating and hot-water; energy generation; ventilation; sanitary appliances, drainage, sewers, grey-water recycling; rainwater collection, recycling, disposal; water conservation; controls (building management systems, heating programmers, monitoring of energy generation equipment performance); alarm systems.
- Interiors: Layout for accessibility; means of escape; internal finishes for internal spread of flame; amenity; space standards.

A further alternative structure might reflect the professional and trade disciplines, to make it easier to administer certification schemes for design or construction.

3 Conclusions

The Dutch Building Decree was originally formulated in 1992, to replace local bye-laws with a centralised system. The form of requirements was criticised as being difficult to use, and was re-formulated, for implementation in January 2003. This study compared the requirements for certain subjects with those from the building regulations of other European countries. The Building Decree takes an approach that is notably different from other countries in terms of terminology and structure, and in the scope of requirements, particularly for fire safety, the prevention of burglary, accessibility, and the dimensions of habitable space.

3.1 Systems of requirements

The systems of requirements were described in Chapter 2: 'Systems and formulations of technical requirements', but the comparative analysis (described in the Appendices 1 to 8) has identified various degrees of variation from the basic description.

3.1.1 Policy context

The Building Decree is not alone in expressing the functional requirements as incontrovertible but the scope, levels of requirements, and application of building regulations should be understood as a matter of deliberate government policy. Ultimately, this must explain the variation in regulations between different countries. In practice, requirements are formulated by executive bodies, and are commonly influenced by past practice. Regulations have also developed in response to events, such as energy supply crises, a catastrophic fire or building collapse; or to lobbies, such as disability rights campaigns. In some countries, there are systems of review which incorporate a consultation procedure, so that requirements may be influenced by the opinions of the construction industry. Some requirements are based on experimental or empirical research, which is almost always undertaken by national bodies, most of which are now privatised.

3.1.2 Intention and scope of requirements

Regulations mostly comprise functional requirements, performance requirements or specifications without detailed explanation of the intention that underlies the requirements. For instance, the Building Decree explanatory notes describe the context of regulation, in terms of history, principles, system

1 VNG, ed. H.L. Marinus (2002).

of regulations, and recent changes, but they do not fully explain the principles that underlie the requirements. One must look to independent guidance[1] for an explanation of target times to raise a fire alarm, evacuate a building and so on.

The English Approved Documents are unusual in explaining the rationale that underlies requirements and relates it to the broader context of quality control mechanisms. For instance, Approved Document B Fire Safety, paragraph 0.18, explains:

"*Building Regulations are intended to ensure that a reasonable standard of life safety is provided, in case of fire. The protection of property, including the building itself, may require additional measures, and insurers will in general seek their own higher standards, before accepting the insurance risk. Guidance is given in the LPC Design guide for the fire protection of buildings.*"

It is not usually possible to tell whether certain issues have been considered for inclusion in building regulations and then excluded as a matter of policy, or they have simply not been considered. However, with the more recently introduced issues, such as accessibility, design guidance is commonly available and it is reasonable in such cases to assume that certain requirements have been excluded deliberately, perhaps as the result of representations by the house-building industry. For instance, the provision of clear space to the lock side of doorways is emphasised in design guidance, including the *European Concept for Accessibility,* but is required in relatively few countries. Where housing is built to low space standards, this requirement would almost inevitably add to construction costs, and presumably this is the reason for its exclusion. Systems of consultation and review allow interested parties to influence the scope of requirements. Some insight into the nature of such influence may be derived from the Construction legislation website for England and Wales.[2]

This study does not consider the role of incentives, such as the conditions of subsidy, in the promotion of housing quality. However, the existence of incentives can be a useful indication of current concerns, which are either not addressed in building regulations, or for which the minimum levels of requirements in the building regulations are not necessarily best practice. For instance, there are various subsidies to promote the use of renewable energy sources, whereas there is currently little consideration in building regulations of their contribution to reducing energy demand.[3] There may also be incentives to achieve 'lifetime homes' provision beyond the levels of accessibility required by building regulations.

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2 www.safety.odpm.gov.uk/bregs.

3 The incorporation of RES in a model building code for housing is currently the subject of an ALTENER-funded research project co-ordinated by OTB.

3.1.3 Form of publication of legislation

Some countries issue self-contained building regulations, such as the Building Decree in the Netherlands. In others, building regulations are an accumulation of decrees and implementing orders.

With a cumulative system, it is sometimes difficult to ensure that there are no requirements for a particular issue. For instance, it was only by enquiring to advisory organisations, such as ANPI-NVBB, an association of Belgian insurance companies, that we could be sure that there was no relevant fire safety legislation for single family housing in Belgium. This problem does not arise with a self-contained document, or the continuously updated *REEF* in France, which collects together all the relevant decrees, implementing orders, and ministerial circulars.

Digital publication of legislation, including the Building Decree, on the internet makes it possible to search quickly through documentation, a considerable advantage over the conventional indexing of paper publications. It also means that access to legislation is free to anyone. Most of the countries studied now publish the requirements on the internet, but to varying degrees of completeness or accessibility.

3.1.4 Approaches to regulation

Whilst countries may wish to set differing standards, the basic formulation of requirements, for example as performance requirements supported by optional approved solutions, should be common for the sake of harmonisation. However, there are varying shades of prescription between the countries studied.

Denmark, Norway, and Sweden adopt a relatively liberal approach, where mandatory performance requirements are supported by general recommendations, which in turn refer to national standards and research documents for detailed recommendations. Although England and Wales has a similar approach, some of the approved solutions that support the regulations are much more elaborate than the Scandinavian recommendations. In each of these countries, alternative solutions are allowed subject to proof by testing. It is not necessary to obtain an exemption, merely to be able to prove compliance.[4]

Belgium (Wallonie) and France take a relatively prescriptive approach, with performance requirements supported by specifications. However, some issues

4 This is different from the apparently similar system in Scotland, where the guidance currently offered in the Technical Standards is 'deemed to satisfy' the requirements and if designers propose alternative solutions, they must obtain a 'relaxation'.

are not fully controlled in Belgium, such as noise, where the acoustic performance of buildings relies on the adoption of the recommendations in national standards. Germany (Hesse) recently changed from a prescriptive approach, with far fewer specifications in the 2002 revision of the *HBO*. Germany (Hesse) places considerable reliance on national standards, although it does not cite them directly. Legislation in France is a little more self-contained.

The Netherlands takes a hybrid approach, with performance requirements and some specifications, but with a heavy reliance on national standards to interpret the requirements and the possibility of calculations to allow innovative solutions.

A survey of outcomes would be needed to evaluate the success or the significance of these different approaches, in terms of the ease with which designers and contractors understand the requirements, the degree to which they rely on external consultants for interpretation, and the design quality of the housing.

3.1.5 Types of requirement

Any comparative analysis tends to reflect the approach of the commissioning country, but the Building Decree is a difficult starting point from which to construct an analysis. Although it incorporates all the elements of the Nordic model of systems of building regulations[5] and the recommendations of CIB/TG11,[6] it presents technical regulations in a different format from any other country.

Classification of each country's regulations in terms of the types of requirement (functional requirement, performance requirement, specification, etc.) is difficult firstly because commentators vary in their understanding of these terms (see Chapter 2: 'Systems and formulations of technical requirements'), and secondly because regulations tend to be inconsistent in the types of requirement used for different subjects.

A useful comparison can be made between the Swedish Building Regulations and the Dutch Building Decree. Both undertook a fundamental review of building regulations and adopted what they claim to be a performance-based approach. Each has a very different interpretation of the meaning of a performance based approach and both also demonstrate inconsistencies.

Generally, the Swedish Building Regulations adopt a formula of mandatory performance requirements supported by general recommendations that sometimes give dimensions; for instance, a performance requirement for passage ways to be designed for independent wheelchair access, supported by recommendations that include the width of corridors and the gradient of ramps. However, there are also several instances of mandatory specifications:

5 Foliente, G.C. (2000); Scholten, N.P.M. (2001).

6 Bowen, R.P. (1997).

for the height of rooms, for the distance of accessible parking spaces from entrances, for periods of fire resistance of protected lobbies and load bearing structure, and so on.

Each clause of the Dutch Building Decree is introduced by a functional description which expresses the intention of the subsequent performance requirements. Where relevant, performance requirements identify limit values which indicate the minimum acceptable level of performance. In fact, there are many more specifications than in Sweden. For instance, the requirements for accessibility and stairways are almost entirely dimensional specifications. However, in one instance the opposite is also true! The Dutch section on noxious substances and materials from the ground comprises only a functional requirement, to limit the presence of noxious or hazardous substances, and an enabling statement, to allow the issue of ministerial decrees to address these issues. In contrast, Sweden has detailed specifications for air quality, including limits on levels of ionising radiation.

It is intended that each requirement of the Building Decree should be an unambiguous legal statement that is measurable and verifiable. At the same time, the expression of requirements is intended to minimise constraints on design freedom and innovation. However, one might question whether design freedom and innovation are significantly prejudiced by requirements in other countries, and whether the high degree of specification in certain sections of the Building Decree are themselves fulfilling this intention. From a simple reading of each document, it appears that the Swedish formulation allows more design freedom (or asserts less control) than the Dutch. It would take a study of the practical implementation of each system to decide whether the differences are significant. It would be interesting to extend such a comparison to France, which has one of the most prescriptive systems, but appears not to specify constructions or present any significant restrictions, in excess of the requirements of the Building Decree.

Generally, there are few limitations on the sub-division of space. For instance, there do not appear to be any requirements in other countries that prevent an open-plan living room and kitchen, although there are some limits on travel distances and the location of the kitchen in the fire safety requirements in England and Wales. There is one instance of a requirement that might be seen to impede design freedom – but surely promotes safety: in England and Wales, there are limits on sleeping galleries,[7] whereas in the

7 i.e. Open plan mezzanine spaces. The requirements limit the sleeping gallery's height above ground level, the distance between the foot of the stairway to the gallery and the room door, the size of the gallery unless an emergency egress window can be provided, and demand the separation or location of any cooking facilities to ensure escape. However, a gallery designed as a home office is not subject to the same restrictions, and there is nothing to stop an occupier from using it as a sleeping space.

Netherlands there is no mention of escape from such mezzanine spaces, so the only relevant limit would be travel distance.

One issue that might have a significant influence on the appearance of housing is the limitation on fire spread between terraced houses. It is possible that in some countries there are limits on windows within a certain distance of a party wall, or requirements for the projection of the party wall, in order to limit spread between neighbouring facades, but unfortunately, because the analysis was based on the formulation of the Building Decree this was not fully explored.[8]

3.1.6 National standards and the specialisation of information

There are subtle differences in the attitude to national standards. For instance, in England and Wales, compliance with British standards as a means to meet the requirements is optional, at least in theory. In contrast, in the Netherlands, compliance with NENs is a mandatory part of some requirements. Curiously, although the building ordinance in Germany (Hesse) must rely on *DIN* standards for the interpretation of its performance requirements, it does not directly refer to any *DIN*.

Some topics, such as acoustics, rely heavily on national standards for the detailed explanation of requirements, yet these are not freely available. Indeed, national standards can be expensive.[9] This reliance on secondary sources suggests that designers may not have easy access to information and consequently, they may not understand technical requirements in detail. Design for compliance with requirements, beyond the use of constructions known to comply with requirements, is increasingly the preserve of specialist consultants.

3.1.7 Explanation of assumptions

It is unusual for building regulations to offer an explanation of the thinking that underlies requirements, beyond a general performance requirement. For instance, the Building Decree explanatory notes go no further than saying that certain parts of buildings should be designed in such a way that a physically disabled person can use them.

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8 The implications of the requirements concerning resistance to fire spread through the open air (*weerstand tegen … brandoverslag*) can only be understood by reading *NEN 6068* and the associated NPR.

9 For example, in England the British Standards Institute charges £138 (€221) for *BS 6187:2000 Code of practice for demolition*.

England and Wales is remarkable for the extent of its explanation and discussion of requirements. This is an important feature of the rolling programme of revisions of the Building Regulations which, as well as reviewing the content, aims to make the requirements better understood. For instance, the guidance to the fire safety regulations states:

"*The provisions for means of escape for flats and maisonettes are based on the assumption that: a. the fire is generally in a dwelling; b. there is no reliance on external rescue (e.g. by a portable ladder); c. measures in Section 9 (B3) provide a high degree of compartmentation and therefore a low probability of fire spread beyond the dwelling of origin, so that simultaneous evacuation of the building is unlikely to be necessary; and d. although fires may occur in the common parts of the building, the materials and construction used there should prevent the fabric from being involved beyond the immediate vicinity (although in some cases communal facilities exist which require additional measures to be taken).*" (*Approved Document B*, 3.3)

3.1.8 Independent design guidance

The Building Decree does not include references to other sources of design guidance. For instance, the accessibility requirements do not refer to the *European Concept for Accessibility*, and the fire safety requirements do not refer to SBR's *Ontwerpen en brandveiligheid*. This is not unexpected because a reference within regulations would infer a special status on such material. In contrast, there are references to independent design guidance in the *Approved Documents* in England and Wales, and in the *REN Veiledning til teknisk forskrift* (Guidebook to the Technical Regulations) in Norway, where the guidance is not mandatory.

3.2 Harmonisation and the Building Decree

In the long term, one would hope that Model European Building Codes would be evolved to cover the descriptions of strategies, as well as product standards.

Potential difficulties in international working caused by the lack of harmonisation were mirrored in the difficulties of the comparative analysis. This was particularly true of fire safety requirements for which, without a common framework of strategies and tactics it was difficult to confirm the absence of requirements, and without common terminology or criteria it was difficult to compare levels of requirements.

Important issues for harmonisation include the classification of buildings and the description of parts of buildings, which are used to describe the application of fire safety requirements. The generic description of spaces that is found in the Dutch Building Decree is probably unhelpful in practice, and it should be possible, in a code describing requirements for housing and for

mixed use buildings, to establish common terminology in a series of annotated diagrams of typical configurations of blocks of flats, or single-family houses, without threatening the independence of designers or opportunities for innovation.

3.2.1 Structure of information: comparison with Building Decree

For most topics, there are hierarchies of information, but the location of each level of information varies between countries, from legislation through to independent guidance. Indeed the structure of information may vary within a country, for different topics, but at some point a designer must be told how to satisfy the requirements.

For instance, in England and Wales, there is a notable difference between the structure of information for fire safety and noise. Government guidance does not include examples of constructions that satisfy the requirements for fire resistance of load-bearing structure. Instead, *Approved Document B* (2000) states that load-bearing structure should either be designed to specifications in independent guidance (a report by the Building Research Establishment *Guidelines for the construction of fire resisting structural elements*), or to national or European standards, 'a relevant British Standard or Eurocode'. Performance is to be determined by reference to a national standard (*BS 476: Part 21: 1987*). In contrast, examples of constructions satisfying the requirements for acoustic performance are given in *Approved Document E* (2003).[10]

The Building Decree tends to be more consistent in the structure of information, due to the comprehensive nature of the review, rather than the cycle of revisions for the various Approved Documents in England and Wales. So, to make the same comparison, the Building Decree does not give any examples of constructions satisfying the requirements for acoustic insulation or fire safety, either in the regulations themselves or the explanatory notes. There are references to national standards, but these describe characteristics, rather than giving examples of constructions. There are no references to Dutch Practical Guidelines (NPRs) for either topic. Indeed there is only one reference to an NPR in the Building Decree, which gives examples of measures to counteract reverberation. There is no clue within the Building Decree as to how to interpret these issues in practice. In fact, guidance is given in publications

10 Until the latest revision, a designer could either select one of these exemplary constructions or prove that an alternative satisfies the requirements, using test methods specified in a national standard, *BS 2750*. The 2003 revision made tests mandatory, even when exemplary constructions are used. However, it is possible that exemplary constructions will be allowed without testing for new-build dwellings, following a consultation on Robust Standard Details developed by the House Builders Federation.

and training courses by Stichting Bouwresearch (SBR), an organisation sponsored by partners in the construction industry which acts as an intermediary between government and practice. Unfortunately SBR publishes only in Dutch (see www.sbr.nl).

The apparent inscrutability of the Building Decree is shared by the approach of the Building Regulations in Sweden. There is similarly no indication in Sweden of any sources that offer examples of constructions that satisfy the requirements, only references to levels of performance given in national standards for acoustic performance, or methods to test fire resistance in advisory publications by *Boverket*, and further regulations regarding load-bearing capacity in case of fire, the Design Regulations of the Board, BKR. *(BFS 1998: 38)*.

In the case of the Netherlands and Sweden, it appears that the practical implementation of requirements relies on an initiation into supplementary sources of information. Newcomers to the Dutch construction industry who do not speak Dutch or Swedish presumably must rely on the assistance of consultants. One must question the advisability of reliance on specialist advice or an induction process in order to understand legislation.

One of the most notable contrasts to the Building Decree is the explicit, informative approach in England and Wales. The Building Regulations were first rewritten as functional requirements plus guidance in 1985, in order to allow flexibility in design. For instance, both the requirements and the guidance are presented in *Approved Document B Fire Safety*, which includes:

- information about the principles and assumptions that underlie the requirements;
- description of parts of buildings using everyday language;
- definitions of specialised terminology;
- diagrams to demonstrate the application of requirements to common configurations in buildings;
- separate sections, where appropriate, for domestic and non-domestic buildings, including differentiated requirements for houses and flats or maisonettes, for different heights of houses and blocks of flats, and for house conversions;
- discussion of detailed implementation, including diagrams to illustrate key conditions.

The approach in England and Wales means that *Approved Document B* works autonomously, as a basic design tool. The requirements and guidance on housing should be understood by designers with relatively little reference to secondary texts and without recourse to specialist advisors.

3.3 Building Decree: quality of explanations

The review of the 1992 Building Decree, by the Market Forces, Deregulation and Legislative Quality (MDW) project, called for greater transparency and accessibility. It recommended a revision and a 1998 Coalition Agreement also called for the simplification of the content of the Building Decree.

The explanatory notes to the Building Decree claims that, without greatly changing their content, the regulations have been restructured and simplified. Following our attempt at analysing the Building Decree, we can only note that there is a very long way to go before the regulations are easily understood. There are some specific structural problems that contribute to the difficulty of their interpretation. Indeed, many of the explanatory notes are attempts to clarify the convoluted expression of requirements.

3.3.1 Terminology

The Dutch Building Decree is remarkable for the peculiar terminology it uses. For instance, it uses the terms *verblijfsgebied* and *verblijfsruimte*, which are not in everyday use and are unfamiliar to native speakers. A literal translation would be 'staying area' and 'staying room', but the intended meaning of *verblijfsruimte* is 'habitable room', used in the same way as in England and Wales' *Approved Document B*: a room for dwelling purposes, including a kitchen or kitchen alcove, but not a bathroom. The analysis also translates *verblijfsgebied* as 'habitable space'. The associated use of *niet-gemeenschappelijk* and *gemeenschappelijk* is also confusing. These terms were translated in the analysis as 'private' and 'shared', respectively.

There are some basic definitions in Article 1.1, but it is often left to the explanatory notes to 'translate' the meaning of the requirements. Such translations into everyday language make the Building Decree appear half-hearted in its abstraction. For instance, see Article 2.146, paragraph 7:

"*An access point, as referred to in the sixth paragraph, to a non-shared communal room is an access point to the fire compartment or the sub fire compartment in which that room is situated, or at the first-mentioned access point a route starts to the latter-mentioned access point which solely passes through rooms which have a smoke alarm, if those rooms are closed.*"

is supported by the explanation:

"*Generally, a dwelling is laid out in such a way that in order to reach a smoke-free escape route or the adjacent area from a certain room or the kitchen, an enclosed room must be negotiated. The seventh paragraph requires the presence of a smoke detector for those intermediate enclosed rooms, such as for example another room, toilet or corridor in the dwelling.*"

There are many instances when it would be much simpler to use diagrams to describe requirements, or to illustrate possible conditions. The diagrams pub-

lished in interpretations of the building decree could be incorporated within the document itself, or at least the *Bouwbesluit_online* could include hyperlinks to this information. This would be particularly welcome for issues of fire safety and accessibility. Only England and Wales, and Norway include diagrams in the main documentation (but not in the regulations themselves).

It should be noted that is also difficult to understand some of the expressions used in Germany, in the Building Order for Hesse and *DIN 4102*, but all the other countries use much more straightforward language.

3.3.2 Design freedom and generic description

Although juridical in format, the Building Decree has the liberal intent of avoiding prescription in design and promoting the innovative use of materials, whilst establishing minimum levels of requirements and methods of calculation. It does not tie itself to existing design solutions or offer detailed official guidance.

The Building Decree attempts to describe requirements in terms that can be applied across a range of 'user functions', as can be found in mixed-use buildings. However, the confusion that arises from generic description and the use of 'navigator' look-up tables seems to outweigh the benefit of identifying such requirements for mixed use buildings, which is the justification given in the explanatory notes. The earlier subdivision of the Building Decree, into housing and other types of buildings, allowed a much simpler expression of requirements.

The use of the term 'user function' is confusing because it is not related to tenure or physical boundaries. User function is defined as "*the parts of one or more construction, plot or site, which share the same intention of use or which together form a user unit*". So, "*the lift in a block of flats forms part of each user function (flat) which relies on the lift*". Therefore it is particularly confusing when the explanatory notes say, with regard to space for the future installation of a lift, "*This space may be within the user function or outside it.*". It is puzzling, and not particularly helpful, that car parks and remote storage rooms in apartment buildings are treated as separate user functions, distinct from dwellings.

Sometimes, the nature of housing means that there are requirements specific to the 'living' function, so that the lower half of the look-up tables is blank and the formulation of requirements is unnecessarily complex. For instance, Article 4.17, which specifies limits on the difference in heights of floor surfaces and thresholds at entrances, only applies to the 'living' function, but the structure of requirements means that it needs an explanatory notes to clarify that it "*is intended to ensure that a wheelchair user can enter a dwelling or block of flats independently*".

The Building Decree apparently tries to avoid assumptions in spatial

design, and describes categories of space, rather than using familiar names for rooms or spaces. This attempt at generic description sometimes breaks down, and familiar terms are used.

Other countries with performance-based requirements share the ambition of design freedom, but do not ally themselves to a similar degree of abstraction. It seems unlikely that the process of harmonisation would accept that design freedom is imperilled by using the expression 'kitchen or kitchen area' instead of 'staying [habitable] room with an installation point for a cooking appliance,' particularly when this is translated in the Building Decree's own explanatory notes as 'kitchen'.

In general, the Building Decree would be much easier to understand if it was split into domestic and non-domestic buildings, and everyday words were used to describe rooms and other spaces. This is of particular significance in the section on Fire safety.

It may seem reasonable to expect that, although the expression of requirements in the Building Decree is differently worded to those in other countries, the practical outcomes are similar. However, characteristics of Dutch housing such as the extensive use of glazing, suggest that there are significant differences in principles and standards of fire safety and conservation of energy. This would best be tested by a comparative evaluation of building designs based on the regulations in different countries.

3.4 Comparison of requirements

The harmonisation of construction regulations to date has been largely restricted to product specification and methods of measurement. Comparative analysis of building regulations demonstrates several impediments to more fundamental harmonisation.

3.4.1 Stairways and ramps

The Netherlands has replaced some of its earlier very low standards for straight stairways, with increased minimum goings and reduced maximum rises. The standard for private stairs is now less steep than in England and Wales, but the standard for common stairs is still the steepest. The concomitant increase in the floor area needed for the stairway will probably encourage the already widespread use of private stairs with tapered treads, which are more common than in other countries. The changes for common stairs are also significant.

However, the Building Decree perpetuates poor safety standards for the guarding of stairways and ramps. It compares unfavourably with requirements in most other countries for guarding to extend the full length of stair-

ways and ramps, and for the height of guardings. Also, it does not require handrails for ramps and has very few requirements for detailing, which means that ramps may be more difficult to negotiate than in other countries.

Lighting has been identified as a contributing factor to accidents on stairs, but none of the building regulations studied addresses the issue of the daylighting or artificial lighting of stairways.

3.4.2 Fire safety

A harmonised system to classify the reaction to fire of construction products was approved in 2002, but there is great diversity in the description of fire safety strategies, classification of buildings, or description of parts of buildings. Mostly, fire safety strategies are similar if differently expressed, but there are some significant differences in levels of requirements.

The Building Decree is unusual in its concepts of sub-fire and smoke compartments, its definition of permanent fire load density, and its control of the smoke production of internal surfaces, but it is difficult to tell whether these create significant differences from other countries in practice. Although the description of compartmentation is different in the Netherlands, the strategy that each dwelling constitutes a compartment is similar to that in Denmark, England and Wales, Norway and Sweden. The only difference is that the entrance door to a flat need not be self-closing, an omission that may prejudice compartmentation in the event of fire. The Netherlands is also unusual in not having requirements for the fire resistance of doors on escape routes, and instead relies on early warning by smoke alarms. Only two other countries require fire or smoke alarms for general needs housing.

There are very few controls on single family housing, and there is no national or federal fire safety legislation for houses in Belgium. The greatest diversity in strategies lies in the provision of means of escape. Several countries allow rescue as a second route, and all allow a single escape route in various circumstances. The only absolute requirements for two independent escape routes for housing are for tall buildings in Belgium and Denmark. The issues of maximum travel distances, and the number and location of exits are common to most countries, but expressed quite differently and with varying levels of requirements. Each country limits characteristics of internal surfaces of escape routes, but only the Netherlands limits the rate of smoke production of surfaces. Only Denmark and England and Wales control internal surfaces of private areas of single family housing. The scope of requirements for external surfaces varies widely.

None of the building regulations studied specifies materials or constructions deemed to satisfy the requirements. Each country refers to national standards for background information, but the Building Decree is unusually reliant on national standards for the interpretation of strategic issues and it

was not possible to understand the scope of requirements from the main document alone.

3.4.3 Prevention of burglary

The Netherlands is the only one of the countries studied to include mandatory requirements for the prevention of burglary in its building regulations. Requirements for locks and hinges are considered to contribute to social safety. However, the narrow range of requirements in the Building Decree contrasts with the broad scope of issues covered by quality labelling schemes supported by police forces.

3.4.4 Noise

Most countries specify levels of requirements within the Building Regulations or associated guidance documents, but Belgium, Germany (Hesse) and Sweden rely on recommendations in national standards.

Despite reference to *EN-ISO* standards, there are important differences between countries in the criteria used to describe acoustic performance, including methods of measurement and the application of different reference curves or spectrum adaptation terms. Belgium and the Netherlands use indices that are not used in any of the other countries, but each is gradually adapting to *EN-ISO 717*.

The varied acoustic criteria mean that it is difficult to compare requirements, but many of the differences are probably barely perceptible. The greatest differences are in levels of requirements for impact sound. Low frequency components of airborne sound often contribute to domestic noise nuisance but only England and Wales, France, and Sweden currently address this issue.

The Netherlands is one of the few countries to require acoustic protection between spaces within the same dwelling. Otherwise, the scope of requirements is broadly similar, with the exception of England and Wales which lacks specific requirements regarding noise from equipment.

Pre-completion testing of buildings is the most demanding and expensive implementation procedure but only Denmark and England and Wales require such testing. In practice, noise control must rely on the use of constructions that are known to satisfy the requirements, but this does not guarantee as-built performance. Even in England and Wales, the house-building industry is being given an opportunity to develop standard details as an alternative to testing. In future, *EN 12354* may be adopted as a way to justify the choice of construction.

Noise control is a topic that is relatively impenetrable to non-experts, and it appears that the design standards are increasingly the domain of specialists.

3.4.5 Noxious materials and substances from the ground

These topics may not be controlled by building regulations, but by other types of legislation. The most commonly controlled materials or substances are formaldehyde, asbestos, radon and methane gas.

The Building Decree gives generalised requirements with reference to ministerial regulations but does not identify the materials or substances for which there are controls. Unlike other countries, there is no government advice on action to counter the risk of radon emissions.

There is EU guidance on radon levels which is widely cited, but the strategies for dealing with radon vary between countries, presumably as the result of differences in construction techniques.

3.4.6 Daylight

Daylight openings are regulated in each of the countries studied, except for England and Wales. However, the nature of requirements is relatively unsophisticated and would not necessarily provide an appropriate standard of daylighting.

The requirements for the size of daylight openings are not directly comparable. Only Norway sets targets for the level of daylighting, rather than the size of openings. Only Denmark and Sweden address issues of sunlight.

Daylighting is treated as a basic amenity in building regulations, but it might be more appropriate to link requirements with energy performance, so that design for daylighting could be seen as making a contribution to reductions in CO_2 emissions.

3.4.7 Accessibility

"*Accessibility enables people to participate in the social and economic activities for which the built environment is intended.*" (*European Concept for Accessibility*) There is striking divergence from the *ECA*, not only in terms of standards, but in the scope of accessibility legislation. The expression of requirements also varies, so that direct comparisons are not always possible.

The Netherlands has generally lower standards of accessibility requirements than Sweden, Denmark, or England and Wales, and a lower standard for blocks of flats than France, or the *DIN* standard in Germany. The limited application of requirements, the lack of some requirements, and the form of expression of others mean that the Building Decree does not guarantee the accessibility or visitability of environments and dwellings.

There are considerable differences in the application and levels of requirements. Overall, the highest standards should be generated by the perfor-

mance requirements in Sweden, which constitute a nearly comprehensive accessibility and usability standard for dwellings on one storey and the entrance storey of other dwellings.
None of the countries studied has particularly extensive standards of provision for people with visual impairments, and there is very little mention of the needs of people with other types of sensory impairment.

3.4.8 Dimensions of habitable space and habitable rooms

Floor area is a key determinant of amenity and accessibility, but space standards are no longer a central consideration of most European building regulations. The Netherlands has more extensive space standards and dimensional requirements for rooms than the other countries studied, but requirements for ceiling heights have been retained in each country except England and Wales.

The Building Decree asserts that its requirements are necessary to ensure a functional design and it would be interesting to discover whether the working of the market achieves this in other countries. The removal of controls in England and Wales resulted in reduced space standards, but it is difficult to evaluate whether or not the designs are functional. It is also difficult to demonstrate whether the flexibility afforded by higher space standards makes a significant contribution to the sustainability of housing development, but it seems sensible to protect the space standards of the housing stock by building regulations, rather than market forces.

3.5 Observations on the Building Decree

The level of requirements of the Building Decree can probably be described as 'average' amongst the countries studied, with a few particularly high or low standards. One of the most valuable strengths of the Building Decree are the requirements for the size of habitable rooms. A particular weakness is the lack of controls on the accessibility of external routes to buildings and the incomplete application of accessibility requirements in smaller flatted buildings.

It is difficult to judge whether the formulation of the Building Decree does promote innovation in practice, because that must rely on other factors, including the implementation of building control, the culture of the construction industry, and the education of professionals.
The Building Decree appears to be highly structured, but this appearance may be skin deep, for there is inconsistency between the sections studied. It adopts a generalising, generic approach and sets out to eschew prescription,

but in some aspects it is one of the more prescriptive of the mechanisms studied. Despite the intentions underlying the review, it is difficult to agree that the revision is particularly accessible, due to the convoluted expression of requirements and use of unusual terminology.

A few measures adopt terminology or parameters that are unique to the Netherlands. As such, they represent a barrier to harmonisation. In the case of the definition of acoustic parameters, harmonised standards are available, but the Netherlands continues to use the slightly different approach of a national standard.

The quality of technical building control in the Netherlands cannot be understood if the Building Decree is seen in isolation from the context of the national standards (NENs), the associated Dutch Practical Guidelines (NPRs), and the support offered by Stichting Bouwresearch's guidance and training. A designer from another country would have considerable difficulty in understanding how to interpret the requirements, and the translation of NENs, NPRs, and SBR guidance documents into other languages would be a great assistance to international practice.

Appendix 1 Stairways and ramps

A1.1 Introduction

The analysis of requirements for stairways and ramps follows the structure of three sections in the Building Decree:

- 2.4 Bridging differences in heights
- 2.5 Stairways
- 2.6 Ramps

Many of the requirements for ramps are included in accessibility sections in other countries. The Building Decree approach is to require an accessible sector for larger buildings, which may incorporate access by ramps, in Section 4.2, but to describe the 'safety' characteristics of ramps in section 2.6, which apply to ramps in any situation.

In Belgium, there are at least three sources of requirements: federal legislation for fire safety, minimum habitability conditions in Wallonie which include stairways, and accessibility legislation in Wallonie for ramps.

England and Wales has separate safety and accessibility requirements for both stairways and ramps, which are described in different sections of the documentation, *Applied Documents K* and *M*. The accessibility requirements apply only to those stairs or ramps provided to make the building accessible to people with disabilities.

France is unusual in only having controls for stairways in buildings without a lift, that are required to be accessible to people with impaired mobility. There are no general safety requirements for stairways.

In Germany (Hesse), there are both mandatory safety requirements, and accessibility requirements that only apply to buildings required to have barrier free dwellings. Some safety requirements are given in the building regulations, but some are given by reference to *DIN 18065*. In Hesse, barrier free dwellings are required on one floor for buildings in suitable locations with more than three dwellings[1]; detailed requirements are given by reference to *DIN 18025 Part 2, Barrier free design*. This analysis was first prepared when the current standard was the 1993 revision of the *HBO*. It has been updated with comments on the revision effective from October 2002.

Norway has a similar separation of safety and usability requirements in chapters 7 and 10 of the building regulations, with accessibility requirements for ramps in chapter 10.

Accessibility requirements are integrated as part of the general requirements in Denmark and Sweden.

The Netherlands has the most extensive range of standards for existing buildings, which may be allowed if the new build standards are not practica-

1 From October 2002, barrier free dwellings are required for buildings with more than two dwellings.

Table A1.1 Bridging differences in height

	Provision of stairways	Provision of ramps
Belgium		
Federal	No specific requirements for provision, but fire safety requirements *(Arrêté royal (AR) du 07-07-1994 fixant les normes de base en matière de prévention contre l'incendie et l'explosion, auxquelles les bâtiments nouveaux doivent satisfaire;* modified by *AR du 19-12-1997.)*	–
Wallonie	*AGW du 11 fevrier 1999 Critères de Salubrité des Logements:* No specification of provision, but requirements for characteristics of stairways giving access to habitable rooms.	
	Code Wallon de l'Aménagement du Territoire, de l'Urbanisme et du Patrimoine (CWATUP):	
	Accessibility requirements for common stairways	Common parts of apartment buildings: accessible route from road to entrance and to lifts and principle places.
Denmark	Ramps supplemented by steps (changes in level on access routes from public roads to apartment building's car parks, recreation areas, entrances). Negotiable stairway to supplement an entrance ramp (houses with a home business).	
	No specific requirements for provision of internal stairways.	Ramps or adjustment of ground levels at changes of level to provide access to entrance (apartment buildings, joined single-family houses, houses with home business; may be waived for owner-occupied, detached houses). Ramps for corridors in common access routes with differences in level ≤ 0.35 m (apartment buildings).
England and Wales	Stairs, ladders and ramps to afford reasonable safety in dwellings for changes of level > 0.6 m.	
	A stepped approach 'to suit ambulant disabled people' is allowed for access to principal entrance on 'steeply sloping' plots > 1 in 15. Negotiable common stairway for ambulant disabled people (apartment buildings).	[Ramps may be used to provide] access to principal entrance from point of alighting from car into dwellings (houses and entrance level apartments).

ble, but England and Wales has some controls specific to stairs used in conversions and Denmark allows narrower stairways for alterations to existing buildings.

A1.2 Bridging differences in height

This section of the Building Decree comprises:
- Articles 2.23-26 Provision of stairs or ramps

The Netherlands is unusual in directly specifying the *provision* of a stairway or ramp for a minimum difference in height (0.21 m new buildings, 0.22 m

	Provision of stairways	Provision of ramps
France	Negotiable stairway for people with mobility impairments to storeys not served by lifts (apartment buildings). No other requirements for stairways.	[Ramps may be used to provide] accessible continuous route to lifts, common spaces, dwellings (apartment buildings).
Germany		
Hesse 2002	'Necessary stairways': to each floor other than ground floor and each usable attic. Removable stairs and ladders permitted for non-habitable roof spaces(classes 1, 2; buildings with max. 2 units, < 400 m², ≤ 7 m. For classifications see Table 5.2b).	Can provide a ramp with a shallow slope instead of a 'necessary stairway'.
DIN 18025: 2	–	Access without steps to ground floor apartments and common rooms (buildings required to provide barrier free dwellings).
DIN 18065	–	–
Netherlands	Provision of permanent ramps or stairways between floors of communal rooms, circulation spaces, WC compartments, and bathrooms, between floors accessible by visitors, or between such floors and adjoining land, at differences in height: > 0.21 m (new buildings), > 0.22 m (existing buildings); requirement also applies to communal areas in new buildings.	Provision of ramp between floors within accessibility sector, between floor in accessibility sector and adjoining land for differences in height > 0.02 m. (Also, provision of lift for differences in height > 0.02 m between flat and entrance to accessibility sector).
Norway	No specific requirements for provision, but description of usability and safety characteristics of stairways. Changes of level delineated to avoid tripping or, if that is not possible, easy to see and well lit.	[Ramps may be used to provide] access to buildings with common entry to more than 4 dwellings by people with mobility impairments.
Sweden	–	–

existing buildings). Otherwise, only Germany (Hesse) specifies provision of stairways to reach storeys other than the ground floor. Most of the other countries give required characteristics for stairways, but provision is assumed. Most also have performance requirements for access that imply or directly specify the provision of a ramp and, in some circumstances, for a stairway that is negotiable by people with mobility impairments. However, none mentions a minimum difference in height or change in level.

Except in those parts of the building that must be accessible, there are no provisions in the Netherlands to deal with the tripping hazard presented by differences in height less than 0.21 m. In contrast, in Norway, any change of level must either be 'delineated', probably with a guarding, or if that is not possible, it must be easy to see and well-lit.

In England and Wales, there are accessibility requirements for stepped approaches to building entrances, which are allowed instead of ramps on sites with plot gradients greater than 1 in 15. Denmark has requirements for steps to supplement ramps. (None of the other countries has similar requirements, and, although shown in the tables, the standards for stepped approaches are not referred to in the analysis.)

A1.3 Requirements for stairways

This section of the Building Decree comprises:
- Article 2.27 Performance requirement for safety of stairways
- Article 2.28 Dimensions of stairways
- Article 2.29 Dimensions of landings
- Article 2.30 Guarding of stairways
- Article 2.31 Handrails to stairways
- Article 2.32 Enclosure of stairways
- Articles 2.33-2.37 Requirements for stairways in existing buildings

A1.3.1 Introduction

A great many factors affect the safety of stairways, apart from the physical capabilities and actions of the users. A study of stair design and safety lists the following factors[2]:
- Dimensions and uniformity of risers and goings
- Height of flights between landings
- Height, graspability, continuity of handrails, strength and security of fixing, extension of beyond top and bottom risers, spacing between handrails
- Quality of surface materials
- Projection and shape of nosings
- Lighting of stairway
- Distractions arising from a change in view.

Each country has some requirements for characteristics of stairways. Denmark, England and Wales, France, and the Netherlands have substantial controls on stairway dimensions. In 2002, dimensional specifications in Germany (Hesse) were replaced by functional requirements, presumably fulfilled by compliance with *DIN 18065*. The range of controls is more limited in Belgium, Norway and Sweden. Specifications in France are given in regulations on accessibility and only apply to stairways required to be negotiable by people

2 CHOWN, G.A. (1993), p.2.

with mobility impairments. Standards for negotiable stairs in England and Wales are additional to general safety requirements.

The Netherlands has two levels of requirement, related to the size of the living function or the total usable area of the living functions served by a stairway. None of the other countries differentiates requirements on the basis of floor area, but there are differing standards for private and common stairs in England and Wales, the *DIN* standard in Germany, and Norway. Requirements in Denmark and France only apply to common access stairs. In Sweden, almost all the requirements apply to all types of stairs, but controls on stair widths apply only in certain buildings. In Belgium, federal fire safety requirements apply to stairs providing common means of escape.

A1.3.2 Width and headroom

Whilst headroom on stairways is clearly a safety precaution, to prevent people from hitting their heads, the purpose of specifying a minimum width for stairways is less clear-cut. The considerations stated in requirements are fire safety (Belgium, England and Wales) and space to move someone on a stretcher (France, Sweden), but other countries do not state the reason for requirements. Presumably, requirements for the width of private stairways are intended to avoid stairways so narrow that people would be forced to climb or descend with their feet at an angle to the stair treads (and perhaps to allow furniture to be moved safely).

There are requirements for the minimum width of stairways in Belgium, Denmark, France, the Netherlands, Norway, and Sweden. Dimensional requirements in Germany (Hesse) were replaced in 2002 by a general performance requirement, but the levels of requirements in *DIN 18065* are similar. The federal requirements for escape stairs in Belgium, given in fire safety regulations, are much higher than the fitness conditions in Wallonie. England and Wales refers to requirements for means of escape in case of fire, but there are few requirements for residential buildings. The width of negotiable stairways is specified in England and Wales (0.9 m) and France (1.2 m, but 0.8 m allowed for one straight flight). The French requirement is probably related to the carriage of a stretcher.

The only requirements that apply to private stairways are in Belgium (Wallonie) (0.6 m), the *DIN* standard in Germany, the Netherlands, and Norway (0.8 m). The highest standards for the width of common stairways are in France, the Netherlands, and Sweden (1.2 m), but in France this applies only to negotiable stairways and in Sweden this only applies if there is no lift for the carriage of a stretcher. The highest overall standard is for large buildings in the Netherlands (1.2 m, stairways serving living functions with total usable area > 500 m^2, and stairways assigned to communal areas > 600 m^2). However, the Netherlands also has one of the lowest standards (0.8 m, apartment build-

Table A1.2 Stairways: Width of stairways, headroom, height

	Min. width of stairways	Min. headroom above stairway	Max. height of stairway or max. continuous flight
Belgium			
Federal	*AR du 07-07-1994*, modified by *AR du 19-12-1997*: Escape stairway (apartment buildings)		
	Width related to number of people using escape stairway (number of people x 0.0125 m), min. 0.8 m; max. projections 0.1 m, < 1m above treads.	2 m	–
	Exterior escape stairways, replacing one stairway (BE tall, BM middle height buildings)		
	0.6 m	–	–
Wallonie	*AGW du 11 fevrier 1999 Critères de Salubrité des Logements:* stairs giving access to habitable rooms:		
	0.6 m	1.8 m	–
Denmark	1 m (common access routes), 0.9 m (common access routes, alterations to existing buildings); 0.9 m (party stairs in houses with 2 flats; outside stairs to 1 dwelling). Dimensions for clear width between handrails or between handrail and wall.	2 m (common access routes)	–
		2 m (common access routes)	–
England and Wales	Reference to requirements for fire escape routes: no widths specified for dwellings, but 1.1 m if stairs used for fire-fighting.	2 m	Min. 30° change of direction between flights for stairs with > 36 rises in consecutive flights.
	Additional requirements for negotiable stairway for ambulant disabled people:		
	0.9 m	–	–
	Additional requirements for stepped approaches to access to entrances:		
	0.9 m	–	*1.8 m (between landings)*
France	General requirement for common circulation:		
	Access from public road to dwellings via stairs or lift for stretcher (2.24-2.34 m x 0.583-0.587 m), carried horizontally.	–	–
	Negotiable stairway for people with mobility impairments to storeys not served by lifts:		
	1.2 m. 0.8 m allowed for one straight flight.	–	–

ings with total usable area ≤ 500 m^2). Belgium also has a low minimum standard (0.8 m), but widths are related to occupancy (0.0125 x number of people). The requirements in Belgium for exterior escape stairs are very low (0.6 m).

There are statutory requirements for the minimum headroom above stairways in Belgium, Denmark, England and Wales, the *DIN* standard in Germany, the Netherlands, Norway, and Sweden. The highest standard is in the Netherlands (2.3 m). The lowest standard, where requirements are given, is the fitness standard in Belgium (Wallonie) (1.8 m, private stairways).

	Min. width of stairways	Min. headroom above stairway	Max. height of stairway or max. continuous flight
Germany			
Hesse 1993	Necessary stairs: 0.8 m (classes A,B,D); narrower stairs allowed for non-necessary stairs with little traffic. 1 m (other buildings).	–	–
Hesse 2002	Necessary stairs and landings sufficient for greatest traffic that can be expected.	–	–
DIN 18065	0.8 m (stairs to habitable rooms, cellars, buildings ≤ 2 dwellings); 1 m (necessary stairs, other buildings); 0.5 m (other stairs).	2 m	Intermediate landing after 18 rises [= 3.42 m at max. rise]
Netherlands	0.8 m[1)] , 1.2 m[2)] (new buildings) 0.7 m (existing buildings) 1) Stairways serving living function(s) with usable area ≤ 500 m². 2) Stairways serving living function with usable area > 500 m² or stairways assigned to communal areas in blocks of flats with total floor area > 600 m².	2.3 m (new buildings) 1.9 m (existing buildings)	4 m
Norway	0.8 m (internal), 1 m (common)	2 m	Max. continuous flight in all buildings 'not considerably more than one normal storey.'
Sweden	1.2 m (buildings > 1 storey with > 2 dwellings and no lift for carriage of stretchers). General recommendations: *Max. projection of strings, skirtings, balustrades, handrails and similar: 0.1 m.*	2 m	–

A1.3.3 Height, goings and rises, tapered treads

The most important safety considerations for stairways are those which affect the risk of falling. A limit on the height of a flight is presumably intended to limit how far there is to fall. Only three countries limit the height of a flight. The *DIN* standard in Germany specifies the intervals at which intermediate landings are required (18 rises, equivalent to 3.42 m) whereas the Netherlands specifies the maximum change in level (4 m). Norway has a

Table A1.3 Stairways: Goings, rises, pitch of stairways

	Min. depth of goings	Max. height of rises	Max. pitch
Belgium			
	AR du 07-07-1994, modified by *AR du 19-12-1997:* Escape stairway (apartment buildings)		
Federal	0.2 m	0.18 m	37°
	Exterior escape stairways, replacing one stairway (BE tall, Bm medium height buildings)		
	0.1 m	0.2 m	45°
Wallonie	*AGW du 11 fevrier 1999 Critères de Salubrité des Logements:* Stairs giving access to habitable rooms:		
	Going ≥ rise. Sum of 1 going + 2 rises ≥ 0.5 m.		[45° by calculation]
	[For example going 0.168 m rise 0.166 m; going 0.2 m rise 0.15 m.]		
Denmark	0.25 m (common access routes)	0.18 m (common access routes)	[36°by calculation]
	Ratio so that stairs are safe to use.		
	Stairways to supplement ramps (access routes for apartment buildings, houses with home business):		
	0.3 m	0.15 m	[45° by calculation]
England and Wales	Any going 0.245 m–0.26 m with any rise 0.155 m–0.22 m; or any going 0.223 m–0.3 m with any rise 0.165 m–0.2 m (private stairs). Any going 0.25 m–0.32 m with any rise 0.15 m–0.19 m (other stairs). Sum of 1 going + 2 rises: 0.55 m–0.7 m.		42° (private stairs) [29°–42° (private stairs), and 25°–37° (other stairs) by calculation]
	Additional requirements for negotiable stairway for ambulant disabled people:		
	0.25 m	0.17 m	[34° by calculation]
	Additional requirements for stepped approaches to access to entrances:		
	0.28 m	0.075 – 0.15 m	[15 – 28° by calculation]
	Conversions of existing buildings: Shallower goings allowed if a spiral or helical stair serves only one habitable room. Alternating tread stairs, with part of each tread cut away, are allowed for attic conversions if there is insufficient space for a conventional stair and handrails are provided to both sides:		
	0.22 m	0.22 m	[45° by calculation]
France	Negotiable stairway for people with mobility impairments to storeys not served by lifts:		
	0.28 m (common)	0.17 m (common)	[31° by calculation]

loosely worded limitation, of about the height of one storey. Only England and Wales limits the length of consecutive flights in one direction, but there is no longer a limitation on the number of rises in a single flight.

The danger of falls and trips increases with steep pitches and shallow treads. The steepness of stairs is governed by the dimensions of the depth and height of treads, known as the going and rise. The pitch of a stairway, calculated from the minimum depth of the goings and the maximum height of the rises, is the clearest indicator of steepness. The depth of tread is important in providing sufficient space for people to rest their feet as they climb or descend the stairs.

Most requirements specify both the minimum depth of goings and maximum height of rises, which allows calculation of the maximum pitch of stairways. The fitness standard in Belgium (Wallonie) does not specify dimensions, but requires that, for private stairs, the going is greater than the rise. However the federal fire safety requirements limit pitch as well as goings and rises. Norway specifies only the minimum going, but the height of rises can

	Min. depth of goings	Max. height of rises	Max. pitch
Germany	Stairs leading to habitable rooms, buildings with < 2 dwellings:		
DIN 18065	0.23 m	0.20 m	[41° by calculation]
	Cellar and attic stairs:		
	0.21 m	0.21 m	[45° by calculation]
	Necessary stairways in buildings with > 2 dwellings:		
	0.26 m	0.19 m	[36° by calculation]
	Also: limitation of shallowness of pitch:		
	max. going 0.37 m	min. rise 0.14 m	[min. pitch: 21° by calculation]
	step ratio recommendation: 2 risers + 1 going = 0.59-0.65 m		*[21°—42° by calculation]*
	safety recommendation: riser + going = 0.46 m		*[24°—40° by calculation]*
	comfort recommendation: going – riser = 0.12 m		*[28°—32° by calculation]*
Netherlands	0.22 m [1)], 0.24 m [2)] (new buildings) 0.13 m (existing buildings)	0.185 m (new buildings) 0.22 m (existing buildings)	[40°,[1)] 38° [2)] (new buildings) by calculation] [59° (existing buildings) by calculation]
	1) Stairways serving living function(s) with usable area ≤ 500 m².		
	2) Stairways serving living function with usable area > 500 m² or stairways assigned to communal areas in blocks of flats with total floor area > 600 m².		
Norway	0.25 m	[0.144–0.181 m (internal), 0.076–0.144 m (external) by calculation]	30–36° (internal stairways), 17–30° (external). Even pitch, easy and safe to use.
Sweden	General recommendations: *0.25 m*	General recommendations: *Equal height or marked if difference – unavoidable. Unchanging pitch within flight.*	

be calculated from limitations on pitch. Sweden only offers a general recommendation. England and Wales allows the combination of certain ranges of goings and rises and is the only country which specifies maximum pitch. Belgium (Wallonie), England and Wales, and the *DIN* standard in Germany offer formulae to limit the relationships between rises and goings. England and Wales and Germany give an upper as well as a lower limit. None of the countries studied mentions that it has considered the average size of feet in determining the depth of tread, and it is unlikely that any of the tread depths would accommodate the full length of most male feet.[3]

However, the *DIN* standard in Germany considers the length of human step-

3 Hill, L.D. *et al* (2000) remarks on the problem for older people of stair treads that are too shallow to accommodate their whole feet, so that they feel that it is necessary to turn sideways when going down stairs. It surveyed the depth of tread for the participants' houses (mean 0.214 m) and the length of their feet without shoes (average 0.267 m for men and 0.243 m for women).

ping, with recommendations referring to comfort as well as safety.

The highest standard for goings and rises on private stairs is in Norway (minimum depth of goings 0.25 m, maximum height of rises 0.144-0.181 m). The highest standard for common stairs is in France, for those stairways that must be negotiable by people with mobility impairments (min going 0.28 m, max rise 0.17 m). Apart from the very low fitness standard in Belgium (Wallonie), the federal requirements for external escape stairs in Belgium, the lowest standard is in England and Wales (going 0.223 m with rise 0.2 m, or going 0.245 m with rise 0.22 m).

These standards can be more easily understood when expressed as pitch. Only Belgium, England and Wales and Norway give direct specifications of the maximum pitch of stairways, but pitch can be calculated from requirements for rises and goings in Denmark, France, the *DIN* standard in Germany, and the Netherlands. The highest overall standards are in Norway (minimum depth of goings 0.25 m, maximum pitch 30-36° for internal stairs, shallower pitch 17-30° for external stairs). This contrasts with low requirements in Belgium for external escape stairs, the fitness standard for private stairs in Wallonie, in Denmark for stairways to supplement ramps, and the *DIN* standard in Germany for stairs to non-habitable cellars and attics (45°). The standard in England and Wales for private stairs is also relatively low (42°). The lowest standards for common stairs are in the Netherlands (40° usable area ≤ 500 m^2, 38° usable area > 500 m^2 or communal area > 600 m^2).

Tapered treads are used to limit the length of stairways but they increase the risk of a fall if the inside edge or the going at the centre are too narrow, or if the treads are too sharply tapered. There are controls on tapered treads in Denmark, England and Wales, and the Netherlands, the *DIN* standard in Germany, and in the fire safety requirements in Belgium and Norway. Only the Netherlands directly specifies each of the critical minimum dimensions (tread depth at narrow end, tread depth at centreline or pitch-line, width from side to pitch-line), but the highest standards are in England and Wales (goings as for straight treads, measured at centre line for stairways < 1 m wide, measured at 0.27 m from each side for stairways ≥ 1m).

Spiral stairways are made up of tapered treads, but may pose additional hazards. The requirements for tapered treads apply to spiral stairways in Denmark, and by implication, to Germany and the Netherlands. Only England and Wales distinguishes requirements for spiral stairways and refers to the design of helical and spiral stairways by reference to a national *BS* standard. England and Wales also has controls for stairs leading to an attic conversion. It is surprising that spiral stairs are allowed for fire escape in Belgium for medium buildings, and in Norway.

Table A1.4 Stairways: tapered treads

	Min. depth of tapered treads	Min. width of tapered treads
Belgium		
Federal	*AR du 07-07-1994,* modified by *AR du 19-12-1997:* Escape stairway (apartment buildings): min. depth 0.24 m at centreline (Bm medium, BB low buildings). Only straight flights (BE high buildings).	
Wallonie	–	
Denmark	0.2 m, at max. 0.5 m from inner handrail.	–
England and Wales	Stairs < 1 m wide: goings as for straight treads at centreline, 0.05 m at narrow end; stairs ≥ 1 m wide: goings as for straight treads (at 0.27 m from each side). Also: design of helical or spiral flights by reference to BS 5395; some exemptions for conversions; design of alternating tread stairs for conversions. Additional requirements for negotiable stairway for ambulant disabled people: goings 0.25 m (at 0.27 m from each side).	– –
	Additional requirements for stepped approaches to access to entrances: goings 0.28 m (at 0.27 m from each side).	 –
France	–	–
Germany		
DIN 18065	0.1 m, at 0.15 m from inner edge (residential buildings with > 2 dwellings)	–
Netherlands	0.05 m[1], 0.17 m[2] (minimum width of tread); 0.23 m[1], 0.24 m[2] (tread at pitch line); 1) Stairways serving living function(s) with usable area ≤ 500 m². 2) Stairways serving living function with usable area > 500 m² or stairways assigned to communal areas in blocks of flats with total floor area > 600 m².	From pitch-line to sides of stairway: 0.3 m (new buildings) 0.2 m (existing buildings)
Norway	0.2 m if the stair is part of a fire escape route.	Width of stair 0.1 – 0.15 m wider than a straight stair, 1 m recommended.
Sweden	–	–

A1.3.4 Landings

A landing at the top of a flight reduces the danger of people falling onto a stairway, whilst a landing at the bottom of a flight can limit the impact of falls. A further consideration is to avoid collisions with doorways opening onto the stairway. However, there are very few requirements for landings. There are specified dimensions for the depth of landings in Norway, and the Netherlands, and different levels of requirements in the two *DIN* standards in Germany. There is also a general recommendation in Sweden for depth of landings equal to the width of the flight. There is a similar requirement in England and Wales but following the removal of almost all controls on the width of stairways in England and Wales, this represents a reduced standard. The highest standards for landings are in the Netherlands (1.2 m, stairs in living functions with usable area > 500 m² or assigned to communal area > 600 m²), and in Sweden (1.2 m, for common stairs in buildings without a lift to accommodate a stretcher). The lowest standard, where requirements are

Table A1.5 Stairways: landings

	Min. width and depth of landings	Other requirements for landings
Belgium		
Federal	*AR du 07-07-1994,* modified by *AR du 19-12-1997:* escape stairway (apartment buildings)	
	Difference in width between flights and landings max. one 'unit of passage', i.e. difference ≤ 0.6 m	–
Wallonie	–	–
Denmark	–	–
England and Wales	As great as the smallest width of the flight.	Min. clear space at foot of flight to door swing: 0.4 m (full width of flight, bottom of flight; only cupboard or duct doors at top of flight). max. slope: 1 in 20
	Additional requirements for stepped approaches to access to entrances:	
	Min. depth 0.9 m	–
France	–	–
Germany		
Hesse 1993	–	Clear space between stairs and door: min. depth equal to width of door swing.
Hesse 2002	–	Sufficiently deep landing between stairs and door.
DIN 18025: 2	1.2 m wide x 1.5 m long	–
DIN 18065	Depth: 0.8 m (stairs to habitable rooms, cellars in buildings with up to two dwellings); 1 m (necessary stairs, other buildings); 0.5 m (other stairs).	–
Netherlands	At top step: 0.8 x 0.8 m [1]; 1.2 x 1.2 m [2] (new buildings) 0.7 x 0.7 m (existing builldings)	–
	1) Stairways serving living function(s) with usable area ≤ 500 m².	
	2) Stairways serving living function with usable area > 500 m² or stairways assigned to communal areas in blocks of flats with total floor area > 600 m².	
Norway	Landings to break falls on stairways: 1.3 x 1.3 m. At entrances to dwellings: dimensioned for use by people with mobility and orientation impairments, 1.4 x 1.4 m + space to open doors if landing to be accessible for wheelchair users.	–
Sweden	General recommendations: *Same as width of stairs*	General recommendations: *Doors should not impede passage: min. depth 1.3 m (apartment blocks)*

given, is *DIN 18065* in Germany (0.5 m, non-essential stairs, stairs not leading to habitable rooms or cellars in buildings containing up to 2 dwellings). Belgium has an unusual requirement, allowing a difference in width between flights and landings (difference ≤ 0.6 m), which is a low standard.

A clear space on landings adjacent to doorways is intended to avoid collisions with a door that is opened as people negotiate a stairway. The only such requirements are in England and Wales and Germany (Hesse), plus a general recommendation in Sweden. The former highest standard in Hesse (depth of

clear space equal to width of door swing) has been removed. England and Wales also requires that doors, other than cupboard or duct doors, are not allowed to open onto the top of a flight of stairs.

A1.3.5 Guardings and handrails

Requirements for the guarding of stairways against falls into adjacent spaces must be distinguished from requirements for handrails, which help people to keep their balance. Often, the requirements must be carefully deciphered to distinguish requirements for handrails and balustrades. As well as preventing falls off stairways by providing guarding of adequate height, guardings can be designed to prevent children climbing over or getting their heads or limbs stuck in gaps within or below the guarding.

There are requirements for the provision of guardings in Belgium (Wallonie), Denmark, England and Wales, the Netherlands, Norway, and Sweden. Provision is related to the height of changes of level in Belgium (Wallonie), England and Wales, and the Netherlands. The 2002 revision of the requirements in Germany (Hesse) refers only to handrails, but the *DIN* standard includes requirements for characteristics of guardings that are similar to those removed from the 1993 revision of the *HBO*. The Building Decree only requires a guarding for stairways that bridge a difference in height of at least one metre. The explanatory notes comment that it would be excessive to expect guarding of stairs comprising four steps. In France, there are only requirements for handrails.

The highest standard for the height of guarding is in Sweden. The general recommendation in Sweden applies to all changes of level and considers the risk of serious falls into the adjacent void, with higher guardings where risk is greater (0.9 m, but 1.1 m if large opening and drop > 1 storey). There are similar approaches, but lower standards, in Germany (0.9 m, but 1.1m if drop > 12 m). and Denmark (0.8 m, but taller if gap beside stairway > 0.3 m wide). The Netherlands has a particularly low standard for existing buildings (0.6 m, from height of 1.5 m). Neither Belgium (Wallonie) or France specifies the height of guarding.

There are also requirements for the length of the guarding. Usually, guardings are required for the entire length of the flight, but in the Netherlands the guarding is not required for the bottom of stairways below 1 metre, a low safety standard.

There are limitations on the size of openings within or below guardings in Denmark, England and Wales, the *DIN* standard in Germany, the Netherlands, and Sweden. The highest standard for the size of openings within guardings is in Norway (maximum opening 0.1 m, but 0.05 m for openings in positions where small children can reach them). Neither England and Wales or Norway allows wider openings above a certain height, as permitted in the Nether-

Table A1.6 Stairways: guardings

	Provision of guardings	Characteristics of guardings
Belgium		
Federal	*AR du 07-07-1994,* modified by *AR du 19-12-1997:* escape stairway (apartment buildings)	
	–	–
Wallonie	Guarding at drops ≥ 0.5 m.	–
Denmark	Guards to stairs and landings (apartment buildings); guard or handrails (exterior stairways, small dwellings); openings designed for child safety.	Min. height: 0.8 m, but 0.9 m at landings; taller for stairwells wider than 0.3 m [additional height not specified] (apartment buildings); 1 m (external stairways, small dwellings). Max. vertical openings: 0.12 m.
England and Wales	Guarding at drops > 0.6 m Design to prevent children being held fast.	Min. height: 0.9 m (single family dwellings, flights in residential buildings); 1.1 (other elements in residential buildings). Max. openings: 0.1 m; design so that children cannot climb guarding.
	Additional requirements for negotiable stairway for ambulant disabled people.	
	–	–
	Additional requirements for stepped approaches to access to entrances:	
	–	–
France	Negotiable stairway for people with mobility impairments to storeys not served by lifts:	
	–	–
Germany		
DIN 18065	–	Min. height: 0.9 m; 1.1m adjacent to drops > 12 m but 0.9 m permissible if stairwell ≤ 0.2 m wide. Max. openings: 0.12 m. Handrails arranged to make it difficult for children to climb over. Max. distance between stair flights or landings and adjacent walls or railings: 0.06 m.

lands. The lowest standards are in Denmark and the *DIN* standard in Germany (maximum openings 0.12 m).

The are few limitations on the gaps between stairways and guardings, which prevent people from falling through, or getting their limbs stuck in gaps. Both Germany and the Netherlands limit the horizontal gap between stairway and guarding. The *DIN* standard in Germany also limits the gap between stairs and adjacent walls. Only Sweden limits the height of the gap below guardings.

Whereas higher guardings are always safer than lower ones, the optimum level of handrails is clearly related to the height of the user and requirements are sometimes given in the form of a range of heights. The continuity and firm support of handrails are important, particularly for elderly people. The extension of handrails to the end of flights, or beyond, is important for people with mobility and visual impairments.

There are requirements for the provision of handrails to stairways in each country. Requirements for handrails to both sides of the stairway are related to the width of the stairway in Denmark, England and Wales, and in Germany

	Provision of guardings	Characteristics of guardings
Netherlands	Both sides, at differences in height: > 1 m (new buildings) > 1.5 m (existing buildings).	Min. height: 0.8 m, from height of 1 m onwards (new buildings), 0.6 m from height of 1.5 m onwards (existing buildings). Max. distance between foot of guarding and stairway: 0.05 m. Max. openings: 0.5 m wide, but 0.1 m wide in area ≤ 0.7 m above level of tread (explanatory notes comment that 'In practical terms, the requirement implies that a sphere with a diameter of more than 10 cm should not be able to pass through an aperture in the partition.') No opportunity for climbing in the area 0.2 – 0.7 m above treads (explanatory notes: this is to stop young children climbing).
Norway	Secure delineation [guarding] of changes of level in circulation areas and stairs. Height, design must hinder chil-dren from getting stuck or climbing over.	Max. openings: 0.1 m, or 0.05 m in positions where small children can get to them.
Sweden	Sides of stairs bounded by walls or provided with balustrades. Limit risk of injury by climbing or crawling.	General recommendations: *Max. distance between foot of guarding and stairway: 0.05 m.* *Balustrades: 0.9 m; 1.1 m (large opening over drop > 1 storey).* *Max. width, vertical openings: 0.1 m; no opportunities for climbing up to 0.8 m.*

(Hesse) to the use of the stairway in France, to the pitch and height of the stairway in the Netherlands, and to the height of the stairway in Sweden. In Belgium, Wallonie requires handrails to both sides for all public stairways; the federal fire requirements require handrails to both sides for external escape stairs, but otherwise relate provision to the width of escape stairs. Only Norway requires handrails to both sides in all circumstances, the highest standard. The lowest standard is in the Netherlands, which exempts shallow stairways and the lowest section of stairs bridging substantial changes of level (handrail one side, stairs with pitches > 34°, from changes of level > 1 m).

There are requirements for the height of handrails in Denmark, England and Wales, the Netherlands, and Norway. The *DIN* standard in Germany confuses the height of guardings and handrails. Minimum and maximum heights, from 0.8 m to 1 m, are given in England and Wales and the Netherlands. Norway has a single, absolute value (0.9 m). The Netherlands has a particularly low standard for existing buildings (0.6 m).

There are requirements for further characteristics of handrails, such as continuity, firm support or an easy-to-grip profile in Belgium (Wallonie), Den-

mark, Germany (Hesse), Sweden, and in England and Wales for negotiable stairways. Belgium (Wallonie) and England and Wales require that handrails on common stairways extend beyond the end of the flight, but in England and Wales this only applies to negotiable stairways. For other stairways in England and Wales, the handrail need not extend to the bottom two steps, a particularly low standard.

A1.3.6 Other requirements for stairways

Only the Netherlands has a prohibition on external stairways to access a living function, which is given in the requirement that any such stairway more than 1.5 m high must be enclosed in a rainproof space. In contrast, England and Wales allows external stairways to serve storeys less than 6 m above ground level. The 2002 revision of the *HBO* in Germany (Hesse) requires necessary stairs to connect directly with the stairs to the roof space.

There are other requirements for negotiable stairways in England and Wales and France. Both require that the stair nosings are easily visible, and England and Wales describes the profile of steps which limit the risk of trips for people with limited mobility.

Belgium (Wallonie) requires anti-trip treads for common stairways, with a tactile strip 0.5 m from the top step and a tonally contrasting strip at landings. The *DIN* standard for barrier free design in Germany requires adequate lighting of landings on common stairways, both day lighting and artificial lighting.

A1.4 Ramps

This section of the Building Decree comprises:

- Article 2.38 Performance requirement for safety of ramps
- Article 2.39 Dimensions of ramps
- Article 2.40 Dimensions of landings
- Article 2.41 Guarding of ramps
- Article 2.42-2.45 Requirements for ramps in existing buildings

A1.4.1 Introduction

Building Decree Articles 2.23-2.26 explain the situation in which a staircase or ramp must be provided (to bridge a change in level of 0.21 m or more) and Articles 2.38–2.45 give requirements for the characteristics of ramps. Article 4.6 on Accessibility explains the situation in which a ramp must be provided to make part of an apartment building accessible (for changes in level of 0.02 m between floors in an accessibility sector). None of the other countries

Table A1.7 Stairways: Handrails

	Provision of handrails	Height of handrails, other requirements
Belgium		
Federal	*AR du 07-07-1994,* modified by *AR du 19-12-1997*: escape stairway (apartment buildings)	
	Both sides but one side if width of stairs < 1.2 m and no risk of falling. Both sides to external escape stairs (BE tall, Bm middle height buildings).	–
Wallonie	Rigid handrail *(AGW du 11 fevrier 1999).* Both sides; continuous, solid (public stairway). *(CWATUP)*	Extending 0.4 m beyond top and bottom step (public stairway). *(CATWUP)*
Denmark	One side, but both sides if distance between handrail and wall/newel > 1.1 m; easy to grip and hold on to.	0.8 m
England and Wales	One side (< 1 m wide), both sides (≥ 1 m wide). Handrails need not be provided beside bottom 2 steps except stairways intended for use by people with disabilities. Handrails can form top of guarding.	0.9 – 1 m
	Additional requirements for negotiable stairway for ambulant disabled people (common).	
	Both sides, if > 2 rises; suitable,* continuous.	0.9 m (flight); 1 m (landings). Also, handrails to extend 0.3 m beyond top and bottom step.
	* No definition of 'suitable'. In earlier version, this referred to profile of handrail, distance between handrail and side wall.	
	Additional requirements for stepped approaches to entrances:	
	Both sides, if > 3 steps.	0.9 m from nosings. Also, handrails to extend 0.3 m beyond top and bottom step.
France	Negotiable stairway for people with mobility impairments to storeys not served by lifts:	
	Both sides, continuous, easy to grip.	–
Germany		
Hesse 2002	At least one firm, grippable handrail. Handrails both sides and intermediate handrails may be required for wider stairways.	–
DIN 18025: 2	–	Diameter 0.03-0.045 m; continuous at stair well (buildings required to provide barrier free dwellings).
DIN 18065	See Table 4.6 Stairways: guardings.	
Netherlands	One side (stairs with pitch > 2:3 [34°]; at changes of level > 1 m (new buildings), > 1.5 m (existing buildings). Stairways which are required to have guardings are also required to have a handrail.	*Top side of handrail, height above nosings:* 0.8 – 1 m, stairways bridging difference in height > 1 m (new buildings) 0.6 – 1 m , stairways bridging difference in height > 1.5 m (existing buildings).
Norway	Good handrails on both sides ['good' refers to both solidity and grip].	0.9 m
Sweden	Easy to grip handrails or similar. Both sides (stairs, ramps > 0.5 m).	–

specifies the minimum change of level for which a ramp must be provided.

In England and Wales, there are both safety and accessibility requirements for ramps, described in different approved documents, Parts K and M. Thus, if a ramp is not required to provide access for people with disabilities, it does not need to meet the accessibility standard. Similarly, in Norway, safety issues for ramps are in Chapter 7, accessibility issues in Chapter 10. Only ramps that are required for accessibility are subject to limitations on length. Germany (Hesse) includes a requirement for the gradient of ramps in the building regulations, but accessibility requirements for buildings required to provide barrier free dwellings are given in *DIN 18025 Part 2*. In all the other countries there is only one set of standards for ramps.

Requirements do not always apply for work to existing buildings, or there are lower standards for such work. In Belgium (Wallonie), the requirements apply to adaptations to existing buildings whereby at least two dwellings are created. In Denmark, the requirements apply to extensions and alterations, but some specified lower standards are allowed if the local authority considers that the full requirements would demand substantial alteration of the building. England and Wales is unusual because requirements do not apply to extensions to residential buildings, although building work must not worsen the pre-existing level of accessibility. In France, requirements apply to renovations and extensions to existing buildings.[4]

In the Netherlands, the standard for new buildings applies to alterations or renovations, but if this is not technically feasible or financially practicable, local authorities may allow the lower standards for existing buildings. Also, under the *Housing Law* (*Woningwet*), all existing buildings should meet the standards for existing buildings. Local authorities can inspect buildings either on their own initiative or in response to a tenant's complaint and they can force the owner to improve the building. If the resulting building work requires a building permit, it must meet the standards for new buildings, but local authorities can grant exemptions and allow the work to be done to the existing building standards.

In Norway, the requirements apply to both new construction and other projects that require planning permission or a building permit. Local authorities may make exceptions in 'special circumstances'; one example is the application of a lower standard for the gradient of ramps (1:12, rather than 1:20).[5]

In Sweden, the mandatory requirements apply to extensions.

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4 In France, conditions of state aid for rental dwellings and foyers include a supplement for the achievement of the quality label 'Label Qualitel Accès aux handicapées' (*Arrêté 10.6.96,* modified *24.7.97, 27.2.98)*.

5 The central authority has urged local authorities to be less lenient, believing that exceptions were being granted too frequently and too easily.

Table A1.8 Ramps: Geometry of ramps

	Max. changes in level	Max. gradient	Max. length of slope
Belgium	*Code Wallon de l'Aménagement du Territoire, de l'Urbanisme et du Patrimoine (CWATUP):*		
Wallonie	common parts of apartment buildings:		
	–	Preferred: 5% [1:20]	10 m
		If impossible, allows: 7% [1:14]	≤ 5 m
		8% [1:13]	≤ 2 m
		12% [1:8]	≤ 0.5 m
		30% [1:3]	≤ 0.33 m.
Denmark	Requirements for ramps apply to Internal and external common access routes, apartment buildings; access route to joined houses and houses with a home business.		
	Landings every 600 mm rise (ramps > 1:25).	1:20	– *[12 m, by calculation]*
England and Wales	General requirements:		
	–	1:12	–
	Additional requirements for ramps providing access for disabled people:		
	None specified [0.66 m or 0.42 m, by calculation]	1:12	5 m (max. gradient 1:12) 10 m (max. gradient 1:15)
France	None specified [0.5 m, by calculation]	5% [1:20]	10 m (gradients > 4% [1:25])
Germany	None specified	6% [1:17]	6 m
DIN 18025	[0.36 m, by calculation]		
Netherlands	New buildings:		
	1 m	1:12 (height difference ≤ 0.25 m)	3 m
		1:16 (height difference ≤ 0.5 m)	8 m
		1:20 (height difference > 0.5 m)	20 m by inference]
	Existing buildings:		
	–	1:10	–
Norway	Landings every 0.6 m rise.	1:20, exceptionally 1:12	6 m for 1:12
	Ramps to be used by people in wheelchairs should not be steeper than 1:20, but may in exception al cases be steeper, up to 1:12. [Commonly, the more rigorous requirement is applied to new construction, the more lenient is applied to conversions and refurbishments.]		
Sweden	General recomendations: *0.5 m (between landings)*	General recomendations: *1:12*	*[6 m by calculation of max. change in level and gradient]*

It is not clear in either Belgium (Wallonie) or Germany (Hesse), whether accessibility requirements apply to extensions.

A1.4.2 Ramps: geometry

There are both safety and accessibility issues for the geometry of ramps. It is tiring to wheel up a long, steep ramp, and it can be dangerous to come down one too fast. The characteristics of ramps should suit the needs of people who are pushed by an assistant as well as independent wheelchair users.

Standards of the geometry of ramps cannot be judged by gradient alone; the length of the ramp is also significant. All countries have limits on the

maximum gradient of ramps.

There are limits on the length of ramps in Belgium (Wallonie), England and Wales, France, Norway, and the *DIN* standard in Germany. In Denmark, the Netherlands, and Sweden, there is a limit on the change of level which can be negotiated by a ramp; in effect, this limits their length, which can be calculated by multiplying change of level by gradient.

The highest standard for the geometry of ramps is the *DIN* standard in Germany (max. gradient 1:17, max. length 6 m, max. height by calculation 0.36 m), but this only applies to buildings required to provide barrier free housing. The highest standard for blocks of flats is in France (max gradient 1:20, max.length 10 m, max. height by calculation 0.5 m), but the standard in Denmark is higher (1:20, max. rise 0.6 m), because it applies to all types of buildings except detached houses which do not have a home business. In the Netherlands, the maximum gradient allowed decreases with the height of the difference in level, which is a higher standard than the single maximum for England and Wales. The lowest standard is in Belgium (Wallonie), which allows short lengths of steep ramps (steepest 30%, length 0.33 m). This is a very low standard because such steep slopes can probably only be negotiated with assistance.

A1.4.3 Width of ramps and landings

Apart from the safety of ramps which form part of a means of escape in case of fire, the width of ramps is an accessibility consideration. There should be sufficient room for someone to wheel themselves without hitting their elbows. Ideally, the width would also be limited so that a person using a wheelchair can reach the handrails to pull themselves up, or slow themselves down.

Landings offer a resting place and perhaps a chance to adjust direction for people negotiating a ramp. The key issue is the length of landing, which should provide sufficient space for the length of someone using a wheelchair.

There are requirements for the width of ramps in Belgium (Wallonie), Denmark, France, the Netherlands, Norway, the *DIN* standard in Germany, and the general recommendation in Sweden. There are also requirements which apply to accessible ramps in England and Wales. The highest standard is in Denmark (1.3 m), the lowest standards where requirements are given are in England and Wales (0.9 m or less) and Norway (0.9 m).

There are specifications for the dimensions of landings on ramps in Belgium (Wallonie), Denmark, England and Wales, France, the Netherlands, Norway, and in the *DIN* standard in Germany. There is a general recommendation in Sweden. There are no requirements in Norway. The general recommendation in Sweden for the length of landings is the highest standard (2 m); the lowest standards, where requirements are given, are in England and Wales

Table A1.9 Ramps: width, landings

	Min. width	Min. width x length of landings
Belgium	*Code Wallon de l'Aménagement du Territoire, de l'Urbanisme et du Patrimoine (CWATUP):*	
Wallonie	common parts of apartment buildings:	
	1.2 m	1.5 m (depth, top and bottom of flights)
Denmark	Requirements for ramps apply to internal and external common access routes, apartment buildings; access route to joined houses and houses with a home business.	
	1.3 m	1.3 x 1.3 m (top, bottom, any intermediate). Also, landings 1.65 m wide every 10 m (access to joined houses, houses with home business)
England and Wales	General requirements:	
	–	As great as the smallest width of the flight or ramp
	Additional requirements for ramps providing access for disabled people:	
	0.9 m (unobstructed)	1.2 m plus any door or gate swing (top, bottom, intermediate)
France	1.2 m	1.4 m (depth, top and bottom)
Germany	1.2 m between kerbs	1.2 x 1.5 m (mid-ramp)
DIN 18025		1.5 x 1.5 m (top, bottom)
Netherlands	1.1 m (new buildings)	Landing at the top of each flight:
	0.7 m (existing buildings)	1.4 x 1.4 m (new buildings)
		0.7 x 0.7 m (existing buildings)
Norway		
	0.9 m (Optimum 1.1 m)	1.4 x 1.4 m
Sweden	General recomendations:	General recomendations:
	1.3 m	*2 m (depth)*

(equal to width of ramp or depth 1.2 m for accessible ramps). England and Wales is alone in considering the hazard of doors opening onto ramps.

A1.4.4 Guardings and handrails

It is helpful to mark the edge of ramps so that they can be identified by people with visual impairments. In some situations there is a also a need to protect people from falls off the sides of ramps. There are requirements for the provision and dimensions of guardings to ramps in Denmark, England and Wales, the Netherlands, and the general recommendations in Sweden. Dimensions are also given in the *DIN* standard in Germany. Although Norway directly addresses the risk of tripping at small changes of level, it does not specify the provision of guarding but general safety requirements apply. There are two types of requirements: for low-level edge guarding, in Belgium (Wallonie), the Netherlands, in the *DIN* standard in Germany, and a general recommendation in Sweden: and for guarding to prevent falls, in Denmark, England and Wales, the Netherlands and Sweden.

In the Netherlands, low-level guarding is allowed for substantial changes of level (up to 1 m, new buildings). The edge guarding specified in the *DIN* standard for Germany is slightly higher (minimum height 0.1 m) than the requirement in the Netherlands (0.04 m), and is required to extend beyond the end

Table A1.10 Ramps: Landings, provision of guardings, dimensions of guardings

	Provision of guarding	Dimensions of guarding
Belgium		
Wallonie	Along length of ramp, at side of change of level.	Edging 0.05 m.
Denmark	–	Min. height: 0.8 m (flights), 0.9 m (landings).
England and Wales	Guarding at drops > 0.6 m. Design to prevent children being held fast.	Min. height: 0.9 m Max. openings: 0.1 m; design so that children cannot climb guarding.
France	–	–
Germany	Wheel deflectors [kerbs] both sides of ramps and landings.	0.1 m wheel deflector [kerb], extending 0.3 m onto landing.
DIN 18025		
Netherlands	Guarding to both sides	min. height: 0.04 m for 1 m drop 0.85 m for > 1 m drop (new buildings) 0.6 m for > 1.5 m drop (existing buildings) max. width of openings in guarding: 0.5 m, but 0.1 m in area < 0.7 m above level of ramp (new buildings) 0.2 m in area < 0.6 m above level of ramp (existing buildings). max. horizontal gap between guarding and ramp: 0.05 m (new buildings), 0.1 m (existing buildings). No opportunities for climbing in area 0.2 – 0.7 m above ramp (new buildings).
Norway	General safety requirements as for stairs. Changes of level delineated to avoid tripping or, if that is not possible, easy to see and well lit.	–
Sweden	Balustrades to limit risk of injury, if ramp not bounded by walls.	General recommendationts: *min. height: 0.9 m; 1.1 m if large side opening and drop > 1 storey.* *max. width, vertical openings: 0.1 m; no opportunities for climbing up to 0.8 m* *Also, min. height of kerbs on usable pathway: 0.04 m*

of the ramp. The highest standard for guarding to prevent falls from ramps is in Sweden (min height 0.9 m or 1.1 m if risk of serious fall). The lowest standards where requirements are given, are in England and Wales (0.8 m, ramps with drop > 0.6 m) and the Netherlands (0.85 m, ramps with drop > 1 m). The Netherlands also has a very low standard for existing buildings (0.6 m, ramps with drop > 1.5 m).

Only the Netherlands limits the width of the gap between guarding and the ramp. Although there are no further requirements for ramps in the Netherlands, this section notes the requirements in other countries.

Handrails besides ramps may be used by people using wheelchairs to pull themselves up or slow themselves while coming down, but this should not be necessary if the ramp is not steep. More commonly, handrails help people to keep their balance. There are requirements for the provision and height of

Table A1.11 Ramps: landings, provision of handrails, dimensions of handrails

	Provision of handrails	Height of handrails	Other characteristics
Belgium *Wallonie*	Double handrail to flights and rest spaces.	0.75 m and 0.9 m	Max. cross-slope: 2% [1:50]. Non-movable, non-slip, without projections, obstacles to wheels; max. width of holes or gaps: 0.01 m.
Denmark	Both sides (slopes > 1:25).	0.8 m	–
England and	General requirements:		
Wales	Handrails to at least one side (ramps < 1 m wide), both sides (ramps ≥ 1 m wide). Handrails to provide firm support and allow firm grip.	Height: 0.9 - 1 m; can form top of guarding.	Headroom over ramps min. 2 m.
	Additional requirements for ramps providing access for disabled people:		
	–	–	Max. cross-slope: 1:40. Firm, even surface, to support weight of user and wheelchair, smooth enough for easy manoeuvre. Loose laid materials not suitable.
France	–	–	Max. cross-slope: 2% [1:50] Stable non-slip surface without obstacles to wheels. Max. opening in surface, 0.02 m [e.g. gratings].
Germany *DIN 18025*	Handrails both sides, 0.03 – 0.05 m diameter, extending 0.3 m onto landing	Height: 0.85 m +/- 0.05 m	–
Netherlands	–	–	–
Norway	Both sides and two heights.	Heights: 0.7 m and 0.9 m	–
Sweden	–	–	–

handrails to ramps in Belgium (Wallonie), Denmark, England and Wales, and Norway. Heights are also given in the *DIN* standard in Germany. There are no requirements in France, the Netherlands or Sweden. Whereas ramps in France have shallow gradients (1:20) and handrails are un-necessary, ramps in the Netherlands and Sweden can be much steeper (1:12). Handrails are required to both sides of a ramp in Denmark and Norway, but provision is related to the width of the ramp in England and Wales. The optimum height of handrails for ramps is related to user need, and this is most clearly reflected in requirements for two sets of handrails at different heights in Belgium (Wallonie) (0.75 m and 0.9 m), and in Norway (0.7 m and 0.9 m). These represent the highest standards. A range of values is given in England and Wales (0.9 m to 1 m) and the *DIN* standard in Germany (0.8 m to 0.9 m). Only the *DIN* standard in Germany requires that handrails should extend beyond the end of the ramp (0.3 m).

There are a few other accessibility requirements for ramps. Cross-slopes or excessive camber can increase the difficulty of steering a wheelchair in a straight line, but there are few limitations on the cross-slope of ramps. Bel-

gium (Wallonie) and France have a slightly higher standard (1:50) than England and Wales (1:40). They also have some requirements for the quality of the surfaces of ramps and pathways. There are also limits on the size of openings in floor grids or gratings which might impede the passage of wheels or crutches, in Belgium (Wallonie) (0.1 m) and France (0.2 m).

A1.5 Conclusions

The Netherlands has replaced some of its earlier very low standards for straight stairways, with increased minimum goings and reduced maximum rises. The standard for private stairs in now less steep than in England and Wales, but the standard for common stairs is still the steepest. It is said that people in the Netherlands learn to take especial care on stairways, and indeed there is a much lower rate of falls on stairways in the Netherlands (5% of all hospitalisations)[6] than the UK (13.5%).[7] However, it seems likely that as people live longer, the issue of stair safety will grow in significance.[8]

The only change in requirements for tapered treads is a slightly deeper tread at the pitch line for common stairs. There are insufficient requirements for tapered treads in other countries to make a comparison.

Requirements that limit the pitch of stairways and maximise the goings of both straight and tapered treads are significant in terms of floor area and associated costs. A shallower pitch increases the length of a stairway. The improved standard for straight stairs in the Netherlands will make a little difference to the planning of private stairs, stairs in buildings ≤ 500 m^2, and common stairs in blocks of flats < 600 m^2. For a stairway with 15 rises, its length increases by 0.14 m, and its area by 0.112 m^2. For three storey houses, this might increase the area by 0.34 m^2 if the size of other spaces remains the same. The changes might encourage the already widespread use of stairs with tapered treads, which are more common than in other countries.

The changes for stairs in buildings > 500 m^2, and common stairs in blocks of flats > 600 m^2 are relatively more significant. As well as a small increase in the depth of goings, there have been notable changes in the height of rises and the width of the stairway. For a stairway with 15 rises, its length increases by 0.42 m, and its area by 0.8 m^2 per storey. The increased width of common stairways now equals the high standards in France and Sweden.

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6 Cited in Adaire Chown, G. (1993).

7 In the UK there are 2.7 million domestic accidents each year which result in a visit to hospital. Falls are the most common type of accident, and a third of all falls happen on stairs or steps (approximately 13.5%). Metra Martech Ltd. (2000).

8 Hill, L.D. *et al.* (2000), p. 1.

However, the Building Decree perpetuates poor safety standards for the guarding of stairways and ramps next to substantial changes in level. It compares unfavourably with requirements in most other countries for guarding to extend the full length of stairways and ramps and, less commonly, to extend a handrail a little beyond the first and last steps. The reason for not requiring handrails at the foot of stairways is so that short flight of stairs need not have handrails, but as a result the safety of all stairways is reduced.

The standard for the height of guardings in existing buildings is very low and it seems a curious exemption, perhaps on aesthetic grounds, because it would not be particularly difficult or expensive to adapt a guarding/handrail by 20 cm.

The Building Decree also does not require handrails for ramps, which means that steeper ramps may be more difficult to negotiate than in other countries. It has very few requirements for detailing (maximum cross-slope, the quality of surfaces, or characteristics of gratings), which also reduces the accessibility of ramps. It may be that these details are considered insignificant; that the standard of specification and detailing is already high; or that there is little use of ramps in the Netherlands.

There are many causes of accidents on stairs, most of them behavioural.[9] Lighting is identified as a contributing factor, but none of the building regulations studied addresses the issue of the daylighting or artificial lighting of stairways.

9 Hill, L.D. *et al.* (2000) refers to Templer, J. (1992) *The Staircase* MIT Press, Massachusetts.

Appendix 2 Fire safety

The interpretation of the Building Decree was compiled with assistance from Adviesburo Nieman. The analysis was discussed with C.S. Todd & Associates Ltd.

A2.1 Introduction

This chapter considers a selection of requirements for means of escape, structural fire precautions, and means for giving warning of fire. It is based on the following sections of the Building Decree:
Stability in the event of fire
- 2.12 Limitation of fire development
- 2.13 Limitation of spread of fire
- 2.14 Further limitation of spread of fire
- 2.15 Limitation of development of smoke
- 2.16 Limitation of spread of smoke
- 2.17 Escape inside a smoke compartment
- 2.18 Escape routes
- 2.19 Design of smoke-free escape routes

There are some further fire safety sections, which unfortunately we were not asked to analyse:[1]
- Limitation of the risk of fire;[2]
- Prevention and limitation of casualties due to fire;[3]
- Fire fighting;[4]
- Large fire compartments;[5]
- High rise buildings and subterranean buildings;[6]

and some related requirements in:
- 4.16 Installation space for a fireplace.

The Building Decree sets prescriptive standards for structural fire precautions and means of escape which vary according to the size of the building and user function. It uses a number of concepts in ways that appear to be quite different

1 Certain strategies are inter-related and should not be viewed in isolation. This is explained in the guidance for England and Wales: "*there is a close link between the provisions for means of escape (B1) and those for the control of fire growth (B2), fire containment (B3), and facilities for the fire service (B5)*".

2 Hearths; materials for shaft and duct linings; exhausts for flue gases; fire hazard of roofs.

3 Fire-fighting lifts, travel distances to escape stairs and fire-fighting lifts.

4 Dry risers, fire hose connection points; distance between sub-fire compartments and dry risers, number of fire hose connection points related to length of hoses; standards for dry risers, connection and location of fire hose reels, maximum length of hoses, pressure and capacity of hoses.

5 Does not apply to residential accommodation.

6 Refers to the performance requirements for fire safety that apply to lower buildings (2.11 - 2.21).

from other countries, although the principles are probably broadly similar. It proved impossible to interpret several requirements without specialist advice on the peculiar concepts and terminology adopted by the Building Decree.

Also, unlike some other sections of the Building Decree, the requirements appear to be incomplete, because the means by which they can be achieved are described in national standards (NENs), with practical examples given in national codes of practice (NPRs). This is more than a simple case of referring to national standards for detailed implementation: some issues, such as penetration through compartment walls, are not mentioned in the Building Decree at all, but are implied by a general requirement and dealt with in the NENs and NPRs.

It is difficult to offer a full comparison because it would be necessary to analyse the associated NENs and NPRs to understand possible interpretations.

A2.2 Identification of regulations for fire safety

The fire safety of buildings is often the subject of national safety legislation and local bye-laws, as well as building regulations.

A2.2.1 Building regulations

Table A2.1 lists the relevant building regulations for fire safety and notes the revision used for the comparative analysis. It also identifies the sections relevant to general needs housing. In France, there are separate regulations for very tall buildings.

A2.2.2 Other fire safety legislation

The regulation of fire safety in housing is not fully described by simple reference to building regulations. We did not make a methodical survey of the full range of fire safety regulations, but encountered some indicative examples.

There is national legislation to control buildings with certain functions, which although it does not apply directly to dwellings, may enhance the safety of neighbouring dwellings and dwellings in mixed-use buildings. For instance, in England and Wales, the *Fire Precautions (Workplace) Regulations* and, in some cases, *The Fire Precautions Act*, apply once non-domestic buildings are occupied. In France, the *Arrêté du 25 juin 1980* addresses the fire safety of buildings open to the public and its requirements would apply to some mixed-use buildings.

Fire safety is not guaranteed by building regulations, and there are systems to regulate the post-occupancy management of buildings in most countries. Certain premises must be licensed for use, usually by local authorities and

fire brigades. For instance, under the Housing Act 1985 (as amended) in England and Wales, local authorities must require means of escape and other fire precautions from Houses in Multiple Occupation, regardless of whether there is an application concerning building work.

There are also local bye-laws on fire safety, which may address issues of both the built environment and the management of buildings. In the Netherlands, municipal fire safety by-laws address site specific issues, including: location of buildings; access for the fire brigade; availability of water; requirements for fire alarm warnings; fire extinguishers; maintenance of mechanical ventilation; installation of sprinklers; and working procedures when buildings are occupied. It is likely that much of the content of such bye-laws will be incorporated in a future revision of the Building Decree. Municipalities also issue user permits to limit occupancy for certain types of building, such as accommodation for students and elderly people, and permits that limit the materials used to finish and decorate the building. Recent disastrous fires in the Netherlands have prompted discussion of the implementation of such controls.

In England and Wales, there are numerous local acts, enforced as part of the Building Control process, which typically allow local authorities to impose conditions requiring access for the fire brigade, fire safety precautions in multi-storey car parks, fire precautions in tall buildings and large buildings used for trade or storage, and means of escape.[7] However, we were not asked to analyse local bye-laws and we did not identify municipal fire safety bye-laws in other countries.

A2.2.3 National standards and European harmonisation

The Building Decree includes notes for guidance, but refers to NENs for interpretation of requirements, which in turn refer to NPRs. Each of the other countries also refers to national standards.

It is only recently that the European Commission developed standards for

7 Advice on the procedures necessary to ensure consultation with all the relevant agencies is contained in: Office of the deputy prime minister (2001).

8 Fire resistance test methods approved by CEN TC 127 in 1999: EN 1363-1 General requirements; EN 1363-2 Additional requirements; EN 1364-1 Non-loadbearing walls; EN 1364-2 Non-loadbearing ceilings; EN 1365-1 Loadbearing elements – walls; EN 1365-2 Load-bearing elements – floors / roofs; EN 1365-3 Load-bearing elements – beams; EN 1365-4 Load-bearing elements – columns; EN 1366-1 Fire resisting ducts; EN 1366-2 Fire dampers; EN 1634-1 Fire doors and shutters. 'Euroclass' reaction to fire system approved by CEN TC 127 in 2002: EN ISO 1182 Non-combustibility test; EN ISO 1716 Calorific potential test; EN ISO 11925-2 Small flame – ignitability test; EN ISO 9239-1 Radiant panel – flooring test; EN 13238 Conditioning of test specimens; EN 13823 Single burning item (SBI) test; EN 13501-1 Classification.

Table A2.1 Regulations for fire safety of dwellings

	Edition of regulations used in analysis	Sections relevant to general needs housing
Belgium	Federal legislation: *Arrêté royal (AR) du 07-07-1994 fixant les normes de base en matière de prévention contre l'incendie et l'explosion, auxquelles les bâtiments nouveaux doivent satisfaire* [standards for prevention of fire and explosion in new buildings]; modified by *AR du 19-12-1997.* There is no fire safety legislation for single family housing, except for a very few regulations by individual communes on houses for rent.	*AR du 19-12-1997:* Annex 1 Terminology; Annex 2 Low buildings; Annex 3 Medium buildings; Annex 4 Tall buildings; Annex 5 Materials' reaction to fire.
Denmark	*Bygningsreglement By- og Boligministeriet Building Regulations* (1995) [Subsequently amended 1999, 2000, and 2001]	Part 6 Fire safety 6.1 General; 6.2 Definitions; 6.3 Distance from boundaries etc.; 6.4 Fire walls and fire-division walls; 6.5 Escape routes; 6.6 Rescue facilities; 6.7 Structural requirements; 6.8 Multi-storey housing
	Bygningsreglement for småhuse: Udfærdiget i medfør af §§ 3,5 og 16, stk. 3-4 i byggeloven, jf. lovbekendtgørelse nr. 452 af 24. juni 1998 *Building Regulations for Small Dwellings BR-S 98* (1998).	Chapter 4 Structures, fire protection and building site; 4.3 Fire protection; Chapter 9 Joined single-family houses; 9.7 Fire protection, supplementary provisions to paragraph 4.3
England and Wales	*The Building Regulations 2000* (Statutory Instrument 2000 No. 2531) Guidance to the interpretation of the requirements is given in *Approved Document Part B Fire Safety* (2000).	Schedule 1: Part B Fire Safety B1 Means of warning and escape: 1 Fire alarm and fire detection systems; 2 Dwelling houses; 3 Flats and maisonettes. B2 Internal fire spread (linings). B3 Internal fire spread (structure). B4 External fire spread. B5 Access and facilities for the fire service.
France	*Code de la Construction et de l'Habitation (CCH):* R. 111-13, R. 121-1 to R. 121-13; R. 122-2. *Arrêté du 31 janvier 1986 relatif à la protection contre l'incendie des bâtiments d'habitation.* [Implementing order for fire protection of residential buildings] Also: *Arrêté du 15 juillet 1982 relatif à la protection contre les risques d'incendie dans les immeubles de grande hauteur* [Regulations for very tall buildings, not analysed] *CCH:* R123-2: in a mixed-use building, any area of flats > 50 m² is subject to the requirements of: *Arrêté du 25 juin 1980: Règlement de sécurité contre l'incendie dans les établissements recevant du public* [fire safety in buildings open to the public, not analysed]	Detailed provisions in *Arrêté 31.1.1986:* Art 1-4 Classification of residential buildings. Art. 5-16 Structure and envelope of residential buildings. Art. 17-43 Escape routes. Art. 44-64 Pipes and ducts. Art. 97-99 Miscellaneous: lifts, dry risers, pedestrian circulation.

	Edition of regulations used in analysis	Sections relevant to general needs housing
Germany, *Hesse*	*Hessische Bauordnung (HBO)* (2002)	13 Fire protection; 25 Load-bearing walls, supporting columns, exterior walls and dividing walls; 27 Firewalls; 28 Floors/ceilings; 29 Roofs; 30 Stairs; 31 Necessary stairways and exits; 32 Necessary corridors and escape routes; 36 Pipes, ventilation systems, shafts, ducts.
	The 1993 version of the HBO was used to compile the initial analysis. The subsequent revision, effective from 1st October 2002, substitutes performance requirements for specifications of periods of fire resistance in some sections, but the specifications are given in an appendix. A few dimensional specifications were removed. Some sections were added and the numbering changed. Any notable changes are noted in the tables.	
Netherlands	*Bouwbesluit* [Building Decree] (2001)	2.2 Stability in the event of fire; 2.11 Limitation of the risk of fire; 2.12 Limitation of fire development; 2.13 Limitation of spread of fire; 2.14 Further limitation of spread of fire; 2.15 Limitation of development of smoke; 2.16 Limitation of spread of smoke; 2.17 Escape inside a smoke compartment; 2.18 Escape routes; 2.19 Design of smoke-free escape routes; 2.20 Prevention and limitation of casualties due to fire; 2.21 Fire fighting; 2.22 Large fire compartments; 2.23 High rise buildings and subterranean buildings. Also, 4.16 Installation space for a fireplace.
Norway	*Tekniske forskrifter til plan- og bygningsloven 1997 med endringer senest ved forskrift 13. desember 1999* [Technical Regulations under the Planning and Building Act 1997, amended] (1999). Detailed guidance is given in: *REN Teknisk veiledning til teknisk forskrift til plan- og bygningsloven 1997, utgave april 1999* [Guidebook to the Technical Regulations, amended] (1999). [New guidance is forthcoming: www.nbl.sintef.no/reports/report_dir/rapportA02103B.pdf]	Chapter VII Personal and material safety 7-2 Safety in case of fire; 7-21 Documentation; 7-22 Hazard classes and fire classes; 7-23 Load bearing capacity and stability in the event of fire; 7-24 Ignition, development, spread of fire and smoke; 7-25 Preparations for fire fighting; 7-26 Spread of fire between buildings; 7-27 Escape of persons; 7-28 Arrangements for rescue and fire-fighting personnel
Sweden	*Boverkets Byggregler (BBR-94: 3) BFS 1993:57* (1997) [Swedish Board of Housing, Building and Planning: Building Regulations] Further mandatory provisions and general recommendations regarding the load-bearing capacity of buildings in case of fire are given in the *Design Regulations of the Board, BKR.* (BFS 1998:38) [not analysed].	5 Safety in case of fire: 5:1 General; 5:2 Fire resistance classes and other conditions (not 5:24); 5:3 Escape in the event of fire (not 5:371-3); 5:4 Protection against the outbreak of fire (not 5:46); 5:5 Protection against the spread of fire inside a fire compartment; 5:6 Protection against the spread of fire and fire gases between fire compartments (not 5:67); 5:7 Protection against the spread of fire between buildings; 5:8 Load bearing capacity in the event of fire; 5:9 Fire fighting facilities.

product testing with regard to characteristics of behaviour in fire.[8] Conflicting existing national standards should have been withdrawn by March 2001. The EN standards are too recent to have been incorporated in most of the documents used in this analysis, but Norway incorporated the harmonised standards as early as 1999.[9] Some are based on earlier ISO standards that are referred to in current building regulations, for instance, in Belgium. In 2003, the harmonised standards should be integrated into the Building Decree, Approved Document B in England and Wales will be amended by a European Supplement, and there are announcements of the substitution of harmonised standards in other countries. However, there is no harmonisation of strategies, such as compartmentation or means of escape, or controls on specification and installation, so that products tested using harmonised standards can be used in different conditions in different countries.[10]

A2.3 Application of requirements to housing

There is considerable variation in the classifications of dwellings and residential buildings which are used to apply certain requirements, such as the fire resistance of structural elements. Classifications are given in primary legislation in Belgium, Denmark, France, Germany (Hesse), the Netherlands, Norway, and Sweden, and in guidance in England and Wales (Approved Document B). In Norway, the risk classes and fire classes are outlined in the Technical Regulations, and explained in the Guidebook to the Regulations.

Any dwelling presents a high risk due to the fact that people sleep there and, unlike commercial premises, there will be an un-managed response to any alarm. Sheltered housing can present an even higher risk, if occupants have a limited ability to escape due to physical, sensory or orientation impairments. The risk of injury or death increases with the height of buildings, which affects the ease of escape, the ease of fire fighting and rescue operations, and the consequences of any large scale collapse. Strategies for dwellings sometimes rely on assisted escape, and access for rescue services is integral to some requirements.

Each country, except Belgium, has some requirements for single-family houses as well as for blocks of flats. In Belgium, the only fire safety controls on single family housing are a very few regulations by individual communes

9 Norsk akkreditering (2002).

10 Deakin, G. (2000).

11 With any system whereby regulations are issued in individual items of legislation, it is difficult to ensure that there are no requirements for a particular issue. The lack of fire safety regulations for single family housing was confirmed by the response to an enquiry by ANPI-NVBB, an association of Belgian insurance companies.

which are conditions for renting.[11] There are relatively simple classifications in Belgium, Denmark, England and Wales, Norway and Sweden, based on the height or number of storeys, and the type of dwelling. Some classifications are more complicated because they consider other parameters. France has four categories based on the number of storeys, type of housing, height, structure, and access for rescue and fire-fighting services. Germany (Hesse) has five classes[12], based on height of storeys, floor area, and for low rise buildings, the number of dwellings they contain. The Netherlands uses various combinations of type, floor area, height of storeys, and fire load density.

There are important differences in the description of heights that are used to differentiate standards. In Denmark, requirements refer to the height of the lower edge of rescue openings in the top storey; in England and Wales to the height of the floor level of the top storey, in France to the height of the lowest floor of the highest dwelling; in Germany to the height of storeys that can contain habitable rooms and similarly in the Netherlands, the height of a floor of a habitable area. Norway and Sweden only refer to the number of storeys.

It is not surprising therefore that there is also a great variety in the heights specified. There are five levels of requirements or classes based on height in Denmark (≤ 6.3 m, > 6.3 m, > 10.8 m, > 23 m, > 45 m). Germany (Hesse) relates requirements to only three heights (≤ 7 m, ≤ 13 m, ≤ 22 m), but has a separate section that applies to buildings over 22 m and 30 m high, which require special statements of provision for certain aspects of fire safety. There are three levels of requirements in Belgium (< 10 m, 10-25 m, > 25 m), and in the Netherlands (≤ 7 m, 7-13 m, > 13 m for new build); and two in France (≤ 28 m, > 28 m and ≤ 50 m) plus separate regulations for very tall buildings. England and Wales is less consistent (mostly ≤ 4.5 m and > 4.5 m, but for certain requirements > 7.5 m, >11 m, > 5 m, > 18 m, and > 30 m). The Dutch figures of 7 m and 13 m for the height of floors of habitable area typically translate as 3-storey and 5-storey buildings. It should be noted that the Building Decree section on high buildings simply refers to the performance requirements for fire safety that apply to lower buildings (sections 2.11 to 2.21), which means that all tall buildings above 13 m are subject to the same standards, apart from a single requirement for smoke protected stair lobbies in buildings > 50 m.

There are few requirements based on floor area. Apart from the definition for a 'large house' in England and Wales (with a storey > 200 m^2), only the Netherlands bases the differentiation of requirements on floor area, for living functions with a user area greater or smaller than 500 m^2 (new build) or greater or smaller than 1000 m^2 (existing buildings). Some criteria refer to a living function with a usable floor area > 500 m^2 that is not in an block of

12 Simplified from eight classes in *HBO* 1993.

flats: examples of this would include student accommodation, or a building converted to provide supported housing for older people.

Occasionally, requirements are linked to permanent fire load, the potential fuel contained in the fabric of the building.

In each country, requirements apply to extensions, renovations, and material alterations to existing buildings as well as new-build. England and Wales allows relaxations of the requirements that would apply if a third storey was added, in the case of attic conversions in 2-storey houses. None of the other countries addresses similar specific issues of existing housing.

The Building Decree explanatory notes state that in the Netherlands, the standards for new buildings also apply to alterations or renovations. However, if this is not technically feasible or financially practicable, local authorities may grant exemptions that allow the adoption of the standards specified for existing buildings. Also, under the Housing Law (*Woningwet*), used in complaints against landlords, all existing buildings should meet the standards for existing buildings. The Building Decree includes requirements for caravans and temporary constructions, but the following analysis only addresses the issues of permanent housing.

A2.4 Stability in case of fire

This section of the Building Decree comprises:

- Article 2.8 Performance requirement: stability for escape and searching
- Article 2.9 Periods of structural resistance
- Article 2.10 Sources for determination of periods of structural resistance
- Articles 2.11-13 Requirements for existing buildings

Each country has requirements for periods of fire resistance for structural elements. Such periods allow time to evacuate the building, for fire fighters to search the building without danger of collapse, and to reduce danger to people in the vicinity of the building.

There are two aspects to the fire resistance of structure: ability to maintain load-bearing capacity, and integrity to resist cracking. A third aspect, insulation, is relevant to most structural elements. Unlike England and Wales and Sweden[13], the requirements in the Netherlands do not differentiate between these three aspects of fire resistance.

The Netherlands presents fire resistance requirements for structural elements separately from those for fire compartments, but some of the other countries do not. In contrast, both France or Germany (Hesse) have require-

13 Also, the recent harmonised European standards for the testing of fire resistance of elements of construction.

Table A2.2a	Application to housing and classification of risk for fire safety
Belgium	Requirements do not apply to single-family houses or buildings ≤ 2 storeys and a total area ≤ 100 m². Classification relative to height of top floor above routes around building that are accessible to fire service vehicles: Batîments bas < 10 m (BB, low buildings), batîments moyens 10-25 m (BM, medium height buildings), batîments élevés > 25 m (BE, tall buildings). Several requirements are expressed relative to 'evacuation level', rather than ground level.
Denmark	Separate regulations for multi-storey buildings and small dwellings. Multi-storey buildings (blocks of flats; includes apartments with more than one storey, 'two-family houses' with two apartments, one above the other). General requirements, supplemented or reduced relative to type and height of building, expressed as height of bottom of rescue opening on top storey > 6.3 m,> 10.8 m, > 23 m, > 45 m. Small dwellings (detached, semi-detached, terraced, linked or cluster houses, etc.). Classification of risk not directly stated, but different requirements are given for: houses; houses with 2 storeys + basement; joined houses (semi-detached, terraced, cluster).
England and Wales	All buildings are designated to purpose groups. Purpose Group 1, residential dwellings*, comprises three categories, differentiated on the basis of type and storey height. 1(a) Flat or maisonette. 1(b) Dwelling house which contains a habitable storey with floor level > 4.5 m above ground level 1(c) Dwelling house which does not contain a habitable storey more than 4.5 m above ground level; includes detached garages and open carports ≤ 40 m². * Includes any surgery, consulting room, office or other accommodation ≤ 50 m², forming part of a dwelling and used by an occupant in a professional or business capacity. Other residential buildings are allocated to Purpose Group 2, which has two further categories: 2(a) Institutional residential buildings [including hospitals] for people with disabilities due to illness or old age or other physical or mental incapacity, or under the age of five years; or place of lawful detention where people sleep 2(b) Hotels, boarding houses, residential colleges, halls of residence, hostels, any other residential purpose. Further differentiations of requirements are used in Part B: Requirements for means of warning and escape: differentiation: - by type: some requirements apply to all dwellings, but there are separate sections for dwelling-houses and for flats and maisonettes [duplex dwellings in blocks of flats]; specific requirements for loft (attic) conversions to 1- and 2- storey houses; also completely separate guidance applies to Purpose Group 2. - by number of storeys and height: houses, flats, and maisonettes with all floors < 4.5 m; one floor > 4.5 m; more than one floor > 4.5 m; floors > 7.5 m; small single stair buildings with floors < 11 m. - also floor area: requirements for fire detection devices specific to large houses with a storey > 200 m². Requirements for periods of fire resistance for elements of structure: differentiation: - by type and height of storeys: for dwelling-houses and for flats and maisonettes; >5 m, >18 m, or >30 m. Most of the other requirements apply to all buildings. Many apply to all buildings including flats and maisonettes, but not dwelling-houses. Some references to sheltered accommodation, student residences and houses in multiple occupation (house conversions), but few specific requirement

Table A2.2b Application to housing and classification of risk for fire safety

France	Residential buildings, including foyers, with lowest floor of highest dwelling < 50 m above ground, accessible to rescue and fire-fighting services; covered car parks attached to such buildings with area 100 m² – 6,000 m². Separate regulations for very high buildings [not analysed].	
	Classification of buildings* by number of storeys, type, height, structure, access for rescue and fire-fighting services:	
	Category 1:	≤ 2 storey detached houses, semi-detached houses, or terraced houses with independent structure; 1 storey terraced houses.
	Category 2:	> 2 storey detached, semi-detached or terraced houses with independent structure; 2 storey terraced houses without independent structure; max. 4 storey blocks of flats (or 5 storey if top floor in duplex accessed at 4th storey).
	Cat. 1 and 2:	excludes houses converted into a number of dwellings. [Not further mentioned]
	Category 3:	Lowest floor of highest dwelling ≤ 28 m, accessible to rescue and fire fighting appliances; either:
	A:	Max. 8 storeys with distance from dwelling entrances to stairway ≤ 7 m; or
	B:	housing not satisfying conditions for A, but may be reallocated to A in communes where rescue and fire-fighting services have ladders to reach lowest floor of highest dwelling.
	Category 4:	Buildings with lowest floor of highest dwelling 28-50 m above ground; accessible to rescue and fire fighting appliances; access to protected stairs max. 50 m from appliance route.
	* The number of storeys is described as ground floor + upper storeys, but this report uses the total number of storeys to allow comparisons with other countries (e.g., more than one storey above *rez de chaussée* = > *2 storeys)*. For categories 1 and 2 'habitations individuelles' is translated as 'houses'.	
Germany *Hesse* 2002	Classification by type, height, number of units, area.	Height is measured from average ground floor level to top surface of highest storey.
	Class 1: detached buildings, max. 2 units, < 400 m²; detached agricultural buildings	≤ 7 m high
	Class 2: buildings, max. 2 units, < 400 m²:	≤ 7 m high
	Class 3: other buildings:	≤ 7 m high
	Class 4: buildings, max. 400 m2 per storey:	≤ 13 m high
	Class 5: other buildings:	≤ 22 m high
	More stringent requirements may be applied if necessary to special buildings, including buildings with storeys over 22 m, or 30 m.	

ments for fire resistance but do not use the term 'compartmentation' with regard to dwellings.[14] Each has requirements for fire walls, to subdivide long buildings. Only Denmark includes examples of constructions that satisfy the requirements for fire resistance of structural elements.

The Netherlands relates requirements for the fire resistance of structure to

14 Hesse does use the term 'compartmentation,' but only with reference to shopping malls and agricultural buildings.

Netherlands	The application of requirements is explained in tables, but there are also some further specific applications in individual requirements. Differentiation of requirements: – by type: living function situated in a block of flats; living function in a caravan, other living function [e.g. single family houses; the term 'living function' corresponds to 'dwelling', but may include ancillary spaces] – by floor area: living function with user floor area < 500 m² (new build) or < 1000 m² (existing buildings) and living function with user floor area > 500 m² (new build) or > 1000 m² (existing buildings); – by combination of type and floor area. – Also some requirements relate to the height of the floor of a habitable area: < 7 m, 7-13 m, or > 13 m; also a single requirement > 50 m (new build) or 5-13 m or > 13 m (existing buildings). – Some requirements relate to fire load density of dwellings or fire compartments ≤ 500 MJ/m² g or > 500 MJ/m² g. NB Section 2.23 on high rise and subterranean buildings is only relevant to buildings with living accommodation on habitable storeys over 70 m above ground level, but it simply refers to the performance requirements for fire safety that apply to lower buildings (sections 2.11 to 2.21).
Norway	Categorisation: – by risk class (1-6): Dwellings are in risk class 4 (except dwellings for severely handicapped people who receive substantial nursing, which are in a higher risk class). – and by fire class (1-4): Fire class 1: single storey and two storey dwellings; three storey buildings where every dwelling unit has a direct escape to the ground. Fire class 2: other three storey and four storey developments. Fire class 3: five or more storeys. – There are also specifications relating to fire load density (MJ/m²).
Sweden	Differentiation of types of buildings: – by classes related to risk: Class Br1: buildings where a fire entails a high risk of injury to people; Class Br2: moderate risk of injury; Class Br3: other buildings. *General recommendations:* *Class Br1: buildings of three or more storeys.* *Class Br2: two storey buildings intended for more than two apartments and with habitable rooms or workrooms on attic storey.* *Class Br3: other dwellings.* – Also, by house type: some special conditions for detached or semi-detached houses. – Some requirements related to fire load intensity f ≤ 200 MJ/m² (dwellings), f < 400 MJ/m², f > 400 MJ/m².

the height of the topmost floor containing a habitable area. It does not differentiate between types of elements of structure (such as 'vertical load-bearing elements', or floors), or their location in the building. However, this is not significant because, despite describing them separately, most countries use the same values for different elements, apart from deep basements.

The Netherlands also relates periods of fire resistance to levels of fire load density. Fire load is the fuel that would be contributed by the materials in the building fabric to feed the growth of a fire and generate smoke. Norway and Sweden also relate fire safety requirements to fire load but the Netherlands

Table A2.3a Structural safety in case of fire: minimum periods of fire resistance or fire retardance (see also Table 5.8a for fire resistance of compartments)

	Elements of structure	Fire resistance (minutes)
Belgium	Tall buildings (BE)	Rf 2h = 120
	Medium buildings (BM)	
	– above evacuation level	Rf 1h = 60
	– below evacuation level and floor at evacuation level	Rf 2h = 120
	– openings in attic floor/ceiling of top storey	Rf ½ h = 30
	Low buildings (BB)	
	– storeys above lowest evacuation level; storeys below ground; floor of evacuation level	Rf 1h = 60
	– single storey buildings; roof structures, if not separated by 30 min. construction	Rf ½ h = 30
Denmark	**Blocks of flats**	BS = fire resistant:
	Load-bearing structures of storeys supporting top 12 m	BS 120
	1-storey + basement: separating floor, supporting structures. ≥ 2 storey buildings: load-bearing structures up to top floor (top storey floor ≤ 12 m), top 12 m (buildings with top storey floor > 12 m), separating floors, access balconies, balconies, structures carrying only single separating floor	BS 60
	Escape stair construction (except 2-storey, class B materials).	BS 30
		BD = fire–retardant:
	Buildings with 2 storeys + basement: load-bearing structures	BD 60
	1-storey buildings ≤ 600 m². Top storey structure; separating wall and ceiling, non-habitable attic. Non-load-bearing external walls.	BD 30
	Houses	
	2 storeys + basement: basement load bearing structures and separating floor	BD 60
	External walls, structural walls, columns, beams, separating floors, similar structures	BD 30
	Fire separating structure must form close joint with outermost roof coverings, must least extend to inside of exterior coverings of external walls. Refers to SBI Direction 189 for examples of construction of BD and BS structures.	

England and Wales			**Flats, maisonettes**	**Dwelling houses**
	Basement storey structure	(lowest basement > 10 m)	90	not applicable
		(lowest basement ≤ 10m)	60	30
	Elements of structure, ground or upper storey; enclosure of stair serving dwellings and other occupancies:			
		buildings with top floor > 30 m	120	not applicable
		≤ 30 m	90	not applicable
		≤ 18 m	60*	60**
		≤ 5 m	30	30
	* except floors within maisonettes that do not contribute to the support of the building; elements of construction in flat conversions with adequately protected means of escape, buildings ≤ 3 storeys; ** except 3-storey dwelling houses.			
	Walls separating building:	buildings with top floor ≤ 5 m	60	60
	Maisonette floors that do not contribute to the support of building; flat conversions in buildings < 4 storeys		30	not applicable

	Elements of structure	Fire resistance (minutes)			
France		Building category			
		1	2	3	4
	Load bearing vertical elements (requirements for facade or gable ends only apply to fires developing in the interior of buildings).	15	30	60	90
	Floors (excludes: floors inside dwellings, raised floors, false ceilings, floor of highest habitable storey if vertical walls surrounding dwellings extend to roof).	15 *	30	60	90
		* floor over basement			
	Separating walls or floors of contiguous car park:	–	60	120	
	No. car park storeys additional to datum storey:	+ 1	+2	> 2, ≤ 28 m above or below datum	
	Car parks associated with residential buildings:	30	60	90	

Germany	Building class:	**1**	**2**	**3**	**4**	**5**
Hesse 2002	- Load-bearing walls, columns, supports to storeys, habitable attics; and floors (except basements); excludes balconies:	B 2	F30-b		F60-a or F90-ba	F90-a
	- Load-bearing walls, columns, supports; floors in basements	F30-b			F90-a	
	- Load-bearing walls, columns, supports to non-habitable attics	B2				
	- Floors below habitable attics	B 2	F30-b		F60-a or F90-b	F90-ba
	- Floors between dwelling and space for agricultural use	F90-b			F90-a	
	- Partitions	–	F30-b		F60-a or F90-ba	F90-a
	- in basements	–	F30-b		F90-a	
	- in non-habitable attics	–	F90-a			
	Essential stairways: - walls	–		F30-b	F60-a +M or F90-ba +M	F90-a +M
	Essential stairs: - load-bearing parts	B2		A or F30-b	A	F30-a
	- load-bearing parts of external stairs	–		A		

A: non-combustible building materials (A 1) and non-combustible building materials with inflammable components (A 2). B: inflammable building materials: flame resistant (B1), normally inflammable (B2); BA: basic parts inflammable, sheathed in non-combustible materials. Load bearing: stability in case of fire; separating walls, floors: resistance to propagation of fire and smoke. M: resistant to additional mechanical load. Periods of fire resistance: F30/60 (fire-retardant), F90 (fire-resistant).

[*DIN 4102* gives examples of materials and constructions that supply the appropriate periods of fire resistance and combustibility, but this is not referred to in either revision of the HBO.]

Table A2.3b Structural safety in case of fire: minimum periods of fire resistance or fire retardance
(see also Table 5.8a for fire resistance of compartments)

	Elements of structure		Fire resistance (minutes)	
Nether-lands	Structure to withstand collapse that would render escape routes unusable: 30 minutes (new build) 20 minutes (existing buildings); also consideration of load combinations which can occur in the event of fire. Requirements for main supporting structure, related to height of floors of habitable area above ground.		Dwellings with permanent fire load density: ≤ 500 MJ/m²	> 500 MJ/m² or ≤ 500 MJ/m² in block of flats
	New build	≤ 7 m	30	60
		7 – 13 m	60	90
		> 13 m	90	120
	Existing buildings	5 – 13 m	30	
		> 13 m	60	
	References Determination of load combinations: *NEN 6702*. Determination of fire load density: *NEN 6090*. Determination of periods of resistance: *NEN 6069* [test methods for fire resistance to collapse], *NEN 6071*, *NEN 6072*, *NEN 6073* [characteristics of construction materials]. Building Decree explanatory notes refer to TNO (Organisation for Applied Research in Construction) *Building Decree; permanent fire load*, *No. 94-BKR-R1448*. NB The term 'above ground' is used here for brevity, instead of 'measuring level,' meaning the level of the ground adjacent to the entrance of the building.			

Norway	Fire class:	Class 1	Class 2	Class 3
	Load bearing structure below 1st basement	R60	R90	R120
	Main structural system	R30	R60	R90
	Secondary structural system (including floors)	R30	R60	R60
	Stairs	-	R30	R30
	R: fire resistance for load-bearing capacity. R60 – 120: fire resistant (non combustible) materials			

Sweden	Elements of structure are assigned to classes R (load bearing capacity), E (integrity), and I (insulation).			
	Class Br1: vertical load bearing structure and horizontal structure which provides stability for the structural frame:	Fire load intensity f(MJ/m²) *		
		$f \leq 200$	$f \leq 400$	$f > 400$
	– Buildings ≤ 4 storeys, floors in 5-8 storey buildings:	R 60	R 120	R 240
	– load bearing structure other than floors in 5-8 storey buildings, buildings ≤ 8 storeys, structure below top basement storey:	R 90	R 180	R240
	* $f \leq 200$ can be applied without special investigation to dwellings and residents' store rooms; it can also be applied to buildings with $f > 200$ MJ/m² that have an automatic sprinkler system.			
	Classes Br2, Br3: vertical load bearing structure and horizontal structure which provides stability for the structural frame:	Building class Br2		Br3
	– structure below topmost basement storey (if $f \leq$ MJ/m²)	R 90		R90
	– residential building	R 30		R 15

has a unique interpretation of fire load density which makes direct comparisons impractical and sets standards which potentially discount much of the load.[15]

However, Adviesburo Nieman advises that the differentiation of standards relative to fire load density is not significant for housing, unlike other user functions.[16] Comparison of periods of fire resistance requires careful consideration of the differences in expression of requirements. In order to simplify analysis, three different types of housing are identified in Table A2.3c.

Table A2.3c gives sample comparisons for the fire resistance of vertical load-bearing elements in a single-family two-storey house, and in blocks of flats with three-storeys, eight-storeys, and twenty-two storeys. Assuming a storey height of 2.65 – 2.85 m this would roughly translate as 2-storey < 3 m, 3-storey < 6 m, 8-storey 19-20 m, and 15-storey 37-40 m (excluding basements).

There are higher standards of fire resistance for a 2-storey single-family house in Denmark, England and Wales, Germany (Hesse, except detached houses), the Netherlands and Norway (30 minutes) than in France or Sweden (15 minutes). In Hesse, there are no requirements for detached houses < 400 m^2. There are no fire safety requirements at all for single-family houses in building regulations in Belgium.

The standards for a 3-storey block of flats are similar in each country (60 minutes) except France and Germany (Hesse) (30 minutes). Belgium and

15 Stollard & Abrahams (1991) notes that there are two components of fire load: the materials of construction, and the contents of the building. The interior wall and ceiling finishes, together with furnishings and fittings are the most likely fuel sources and contribute most to the rapid spread of fire. Structural materials, unless they form the interior finish, are unlikely to contribute to fire load.
However, NEN 6090 states that the calculation of fire load density should consider only the structure and the non-load bearing elements required to fulfil other Building Decree requirements. The Dutch rationale is to set a demanding standard for the essential permanent elements of the building and to discount the contribution of secondary elements because so much of the remaining fire load, from furniture and fittings, is unpredictable. It includes components required by the Building Decree for other purposes, such as acoustic performance, but would often exclude some or all of the partition walls, dropped ceilings or skirting boards, despite the fact that these might contribute a significant proportion of the permanent fire load. This is quite different from the approach used in Sweden, where fire load intensity is not directly defined, but paragraph 5.821 on fire resistance classes states: "*If the element of structure contains combustible material, this need not be taken into consideration other than to a reasonable extent in calculating the fire load intensity*." Similarly, in Norway, fire load is defined with regard to 'a fire compartment's surrounding surfaces'.

16 All flats must adopt the higher standard of fire resistance, regardless of fire load density. Also, although the higher standard would probably be applied to timber frame housing (due to the peculiar definition of fire load density, to include structural elements), in practice most houses in the Netherlands are built with a construction system that means the fire load density is low.

Table A2.3c Comparison of minimum periods of fire resistance or fire retardance for vertical load-bearing elements of structure

	Single-family house	Blocks of flats		
	2 storeys	3 storeys	8 storeys	15 storeys
Belgium	– (no requirements for single-family dwellings)	60 (BB top floor < 10 m)	60 120 in basements (BM top floor 10-25 m)	120 (BE top floor > 25 m)
Denmark	BD 30 (fire retarding)	BS 60 (load-bearing structures, top storey floor ≤ 12 m)	BS 60 (top 12 m) BS 120 (load-bearing structures of storeys supporting top 12 m)	
England and Wales	30 60 (walls separating buildings) (ground, upper storeys; with top floor ≤ 5 m);	60 (ground, upper storeys; with top floor ≤ 18 m)	60 (ground, upper storeys; with top floor ≤ 30 m) 60 (basement < 10 m), 90 (basement > 10 m)	120 (ground, upper storeys; with top floor ≤ 30 m);
France	15 (category 1)	30 (category 2)	60 (category 3)	90 (category 4)
Germany *Hesse* 2002	– (class 1) 30 (class 2)	30 (class 3)	90 (class 5)	more stringent requirements may be applied (buildings with storeys > 22 m or > 30 m)
Netherlands	30	60	90	
Norway	R 30 (fire class 1)	R60 (fire class 2; including first basement)	R90 (fire class 3; including first basement)	
Sweden	R 15 (class Br3)	R 60 (class BR1, ≤ 4 storeys; including topmost basement)	R 90 ($f \leq 200$ MJ/m^2) (class Br1; including topmost basement)	

France have a lower standard for an 8-storey block of flats (60 minutes) than the other countries (90 minutes); Denmark has the highest standard, a combined requirement (120 minutes for structure supporting top 12 m, 60 minutes for top 12 m structure). In Denmark, the Netherlands, Norway, and Sweden the standards that apply to 8-storey blocks would also apply to 15-storey blocks; only Belgium, England and Wales, and France specify higher standards. Belgium and England and Wales have the highest specified standards for 15 storey blocks (120 minutes).

A2.5 Limitation of fire development

This section of the Building Decree includes the following articles which are relevant to permanent housing:

- Article 2.91 Performance requirement: prevention of rapid development of fire
- Article 2.92 Fire propagation classes for internal surfaces
- Articles 2.93-94 Fire propagation classes for different elements of construction

Table A2.4 Classification of materials for spread of flame and fire propagation

	Highest class	Other classes
Belgium	Three test methods for surface spread of flame: ISO 1182; or NF P 92-501 (France); or BS 476: Part 7 (England and Wales). Five classes of materials.	
	A0 (non-combustible ISO 1182)	A1 (= Category I NF or Class 1 BS) A2 (= Category II NF or Class 2 BS) A3 (= Category III NF or Class 3 BS) A4 material not covered by test methods
	NB: *l'AR du 19 août 1998* advocates that BS 476: Part 7 and the out-dated NF P 92-501 should be replaced by more realistic tests.	
Denmark	Class 1	Class 2
	Ref: DS 1052.1 (building constructions) DS 1052.2 (doors), DS 1057.1 (building materials), DS1063.2 (floorings), DS 1065.1 (class A and B building materials), DS 1065.2 (class 1 and 2 coverings)	
England and Wales	Class 0 *	Class 1, Class 3
	Ref: BS 476: Part 7 (1971, or 1987 or 1997); Part 6 (1981 or 1989). Approved Document Part B includes examples of performance ratings of certain materials.	
	[* Class 0 only has a meaning within the Building Regulations. It is based on a combination of performances in a combination of tests, related to surface spread of flame and heat release.]	
France	Class M1	Class M2, M3, or M4
Germany *Hesse* 2002	A1: non-combustible building material	A2: non-combustible building materials with inflammable components. B: inflammable building materials; B1: flame resistant, B2: normally inflammable. AB: essential part consists of non-combustible building material. BA: basic parts inflammable, sheathed in non-combustible materials.
Netherlands	Class 2 T1 Ref: NEN 6065, NEN 1775.	Class 4; NEN 6065 also describes Classes 1, 3, 5. T3
Norway	Internal surfaces In1 External surfaces Ut1 Insulation of pipes and ducts PI	Internal surfaces In2 External surfaces Ut2 Insulation of pipes and ducts PII, PIII
	The surface of concrete, brick- or blockwork (both may be painted or wallpapered) and tiles correspond to In1. The surface of chipboard, wood panelling and plywood correspond to In2 Norwegian guidelines refer to the system of Euro-classes described in harmonised standards which will be made mandatory in EU and EU-affiliated countries including Norway.	
Sweden	Class I	Class II, Class III
	Class G (floor coverings), Class T (roof coverings) General recommendations include examples of materials of Class III.	

- Article 2.95 Exemption from requirement for part of room
- Article 2.96 Application to restorations, alterations, extensions
- Articles 2.98-102 Requirements for existing buildings

The rapid development of fire can be limited by selecting materials according to the characteristics of rate of surface spread of flame and rate of heat emis-

sion when burning. Each country relates a system of classification of materials to spatial conditions in which such materials are used. Explanation of the systems of classification is usually by reference to secondary sources which describe methods of testing, and an accurate description of requirements would require comparison of such sources.

The variety of testing systems are illustrated in Belgium, where classifications refer to three test methods, from an ISO, a *Norme française*, and a British Standard. The French and British classes are similar. However, a different, later *Norme* was used in French fire legislation. There are also differences in the definition of fire behaviour, as illustrated by a comparison of classes used in Germany (A1, A2, AB, B1, B2, BA), which are based on degrees of combustibility and flammability, and the classes of the harmonised standards (A1, A2, B, C, D, E, F), which are based on contribution to fire and periods of flashover.

The differences between test methods will be removed by mandatory harmonised European standards for elements of construction, but only Norway had incorporated the standards at the time of writing.

A2.5.1 Requirements for internal surfaces

Each country has requirements for the internal surfaces of stairways or escape routes. Some also have requirements for rooms. There are fewer requirements for floors than for ceilings and walls. It is interesting that the Netherlands sets standards for the upper surfaces of floors and stairs, whereas England and Wales exempts these as insignificant to occupant safety.[17]

Despite the difficulty in direct comparison of classifications, some differences are clear. The highest standard is in England and Wales (walls and ceilings to class 0 for common circulation in all blocks of flats and maisonettes and class 1 for rooms and circulation within dwellings). The Netherlands has a very low standard of requirements for internal surfaces (class 2 ceilings, walls and floors for all escape routes in blocks of flats, fire-free and smoke-free escape routes in large houses). Only Denmark and England and Wales have requirements for the internal surfaces of private areas of single family housing. None of the building regulations studied specifies materials or constructions deemed to satisfy the requirements, although England and Wales includes some typical performance ratings for internal linings.

17 In England and Wales, a single escape stair serving a 4-storey block of flats would have to be constructed using materials of limited combustibility (ADB, 6.19a), but the stairs could then be carpeted (ADB, B2.ii).

Table A2.5a Fire development: limit values for internal surfaces, surface spread of flame

	Location of surfaces	Classification		
		Ceilings	Walls	Floors
Belgium	Parking; collective kitchens; machine rooms, lift shafts etc; rubbish chutes:	A0	A0	A0
	Internal stairwells including lobbies and landings; escape routes; lift landings; kitchens in BM medium, BE high buildings:	A1	A1	A2
	Stairs (BM medium, BE high buildings)	–	–	A2
	Lift cars	A2	A2	A3
	Rooms	A2	A1	A3
	Other areas (BE high buildings)	A3	A2	A3
	Other areas (BM medium, BB low buildings)	A4	A2	A4
	Requirements do not apply to private parts of individual dwellings			
Denmark	Internal	1	1	–
	Escape routes	1	1	G
	Buildings > 6.3 m and < 23 m	2	–	–
	Houses: structures adjacent to non-habitable attics	2	2	–
	Exemptions: walls up to 1.2 m in escape routes may be class 2.			
England and Wales	Small rooms < 4 m^2; garages		3	– *
	Other rooms; circulation spaces within dwellings		1	– *
	Common areas of flats and maisonettes		0	– *
	Exemptions: parts of walls in rooms may be lower class, but min. class 3 if total area of those parts < 0.5 floor area of room but max. 20 m^2.			
	* "The provisions do not apply to the upper surfaces of floors and stairs because they are not significantly involved in a fire until well developed, and thus do not play an important part in fire spread in the early stages of a fire that are most relevant to the safety of occupants." (ADB B2.ii)			
France	Stairways: - category 2 collective housing	M2 or wood if direct exit to exterior		–
	- other collective housing		M0	M3 (stair treads)
	Escape route, open air	M2 or wood if direct exit to exterior		–
	Escape route, smoke protected	M1	M2	M3
		use of wood allowed in entry hall if direct exit to exterior		
Germany	Essential corridors and open decks:		B 2 (class 3), A (class 4, 5)	
Hesse 2002	Essential stairways: surfaces		A	
	floor coverings:			B1 (coverings)
	External wall linings	–	B2 (class 1,2,3), B1 (class 4, 5)	–
	See also the suffixes of requirements for fire resistance of structure, other components.			

Table A2.5b Fire development: limit values for internal surfaces, surface spread of flame

	Location of surfaces	Classification		
		Ceilings	Walls	Floors
Netherlands	Fire-free, smoke-free escape routes*, all living functions except caravans; smoke-free escape routes in blocks of flats, houses > 500 m² (new buildings), > 1,000 m² (existing buildings).		2	–
	Upper surface of floor, ramp, staircase			
	- fire-free, smoke-free escape route			T1
	- other			T3
	Smoke-free escape routes in houses ≤ 500 m².		4	–
	Other [parts of the building]. All doors, windows, frames, equivalent construction elements.			
	Exemption: 5% of total area of construction components in each individual room.			
	* A 'smoke-free escape route' is a route whereby people can independently achieve safe escape passing only over one or more floors, staircases or ramps, without use of mechanical devices such as lifts or escalators. A 'fire-free and smoke-free escape route' is unobstructed means of escape, passing only through one or more circulation spaces, which must prevent the escape route being obstructed by fire as well as complying with requirements for smoke-free escape routes. [Controls concerning characteristics of fire-free, smoke-free escape routes apply to other types of housing as well as blocks of flats.]			
Norway	Internal escape routes, fire class 1		–	G
	Internal escape routes, fire class 2 and 3		In1	G
	Internal, buildings fire class 2 and 3		In1	–
	Buildings in fire class 2 and 3: insulation of pipes and ducts must be PII.			
Sweden	Protected lobby	—	*General recommendations:* I*	non-combustible or class G
	* Mandatory performance requirement: 'material or material combination which does not aggravate risk of spread of fire and fire gases', general recommendation gives example, ignition retardant cladding with surface finish Class 1.			
	Escape routes, buildings Class Br1	—	I	*General recommendations: class G or non-combustible* *
	* Mandatory performance requirement 'moderate propensity to spread fire and evolve fire gases'.			
	Escape routes, buildings Class Br2	I	I	—
	Escape routes, buildings Class Br3, common to 2+ dwellings	I	II	—
	General recommendations:			
	Other spaces, Class Br1	*I* *	*II*	—
	Other spaces, Class Br2	*II* *	*III*	—
	Other spaces, Class Br3	*III*	*III*	—
	Exemptions: small elements of structure and rooms where surface finish does not affect safety of escape from building, may be to lower class, but min Class III.			
	** Applied to non-combustible material or ignition retardant cladding.*			

A2.5.2 Requirements for external surfaces

External fire spread can be controlled by: limits on characteristics of external surfaces; limits on the size and location of unprotected areas of façades, including openings; and requirements for the fire resistance of external walls. There are also separate requirements for the fire resistance of party walls between buildings. Issues of fire resistance are dealt with in other sections of the analysis, but there is no discussion of limits on unprotected areas of façades because there are no requirements in the Building Decree.

All countries have some limitations on characteristics of the external surfaces of façades, but there is considerable variation in the scope of requirements. Some distinguish different standards for parts of façades related to: the height of the façade, with lower standards for façades at ground level (Belgium, Denmark), higher standards for façades above a certain height (England and Wales, Netherlands); the height of buildings (England and Wales); the distance of a façade from a boundary (England and Wales, France); or the classification of the building (France, Norway, Sweden).

Norway allows reduced standards for external surfaces if there are screens, balconies, or recesses that hinder the spread of fire between storeys. It also allows reduced standards related to access for fire services. There are also limits on rubbish chutes (Belgium, England and Wales).

The Netherlands is unusual in differentiating between external surfaces on certain categories of escape routes[18] and other parts of the building. Other countries do not deal with the protection of buildings from neighbouring buildings.

Differences in classification systems and reliance on secondary sources to explain such systems, make it difficult to compare standards for characteristics of external surfaces, apart from whether or not there are requirements for non-combustible materials. The only instances of requirements for non-combustible materials are in Belgium, for refuse chutes and storage areas, and in England and Wales, for refuse chutes passing through a compartment wall or floor.

We were not asked to analyse the requirements for the external surfaces of roofs (Building Decree Section 2.11, Article 2.85 and NEN 6063).[19]

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18 It seems surprising that requirements concerning fire-free, smoke-free escape routes apply to other types of housing as well as blocks of flats.

19 Section 2.11 Limitation of the risk of fire, requires that roofs should not constitute a fire hazard. It refers to NEN 6063 rather than specifying standards and limits the application of the requirement to buildings with habitable space on floors higher than 5 m, within 15 m of the boundary.

Table A2.6 Fire development: limit values of vertical external surfaces, surface spread of flame

	Type of building, location of external surfaces	Classification	
Belgium	Refuse chutes, rubbish storage areas	A0	
	Façades	A2	
	Decorative elements of façades at ground level	A3	
Denmark	Buildings > 1 storey, external surfaces	1, class A for rain-screens	
	1 storey buildings, external surfaces	2	
	Exemption: parapets, vent hatches, similar small parts of external walls of buildings < 23 m may be class 2, max. 20% of area, max. 50% height of individual storey		
England and Wales	External wall surface < 1 m from boundary	0	
	Buildings ≥ 1 m from boundary, external wall surfaces up to 18 m	fire propagation index (I) max. 20, also timber cladding min. 9 mm thick	
	Requirement concerning common areas of flats and maisonettes *could* apply to an access balcony, if regarded as internal.	0	
	Refuse chutes passing through a compartment wall/floor (except compartment walls separating buildings or occupancies); flues passing through a compartment wall/floor or built into a compartment wall:	non-combustible	
	Alternative method of meeting requirements by reference to BRE Fire Note 9 *Assessing the fire performance of external cladding systems:* a test method (1999). Also limits on size and location of unprotected areas of façades, including openings.		
France	Category 1 and 2: facades, excluding fixtures:	M.3 or made of wood	
	exception: category 1 individual detached dwellings, solid parts class > 4 m from limit of property:	M.4	
Germany *Hesse* 2002	Building classes:	1, 2, 3	4, 5
	Surfaces of external walls	B2	B1

A2.6 Limitation of spread of fire

This section reflects two sections of the Building Decree, Limitation of spread of fire and Further limitation of spread of fire, of which the following articles are relevant to permanent housing:

- Article 2.103 Performance requirement: limitation of spread of fire
- Article 2.104 Fire compartments
- Article 2.105 Extent of fire compartments
- Article 2.106 Resistance to spread of flame, 'WBDBO'
- Article 2.107 Openings in fire compartment partitions
- Article 2.108 Application to restorations, alterations, extensions
- Articles 2.110-114 Requirements for existing buildings

and

- Article 2.115 Performance requirement: further limitation of spread of fire

	Type of building, location of external surfaces	Classification
Netherlands	Fire-free, smoke-free escape routes, all living functions except caravans; smoke-free escape routes in blocks of flats, houses > 500 m² (new-build), > 1,000 m² (existing). Parts of components at levels > 13 m, excluding doors, windows, frames (new build only).	2
	Smoke-free escape routes in houses ≤ 500 m². Other [parts of buildings]. *Exemption*: 5% of total area of construction components in each individual room.	4
Norway	Buildings in fire class 2 and 3	Ut1
	Buildings in fire class 1. Buildings in fire class 2 and 3 ≤ 4 storeys where fire services can reach site in 10 minutes, access all external walls, sufficient equipment for fire fighting; or with flame screens/balconies or recessed parts of the frontage (< 1,2 m deep) which hinder the spread of fire between storeys.	Ut2
	Buildings in fire class 3, the surface materials must be fixed to non combustible material.	
Sweden	External walls, building class Br1 to limit spread of fire inside wall and along the facade surface. *General recommendations: Wood panels or material of low ignitability, buildings ≤ 2 storeys, or cladding only to ground storey, or sprinkler system, or projecting roof above windows and doors, or limit covering of façade. Reference to Boverket Publication No 1993:2, 'Guidelines for type appro-val, Fire protection.'*	
	Windows in different fire compartments within 1.2m vertical distance:	*E 15 or min 1.2 m vertical distance between windows*
	2m separation with acceptable radiation level between detached / semidetached houses or between de tached/semidetached houses < 4 m from ancillary buildings with min area 10 m² . Alternatively, 60 minutes fire resistance between dwellings in detached/semidetached houses; 30 minutes for detached/semidetached houses < 4 m from ancillary buildings with min area 10 m². *General recommendations: Alternatively, EI60 fire resistance between dwellings in detached/semidetached houses; EI 30, facing walls, for detached/semidetached houses < 4 m from ancillary buildings with min area 10 m2. Max radiation from flames: 15 kN/m2 for min 30 minutes, or alternative based on material and detailing of cladding.*	

- Article 2.116 Sub-fire compartments
- Article 2.117 Extent of sub-fire compartments
- Article 2.118 Resistance to spread of flame between sub-fire compartments
- Article 2.119 Openings in sub-fire compartment partitions
- Articles 2.120-124 Requirements for existing buildings

Two main strategies can be used to limit the spread of fire: compartmentation and controls at boundaries.

The Building Decree does not specify any controls at boundaries, but they are implied by the Building Decree's WBDBO requirements (resistance to spread of flame across the enclosure of a fire compartment via a construction component and through the open air). NEN 6068 does not specify conditions, such as the distance of openings from party walls, but gives a method to calculate fire radiation at particular points on façades. Examples of practical

solutions are given in NPR 6091, including tables that relate the width and height of windows to distances between facades. If architects wanted to use different solutions, they would ask consultants to perform the calculations given in NEN 6068.

This chapter is structured around the contents of the Building Decree, so there is no detailed analysis of controls at boundaries, such as the size and location of openings, even though there are extensive requirements in other countries.[20]

A2.6.1 Provision of compartmentation

The Building Decree is unique in describing sub-fire compartments as well as fire compartments. Each house must form a separate fire compartment. In flatted buildings, each flat is a sub-fire compartment within a fire compartment: for instance, up to six flats that share an escape route may form a fire compartment. The definition of flats as sub-fire compartments appears similar to the requirements in Denmark, England and Wales, Norway and Sweden, where each self-contained dwelling, whether it is a house or a flat, must form a fire compartment. In theory, this would allow one flat to be occupied, even if there was a fire in a neighbouring flat. [21]

There are no specific requirements for the compartmentation of individual dwellings in Belgium, although there are other requirements for compartmentation. Neither France, or Germany (Hesse) use the term 'compartmentation' in relation to dwellings, but have requirements for the fire resistance of walls between dwellings.

Only Denmark and Norway specify that an escape route must itself be a fire compartment, which implies protection from both the dwellings opening onto the escape route and from adjacent spaces. In those countries where each flat must form a compartment, including the Netherlands where individual flats are sub-fire compartments, the wall between flats and the escape route is a compartment wall, which protects the escape route from a fire that starts in a flat. However the degree of protection varies: for instance, in the

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20 In other countries there are limits on the fire resistance of external walls and roofs relative to their distance from boundaries, as well as some limits on the use of materials or the size of openings. For instance, for small dwellings in Denmark, an external wall that is less than 2.5 m from a boundary must be fire retarding (60 minutes) and must fit closely against the roof coverings. In France, for housing in categories 3 and 4, the total dimensions of openings in a facade are related to its combustible mass.

21 This is made explicit in paragraph 3.3, Approved Document B in England and Wales: "*The provisions for means of escape for flats and maisonettes are based on the assumption ... [of] a high degree of compartmentation and therefore a low probability of fire spread beyond the dwelling of origin, so that simultaneous evacuation of the building is unlikely to be necessary.*"

Netherlands the entrance door to a flat need not be self-closing, unlike in Belgium, England and Wales, and Sweden.

A separate fire compartment is specifically required for each type of function in mixed-use buildings in England and Wales, the Netherlands and Sweden. In France and Germany (Hesse) fire resisting walls and floors are required to separate dwellings from other uses. It should be noted that the analysis for France is incomplete, because additional regulations apply to mixed-use buildings and for buildings over 50 m high.

The separation of basements from other parts of the building is also a common requirement, but is not usually described as compartmentation. Mostly, requirements are given in terms of fire resistance for structural stability of the floor between the basement and ground level storey and for a door to separate basement escape stairs and stairs from upper storeys.

There are compartmentation requirements concerning car parks in several countries, including the Building Decree, but except for France, requirements tend to be given for the car parks themselves, rather than the dwellings. In the Building Decree car parks are included in user function 11 'Other functions' which we did not analyse. This also covers storage rooms on the ground floor of apartment buildings or in basements.

In the Netherlands, there are no direct requirements for the sub-division of dwellings.[22]

Of the other countries, the only requirement for sub-division of dwellings is in Denmark, for large dwellings (> 150 m^2).

A2.6.2 Size of compartments, other requirements

Some countries limit the size of fire compartments in terms of area, number of storeys, volume or length. In Belgium, compartments are normally limited to one storey, but duplexes are allowed if limited in area (max 2,500 m^2) and volume (25,000 m^3). Denmark also allows 2-storey compartments, but they must be much smaller (150 m^2). The Netherlands also limits the area of compartments and relates standards to the loading of escape routes (1,000 m^2, but 800 m^2 or 6 dwellings for dwellings relying on a shared escape route). Norway requires the sub-division of large dwellings (max 1,200 m^2 without fire alarms, sprinklers or fire ventilation); requirements are also related to fire load.. There is no limitation of the area or height of compartments for residential buildings in England and Wales, Germany (Hesse), or Sweden, and in France there is only a limitation for car parks. It is difficult to make comparisons, but the highest standard is probably in Denmark.

22 However, there is always a hallway, the result of a privacy requirement in another section of the Building Decree that utility supply meters should not be located in a habitable room.

Table A2.7a Limitation of spread of fire: compartmentation

	Areas to be contained or compartmentation required	Maximum size of fire compartments	Other conditions for fire compartments
Belgium	Division of building into compartments < 2,500 m² but single storey buildings: max. 3,500 m², max. length 90 m. Max. height of compartment = storey height, except duplexes with total area < 2,500 m²; or technical spaces. Larger compartments permissible if automatic extinguishing system, smoke and heat extraction systems. Ground and first floor may be one compartment if cubic capacity ≤ 25,000 m³ (BM medium height, BE tall buildings).		*Openings between two compartments*: BM medium, BE tall build ings: lobby, min. area 2 m², self closing fire doors. BB low rise buildings: fire door, with self-closer or automatic closing in case of fire.
Denmark	Each dwelling; one or more rooms. Horizontal escape route and escape stair each constitute separate fire compartments.	Subdivision of dwellings > 150 m². Max. height = 2-storeys with floor area 150 m².	–
England and Wales	Compartment walls: – walls common to two buildings, walls between semi-detached or terraced houses; – walls separating a flat or maisonette from any other part of the building, except external balcony/deck access; – walls enclosing a refuse storage chamber. Compartment floors: – floors in buildings containing flats or maisonettes, except floor within a maisonette. Compartment walls and floors: – walls and floors between two different purposes if one not ancillary to other * – protected shafts between compartments.	No controls for dwellings on size of compartments. [Limits on area of compartments only apply to hospitals: 2000 m² (multi-storey), 3000 m² (single storey). *Fire code HTM81*, the design guide for hospitals which is enforced by building control, also has requirements for much smaller sub-compartments.]	Door for means of escape in compartment walls or between occupancies: same fire resistance as wall (but doors to flats and maisonettes from common parts 30 minutes); door openings max. 25% of length of a compartment wall, unless doors provide both integrity and insulation to the appropriate level. Lowest floor need not be compartment floor. Compartment walls to full height of building (between two buildings), full height of storey (other). Junctions to maintain resistance of compartmentation. Compartment walls to meet underside of roof covering/deck, fire-stopping at junction. Protected shafts to restrict fire spread between compartments.
	* *Ancillary purposes*: surgery, consulting room, office or other accommodation ≤ 50 m², forming part of a dwelling and used by an occupant in a professional or business capacity. In mixed-use buildings or compartments, a flat or maisonette should be treated as belonging to a purpose group in its own right. ADB 9.5 also notes 'special forms of compartmentation,' including fire-resisting enclosure of places of special fire hazard (e.g. boiler rooms) and integral garages in houses. However, 9.12 notes that these are not compartment walls and floors.		

	Areas to be contained or compartmentation required	Maximum size of fire compartments	Other conditions for fire compartments
France	*CCH* does not use the term 'compartmentation' (*cloisonnement*), except for car parks, but has requirements for fire resistant separation:		
	Sub-division of terraces of houses and very long buildings by fire-stop walls.	Sub-division at least every 45 m.	
	Requirements for fire resistance of walls or floors separating car park from a residential building. Category 3 and 4: 1 hour fire-resistant partition walls and floors to separate cellars, stores from other parts of building. Cellars must not open into car park.	Sub-division of car parks associated with housing max. area 3000 m².	3 m² lobby, two self-closing doors opening towards interior of lobby, flame resistance: 30 minutes
	Conditions for workplaces, offices or organisations receiving the public in a Category 4 mixed-use building, otherwise re-classified as a 'very tall' building and subject to other legislation:		
	Separation from living accommodation by fire resistant partitions (except workplace within rooms for family life).	Max. area of workplace: 200 m²; must not admit more than 20 people to one storey.	Flame resistant doors in fire resistant wall.
Germany *Hesse* 2002	Construction to prevent the spread of fire. The HBO does not use the term 'compartmentation' (*Brandabschnitte*) for residential buildings.		
	a) Floors to be fire resisting and prevent propagation of fire and smoke.	–	– openings permitted if closers to same level of fire resistance; any pipes penetrating floors must prevent transmission of fire and smoke (does not apply to class 1, 2 or within same unit < 400 m²).
	b) Walls between dwellings or between dwellings and other uses (except class 1, 2) to resist propagation of fire and smoke.		– openings in partitions permitted if limited in number and size, with fire-protecting closers.
	c) Fire-resistant, non-combustible fire walls:		
	– to partition long buildings; – at ends of buildings within 2.5 m of boundary, unless 5 m distant from existing building or location of permissible future buildings; – between residential buildings and agricultural buildings on the same plot, or between living and agricultural parts of a building; – at corner junctions (except junction > 120°), at least 5 m from corner.	– at max. 40 m intervals	– continuous across storeys, up to the roof, but some exemptions; – to project 0.3 m above roof or non combustible collar 0.5 m to each side at level of roof membrane, but may only extend up to roof membrane in class 1-3 buildings; – openings permitted only in internal fire walls, and if furnished with fire-protecting closers.

Table A2.7b Limitation of spread of fire: compartmentation

	Areas to be contained or compartmentation required	Maximum size of fire compartments	Other conditions for fire compartments
Netherlands	All spaces in buildings to be in a fire compartment, except: WC, bathroom, meter space, space for a boiler not in a boiler room. Includes rooms for storage of combustible materials; boiler rooms. Separate fire compartment for technical rooms > 50 m² (new), 100 m² (existing buildings); boiler rooms with installation space for heating appliance ≥ 130 kW (< 160kW in existing buildings).* A space through which a fire- and smoke-free escape route passes is not a fire compartment.	Max. one site. Only one living function and ancillary user function per compartment. Max. one dwelling if not in block of flats. Max. user area of fire compartment 1,000 m² (new), 2,000 m² (existing buildings). Fire compartments for block of flats with shared escape routes: max. 6 dwellings or dwellings with user area < 800 m².	Internal partition to which spread of flame requirements apply: no movable construction parts other than a self-closing door; no exemption for renewal, adaptation or extension projects; also applies to existing buildings. Reference to NEN 6068.
	* [In practice, residential buildings do not have technical rooms > 50 m² and common heating appliances are now unusual, so that the requirement concerning heating appliance ≥ 130 kW is probably irrelevant.]		
Norway	Each dwelling. Each escape route. Communal basement or attic must be divided into at least two fire compartments	Subdivision of large dwellings (m²):	

Fire load MJ/m²	No special safety installations	Fire alarm installed	Sprinkler	Fire ventilation*
> 400	800	1,200	5,000	unsuitable
50 - 400	1,200	1,800	10,000	4,000
< 50	1,800	2,700	no limit	10,000

* Single storey buildings only

Sweden	Fire compartments: a room or groups of rooms for activity with no connection with other activities in building. Separation of dwellings in detached/semi-detached houses. *General recommendations: Fire compartments: dwellings, stairways, garages, boiler rooms, refuse storage rooms. Separate fire compartments for high risk areas. (gen. rec).*	No limit on size of compartments. *General recommendations: If risk of fire spread between detached/semi-detached houses, either sub-division by division walls into groups < 600 m² (800 m² for single storey buildings) or ignition retardant cladding of internal walls and ceilings.*	Doors, shutters and access panels normally constructed to the same fire resistance class as for the element of structure.

Compartmentation must be maintained at openings within compartment walls. The highest standard is in Belgium for tall or medium height buildings, where a protected lobby is required; all the other requirements refer only to single doors. There is no specific mention of the fire resistance of doors in the Building Decree, but they are counted as part of the compartment enclosure. Nor is there any mention of penetration of compartments, and therefore other countries' limits on penetration are not included in this analysis. However, this is dealt with in NEN 6068.

There are also some requirements to sub-divide groups of houses. In Sweden, groups of two-storey detached/semi-detached houses must be separated into groups less than 600 m^2, unless internal walls and ceilings have ignition retardant surfaces, in addition to the compartmentation of individual houses. This is a higher standard than the requirements for sub-division of long terraces in France (45 m intervals). In Germany (Hesse), the 1993 revision of the *HBO* specified fire walls to sub-divide contiguous residential buildings (classes B, D; at 60 m intervals), but it appears that the 2002 revision only requires the partitioning of long buildings (at 40 m intervals), and it is not clear whether this is relevant to housing.

A2.6.3 Fire resistance of compartments

In most countries, levels of fire resistance are specified for particular situations, for example compartment walls between flats, or the floor between a basement and the storeys above. Also, levels of fire resistance are specified for openings within compartment walls.

In the Netherlands, requirements for structural fire resistance are conjoined with limits on external spread of flame. One of the central concepts of the Building Decree, known by the Dutch abbreviation 'WBDBO', is resistance to spread of flame across the enclosure of a fire compartment via a construction component and through the open air. The Building Decree specifies periods for WBDBO but does not describe measures to achieve the requirement. NEN 6068 describes calculations in respect of the WBDBO requirement, supported by an NPR that gives rules of thumb for common conditions in order to avoid detailed calculations.

The Building Decree specifies identical periods of resistance for compartments and sub-fire compartments and it seems reasonable to compare the Building Decree's requirements for sub-fire compartments with those for fire compartments in other countries. Rather than attempting to compare the full range of requirements for fire resistance of compartments, a sample comparison is made in Table A2.8b, for single-family two-storey houses, and blocks of flats with three, eight, and fifteen storeys. It includes requirements for the fire resistance of dividing walls and floors in France and Germany (Hesse).

There are requirements for the compartment walls between two-storey,

Table A2.8a Limitation of spread of fire: fire resistance of compartments

	Location	Fire resistance (minutes)
Belgium	Compartments: BE, tall building:	Rf 2 h = 120
	BM, medium height building, BB, low rise:	Rf 1 h = 60
	single storey buildings:	Rf ½ h = 30
	Lobby walls to openings in compartment walls:	
	BE, tall building:	Rf 2 h = 120
	BM, medium height building:	Rf 1 h = 60
	Vertical partitions surrounding places occupied at night:	Rf 1 hr = 60
	Doors in compartment walls:	
	BB, low rise: doors with self-closer or closer activated in case of fire. BM medium height, BE tall buildings: lobby with self-closing doors:	Rf ½ h = 30
Denmark	Walls between joined single-family houses or houses < 5 m apart:	BD 60
	Compartments and non-habitable attics. Houses: separating floors, door between basement and upper storeys:	BD 30
	Dwellings to common lobby, common lobby to protected stairs:	BD60
	Doors to dwellings and stairs, not self-closing:	BD 30-M
England and Wales	Dwelling houses: Walls separating semi-detached or terraced houses, including basements:	60
	Flats and maisonettes:	Buildings with top storey floor
		< 5 m / 5-18 m / 18-30 m / >30 m
	All floors (except inside maisonettes), walls separating flat or maisonette from another part of the building (except external balcony/deck access), walls enclosing a refuse chamber:	30 * / 60 / 90 / 120
	* Increased for compartment walls separating buildings.	60
	Doors in compartment walls:	
	– wall separating buildings:	60
	– wall separating flat or maisonette from space in common use, enclosing protected stairway shaft:	FD 30S +
	+ specification of maximum smoke leakage rate at head and jambs	
	– wall enclosing protected lift or service shaft:	half period of fire resistance of wall, min. 30
	Also 'special forms of compartmentation,' including fire-resisting enclosure of places of special fire hazard (e.g. boiler rooms) and integral garages in houses (but these are not compartment walls and floor):	30

France	Category of housing				
	1	2 ind	2 coll	3	4
Separating walls between dwellings:	15		30		60
Fire-stop walls subdividing terraces every 45 m:	30	60		90	
Including self-closing fire doors:	30				60
Exterior wall of non-contiguous car park, min. 8 m from inhabited building:	15		60		
Landing doors: resistance to flames:	–		15		30
Separation of cellars and stores from other parts of building:	–	–		60	
No other requirements for floors apart from structural stability:	15	30		60	90

Location		Fire resistance (minutes)				
Germany	**Building class:**	**1**	**2**	**3**	**4**	**5**
Hesse 2002	Load-bearing walls, partitions, floors (excludes balcony escape routes):	–	F30-b		F60-a or F90-ba	F90-a
	Floors between dwelling and space for agricultural use	F90-b			F90-a	
	Fire walls	F90-a+M				
	'Abschlüssen' [doors, dampers] to openings in internal fire walls	–	T 90 (fire-resistant)			
	Walls permitted in place of internal fire walls	–	F60-a or F90-ba		F60-a +M or F90-ba +M	F-a

Netherlands

Fire compartments:

Resistance to spread of flame across enclosure of a fire compartment via a construction component or through the open air (WBDBO):	Permanent fire load density of fire compartment < 500 MJ/m²	≥ 500 MJ/m²
– to an enclosed room (not an enclosed safety staircase):*	30	60
– to a non-enclosed safety stairway:	60	
– to enclosed room on same site, floors in habitable area ≤7 m high, or to a space through which a fire- and smoke-free escape route passes:	30	
– to a room in a building (existing buildings):	20	

* Determination of period of resistance from compartment to building on adjacent lot: assumes identical other building, mirrored to boundary across centre-line of public road, water, or greenery.

Sub-fire compartments:**

Resistance to spread of flame via construction component and open air in a sub-fire compartment:	Permanent fire load density of sub-fire compartment < 500 MJ/m²	≥ 500 MJ/m²
– to an enclosed room in a building:	30	60
– to a room in the same dwelling, height of floors in habitable area ≤ 7 m, or a space through which a smoke-free escape route passes:	30	
– to a room in a building (existing buildings:	20	

** Sub-fire compartmentation:

New buildings: Both shared and private habitable areas must be in a sub-fire compartment (blocks of flats). Sub-fire compartments must be contained in a single fire compartment. A sub-fire compartment must contain only private rooms of one user function. Maximum habitable area of a sub-fire compartment containing a habitable room: 40 m².

Existing buildings: Private habitable rooms in one user function; sub-fire compartment with a shared habitable room contains only habitable rooms, circulation spaces, ancillary WCs and bathrooms. Maximum habitable area of a sub-fire compartment containing a habitable room: 60 m². Internal partition of sub-fire compartment: no movable construction parts other than a self-closing door.

Ref: NEN 6068, NEN 6090.

Table A2.8b Limitation of spread of fire: fire resistance of compartments

	Location	Fire resistance (minutes)		
Norway		fire class 1	classes 2, 3	
	Constructions surrounding fire compartments (including windows)	EI 30	EI 60	
	Doors	EI 15	EI 30	
	Doors to stairways: type Tr1: fire compartment to stairway:	EL30-CS		
	type Tr2: corridor or fire compartment to stairway	EL60-CS		
	type Tr3; corridor to stairway			
	* Classification of stairways: Tr1: Stairway with doors opening directly to a dwelling unit. Tr2: Stairway separated from dwelling units by a separate fire compartment. Tr3: As above, but with smoke detectors and fire ventilation in the space separating the dwelling unit from the stairway.			
Sweden	Separating elements imperforate to penetration of flames and games; thermal insulation to limit temperature to avoid risk of fire spread.	Fire load intensity f (MJ/m²)		
		$f \leq 200$	$f \leq 400$	$f > 400$
	Elements of structure separating fire compartments; floor above a basement (buildings of class Br1):	EI 60*	EI 120	EI 240
	Element of structure separating flats in a block of flats (classes Br2 Br3):	EI 60		
	Walls and ceilings in 1-storey attic conversion next to unused attic space (buildings of class Br1), element of structure separating fire compartments in general (classes Br2 Br3):	EI 30		
	Separating structure between protected lobby and adjoining spaces:	EI 60, doors to EI-C60		
	Stairway** Tr1; protected lobby doors may be lower class. Stairway Tr2:	60, doors to EI-C60		
	General recommendations:			
	Lower class doors to stairway Tr2 in building < 8 storeys	*EI-C30*		
	Doors between dwelling and protected lobby	*EI-C60*		
	Doors between stairway and protected lobby, between dwelling and protected lobby abutting communication route in its own fire compartment	*E-C30*		
	Communication between Tr2 stairway and dwellings through space in its own fire compartment, but EI-C60 doors allowed between stairway and attic spaces with occupants' store rooms			
	General recommendations:			
	Separation of escape routes	*E-C15*		
	Subdivision of corridors in max. 60 m sections	*E15*		
	* Distinction of characteristics of fire resistance of elements of structure: E (integrity), R (load bearing capacity), and I (insulation) depending on function. C indicates doors with an automatic closing device. ** Classification of stairways: Tr1 and Tr2: no lift, inlet opening to a refuse chute or similar inside the stairway; constructed to prevent spread of fire and fire gases to the stairway for min. 60 minutes. Tr2: doors to stairway serving a building with < 8 storeys may be constructed to a lower class; communication between stairway an dwellings only through a space in its own fire compartment. Tr1: communication with other spaces through a protected lobby open to external air or provided with arrangements to prevent the spread of fire gases to the stairway; doors to protected lobby may be to a lower fire resistance class; separation from storey below level of escape exit to external air.			

single-family houses in Denmark, England and Wales, France, the Netherlands, Norway, and Sweden. The standards for constructions between buildings with fire load density < 500 MJ/m^2 in the Netherlands, and for compartment walls between two-storey houses in Norway (30 minutes) are lower than in Denmark, England and Wales, and Sweden (60 minutes). However, the lowest standards are in France (15 minutes), and in Belgium, where the requirements do not apply to single-family houses.

Requirements for fire-resisting construction in 3-storey and 8-storey blocks of flats are similar in most countries (60 minutes, with a few exceptions for certain conditions), but there are high standards for 8-storey buildings in England and Wales, and Germany (Hesse) (90 minutes), and low standards in France for 3-storey blocks (30 minutes walls, floors; 15 minutes doors) and Germany (Hesse) (30 minutes). Belgium also has a high standard in requiring a lobby to any openings in compartment walls. In Denmark, the Netherlands, Norway, and Sweden the standards for compartmentation that apply to 8-storey blocks also apply to 15-storey blocks; only Belgium, England and Wales, and France give higher standards in the documents studied. Belgium and England and Wales have the highest specified standards for compartmentation in 15 storey blocks of flats (120 minutes).

None of the building regulations studied gives examples of constructions that satisfy the requirements.[23]

A2.7 Limitation of development of smoke

This section of the Building Decree comprises:
- Article 2.125 Performance requirement: limitation of development of smoke
- Article 2.126 Density of smoke production of internal surfaces
- Article 2.127 Exemption for different elements of construction
- Article 2.128 Exemption from requirement for part of room
- Articles 2.130-133 Requirements for existing buildings

The Netherlands controls the characteristics of internal surfaces, particularly on escape routes, to limit the fast development of smoke. It sets limits for smoke density, using tests defined in an *NEN*.

23 For instance, in England and Wales, Appendix A to *Approved Document B* describes situations in which particular materials can be used, but does not identify constructions that meet the requirements. It includes typical performance ratings of generic materials and products, but warns that test evidence is required for certain products. In Hesse the building regulations do not refer to sources of information on constructions that satisfy the performance requirements. However, the national standard *DIN 4102* has extensive lists of constructions and materials that satisfy the requirements.

Table A2.8c Comparison of periods of fire resistance for compartments

	Single-family house		Blocks of flats	
	2 storeys	**3 storeys**	**8 storeys**	**15 storeys**
Belgium	No requirements for single-family dwellings	60: (structure above lowest evacuation level or below ground; ground level floor) Openings between two compartments: 30 (door) (BB top floor < 10 m)		120: 60: (lobby walls), 30: (door) (BM top floor 10-25 m, BE top floor > 25 m)
Denmark	BD 60: walls between joined single-family houses or houses < 5 m apart; separating floor over basement. BD 30: separating floors, door between basement and upper storey.	BD 60: between compartments; between dwellings and common lobby to access protected stairs. BD 30: between compartments and non-habitable attics. BD 30-M: doors to dwellings and stairs, not self-closing.		
England and Wales	60: walls between semi-detached or terraced houses.	60: compartment walls separating buildings; walls and floors between flats and between flats and other parts of building except external balcony or deck access; doors for means of escape.	90: ground and upper storey structure (building with top floor 18-30 m). Also, 90: doors between compartments [but unlikely to arise].	120: ground and upper storey structure (building with top floor > 30 m).
	Also, special forms of compartmentation, but not compartment floors or walls:			
	30: floors over basements; walls and floors separating house from integral garage.	30: fire resisting enclosures of places of special fire risk, such as boiler rooms.		
France	15: walls between joined houses (category 1, 2 individual) 30/60: fire-stop walls (category 1/2 individual)	60: fire-stop walls 30: separating walls between dwellings, doors in fire-stop walls 15: landing doors 30: floors (category 2 collective)	60: floors (category 3)	90: fire-stop walls 60: separating walls between dwellings, doors in fire-stop walls 30: landing doors 90: floors (category 4)

	Single-family house		Blocks of flats	
	2 storeys	**3 storeys**	**8 storeys**	**15 storeys**
Germany	– (class 1)	30	90	more stringent require-
Hesse 2002	30 (class 2)	(class 3)	(class 5)	ments may be applied
	Fire walls, floors between dwelling and space for agricultural use: 90 (all classes)			(buildings with storeys > 22 m or > 30 m)
Netherlands	30: between: - fire compartment with permanent fire load density ≤ 500 MJ/m² and an enclosed room; - fire compartment and closed room on same site, all habitable floors < 7 m high.	60: between fire compartment or sub-fire compartment with permanent fire load density > 500 MJ/m² and an enclosed room (not a safety stairway) flats would have a fire load density ≥ 500 MJ/m²]; 30: between a sub-fire compartment and a room in the same dwelling; between a fire compartment or sub-fire compartment and an enclosed room through which a fire-free and smoke-free escape route passes.		
	All spaces in building to be in a fire compartment, except: WC, bathroom, meter space, space for installation of heating appliance < 130 kW.			
Norway	Constructions surrounding fire compartments (including windows): EI 30 Doors: EI 15		EI 60 Doors: EI 30; EI 30-C: doors to stairway types Tr1, Tr2; EI 60-C: doors to stairway type Tr3	
Sweden	EI 60: structures separating detached/ semi-detached houses (class Br3)	EI 60: walls and floors separating flats EI-C30: doors to Tr2 stairway (class Br1 < 8 storeys, fire load density ≤200 MJ/m²)	EI 60: walls and floors separating flats; EI-C60: doors to Tr2 stairway (class Br1, fire load density ≤200 MJ/m²)	

Table A2.9 Limitation of development of smoke

Netherlands	Internal surfaces (except top side of floor, ramp, staircase) of:		Maximum smoke density
	- construction elements (new, existing)		10 m^{-1}
	except:		
	- construction component in closed room through which a smoke-free escape route passes with internal surfaces:	to class 2	2.2 m^{-1}
		to class 1	5.4 m^{-1}
	- construction component in closed room in existing building through which an escape route passes (dwellings > 1,000 m^2)		5.4 m^{-1}
	Requirements do not apply to ≤ 5% of surface of construction elements in each separate closed space. References NEN 6065, NEN 6066.		

None of the other countries deliberately controls the generation of smoke and fumes through characteristics of internal surfaces; indeed in England and Wales, Approved Document B notes that Section B2 Internal fire spread (linings) "*does not give guidance on other properties such as the generation of smoke and fumes*." Requirements to limit spread of flame would often serve the same purpose, with the use of materials of limited combustion, but the primary strategy in most countries is to keep escape routes clear of smoke, by limiting the ingress of smoke with smoke control doors and smoke ventilation.

A2.8 Limitation of spread of smoke

This section of the Building Decree includes four articles of relevance to permanent housing:

- Article 2.134 Limitation of spread of smoke to allow escape
- Article 2.135 Provision of smoke compartments
- Article 2.137 Periods of resistance to spread of smoke
- Article 2.138 Openings in smoke compartment partitions
- Articles 2.140-144 Requirements for existing buildings

The spread of smoke between parts of the building can impede both safe escape and fire fighting.

The Building Decree structures and expresses its requirements for limiting the spread of smoke and for the provision and design of escape routes quite differently from other countries. Comparative analysis is also made difficult by the formulation of the requirements and the Building Decree's reliance on reference to national standards.

A 2.8.1 Smoke compartmentation

The Netherlands appears to be unique in specifying the sub-division of fire compartments into smoke compartments. The Building Decree does not explain where smoke compartmentation should be provided, except in tall buildings, but it specifies periods of resistance to smoke leakage between a smoke compartment and an enclosed room. It also requires self-closing doors

Table A2.10 Limitation of spread of smoke: smoke compartmentation

	Smoke compartmentation	Periods of smoke resistance	
Netherlands	Sub-division of a fire compartment into smoke compartments. Internal partition of smoke compartment: no movable construction elements except self-closing element; does not apply to dwelling entrances in blocks of flats. Buildings with storey > 50 m above ground: smoke compartment between entrance to a habitable area and entrance to enclosed closed escape stairway: enclosed circulation space, min. 2 m long [i.e. smoke-protected lobby].	Smoke resistance between smoke compartment and closed room: – new build, work to existing buildings – existing buildings Reference to NEN 6075	 30 20

in smoke compartment partitions, except for dwelling entrance doors. Without reading the *NEN*, it is difficult to tell whether there is a significant difference between the Dutch requirements for smoke compartmentation and those in other countries to protect stairways and horizontal circulation by means of doors that limit smoke leakage or fire dampers operated by smoke detectors.

This section of the Building Decree also requires lobbies to protect stairways in buildings with habitable space on storeys above 50 m. This is similar to requirements for smoke-protected lobbies in other countries, but is different in the sense it describes them as smoke compartments. (See section A2.10.5 Other measures to protect escape routes)

All the requirements in other countries that concern limitation of the spread of smoke in blocks of flats are distributed between various headings below, which reflect the structure of the requirements in the Building Decree.

A2.9 Escape inside a smoke compartment

A2.9.1 Structure of requirements for means of escape

The Building Decree divides requirements for means of escape between three sections:

- 2.17 Escape inside a smoke compartment
- 2.18 Escape routes
- 2.19 Design of smoke-free escape routes

This differs from the three-stage approach that several countries use to structure their requirements for escape from upper storey dwellings in blocks of flats:

- from within a dwelling to its entrance door;
- across a hall or along a corridor to a stairway or to a lobby protecting a stairway;
- down the stairway and out to the final exit.

Table A2.11a Horizontal escape within dwellings and from dwellings

	Max. walking/travel distance			
Belgium	BM medium height, BE tall buildings:		places occupied:	
			only in daytime	night-time
	- from any point in compartment:	to escape route to stairs or exits:	30 m	20 m
		to stairway or closest exit:	45 m	30 m
		to second stair or exit:	80 m	60 m
	Dead end portions of escape routes:		15 m	
	Calculation of travel distances excludes open air sections of escape routes.			
Denmark	From dwelling entrances:	– to lobby of protected stairway	corridor 6 m long x 1.5 m wide (combined area of dwellings opening onto corridor ≤ 600 m²)	
		– to stairway door	25 m (access balconies to stairs, buildings with lower edge of rescue opening > 10.8 m)	
		– to stairs in two opposite directions	25 m (access balconies to stairs, buildings with top storeys with lower edge of rescue opening > 23 m); max. 50 m between 2 stairs on same escape route.	
England and Wales	Flat with a floor > 4.5 m above ground, max. travel distance to dwelling entrance door:		9 m*	
	– from door of a habitable room (if hallway protected by 30 minute fire-resisting construction, self-closing FD20 fire doors); or			
	– from any point in a habitable room (if cooking facilities are remote from entrance and do not prejudice escape route):			
	* Limitation on travel distance relaxed if alternative exit from bedroom area, with bedrooms and living accommodation separated by 30 minute fire-resisting construction and self-closing FD20 fire door.			
	Common escape routes from dwelling entrance to stairwell:			
		– with alternative routes	30 m	
		– one direction of travel	7.5 m (automatic opening vent to corridor or lobby)	
			4.5 m (without automatic vent, small single storey buildings)*	
	* Various conditions for small single storey buildings, with top floor ≤ 11 m, ≤ ground floor plus 3 storeys, stair separate from closed car park. Includes dwellings opening direct to stairway if only two dwellings per storey and protected internal hallways.			

	Max. walking/travel distance		
France	Maximum walking distance from landing door of:		
	– each dwelling	to door to stairway or access to open air	15 m
	– furthest dwelling	to access to stairs (category 3A)	7 m
Germany	Escape/rescue route:		
Hesse 2002	– from all points in a habitable room; from basement	to a essential stairway or to open air:	35 m
	If several essential stairways, they must be distributed to minimise the length of emergency routes.		
Netherlands	Walking distance:*		
	– from entrance to private habitable room	to entrance to smoke compartment or sub-fire compartment that contains it:	15 m (new-build; all dwellings except caravans)
	– from any point in a common habitable space	to an entrance to the sub-fire compartment that contains it:	blocks of flats, dwellings > 500 m²: 20 m (new build)
	– from any point in a common habitable room		30 m (new build), 45 m (existing)
	Section 2.19 also limits the length of enclosed escape routes between two access points in the smoke-free escape route:		30 m (new build, all dwellings except caravans)
	* Any non-structural construction component in habitable area is disregarded in calculation of walking distance.		
Norway	– Distance from door in a fire compartment	To exit or stairway:	15 m (one exit/stair) 30 m (two exits/stairs) 15 m (escape balconies, two storey buildings)
Sweden	Travel distance		For compartment evacuation before critical conditions arise.
	– inside a fire compartment	to nearest escape route	For rapid escape.
	– along an escape route	to nearest stairway leading to another storey, or to exit leading into street or similar space	*General recommendations*: *30 m*

However, the objectives are shared: to protect escape routes from smoke and flames, to limit the horizontal travel distances, and to offer alternative routes in certain circumstances.

A2.9.2 Escape inside a smoke compartment

This section of the Building Decree includes the following articles that are relevant to permanent housing:

- Article 2.145 Performance requirement: escape inside a smoke compartment
- Article 2.146 Travel distances; number of access points to escape routes; travel distance between access points; smoke alarms
- Article 2.147 Number of access points to sub-fire compartment
- Article 2.148 Distance between a fireplace and staircase; number of access points to smoke compartments
- Articles 2.150-152 Requirements for existing buildings

The terms 'sub-fire compartment' and 'smoke compartment' are unique to the Building Decree. Careful interpretation is needed to compare requirements in other countries that are expressed in more everyday terms, such as 'corridor'. It became clear in writing this analysis that it was essential in practice to refer to further guidance on the implementation of the requirements. In particular it is necessary to understand the extent of fire, sub-fire, and smoke compartments, which vary with the type of building.[24]

A2.9.3 Travel distances, number and location of access points

The issues of maximum travel distances, and the number and location of exits are common to most of the other countries, although expressed very differently. The requirements are probably mostly clearly explained in England and Wales, where diagrams are used to demonstrate various conditions. Requirements are expressed in different ways and they are difficult to compare. A breakdown is given in Table A2.12b.

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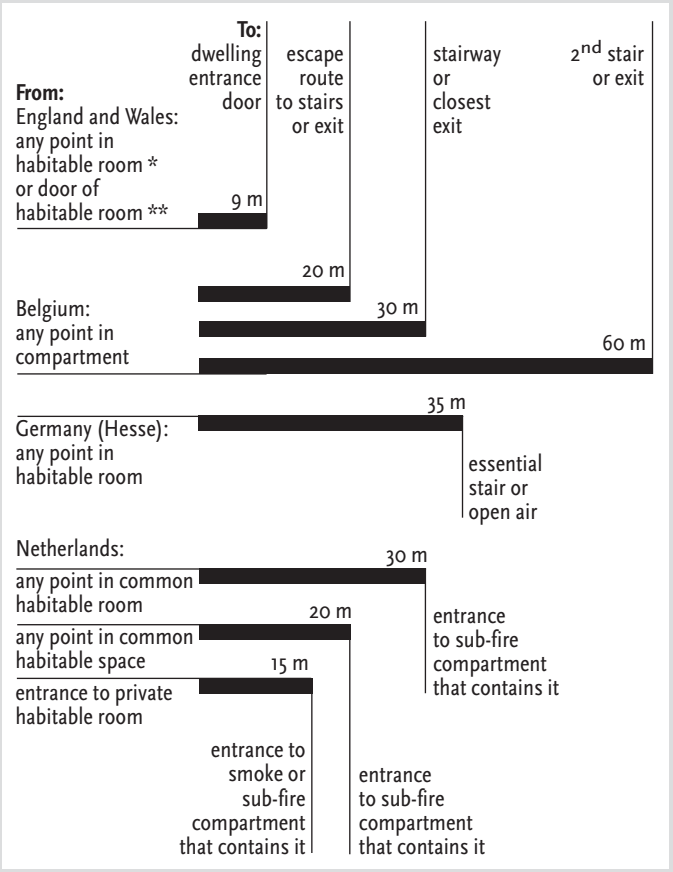
24 For example, the travel distances for a single family house apply to the distance from room doors to the outside door, because the whole house constitutes a smoke compartment. A building with no more than six flats accessed by a single stairway constitutes a fire compartment and each of the flats is a sub-fire compartment. The halls and stairway constitute a smoke-free escape route, but not a fire-free, smoke-free route because they are already within a fire compartment. For a deck access or gallery access block of flats, each dwelling is a sub-fire compartment and together the flats form a fire compartment. The dwellings and decks together form a smoke compartment. The stairways are outside the fire compartment and must be fire-free and smoke-free escape routes.

Figure A2.1 Differences in description of travel distances from within dwellings in blocks of flats or maisonettes



* If hallway protected by 30 minute fire-resisting construction, self-closing FD20 fire doors.
** If cooking facilities are remote from entrance and do not prejudice escape rout Both apply only to flats with a floor > 4.5 m above ground level.

There are further requirements for travel distances in a later section (see Section A2.10 'Design of Smoke-free Escape Routes').

Each country limits horizontal travel distances in common escape routes, but only Belgium, England and Wales, Germany (Hesse), and the Netherlands address travel within flats or maisonettes. However different start or finish points are described, and there are qualifying conditions for some of the requirements. Comparisons require particular care, as is illustrated in Figure A2.1.

Belgium and Germany (Hesse) limit the entire journey, from within dwellings to the stairway; other countries limit travel between dwelling entrances and stairways. There are roughly two ranges of requirements for travel from dwelling entrances to a stairway: relatively short distances which seem to relate to blocks with a single, central stairway, and much longer distances for corridor or balcony access. The lowest standard, where standards

Table A2.11b Comparison of travel distances

From:	to escape route	to stairway or exit	to second stair
furthest point...			
in compartment	Belgium: 20 m	Belgium: 30 m	Belgium: 60 m
in a habitable room	England and Wales: (to dwelling entrance door) 9 m * (subject to location of cooking facilities)	Germany (Hesse): 35 m	–
in common habitable area	Netherlands: (to entrance to fire/sub-fire compartment) 20/30 m		
door to a habitable room	England and Wales: 9 m Netherlands : 15 m	–	–
dwelling entrance	–	Denmark: approx. 6 m corridor, 25 m balcony access	Denmark 25 m
		England and Wales: 4.5 or 7.5 m (1 way); 30 m (2 way)	–
		France: 7 or 15 m	–
		Germany (Hesse): 15 m (1 way)	–
		Norway: 15 m (1 way) 30 m (2 way)	Norway: 30 m
		Sweden: 30 m	–
Between access points on horizontal escape route	Netherlands: 30 m		

for the distance between dwelling entrances and a stairway are given, is in Sweden, which has only one recommendation (30 m); the highest standards are in England and Wales, with a range of requirements (4.5 m for an unventilated hallway, 7.5 m for single escape routes, 30 m for alternative routes). The Netherlands does not limit distances in relation to stairways or final exits, but limits the length of enclosed escape routes (30 m between access points).

A2.9.4 Fire and smoke detection and alarm systems

The Building Decree's escape route strategy is also related to the provision of smoke alarms. Requirements are included in Section 2.17, but the full implications are only explained in NEN 2555. These include the provision of a smoke alarm on an escape route passing through a living room.

Only England and Wales, the Netherlands, and Norway require smoke alarms in all general needs housing. In England and Wales, and the Netherlands the alarms must be mains operated, but there are differences in the specification of types of alarms. The Netherlands always requires a non-ionising detection chamber; England and Wales allows ionisation chambers or optical detectors, but recommends optical detectors.

Table A2.12 Fire and smoke detection systems

	Provision	Performance/specification of systems
Belgium	Requirements to be determined by fire service. Warning equipment is mandatory.	Number of alarms to be determined according to dimensions, situation and risk.
Denmark	—	—
England and Wales	Houses:	
	Mains-operated smoke alarms on each floor level; normally in circulation space between sleeping spaces and places where fires are most likely to start (e.g. kitchens and living rooms); within 7.5 m of door to every habitable room; close enough to bedroom doors to wake occupants. Linked smoke alarms on each floor of houses with loft conversions.	Requirements for mounting of smoke alarms, and of heat detector in kitchen. Linking of multiple smoke alarms. Product standard for alarms: BS 5446 Part 1: 2000. Good practice in design and installation: BS 5389 Part 6: 1995.
	Large houses (with any storey > 200 m):	> 3 storeys (including basements): L2 system to BS 5839: Part 1: 1988; ≤ 3 storeys (including basements): Grade B LD3 system to BS 5839: Part 6: 1995
	Flats and maisonettes: Same principles as for houses. Provisions do not apply to common parts, do not include inter-connection of installations in separate flats.	
	Also, requirements for student residential accommodation; requirements for central monitoring by warden in sheltered housing.	
France	Not required in general needs housing, but requirements for foyers: accessible phone, linked to public network to alert public rescue and fire-fighting services. Audible alarms to each storey in units for ≤ 10 persons, in each unit if > 10 persons.	
Germany		
Hesse	–	–
Netherlands	Provision of a non-ionising, mains-wired smoke alarm in any enclosed room on a route from an entrance to a private habitable room that is also the entrance to a fire compartment or sub-fire compartment containing the room. [e.g. a hallway]. Reference to NEN 2555 for connection to electricity supply. [Also guidance on the location of alarms, conditions when additional alarms are required.]	
Norway	Risk class 4 [dwellings]: smoke detectors. Risk classes 5 and 6 [including sheltered accommodation]: automatic fire alarm installation.	–
Sweden	Not required in general needs housing, but requirements for 'alternative forms of dwelling' (housing on one storey for elderly and people with functional impairment who are not confined to bed or physically disabled): Devices for early detection of fire and escape alarms. It must be possible to detect alarm signals in areas where people are present on a regular basis. *General recommendations:* *Battery operated or mains-connected alarms, placed in connection with bedrooms, at least one fire alarm per storey, tested to NT ELEC 004.*	

Table A2.13 Escape routes: exits from habitable areas, habitable rooms, and sub-fire compartments

Netherlands	Blocks of flats and large houses with user area > 500 m²: 2 entrances to a habitable area or habitable room > 75 m² if no cooking appliance, or > 25 m² with cooking appliance (except common habitable area < 500 m² in sub-fire compartment). Entrances to a common habitable room and to the sub-fire compartment that contains it: either same entrance or linked by common circulation space; entrance to shared habitable room may be in another habitable room with two entrances, at least 5 m apart, that lead to circulation space to entrance of sub-fire compartment. Entrance to a sub-fire compartment containing a habitable area direct must either be entrance of smoke compartment that contains it, or open onto smoke-free escape route to entrance of smoke compartment. Min. 2 entrances to sub-fire compartment > 500 m², and smoke compartments > 500 m². For existing buildings: min. 2 entrances to smoke compartment > 500 m², each opening to separate independent smoke-free escape routes (houses with user area > 500 m², dwellings in blocks of flats).

In Belgium, requirements are to be determined by the fire service. There are further requirements in England and Wales, France, the Netherlands, Norway, and Sweden for other forms of accommodation, such as foyers, sheltered apartments, or student accommodation, but these were not analysed. There are no requirements for smoke detection or alarm systems in Denmark or Germany (Hesse).

A2.9.5 Other requirements for escape within smoke compartments

Building Decree Section 2.17 'Escape within smoke compartments', also has requirements for:

- Article 2.146
  - the number of entrances to habitable areas and habitable rooms in very large houses and blocks of flats, related to floor area and the presence of a cooking appliance;
  - the relationship between the entrances to common habitable rooms and sub-fire compartments; and
  - the relationship between sub-fire compartments and smoke compartments.

No other country has similarly-expressed requirements. Some have special requirements for sheltered accommodation, such as the 'alternative forms of dwelling' in Sweden, but the requirements do not specifically mention common rooms.

The Building Decree also specifies the minimum distance between a heater and a stairwell within this section on escape. Although some countries control the distance between heating appliances and combustible elements of buildings, none has a directly comparable requirement. The Building Decree has further requirements for heat-producing appliances in sections 2.104 and 4.88, which we were not asked to analyse.

Table 2.14 Escape routes: strategy: houses

Belgium	No requirements for single-family houses (see Table 5.1a).
Denmark	Rescue openings in habitable rooms and kitchens or two doors to two other separate rooms allowing rescue.
England and Wales	Restrictions on habitable inner rooms and sleeping galleries; include requirements for emergency egress window in any inner room ≤ 4.5 m above ground level. Escape from habitable rooms in basement storey: external egress door or window or protected stairway to final exit. Dwelling houses with all floors ≤*4.5 m:* emergency egress via window or door for 'self-rescue' from each upper storey room, except kitchen (houses with one stairway); single window may serve two rooms if both rooms have their own access to stairs, and communicating door between rooms to avoid passing through stairway. Ground floor habitable rooms, except kitchens, to open directly onto hall leading to entrance or other suitable exit, or emergency egress window or door. Small loft conversions to two-storey houses: protected enclosure of existing stairs leading to final exit or access to 2 separate escape routes, window for rescue by ladder. Dwelling houses with one floor > 4.5 m: protected stairway to final exit or access to 2 separate escape routes at ground level; or separation of top storey and provision of alternative escape route. Dwelling houses with more than one floor > 4.5 m: alternative escape route from storeys ≥7.5 m.
France	–
Germany *Hesse* 2002	At least two independent emergency routes from each storey; both may lead through the same 'essential' corridor within a storey; 1st route must lead to essential stairs; 2nd route can be further necessary stairs or place that can be reached with fire brigade evacuation equipment. Exemption from second emergency route if rescue via a smoke and fire-protected stairway (safety stairway). Necessary stairs to serve each storey, directly connected with stair to roof space (buildings class 1-3, not within dwellings). Usable width of essential stairs and landings sufficient for greatest anticipated traffic.
Netherlands	Smoke-free escape route, without passing through doors that must be opened with a key, to an adjacent site and from there to the public road.
Norway	No requirements for escape routes, but requirements for escape windows and balconies; also definition of Fire class 1 includes three storey buildings where every dwelling unit has a direct escape to the ground.
Sweden	Escape from habitable room in Class Br3 building without assistance of rescue service. *General recommendations:* *Escape from habitable room by: exit to an escape route or direct to external air at ground level or to outside stairs or fixed ladder leading to ground level; or openable window; or via another room on same storey if room can be separated from storey below by closing one or more doors.*

A2.10 Escape routes

This section of the Building Decree includes the following articles that are relevant to permanent housing:

- Article 2.153 Performance requirement: provision of escape routes
- Article 2.154 Conditions of smoke-free escape routes
- Article 2.156 Escape routes from smoke compartments
- Article 2.157 Escape routes from sub-fire compartments
- Article 2.158 Escape staircases
- Articles 2.160-165 Requirements for existing buildings

It covers escape routes from entrances to 'smoke compartments' and 'sub-fire compartments'. These are spaces outside the dwelling in blocks of flats, but the

requirements also apply to single family houses. In order to make a full comparison, the analysis is broadened to consider the overall strategies of escape.

The Building Decree is unique in distinguishing between 'smoke-free' and 'smoke-free and fire-free' escape routes. Other countries only use the term 'escape route' but then apply conditions for fire- or smoke-protection to the walls and doors on that route. As noted earlier, the Building Decree's escape route strategy is also related to the provision of smoke alarms but requirements are only made explicit in the associated NEN (see above).

There are requirements for provision for escape from single-family houses in Denmark, England and Wales, the Netherlands, Norway, and Sweden, but the only requirements for protected escape routes concern taller houses in England and Wales. Escape from inner rooms (rooms whose only escape route is through another room) is only considered in Denmark, England and Wales, and Sweden. There are no requirements for escape from single-family houses in Belgium or France. The highest standard for escape from houses is in England and Wales, which has a range of requirements, including protected or alternative stairways for taller houses, and the provision of emergency egress windows for any inner room up to 4.5 m above ground level.

Although building regulations state broad objectives for evacuation, there are no explicit statements of target evacuation times. Independent commentaries in England and Wales note examples of fires that have been used to develop particular aspects of regulations but the Approved Document does not explain objectives in terms such as the time within which evacuation must be achieved. However, there is an inherent consideration of time within the figures used for exit widths, which is based on experience of fires.[25]

In the Netherlands, independent guidance explains that the objectives of the fire safety requirements are to raise the alarm within 15 minutes; for the fire brigade to start working and for everyone to have escaped within 30 minutes; and for the fire to be under control within 60 minutes.[26]

A2.10.1 Alternative means of escape

Although provision of alternative means of escape is a common requirement in blocks of flats, two routes for independent escape are rarely required. Instead, provision for rescue is often specified as the second means of escape.

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25 Evacuation times were based on fires in public assembly buildings in the early twentieth century, including a fire at the Empire Palace Theatre in Edinburgh in 1911, when the entire audience was evacuated during the 2.5 minutes it took for the orchestra to play 'God Save the King' (Stollard & Abrahams, p.66). A history of the development of UK fire safety regulations is given in Bickerdike Allen.

26 Vereninging Nederlandse Gemeenten (2002) *Standaardregelingen in de Bouw.*

Neither Belgium or the Netherlands mentions rescue as a second means of escape, or has requirements for rescue openings. England and Wales only mentions rescue as a means of escape for small loft extensions to two-storey houses and states that "provisions for means of escape from blocks of flats and maisonettes are based on the assumption that … there is no reliance on external rescue". Blocks of flats may be designed for rescue as well as escape in Denmark, France, Germany (Hesse), Norway, and Sweden. Indeed, France allows the classification of certain blocks of flats on the basis of the local availability of appropriate rescue equipment. Denmark, Norway, and Sweden have various requirements for rescue windows or balconies; Norway limits the height of such openings, Denmark requires rescue openings in all dwellings. Several countries allow the internal planning of dwellings to be part of the escape strategy. Alternative escape via adjacent rooms is allowed in Denmark, England and Wales, Norway, and Sweden. Each of the other countries, including the Netherlands, assumes escape via common spaces outside the dwelling.

The requirement for alternative means of escape in the Netherlands is the highest standard (two escape routes from one entrance to each smoke compartment or sub-fire compartment), because it neither allows secondary routes via rescue openings or exemptions on the basis of the height of buildings. It also has extensive requirements concerning the number of exits and escape routes from smoke compartments and sub-fire compartments that are difficult to understand or to compare with requirements in other countries, except by reference to independent guidance.

The Building Decree also mentions two different types of staircase: a safety staircase and an escape staircase. It does not make clear the difference between them. The Building Decree does not define the characteristics of the safety staircase, but gives conditions when a safety staircase is required and limits the fire load of storeys served by a safety staircase.[27]

The lowest standards are in France and Germany. In France, a second stairway is optional even in category 4 buildings (top floor 28-50 m). In Germany (Hesse), an alternative means of escape is only required if there is no protected stairway and may constitute rescue by the fire brigade, provided appropriate evacuation equipment is available.

Of the other countries, the clearest statement of requirements for second escape routes are for tall buildings in Belgium (buildings with floor of top storey > 25 m) and Denmark (lower edge of rescue opening > 23 m), presumably out of reach of rescue appliances. More often, requirements are given in terms of situations in which single escape routes are allowed. In England and

27 Nieman Consultants showed us an example of escape from a building with six flats where there is a storey higher than 12.5 m, via a landing out of doors, then into a safety stairway.

Table A2.15a Escape routes: strategy: blocks of flats

Belgium	Exits to outside or to another compartment. Internal or external stairs to link compartments to evacuation level. Stairs linking several compartments to be enclosed. Stairways to give access to evacuation level and to each storey, except for smaller storey in duplex < 300 m² total area. Protected lobby to stairways (BE tall, BM medium height buildings), self-closing fire door to stairway (BB low buildings). Stairways to access roof if serving > 3 storeys above evacuation level, and roof is flat or pitch < 10° (BE tall, BM medium height buildings). Two exits, except top two basement levels used for storage. (BE tall buildings).
Denmark	Escape from each dwelling to outside, or stairway to exit at ground level. Rescue openings in habitable rooms and kitchens if no access from dwellings to protected stairs; conditions for one rescue opening if > 10.8 m. Rescue balconies if door between stairway and basement and a rescue opening > 10.8 m). Escape route corridor in separate fire compartment; each stairway enclosure constitutes a separate fire division, except exterior stairs in 2-storey buildings. Protected stairs: separate enclosure, only access from outside building and from lobby. Access to stairs in opposite directions (top storeys with lower edge of rescue opening > 23 m).
England and Wales	Escape without external assistance. Direct escape to open air place of safety or to place of relative safety on a route to an exit, such as protected stairway or protected corridor. Alternative escape from most situations. Automatic fire detection and alarm systems. Prohibition of inner rooms except sanitary accommodation, kitchen, dressing room, rooms < 4.5 m above ground level if there is an escape window. Additional requirements for maisonettes [duplex apartments]. Buildings with all floors ≤ 4.5 m: emergency egress via window or door from each storey for 'self-rescue'. Buildings with floors > 4.5 m: protected entrance hall, or cooking facilities located to avoid impeding escape, or alternative exit; access to alternative escape routes; or single stair with dwellings separated from stair by protected lobby or corridor; dead end parts of common corridors served by two common stairs are allowed subject to travel distances and sub-division of corridors; modified requirements for small single stair building with top floor ≤ 11 m, ≤ 3 storeys above ground level, limits on connections to car park and ancillary accommodation. Alternative exits: remote from entrance door, to final exit or common stair via door or private stair to access corridor, access lobby or common balcony, or door to common stair, or external stair, or door onto an escape route over a flat roof to storey exit or external escape route. Balcony or deck access: reference to BS 5588, Part 1: 1990. Direct discharge to final exit or protected exit passageway to final exit from common stairs in fire-resisting enclosure.
France	Exit routes to allow occupants to escape with or without exterior help. Category 3 classifications related to access for rescue, including local availability of long ladders. Exit at ground floor to outside, or to well-ventilated hall or horizontal circulation. 4-storey buildings with lowest floor of highest dwelling > 8 m must have enclosed stairway. Horizontal circulation linking each dwelling to a protected stairway or to the exterior for ground floor dwellings. Single stairways, but three options for category 4 buildings related to number of stairways, lobbying and pressurisation: exits to 2 protected stairways, or 1 lobbied stairway, or 1 pressurised stairway (plus associated requirements for horizontal escape routes). 2 stairways only mandatory for foyers with 201-400 occupants.

Germany *Hesse* 2002	Two independent emergency routes, one route via 'essential stairway'; second route can use another essential stairway or fire brigade evacuation equipment via 'essential window,' Second route is not required when first route leads through a safety stairwell that excludes fire and smoke. Essential corridors required for emergency routes from habitable rooms or dwellings to essential stairways or exits to open air (except building classes 1,2; dwellings < 200 m²), and for storeys with > 4 dwellings. Each essential stairway to have an external wall, with a direct exit to open air; interior essential stairways permitted if smoke protected. Route from essential stairway to exit same width as stairs, with smoke protected doors to essential corridors, without openings to other areas. Ramps permitted instead of essential stairs.
Nether-lands	Smoke-free escape route, without passing through doors that must be opened with a key, to an adjacent site and from there to the public road. New build, refurbishments, adaptations, and extensions to existing buildings: Escape routes from smoke compartments and sub-fire compartments: [In practice, a smoke compartment in a deck or corridor access building would comprise a number of flats plus horizontal access to the flats. A sub-fire compartment would constitute a single flat.] Two independent fire-free and smoke-free escape routes from access point of smoke compartment or sub-fire compartment, but requirement for two escape routes does not apply to smoke compartments < 250 m² with no habitable room. [Consultants advise us that this requirement is to be changed to two smoke-free escape routes.] Conditions permitting a single smoke-free escape route. Only one route is required if there is more than one access point and there are two independent smoke-free escape routes from another access point. Detailed requirements for number of exits, related to area of smoke compartment or dwelling, height of building, provision of habitable rooms, number of flats served by a single staircase. Number of exits and escape routes from smoke compartments and sub-fire compartments; distance between exits; separation of escape routes. Escape staircase: an escape stair bridging > 8 m must be part of a fire-free, smoke-free escape route. Safety staircase: requirements related to fire load: max. fire load density x net floor area: 3,500 MJ per storey; ref: NEN 6090. Two smoke-free escape routes may only coincide in a safety staircase. A fire-free, smoke-free escape route bridging > 12.5 m must be in a safety staircase. Existing buildings: Max. fire load per storey: 7,000 MJ. Reference to NEN 6090. Two smoke-free escape routes, but one smoke-free escape route if total area of dwellings < 500 m² and there is no habitable room, or one fire-free and smoke-free escape route for total area 500-1,500 m². Also: no installation spaces for a fireplace in a fire-free and smoke-free escape route (4.16 Installation space for a fireplace)
Norway	3 stage escape route: 1) escape within a fire compartment; either to escape route in another fire compartment or directly to the outside at ground level; 2) escape thorough an escape route on the same level as the fire compartment from which escape takes place; 3) escape via stair(s) to a secure place (usually at ground level outdoors). One escape to a secure place, usually to the ground outdoors; one escape to a corridor accessing two separate escape routes to stairways or a secure place; two exits to separate stairs/escape routes. Escape through window, max. height 5 m. Escape balconies (two storey buildings), max. height 15 m. Escape to stair (blocks of flats ≤ 8 storeys): two Tr1 stairways; one Tr3 stairway; or one Tr1 stairway plus escape windows from each dwelling. Also, one escape window per 100 m² gross area and at least one escape window through different external walls for every second habitable room. Escape route must be a separate fire compartment. Escape route may contain smaller rooms for other purposes (e.g. reception area/lobby).

Table A2.15b Escape routes: strategy: blocks of flats

Sweden	Escape route from fire compartment to exit directly to street or similar or to a terrace, courtyard etc accessing a street or similar space. Min. two mutually independent escape routes; dwellings with > 1 storey, min. one escape route per storey. One escape route may be a window, if escape can take place safely; consider feasibility of use of rescue service equipment. Consider risk of being trapped in recesses or dead ends. Escape from habitable room in Class Br2 building without assistance of rescue service. Single escape route allowed: in building with Tr1 stairway; buildings < 8 storeys with Tr2 stairway. *General recommendations:* *Escape route may comprise corridors or stairs within their own fire compartment, access balconies and similar spaces outdoors. Ref: Boverket Report No 1994:10, Design for escape. Requirements for escape windows, but balcony accessible from rescue road required for flats larger than one room and kitchen. Escape from habitable room by: exit to an escape route or direct to external air at ground level or to outside stairs or fixed ladder leading to ground level; or openable window; or via another room on same storey if room can be separated from storey below by closing one or more doors.*

Wales, there is a general requirement for alternative escape within common parts of flats and maisonettes, but single escape routes are allowed in small buildings (floor of top storey ≤ 11 m, other conditions), or subject to travel distances (max 7.5 m dead end). Both Norway and Sweden allow single escape routes from buildings with less than 8 storeys if there is a protected stairway.

Both Belgium and England and Wales mention access to flat roofs as part of an escape strategy. However, Belgium seems to intend rooftops as a refuge for tall buildings, whereas England and Wales requires that escape over a flat roof should lead to a storey exit or external escape route.

A2.10.2 Doors on escape routes

Certain aspects of doors are important to the safety of escape routes. The Building Decree addresses the issues of direction of opening and locking of doors on escape routes, but it does not require self-closers on escape routes or entrances to individual flats. Some of the other countries have requirements concerning self-closers, resistance to fire or smoke, ease of opening, and types of doors.

Doors opening in the direction of travel are required in Belgium, Denmark, France, the Netherlands, Norway, and Sweden. Only Sweden specifically exempts entrance doors to dwellings. Opening in the direction of travel is not required for residential buildings in England and Wales; this is only recommended for non-domestic buildings where over 60 people would use the escape route. There are no requirements in Germany (Hesse).

There are limitations on locks and bolts for doors on escape routes in each country except France, where the only limits on locks apply to basements, cellars, and car parks.

There are requirements for self-closing devices to fire doors on escape routes in Belgium, Denmark, England and Wales, France, and Germany (Hesse).

The Building Decree does not specify periods of fire resistance for doors on escape routes, or limitations on smoke leakage at doorways. The explanatory

Table A2.16a Escape routes: doors

	Direction of opening, locks, closers, hinges, vision panels	Fire resistance	
Belgium	Bolts must not impede opening in direction of escape. Door width: 0.8 m or related to number of occupants. Self-closing (BE tall, BM medium height buildings).	Door on escape route: Door on escape route at evacuation level: (BE tall buildings).	30 minutes 60 minutes
Denmark	Escape route doors to open in direction of escape, without key or special tool, double doors opened with single handle at convenient height; non-lockable door to protected stairways. Prohibition of automatic doors, sliding doors, revolving doors. Self-closers on doors to stores on escape route corridors, doors to protected stairways and between lobby and stairway enclosure. *Recommendations:* *Doors dividing corridors > 50 m: self-closing, smoke control doors. Automatic system to keep open self-closing doors.*	Door on escape route corridor: Door to storeroom on escape route corridor, door toprotected stairways, between lobby and stairway enclosure: *Recommendations:* *Doors between corridors and escape route stairs:*	BD 30-M BD 30 *F 30*
England and Wales	Houses: Doors on any protected stairway: self-closing fire door Small loft conversions in 2-storey houses: self-closing fire door to prevent smoke entering new storey. Self-closing device in houses may be rising butt hinges; spring or other automatic device. Flats and maisonettes with a floor > 4.5 m above ground level: Fire doors self-closing, including dwelling entrances onto protected corridors or hallways. Cupboard doors opening onto protected hallways need not be self-closing; they can instead be kept locked. Doors on escape routes (whether or not fire doors), should not be fitted with lock, latch or bolt fastenings, or should only fitted with simple fastenings readily operated from the side approached by people making an escape; operation readily apparent, without use of key, without having to manipulate more than one mechanism.	Doors on protected stairways (new build): Door to new storey in loft conversion: [no smokes uffix but specifically mentions smoke]: Fire-resisting glazing if glazed panels (new or existing). Doors (except WC) onto any protected hallway or landing inside dwellings: Doors to dwelling entrances, doors to common stair: Doors of protected lobby separating dwelling entrances from common stair (flats or maisonettesserved by one common stair); doors sub-dividing corridors to limit travel distances, to separate dead ends (flats or maisonettes served by more than one common stair)	FD20 FD20 FD20 FD30S FD20S
	The suffix S indicates a door that restricts smoke leakage at ambient temperatures. Like all fire doors, doors to restrict smoke leakage are fitted with automatic self-closers.		

Table A2.16b Escape routes: doors

	Direction of opening, locks, closers, hinges, vision panels	Fire resistance
France	Doors in stairway enclosures, between smoke protected stairway and protected circulation or doors in protectedstairways open to air:	
	Opening in direction of exit. Self- closer. 0.8 m wide; must not obstruct stairway when open, signage 'Fire door, to be kept shut'	resistance to spread of flames (pare-flammes): 30 minutes
	Doors between basements, cellars or stores and stairways to other storeys:	
	Opening without a key from the interior.	fire resistance (coupe-feu): 30 minutes
Germany *Hesse* 2002	[HBO refers to '*Abschlüssen*' which translates as closers or conclusions, i.e. doors or dampers; 'doors' is used here for brevity]. Requirements apply only to buildings of classes 3-5:	
	Self-closing, tightly fitting (doors from essential stairways).	T 30 (door in partition between dwellings and different uses; door in wall of essential corridors to basement stores)
	[It is not stated, but is implied that doors with T30, T90, RS ratings are self-closing.]	T 30-rs (doors from essential stairways to basements, unused roof spaces, workshops, shops, stockrooms < 200 m²)
	Tightly closing (doors in walls of essential corridors).	RS (door between internal essential stairway and essential corridor)
	Non-lockable (doors to sub-divide essential corridors > 30 m)	T 90 (doors in internal fire walls) [it is not clear whether this is relevant to escape routes in residential buildings]
		T 30: fire-retardant, 30 minutes; T 90: fire-resistant, 90 minutes; RS smoke protecting)
Netherlands	Doors between enclosed escape route and escape stairwell open in direction of escape. No doors opened by key on escape route. Self-closers are not required for doors at dwelling entrances. [Although they form part of a sub-fire compartment wall, the requirement for self-closers does not apply to housing.]	None [In practice, fire resistance as per sub-fire compartment walls, 30 minutes.]

notes to the Building Decree (section 4.5) report that the MDW enquiry into legislation recommended that the fire safety requirements were too rigorous, and that as a result the regulations for fire-resistant doors were replaced by the stipulation of a mains-wired smoke detector.

There are varied requirements for the performance of doors on escape routes in Belgium, Denmark, England and Wales, France, Germany (Hesse), Norway, and Sweden, for resistance to fire and smoke, resistance to fire alone, fire retardance, or resistance to spread of flames.

The periods of resistance for doors on escape routes are similar (30 minutes), except in England and Wales (30 minutes for dwelling entrances to flats and maisonettes and entry to escape stairway, but 20 minutes for doors subdividing corridors), Norway (30 minutes stairway type Tr2, 60 minutes stairway type Tr3), and Sweden (30 minutes, but 60 minutes for dwelling entrances and for buildings > 8 storeys). The highest standards for periods of resistance are

	Direction of opening, locks, closers, hinges, vision panels	Fire resistance	
Norway	Doors to open towards direction of escape, but inward opening doors allowed for fire compartments intended for less than 10 persons. Door in escape route may be locked if the building has a fire alarm system and the lock opens automatically in case of fire. Doors fitted with a device which per-mits persons to return after they have passed through. Doors easy to open, max. force 67N. Doors easy to identify as exits. Self-closers on doors to stairways Tr2, Tr3.	Doors to stairway Tr2: Doors to stairway Tr3:	EI 30 C EI 60 C
Sweden	Doors to open outwards direction of escape, but inward opening allowed for entrances to dwellings. Revolving or sliding doors permitted if they provide the same degree of safety as outward opening side hung doors. Doors opened only with a key allowed if building used by small number of persons expected to have access to a key. Doors fitted with a device which per-mits persons to return after they have passed through. Self-closers on doors between stairway and protected lobby, doors between dwelling and protected lobby, doors to protected lobby that abuts a route in its own fire compart-ment, for both Tr1 and Tr2 stairways. Easy to open doors on escape routes. Max. 130 N force needed to open the door. Doors easy to identify as exits.	Tr1 stairways: doors between stairway and protected lobby: doors between dwelling and protected lobby: doors to protected lobby that abuts a route in its own fire compart-ment: Tr2 stairways:	 E-C30 EI-C60 EI-C30 EI-C60 EI-C30 for buildings < 8 storeys.

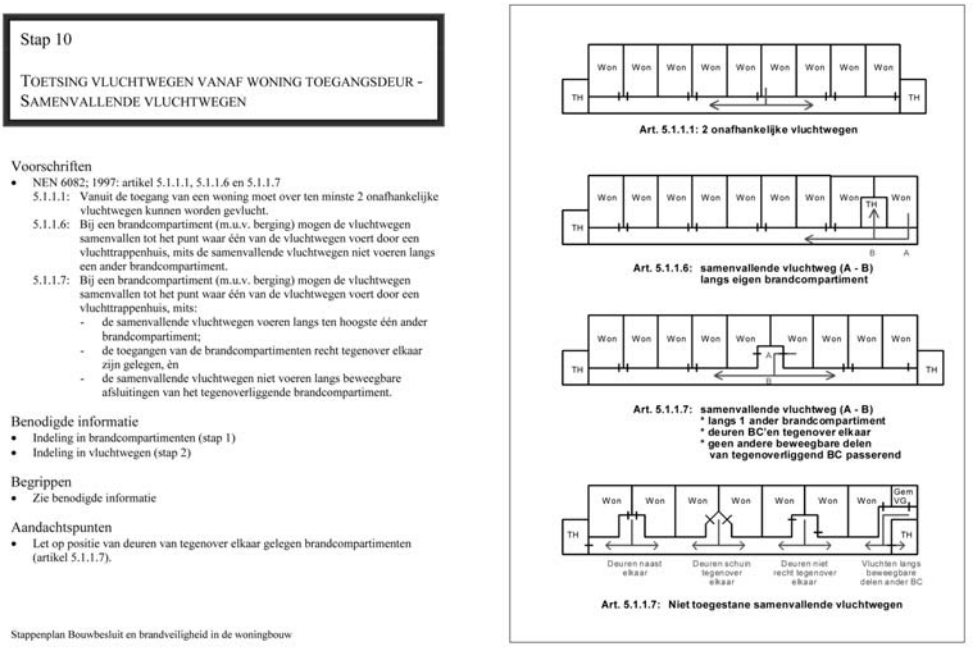
in Sweden. In England and Wales, the requirement for resistance to smoke leakage, as well as a self-closing device, is a relatively high standard. Only Norway and Sweden require that doors on escape routes should be easy to open. The standard in Norway (67 N) is much higher than in Sweden (130 N).

Whereas Denmark bans automatic, sliding and revolving doors, these are permitted in Sweden if they provide the same degree of safety as side hung doors [which may conflict with accessibility requirements]. None of the other countries mentions this issue for housing.

A2.10.3 Description of separation of escape routes

The Building Decree has complicated requirements for the separation or sharing of escape routes and there are further requirements in the next section on 'Design of Escape Routes'. Due to the use of the expressions 'smoke

Figure A2.2 Diagrammatic explanations of escape route requirements in Dutch



Stap 10

TOETSING VLUCHTWEGEN VANAF WONING TOEGANGSDEUR - SAMENVALLENDE VLUCHTWEGEN

Voorschriften

- NEN 6082; 1997: artikel 5.1.1.1, 5.1.1.6 en 5.1.1.7
  - 5.1.1.1: Vanuit de toegang van een woning moet over ten minste 2 onafhankelijke vluchtwegen kunnen worden gevlucht.
  - 5.1.1.6: Bij een brandcompartiment (m.u.v. berging) mogen de vluchtwegen samenvallen tot het punt waar één van de vluchtwegen voert door een vluchttrappenhuis, mits de samenvallende vluchtwegen niet voeren langs een ander brandcompartiment.
  - 5.1.1.7: Bij een brandcompartiment (m.u.v. berging) mogen de vluchtwegen samenvallen tot het punt waar één van de vluchtwegen voert door een vluchttrappenhuis, mits:
    - de samenvallende vluchtwegen voeren langs ten hoogste één ander brandcompartiment;
    - de toegangen van de brandcompartimenten recht tegenover elkaar zijn gelegen, èn
    - de samenvallende vluchtwegen niet voeren langs beweegbare afsluitingen van het tegenoverliggende brandcompartiment.

Benodigde informatie

- Indeling in brandcompartimenten (stap 1)
- Indeling in vluchtwegen (stap 2)

Begrippen

- Zie benodigde informatie

Aandachtspunten

- Let op positie van deuren van tegenover elkaar gelegen brandcompartimenten (artikel 5.1.1.7).

Stappenplan Bouwbesluit en brandveiligheid in de woningbouw

Won TH

Art. 5.1.1.1: 2 onafhankelijke vluchtwegen

Art. 5.1.1.6: samenvallende vluchtweg (A - B) langs eigen brandcompartiment

Art. 5.1.1.7: samenvallende vluchtweg (A - B)
* langs 1 ander brandcompartiment
* deuren BC'en tegenover elkaar
* geen andere beweegbare delen van tegenoverliggend BC passerend

Deuren naast elkaar | Deuren schuin tegenover elkaar | Deuren niet recht tegenover elkaar | Vluchten langs beweegbare delen ander BC

Art. 5.1.1.7: Niet toegestane samenvallende vluchtwegen

Source: 'Producten: Stappenplan brandveiligheid woonfuncties' at www.nieman.nl

compartment' and 'sub-fire compartment', it is difficult to make comparisons with other countries except by reference to diagrams, but the Building Decree does not include diagrams.

Nieman Consultants offers a guide to the interpretation of requirements on its website, including diagrams. The illustration given below show situations in which a single escape route is permissible (second and third diagrams), and situations that are not allowed (fourth diagram). It refers to requirements in *NEN 5082: 1997* that:

- a single escape route should only pass one other fire compartment;
- the doors to two fire compartments with a single escape route should be opposite each other;
- the route should not pass alongside moving parts (windows, doors) of the other fire compartment.

A2.11 Design of smoke-free escape routes

This section of the Building Decree includes the following articles that are relevant to permanent housing:

- Article 2.166 Performance requirement: escape from smoke compartments
- Article 2.167 Dimensions of routes

- Article 2.168 Resistance to spread of flame and openings between escape routes
- Article 2.169 Smoke extraction from smoke-free escape routes
- Article 2.170 Provision of safety staircases; conditions for escape staircases
- Article 2.171 Direction of door opening
- Article 2.172 Distance between access points on escape route
- Article 2.175-179 Requirements for existing buildings

Following two sections of requirements that are mostly phrased differently from requirements in other countries, this section gives many more specific requirements that are easier to compare.

A2.11.1 Dimensions of escape routes

There are requirements for the width of escape routes in Belgium, Denmark, England and Wales, the Netherlands, Norway, and Sweden. In Germany (Hesse), specifications for the width of stairs and corridors were replaced by a performance requirement in 2002, but specifications for escape windows were retained.

The Netherlands has the lowest standard for the width of escape routes (0.6 m); the highest standards are in Norway and Sweden (0.9 m). The only requirements for the height of escape routes are in Belgium (2 m) and the Netherlands (1.9 m). Where rescue is one of the means of escape, there should be appropriately located openings of adequate size. There are requirements for the size and locations of rescue openings in Denmark, Germany (Hesse), Norway, and Sweden, and for houses in England and Wales. The most extensive requirements are in Denmark. There are no fire safety requirements for the size of windows in blocks of flats in England and Wales (flats with a floor > 4.5 m above ground level)[28], rance, or the Netherlands.

A2.11.2 Smoke-free escape routes: distances between entrances and stairways

As noted earlier, the Building Decree separates requirements for travel distances within a smoke compartment and requirements for travel distances on smoke-free escape routes.

The Building Decree limits the distance between two entrances within an enclosed space through which an escape route passes (which appears to

28 Windows designed for emergency egress are required for all ground floor habitable rooms that do not open into a hall leading to an exit, or for upper storey rooms in flats with floors ≤ 4.5 m above ground which do not comply with requirements for internal planning.

Table A2.16 Design of escape routes: dimensions

	Dimensions of route	Windows for emergency escape
Belgium	Min. width: 0.8 m (escape routes, doors, stairway flights, landings, lobbies); 0.6 m (corridors); min. height: 2 m.	–
Denmark	Min. width doors: 1 m (escape routes in buildings designed for > 50 people).	Rescue opening: window, hatch, door; clear opening height + width ≥ 1.5 m, min. height 0.6 m, width 0.5 m; lower edge max. 1.2 m above floor. Buildings with lower edge of a rescue opening > 10.8 m: min. 0.8 m open height of rescue opening in roof; all other openings made as doors or vertically pivoting, side hinged or sliding window, or side-hinged hatch. Openings in attic rooms > 5.5 m above ground max. 1.4 m horizontal distance from roof edge; 0.2 m wide sill max. 0.8 m above floor, 0.4 m below opening. Sun-shading devices must not prevent use of rescue openings.
England and Wales	Min. width 0.75 m; min. width of common stairs if used for fire-fighting: 1.1 m (blocks of flats).	Houses: emergency egress windows: unobstructed openable area min. 0.33 m2, 0.45 m high, 0.45 m wide; bottom of openable area max. 1.1 m above floor. Small loft conversions in 2-storey houses: opening max. 1.7 m from eaves, 0.8-1.1 m above floor (dormer), 0.6-1.1 m (roof light).
France	Doors separating smoke-protected stairway and horizontal circulation: 0.8 m.	–
Germany *Hesse*	Exit routes as wide as the stairs.	0.9 x 1.2 m; lower edge of openings in roofs, max. 1 m horizontally, 1.2 m vertically from edge of floor. Secondary escape routes via windows with top of cill > 8 m above ground allowed only if fire-brigade has appropriate evacuation equipment.
Hesse 1993	Usable width, essential stairs and landings: min. 1 m (class C,E,F,G), 0.8 m (class A,B,D)	
Hesse 2002	Width of essential stairs, landings, corridors: sufficient to accommodate expected traffic.	
Netherlands	Min. width: 0.6 m, min. height 1.9 m (new build), 0.5 m, 1.2 m (existing buildings).	–
Norway	Min. width 0.9 m or 0.01 m per person. Min. clear opening width of doors 0.9 m Subdivision of corridors longer than 30 m: doors min. EC 15-C, max. 30 m apart.	Escape windows: max. height 5 m [above ground]; min. dimensions of windows: 0.6 m tall x 0.5 m wide; but basement windows 0.5 m tall x 0.6 m wide.
Sweden	To permit ease of movement to serve intended number of persons. *General recommendations:* *Min. width: 0.9 m.*	*General recommendations:* *Windows fot emergency escape: openable without key or other implement; clear vertical opening min. 0.5 m wide, 0.6 m high, sum of width and height min. 1.5 m, bottom of opening max. 1.2 m. Flats larger than one room and kitchen: balcony accessible from rescue road.*

Table A2.17 Design of escape routes: distances between entrances and stairways on escape routes

	Distances between entrances on escape routes	Distances between stairways on escape routes
Belgium	Not expressed in this manner, but by implication 40 m [see Table 5.12: deduct distance from any point in compartment to escape route from distance to second stair or exit].	10-60 m (BE tall, BM medium height buildings).
Denmark	Not expressed in this manner.	Max. 50 m between 2 stairs on same escape route.
England and Wales	Not expressed in this manner. Limits travel distance from dwelling entrance door to common stair, or to lobby door in corridor-access single stair flats: escape in one direction: 7.5 m; escape in more than one direction: 30 m.	
France	Not expressed in this manner.	Min. 10 m (category 4 housing).
Germany *Hesse* 2002	Not expressed in this manner. Essential corridors (except open decks): sub-divided into smoke sections max. 30 m long by non-lockable smoke resisting closures; max. length of corridors with escape in only one direction to safe stairway: 15 m. Essential corridors must not contain flights of steps with less than 3 steps. Essential stairways distributed to minimise length of emergency routes.	
Netherlands	Smoke-free escape routes: Maximum 30 m walking distance between two entrances within enclosed space through which escape route passes (except stairwell).	–
Norway	Max. distance from door in a fire compartment to exit or stairway:15 m if one exit or stair, 30 m if two exit or stairs.	
Sweden	Subdivision of corridors that are common portions of otherwise separate escape routes, to prevent spread of fire gases. *General recommendations:* *Subdivision of corridors every 60 m.*	Distance along escape route to nearest stairway for rapid escape. *General recommendations:* *30 m*

mean the maximum length of a smoke-protected corridor).

Other countries do not express travel distances in this way, but it appears that some of the distances shown in Table A2.12 are intended to be similar in effect. Other countries have requirements for distances between stairways on escape routes, which may or may not mean the same in practice. The differences in expression of requirements make comparisons unreliable.

Only Germany (Hesse) mentions limits on changes of level within horizontal escape routes.

A2.11.3 Separation of escape routes

Shared escape routes occur whenever escape routes enter the same stairway. Also, buildings with corridors may offer alternative escape routes via a subdivided common corridor. However, it appears that separation of escape routes, without exceptions, is required in Denmark, where each protected stairway is deemed to constitute a separate fire division and there are no provisions for the sub-division of corridors serving two escape routes. In contrast, the Building Decree describes various conditions in which coincident escape routes are allowed. Only Belgium specifically allows exit via a reception hall that including lifts, but this is implied in other countries.

Table A2.18a Design of escape routes: separation, fire resistance

	Separation of escape routes	Fire resistance of escape routes (minutes)
Belgium	Stairways from basements: separate egress or separation from stairs to upper levels via lobby. Evacuation level windows of a commercial part of building must not open onto an escape route from other parts of building, except final 3 m. Escape route can include entrance hall at evacuation level, including lift, reception spaces. Lobby at each level between escape route and stairwell (BE tall building).	Separation of stairways from basements: 120 minute walls. Fire resistance of evacuation level, including glazing of commercial part of building opening onto escape route from other parts of building: BB < 10 m: 30 — BM 10-25 m: 60 — BE > 25 m: 120 Upper storeys: 30 — 30 — 30 120 minute fire resistant walls to lobbies between escape route and stairwell (BE tall building); at evacuation level, lobby can be replaced by 60 minute fire door (BE tall, BM medium height building), 30 minute door (BB low building).
Denmark	Basements: stairway access via open air or lobby, or doorway if rescue balcony to each dwelling (buildings with rescue opening > 10.8 m). Protected stairway: enclosure with direct exit to outside at ground level, constitutes fire division (except exterior stairs to 2-storey buildings); tight junction of walls with outer roofing; fire division structure between stair enclosure and attic. 2-storey dwellings with rescue openings in upper storey > 23 m above ground level: internal stairway in separate fire compartment or access to stairs with exit at ground level. Max. 4 dwellings per floor may be served by non-protected stairways; exemption if access to stairs via access balcony. Escape route is a separate fire compartment, must not lead through another dwelling or industrial or commercial unit.	Common lobby to protected stairs and dwelling doors in common lobby: BD60 Other doors, not self-closing: BD30-M

	Separation of escape routes	Fire resistance of escape routes (minutes)
England and Wales	Basements: separate stair if only one escape route from an upper storey; if more than one escape stair from upper storey, only one needs to be terminated at ground level and other stairs may connect with basement storey(s) if protected lobby or corridor. Imperforate enclosure of 2 adjacent protected stairways.	Enclosure to protected lobby, protected corridor, protected stairway: 30 Doors to lobby between basements and stairs from upper storeys; door forming part of the enclosures of: protected stairway, protected lobby approach (or protected corridor) to a stairway;
	Mixed-use buildings: independent alternative route plus protective lobbies but stair may be shared by dwellings and other occupancies if protected by lobbies at each level for buildings ≤ ground floor + three storeys.	door in stair enclosure serving dwellings and other occupancies:. FD 30 S
	Wall between each dwelling and a corridor should be a compartment wall (excludes external balcony/ deck access).	Compartment wall separating a flat or maisonette from corridor: 60, or as structure if less Door in compartment wall: FD 30 S
	Sub-division of common corridor connecting two storey exits; separation of any dead end portion of common corridor from rest of corridor.	Sub-division/separation by self-closing fire door: FD20S
France	Category 2, 3, 4: Stairways from basements must empty at ground floor in hall or horizontal circulation, must not empty into stairways serving upper storeys.	Category 2, 3, 4: self-closing fire door to stairways linking basements and the rest of buildings: 30
	Category 3B: Smoke-protected stairway separated by fire resistant door from protected circulation	Category 3B: smoke-protected stairway: – enclosure: 60 – separating door: 30
Germany *Hesse* 2002	Internal essential stairways permitted if no openings to other areas. Two exits to essential stairways or open air for every basement storey.	Building class: 1 2 3 4 5 Essential stairways: – F30-b F60-a +M or F90-ba +M* F90-a +M* Walls: Essential corridors and open decks: – walls: – F30-b F30-ab or -ba – walls in basements: – F30-b F90-a M: resistant to additional mechanical load. Any drop ceilings in essential corridors to be fire-retardant.

Table A2.18b Design of escape routes: separation, fire resistance

	Separation of escape routes	Fire resistance of escape routes (minutes)
Netherlands	Parts of escape routes from sub-fire compartments may coincide, but not in a stairwell or next to another sub-fire compartment, except: total area of use of dwellings reliant on stairwell < 800 m², each < 150 m² and max. height of habitable area 12.5 m; or max. 6 dwellings reliant on stairwell and max. height of any habitable area 6 m; or safety staircase; coincident part may be adjacent to one other sub-fire compartment if their access points are directly opposite and the coincident part does not run alongside other moveable construction components. Two smoke-free escape routes may share a protected stairwell. First 8 m of escape routes from technical room may be shared. No movable construction parts in internal partition between two escape routes, except a self-closing door (new and existing buildings). Ref: NEN 6068.	Min. resistance to spread of flame via construction component between smoke-free escape routes: 30 minutes (new build), 20 (existing buildings), except coincident parts of escape routes and start of two smoke-free escape routes at access points to smoke compartments.
Norway	Escape route must be a separate fire compartment. Separation of escape route so that only one can fill with smoke or be blocked by same fire. Subdivision of corridors that are common portions of otherwise separate escape routes, into appropriate length to prevent spread of fire gases.	Depends on class of building and compartmentation
Sweden	Basements: single escape stairways separate from basements; access for rescue service to basement via class Tr2 stairway. Independence of escape routes. Subdivision of corridors that are common portions of otherwise separate escape routes. *General recommendations:* *A corridor in its own fire compartment, an access balcony or similar in direct communication with dwelling may constitute a common portion of otherwise separate escape routes.*	*General recommendations:* *Escape routes: E-C15.* *Subdivision of corridors: Class E15, every 60 m.*

The Building Decree does not specifically mention the separation or lobbying of basement storeys from escape stairways serving upper storeys, but this is described in NEN 6068. All the other countries specify requirements for the separation or lobbying of basement storeys, but exceptions are allowed in Denmark (buildings with rescue openings < 10.8 m), and in Sweden (more than one escape stairway, type Tr2).

There is considerable variation in requirements for the fire resistance of escape routes. The highest standard is for the evacuation level of tall buildings in Belgium (120 minutes). Otherwise, the highest standards are in Den-

Table A2.19 Design of escape routes: ventilation

	Ventilation
Belgium	Ventilation opening, min. 1 m^2 to upper level of stairwell, normally closed, manual control in visible place at evacuation level (BE tall, BM medium height building). Ventilation of escape stair lobbies (BE high buildings).
Denmark	Escape stairway smoke ventilation and fire-fighting: hinged windows, height and width min. 0.5 m; or smoke hatch, min. 1 m^2, operable from entrance floor, plus well width min. 0.2 m or connection to dry riser on each floor. Reference to Danish Institute of Fire Technology *Fire-technical Guideline no. 27*
England and Wales	Ventilation of common escape routes: Openable vent at high level in stairway for fire service use, min. free area 1.0 m^2: - in stairways; may be replaced by vent over stair in small single stair buildings; - at ends of corridors (corridors with dwellings on one side only, or corridor access without dead ends). Automatic ventilator triggered by smoke detector, min. free area 1.5 m^2: - ends of corridor with dead ends (more than one common stair); - ends of corridor, or duct to external wall (single stair buildings). Reference to BS 5588: Part 4 for design of pressurisation of common escape routes. Precautions to stop air circulation systems spreading smoke or fire into a protected entrance hall or landing (houses and flats with floor > 4.5 m above ground).
France	Stairways: Category 2 collective, 3A: high level smoke vent, min. 1 m^2, control at ground floor. Category 3B: 'open air,' or 'smoke protected' with vent, or pressurisation. Category 4 options: 2 smoke protected stairways, min. 10 m apart, 'open air' or 'smoke protected' horizontal circulation; or 1 smoke protected stairway, lobby at each storey, open air or smoke protected with mechanical extract; or 1 smoke protected stairway with pressurisation to 0.8 m^3/s, ventilated lobby, smoke protected horizontal circulation, mechanical extraction. Category 3B: horizontal circulation: 'open air' or 'smoke protected' by natural or mechanical extract ventilation. Category 3, 4: detailed requirements for air supply and extract (materials, fire resistance, height of vents, length and section of ducts); automated control of smoke exhaust shutters; extraction rates. Permanent ventilation systems: provision to prevent spread of smoke to other storeys.
Germany *Hesse* 2002	Ventilation of essential stairways; openable windows min. 0.5 m^2 to each storey above ground. Class 5 buildings: high level smoke opening 1 m^2 operable from ground floor and highest landing (internal essential stairways and essential stairways).
Nether-lands	Provision for supply of fresh air and extraction of smoke to non-enclosed room through which a smoke-free escape route passes, of sufficient capacity to allow escape. Capacity specified for existing buildings (16d m^3/sec = 16 litres/sec).
Norway	Ventilation of Tr3 stairways. Automatic closing of ducts through fire compartment walls triggered by smoke detectors. Otherwise as fire compartments.
Sweden	Protected lobby to Tr1, Tr2 stairway: open to external air or arrangements to prevent spread of gases. Fire gas ventilation from basements, except detached, semi-detached houses. Specification for fan performance, area of smoke vents related to sprinkler installation; windows for Class Br1 buildings. Ventilation from lift well. Ventilation openings in compartmented sections of attics which can be used as storage space, buildings > 4 storeys. Other requirements: Design to limit values for critical conditions in building. *General recommendations:* *Recommended limit values for visibility, thermal radiation, temperature, noxious gases.*

Table A2.20 Design of escape routes: other means of stairways protection

Belgium	Ventilated lobby at each level between escape route and stairwell with two 30-minute self closing doors, min. 2 m² (high buildings). 2 m² stair lobbies with one door (medium and low buildings).
Denmark	Access between basement and stairway enclosure via open air or lobby* (buildings with top storeys with lower edge of rescue opening > 10.8 m). Lobbies: one side open to outside air over full width above guarding; max. depth twice width at façade; open area min. 2 m² for each entrance to basement, min. dimension 0.8 m, limits on screening. No combustible materials in stairways and lobbies except handrails. * Air-lock in original translation; lobby is used here for sake of comparisons.
England and Wales	Protected stairway cannot be used for anything else except a lift well or electricity meters. Sub-division of common corridor connecting two or more storey exits, by self-closing fire door, positioned so that smoke will not affect access to more than one stairway.
France	Collective housing category 2, category 3A:smoke vent high in stairway, control at ground floor. Category 3A: automatic control system. Category 3B: protected stairway open to air or smoke protected, directly accessed at each level by a protected horizontal route; must not include lifts, ducts (except ductwork for electric lighting, metal drain pipes, water supply pipes, and gas pipes with 15 minutes fire resistance), refuse chutes, access to other places; requirements for emergency lighting; category C2 non-enclosed ducts (reference to NFC 32 070). Category 4: options including smoke protected routes and pressurisation.
Germany *Hesse 2002*	Pipes permitted in essential stairways or their exits, or essential corridors, provided emergency route can be used for as long as possible. Buildings class 3-5: pipes ducted to protect against transmission or propagation of fire. Does not apply to ventilation ducts. Lighting of essential stairways. Class 5 buildings: emergency lighting of essential stairways.
Netherlands	Safety stairway: fire load: ≤ 3,500 MJ per storey (new-build), ≤ 7000 MJ per storey (existing building). Reference: NEN 6090. Escape stairway (not a safety stairway): no direct access to or from lift, technical room, or a space through which a smoke-free escape route passes, if fire load density x net floor area of each storey plus any rooms opening directly onto staircase > 3,500 MJ per storey (new-build).
Norway	Escape route must be a separate fire compartment. Ventilation of Tr3 stairways.
Sweden	Protected lobby to Tr1, Tr2 stairway. *General recommendations:* *Tr1, Tr2 stairways: Doors between dwelling and protected lobby* *EI-C60* *Tr1 stairway: Doors between stairway and protected lobby, between dwelling and protected lobby abutting a route in its own fire compartment.* *E-C30* *Tr2 stairway: doors to stairway in building < 8 storeys.* *EI-C30*

mark and England and Wales (60 minutes between dwellings and common lobbies). The lowest standard, where fire resistance requirements are given, is in Sweden (15 minutes).

A2.11.4 Ventilation of escape routes

Ventilation is a means to protect escape routes by keeping them sufficiently clear of smoke to allow escape. Each country has specifications for ventilation of escape routes. Only Belgium, Denmark, England and Wales, France, and Germany (Hesse) specify the size of openings and their operation. The Building Decree specifies ventilation capacity, but only for existing buildings.

A2.11.5 Other measures to protect escape routes

Stairways can also be protected from smoke by the provision of lobbies at storey exits to stairways and sub-division of adjacent corridors. Usually, such measures are used in tandem with the ventilation of stairways and periods of fire and/or smoke resistance for doors. Most countries give requirements for fire resistance of protected stairways, rather than separately describing smoke protection.

The Netherlands is unique in relating smoke protection of stairways to fire load density. However, the Building Decree is not clear (Article 2.106) in its requirements for WBDBO with regard to safety staircases and does not detail measures to meet the requirements. The explanatory notes to the Building Decree (p. 247) state that "A safety staircase is an escape staircase into which no fire and smoke can penetrate". The notes imply, but do not specify, that a safety staircase must always be accessed via a space open to the air in order to protect it from smoke. There are also requirements for 'smoke compartments' [i.e. protected lobbies] to stairways in buildings with a storey > 50 m (see Table A2.11).

Of the other countries, protected lobbies are only required for stairways in Belgium, France, and Sweden. However, it should be noted that in England and Wales, and possibly in other countries, protected corridors normally have two doors between fire risks (i.e. accommodation) and stairways, which is similar in effect to a protected lobby. The highest standard is in Belgium, which requires stair lobbies even for medium and low buildings.

Further measures include the restriction of services and materials within a protected stairway.

A2.12 Conclusions

The Comité Européen de Normalisation (CEN) completed approval of a harmonised system to classify the reaction to fire performance of construction products in 2002, but there is no harmonisation of the description of fire safety strategies. Mostly, the national approaches are similar if differently expressed, but there are some significant differences in levels of requirements. It is difficult to understand why there should be such diversity in travel distances, or in periods of fire resistance between neighbouring dwellings, for there cannot be national differences between the speed of people's movements, or the development of fire.

Despite the length and complexity of the analysis, it does not yet represent a complete account of fire safety controls for residential buildings. Firstly, national building regulations do not encompass all the issues of fire safety. There may be further legislation at national level which addresses provision

for high risk accommodation or mixed-use buildings, and local legislation which addresses site-specific issues. Also, there is a considerable body of controls on the management of buildings, including the licensing of certain types of premises such as sheltered accommodation for older people.

Secondly, all the systems studied refer to national standards for background information, but the Building Decree in the Netherlands is unusually reliant on national standards for the interpretation of strategic issues and it was not possible to understand the scope of requirements from the main document alone. For instance, the requirements for resistance to spread of flame across the enclosure of a fire compartment refer to a national standard (an *NEN*). We learnt from a consultant that this does not specify conditions, such as the distance of openings from party walls, but gives a method to calculate fire radiation at particular points on façades. Examples of practical solutions are given in further guidance (an *NPR*), including the size of windows related to the distances between facades.

Guidance on the interpretation of building regulations is particularly important for fire safety issues. The tasks of the designer of buildings and the designer of building regulations should be complementary, but each has a different perspective on information about fire safety. Ideally, designers would develop proposals for buildings by considering the possible sources of fire, the nature of occupancy, and the requirements for escape from different places around the building. Their approach to design would be informed by a set of strategic principles, from which detailed tactics could be deduced. However, it is probably much more common for designers to apply the requirements of building regulations to already-developed designs. In either case, there is a design that can be tested against the demands of fire safety.

In contrast, building regulations must provide information that is capable of being applied in a good many different situations. Unless there is a demonstration of the application of fire safety requirements to a variety of planning configurations, the information is essentially generic and requires a degree of interpretation in practice. Guidance can supply such interpretation or refer to secondary sources. It can also have an educational role in describing the rationale that underlies the requirements.

Comparison was further complicated by some of the difficult features of the Building Decree's expression of requirements mentioned earlier:

- limited explanation of the strategies that underlie the requirements;
- use of specialised terminology with insufficient explanation of its interpretation in terms of spatial conditions and insufficient definition of the expressions used;
- the long-winded descriptions that arise from the formulation of requirements followed by qualifying conditions or exemptions, and the generic description of 'user functions', which creates long-winded descriptions.

The international comparison of levels of fire safety requirements was further complicated by differences in the application of requirements, with differing criteria and classifications of buildings. Often, it was possible to identify the highest and lowest levels of requirements overall, but in the case of the fire-resistance of structure and compartments, the comparison had to be rationalised by considering the requirements that would apply to two-storey houses and to blocks of flats with differing numbers of storeys.

There are three common bases for the classification of buildings: function, type of buildings, and height. There are relatively few instances where the application of requirements for dwellings is related to floor area. Countries vary in the ways in which they differentiate between requirements for living accommodation and other functions. In some cases this reflects the overall format of the regulations, for instance in France where there is dedicated legislation for residential buildings. More commonly, fire safety regulations must make special mention of dwellings, with sub-sections for dwellings and other buildings for certain issues, but not for others. In the Netherlands, the application of requirements is identified in 'navigation' tables. Belgium is unusual in having requirements which are applied without differentiation of function, but do not apply to single family houses. Some countries have clearly different requirements for flats and houses, some also differentiate between detached and joined single family houses, while others have combined requirements for flats and houses, but with differences related to height.

One might anticipate that the fire safety classification of buildings would clearly relate to fire-fighting equipment and the time it would take to evacuate the building, but there is considerable variation in the classification of buildings by height. The upper limit of the first safety class varies from 4.5 m in England and Wales, to 28 m in France. There is similar variation in the highest safety class, with tall buildings classified either directly (for instance in France, as buildings over 50 m tall), or by implication (for instance in Sweden, as buildings with three or more storeys). In Belgium, the only classification of buildings is by height, with differing requirements for low, medium and tall buildings.

One result of basing the analysis on only part of the fire safety requirements of the Building Decree is that it does not fully explore requirements for mixed use buildings.[29] One of the most demanding areas of fire safety design is the interface between accommodation for different functions in mixed use buildings. Mixed-use buildings raise issues about the separation of different functions with fire-resisting construction, the protection of escape routes, the

29 There are also requirements specific to housing for vulnerable people, such as residential care homes for the elderly, which are not addressed in the analysis, due to the limited selection of sections of the Building Decree.

extent and management of alarm systems, implications of security systems for fire safety, external spread of flame between functions, and, in tall buildings, the extent of sprinkler systems. The drafting of the Building Decree, with its use of generic user functions, was intended to clarify the requirements of differing functions in mixed use buildings, but the structure of the regulations means that it is left to the accompanying notes to explain that the highest standard must be used where differing functions use the same space.

The BD includes four fire safety strategies that are common to all, or almost all, of the countries studied:

- stability in case of fire (fire resistance of structure);
- limitation of spread of fire (compartmentation);
- escape routes;
- limitation of the development of fire (spread of flame, characteristics of internal and external surfaces).

It includes one issue that is only addressed by two other countries for general needs housing:

- fire or smoke detectors and alarms.

Some countries have requirements to limit the spread of smoke, but none uses the same strategy as the Building Decree:

- limitation of spread of smoke (smoke compartmentation).

None of the other countries includes requirements for:

- limitation of smoke development (smoke production density of internal surfaces).

Product standards were not explored, but it is worth noting that until the harmonised European standards for testing are adopted, there may be differences between countries in the constructions that satisfy the same requirements for fire resistance.

There is considerable similarity between countries in the four primary strategies, but there are some notable differences in the application and levels of requirements for fire safety. The lack of any requirements for single-family houses in Belgium is probably easiest to understand as a political, non-interventionist policy. In fact there are very few controls on single family housing in most of the other countries. Similarly, the Netherlands no longer controls the fire resistance of doors on escape routes, as the result of a Market Forces, Deregulation and Legislative Quality (MDW) inquiry that decided the performance requirements for fire safety were too rigorous.

It is more difficult to understand why levels of requirements should vary. For instance, each country specifies periods of fire resistance to protect the stability of elements of structure. There is usually no difference between levels of requirements for walls and floors, but there are varying levels of requirements related to height, except in France and Norway. Presumably,

periods of fire resistance are calculated to provide sufficient time for escape and fire-fighting, or based on empirical study. It would be interesting to know, but impossible to discover, why France has lower levels of requirements than other countries for both single family houses and blocks of flats. Equally, it would be interesting to discover whether there is any correlation between the rate of death and injury in fires and the levels of requirements for fire resistance.

The strategy of compartmentation is designed to limit the spread of fire by containment within fire resisting walls and floors. As well as reducing the danger of trapping the occupants, the size of the fire is limited, reducing the danger to occupants, fire fighters, and people in the vicinity of the building. Requirements usually vary according to user function and the size of buildings.

Each country, apart from France and Germany (Hesse) has some requirements for the compartmentation of residential buildings. Only the Netherlands uses the concepts of 'sub-fire compartments' and 'smoke compartments', in addition to fire compartments. In practice, the strategic requirements in the Netherlands are similar to those in Denmark, England and Wales, Norway and Sweden, where each self-contained dwelling, whether it is a house or a flat, must form a fire compartment. This should allow one flat to be occupied, even if there was a fire in a neighbouring flat. Where each flat must form a compartment, the wall between flats and the escape route protects the escape route from a fire that starts in a flat, but in the Netherlands the entrance door to a flat need not be self-closing, unlike other countries. This exception is difficult to understand: self-closers are intended to protect escape routes during evacuation, because although people would usually close the door to their home as they leave, they many not do so when escaping from a fire.

There are no specific requirements for the compartmentation of individual flats in Belgium. Neither France or Germany (Hesse) uses the term 'compartmentation' in relation to dwellings, but there are requirements for the fire resistance of walls and floors between flats. There are also some requirements to sub-divide groups of houses with fire-resisting construction, either limiting the area of groups of houses in Sweden, or the length of long terraces in France and Germany. It is common to require the separation of basements from other parts of the building, by means of a fire-resisting floor and a door to separate basement escape stairs and stairs from upper storeys, but this is not usually described as compartmentation.

The greatest diversity in strategies lies in the provision of means of escape. Although there are some requirements for two independent escape routes, several countries allow rescue as a second route, and all allow a single escape route in various circumstances. The only absolute requirements for two independent escape routes are for tall buildings, in Belgium (buildings with floor

of top storey > 25 m), and Denmark (lower edge of rescue opening > 23 m). In France, a second stairway is optional even in category 4 buildings (top floor 28-5 0m). Relaxations allowing alternative routes are usually related to the height of buildings, but some are also related to the protection of stairways or to travel distances. Rescue is allowed as an alternative route from dwellings in blocks of flats, in Denmark, France, Germany (Hesse), Norway, and Sweden. None of the countries requires a protected escape route from upper storey bedrooms in two-storey houses, but England and Wales requires windows for emergency egress from storeys up to 4.5 m above ground level.

There is no explicit mention of the situation when a fire starts (or is started) in the hallway of a dwelling, or a corridor outside a dwelling, so that the first stage of escape is blocked. Indeed, in Denmark and France there are no controls on escape from within dwellings. There are requirements in England and Wales for the protection of hallways within dwellings by fire-resisting room doors, for flats with floors more than 4.5 m above the ground, but this strategy is intended to allow long internal travel distances, rather than protect the rooms within the flat. However, the provision of alternative exits via windows, balconies or doors to escape routes distant from the entrance, could provide a safe escape from such a fire.

The issues of maximum travel distances, and the number and location of exits are common to most countries, but expressed quite differently. The requirements are probably mostly clearly explained in England and Wales, where diagrams are used to demonstrate various conditions. Each country limits horizontal travel distances in common escape routes, but only Belgium, England and Wales, Germany (Hesse), and the Netherlands address travel within flats or maisonettes. Comparisons require particular care because different start or finish points are described, and there are qualifying conditions for some of the requirements. Limits on travel distances from dwelling entrances to a stairway fall into two categories: relatively short distances which seem to relate to blocks with a single, central stairway, and much longer distances for corridor or balcony access. The lowest standard is in Sweden, which has a single recommendation, 30 m.

The requirements for smoke alarms in England and Wales, the Netherlands, and Norway enhance generally low standards for escape within dwellings. In the Netherlands, alarms can be used to safeguard open planning, so that an escape route may pass through a living room, instead of passing through a separate circulation route if an additional detector is provided. Open planning may appear to imperil escape, but early warning may be more effective in saving lives than the provision of a dedicated escape route within a dwelling. The value of smoke alarms has been demonstrated by progressive reductions in fatal and non-fatal injuries in the USA. In England and Wales, the contribution of smoke alarms to reductions in rates of death in domestic fires is confused by the impact of legislation to control the

characteristics of furniture.[30] However, fire safety statistics[31] show that "Fires discovered by smoke alarms continued to be discovered more rapidly after ignition, be associated with lower casualty rates and cause less damage".

Limits on travel distances from dwelling entrances to a stairway fall into two categories: relatively short distances which seem to relate to blocks with a single, central stairway, and much longer distances for corridor or balcony access. The lowest standard is in Sweden, which has a single recommendation, 30 m.

Each country limits characteristics of internal surfaces of stairways or escape routes, in terms of surface spread of flame and rate of heat emission when burning. Some also have requirements for rooms. There are more requirements for ceilings and walls than for floors. England and Wales explains that the upper surfaces of floors and stairs "do not play an important part in fire spread in the early stages of a fire that are most relevant to the safety of occupants", but each of the other countries has requirements for floor surfaces, at least in escape routes. It is not possible to compare the specified levels of requirements, due to the different testing and classification systems. Only the Netherlands limits the rate of smoke production of surfaces. Only Denmark and England and Wales have requirements for the internal surfaces of private areas of single family housing.

All countries have some limitations on characteristics of external surfaces of façades, but there is considerable variation in the scope of requirements. Some distinguish different levels of requirements for parts of façades related to: the height of the façade; the height of buildings; the distance of the façade from a boundary; or the classification of the building. There are few requirements to limit the vertical spread of flame between storeys. Norway is alone in allowing reduced levels of requirements for external surfaces related to access for fire services. The Netherlands is unusual in differentiating between external surfaces on certain categories of escape routes and other parts of the building. Other countries do not deal with the protection of buildings from neighbouring buildings. Differences in classification systems and reliance on secondary sources to explain such systems, make it difficult to compare levels of requirements for characteristics of external surfaces. The analysis did not discuss limits on the size or location of unprotected areas of façades, such as windows, because there are no requirements in the Building Decree, but this is clearly a significant strategy in some countries, including Denmark, and England and Wales. Also, we were not asked to analyse the section that contains requirements for external spread via roofs.

None of the building regulations studied specifies materials or construc-

30 Polymer Research Centre/DTI (2000).

31 Watson, L., Gamble, J., & Schofield, R. (2000).

tions deemed to satisfy the requirements, although England and Wales includes some typical performance ratings for internal linings.

Despite the independent development of fire safety regulations, there are very few instances of emphases peculiar to only one country. However, these few examples raise some interesting questions. For instance, the predominance of single family houses in England and Wales, coupled with the age of the housing stock, probably explains the inclusion of a section on attic conversions, but it isn't clear why there is no explicit mention of the issue in other countries. It may be that escape within a dwelling from a third storey room is not perceived as a particular risk, or because it is not politically acceptable to control the interiors of single-family houses, except where they affect their neighbours.

Of the countries studied, only the Netherlands controls the smoke production of internal surfaces, particularly the walls and ceilings of escape routes. Other countries do not address the limitation of smoke production but requirements to limit spread of flame would often serve the same purpose, with the use of materials of limited combustibility. The primary strategy in most countries is to keep escape routes clear of smoke, by limiting the ingress of smoke with smoke control doors and smoke ventilation.

The Netherlands appears to be unique in specifying the sub-division of fire compartments into smoke compartments, but without reading the associated *NEN*, it is not possible to tell from the Building Decree whether there is a significant difference between the practical implementation of its requirements for smoke compartmentation and requirements in some other countries to limit smoke leakage at doorways or for fire dampers operated by smoke detectors. This section of the Building Decree also requires lobbies to protect stairways in buildings with habitable space on storeys above 50 m. This is similar to requirements for smoke-protected lobbies in other countries, but is different in the sense it describes them as smoke compartments. In contrast to the Netherlands, Belgium only addresses the issues of fire and not smoke, to the extent that the word 'smoke' does not appear in the annexes giving the requirements.

The Building Decree is unique amongst the countries studied in terms of its definition of 'permanent fire load density', which includes consideration of structure while discounting the contribution of most interior finishes. This appears to be different from the Scandinavian description of 'fire load intensity'. The Dutch differentiation between escape routes that are 'fire-free and smoke-free', and those that are 'smoke-free' is confusing, but this appears to be a simple issue of the formulation of requirements, because smoke free-routes are already fire-free.

Instead of requirements for the fire resistance of doors on escape routes, the Netherlands requires mains-wired smoke alarms. While this might be seen as prejudicing the success of sub-fire compartmentation and smoke

compartmentation, this choice reflects the priority of protection of life, rather than property. Early warning should ensure that escape is complete long before a compartment would be breached.

Appendix 3 Prevention of burglary

A3.1 Introduction

This chapter considers two sections of the Building Decree:
- 2.24 Entrance of a building
- 2.25 Prevention of burglary

A3.2 Entrance of a building and prevention of burglary

This section of the Building Decree comprises:
- Articles 2.210-2.213 Access to prevent common crimes
- Articles 2.214-2.215 Resistance to burglaries

The Netherlands is the only one of the countries studied to include requirements for the prevention of burglary in its building regulations.[1]

Denmark is the only other country to consider burglary in its building regulations, but instead of specifying requirements it gives recommendations by reference to a national code of practice. In contrast, England and Wales states that locks should not be the subject of building regulations.[2]

This is not to say that other countries are unconcerned with the prevention of burglary, only that the provision and quality of security devices is left to other mechanisms, such as the conditions of insurance companies, which refer to national standards. For example, in Germany there is no statutory requirement to fit devices to a particular standard, but *DIN 18054*, *DIN 18073, and DIN 18103* define classes of resistance for windows, roller shutters, blinds, and doors.

There are also a number of police schemes to promote safer housing. For instance, the Police in England and Wales run a quality labelling programme *Secured by Design,* which emphasises that sites should allow supervision by residents to make it easy to identify intruders, as well as setting standards for building elements and ironmongery. The label is associated with an increment in funding for social housing.[3]

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1 A requirement in Germany (Hesse), for dwelling entrances to be lockable was removed in the 2002 revision of the *HBO*.

2 "*The need for easy and rapid evacuation of a building in case of fire may conflict with the control of entry and exit in the interest of security. Measures intended to prevent unauthorised access can also hinder entry of the fire service to rescue people trapped by fire.... It is not appropriate to seek to control the type of lock used on front doors to dwellings under the Building Regulations.*" (*Approved Document B: Fire Safety.)*

3 *Secured by Design* certification plus a 'Good' rating under the environmental impact labelling scheme *Eco-Homes* can be rewarded by a Sustainability supplementary multiplier in the calculation of total costs eligible for subsidy by The Housing Corporation.

Table A3.1 Entrance of a building, prevention of burglary

	Entrance of a building	Prevention of burglary
Belgium		
Wallonie	–	–
Denmark	Reference to NP 206 Code of practice for technical prevention of burglary.	
England	–	–
France	–	–
Germany	Special entrance to dwellings in mixed use buildings.	–
Hesse 2002		
Netherlands	*Dwellings in blocks of flats:* *New and existing buildings:* Entrance to apartment buildings to prevent common crimes. Self-closing door, only opened with key from outdoors (explanatory notes state that this also includes a magnetic code card). At least one entrance must have a device that gives a signal perceptible inside the flat [i.e. a door buzzer] *New build only:* At least one entrance to have an intercom that can be operated and can open the door from the non-habitable area of a flat accessed from the entrance [i.e. hallway].	*New build, all dwellings (except caravans):* Buildings to offer resistance to burglary. Doors, windows, frames and comparable parts of structures: burglary-resistance class 2. Reference to NEN 5087, NEN 5096. Applies to : - external walls accessible to burglars - internal walls between flat and room not located in the flat (Building Decree explanatory notes give examples of surgeries, offices, garages, a shared porch or shared lounge).
Norway	–	–
Sweden	–	–

There is a similar labelling scheme in the Netherlands, the *Police Department Quality Mark for Safe Housing*, which includes speed-limiting measures, public lighting, and design for surveillance, as well as devices to prevent burglary. The Building Decree explanatory notes compares burglary resistance class 2 to the standard of the *Police Department Quality Mark for Safe Housing*, and comments that the requirements mean that a burglar would need 3 minutes to break into a dwelling.

A3.3 Conclusions

The Netherlands is the only one of the countries studied to include mandatory requirements for the prevention of burglary in its building regulations. The protection of possessions is not normally a building regulations issue, but it may be argued that entrance by intruders could lead to personal assault, and the Building Decree explanatory notes suggest that requirements for locks and hinges contribute to social safety.

The prevention of burglary demands consideration of site planning rather than just building-related measures. The narrow range of requirements in the Building Decree (for burglary-resistant doors and windows, and for a door entry intercom system in blocks of flats) contrasts with the broad scope of

issues covered by quality labelling schemes, such as *Secured by Design* in England and Wales, or the *Police Department Quality Mark for Safe Housing* in the Netherlands. Other very basic requirements for the entrance to a block of flats apply to both new and existing buildings: a self-closing door, opened from outside with a key or magnetic coded card, and a door buzzer. There is no requirement to make doors and windows in existing buildings burglary-resistant.

It is interesting that whilst the scope of the Building Decree is being expanded by the addition of requirements to prevent burglary, the rolling review of the Building Regulations for England and Wales is eliminating any issues that do not further the central objectives of health and safety, energy conservation and accessibility.

Appendix 4 Noise

The following analysis was prepared jointly with Sophie Maluski of the Acoustics Research Unit of the University of Liverpool.

A4.1 Introduction

The following analysis is based on three sections of the Building Decree:
- 3.2 Protection against noise from installations
- 3.3 Sound insulation between habitable rooms within one unit
- 3.5 Sound insulation between rooms in different user functions

It does not consider two other sections which address issues of acoustic performance:
- Protection against external noise
- Limitation of reverberation

Each section applies to new buildings, but also includes requirements for alterations or extensions to existing buildings.

A4.1.1 Noise in dwellings

Noise control requirements are designed to limit the intrusion of unwanted sound. Noise nuisance accounts for a considerable proportion of neighbour disputes. For instance, in England and Wales, there are 5000 complaints about noise per million population.[1]

The main types of noise which cause annoyance to people in dwellings are:
- noise from domestic activities: internal sources of noise, propagated within the building, such as speech, music and TV transmitted through walls and floors, or footsteps and movement of furniture transmitted through ceilings;
- noise from equipment in buildings: sources may include heating systems, ventilation systems, lifts, laundries, WCs, water supply systems and refuse chutes; and
- environmental noise: external sources of noise such as traffic, aircraft and industrial noise transmitted into the building via facades, windows, roofs etc.
- These different types of noise are transmitted in the building either by air or by the structure of the buildings:
- airborne transmission whereby noise is transmitted via the air, for example speech, music, TV, aircraft, traffic noise and some domestic appliances;

1 Chartered Institute of Environmental Health (2001) *No Noise is Good Noise.*

- impact transmission whereby noise propagates by putting into vibration the internal surfaces of the room, from sources such as footsteps, movement of furniture, vibrations caused by ventilation systems, lifts, water supply systems, WCs and refuse chutes; and
- flanking transmission whereby sound is transmitted indirectly through elements of structure other than a separating wall or floor; for example when someone walking on the fourth floor is heard on the ground floor or the sound of a hi-fi is transmitted via a side wall between neighbouring rooms.

A4.1.2 Descriptions of acoustic performance

There are various important differences and similarities between acoustic parameters that may need explanation in order to understand this analysis. This section gives a brief explanation of terms and measurements used in acoustics.

I Sound pressure level

Sound is an energy that propagates via a medium – air or structure. This propagation creates an acoustic wave, which is characterised by its amplitude and frequency. Sound pressure levels are measured in decibels (dB), a logarithmic unit which is used to reflect the nature of the ear's response to sound.

Sound pressure levels range from the rustle of leaves at 10dB, to ordinary conversation at 50dB, to a jet airplane at 130dB. Small differences in decibel levels of continuous sound are difficult to detect: 3dB is the smallest audible change that can be detected over time; 5dB is easily perceptible; 10dB is twice as loud. If there is more than one source of noise, with one source louder than the other, the resultant sound pressure level is only a little higher than the highest level. If two sources have the same level the combined pressure level is 3dB greater than the individual level.

II Airborne sound insulation

Airborne noise or sound created for instance by conversation or music, is absorbed and reflected by the room boundaries, but if the energy is sufficient it puts into vibration the structure of the building which then radiates into the adjacent rooms, creating unwanted noise. The transmitted sound energy in the adjacent room is controlled by the material properties of the wall or floor:

- the stiffness, mass and damping of the wall;
- the dimensions of any wall cavity;
- type and thickness of the material inserted inside the cavity; and
- connections between leaves if the party wall is a double wall.

The airborne sound insulation characteristics of a wall or floor may be

described in terms of the sound reduction index, apparent sound reduction index and/or the standardised level difference.

a) Measurements of airborne sound insulation characteristics of an element of construction

The characteristics are identified by measuring the sound pressure level difference between the source room (the room with the noise source) and the receiving room (to which the noise is transmitted). The level difference is then corrected by a factor which takes into account the reverberance of the receiving room.

R Sound reduction index: characterises the sound insulation characteristics of a wall or floor; R is measured in a laboratory, where the source room and receiving room are isolated, with no flanking transmission.

R' Apparent sound reduction index, measured in the field, where there may be flanking transmission between the two rooms.

D_n Level difference between the source room and the receiving room, measured in the field.

D_{nA} Level difference corrected by the standard absorption area of A=10 m^2 for the receiving room.

D_{nT} Standardised level difference, i.e. D_n corrected by the standard reverberation time T of the receiving room.

b) Indices characterising the airborne sound insulation performance of the wall

The different indices, measured from 100Hz to 3150Hz, can be characterised by a single value number, which is estimated by comparing, frequency band by frequency band, the measured curve to reference curves given in *EN ISO 717:1:*

R_w Weighted sound reduction index, laboratory measurement.

R'_w Weighted apparent sound reduction index, field measurement.

$D_{nT,w}$ Weighted standardised level difference, field measurement. This may be corrected by the correction terms C or C_{tr}:[2].

$D_{nT,A}$ Weighted standardised level difference measured with 'pink noise' in dB(A), field measurement: $D_{nT,A} = D_{nT,w}+C$.

$D_{nT,A,tr}$ Weighted standardised level difference using the traffic noise correction term, field measurement: $D_{nT,A,tr} = D_{nT,w}+C_{tr}$.

Values of airborne sound insulation that are measured in the laboratory dif-

2 The correction term C is appropriate to speech, music, radio, TV, noise from children playing, and for some outdoor noise such as medium and high frequency noise from factories, or noise from motorways with traffic faster than 80 km/h. C_{tr} is appropriate to noise such as urban traffic, trains at low speed, aircraft, night-club music, or low and medium frequency noise from factories. It is mentioned here because C_{tr} is now used in England and Wales, with reference to separating walls and floors between dwellings.

fer from field measurements of the same construction because, unlike dwellings, the source room and receiving room are well isolated from each other another and there is therefore no flanking transmission.

The larger the index, the higher the level of airborne sound insulation. The human ear can roughly identify the sound insulation characteristics of walls between dwellings or between rooms and another part of the building:

- normal conversation next door could be heard distinctly if the wall has a sound reduction index of 30dB (laboratory measurement);
- normal conversation next door could be heard with difficulty if the wall has a sound reduction index of 40dB (laboratory measurement);
- loud conversation or music next door could be heard distinctly if the wall has a sound reduction index of 50dB (laboratory measurement);
- loud conversation or bass from a hi-fi next door could be heard with difficulty if the wall has a sound reduction index of 60dB (laboratory measurement).

A wall with a sound insulation index greater than 60dB will isolate any type of sound. Such walls can be found between cinema projection rooms, or between music practice rooms.

III Impact sound insulation

A direct impact on a building element that separates two spaces creates impact sound, which may be transmitted through that element. Requirements to limit impact sound usually refer to floors, but can also apply to walls.

a) Measurements of impact sound level between rooms

Impact sound levels are measured in a room where the floor above is excited by an impact source, such as a tapping machine. The level is then corrected by a factor taking account the reverberance of the room:

L_n, L_{nA} Normalised impact sound pressure level in the room, laboratory measurement; level corrected by the standard absorption area of the room.

L'_n, L'_{nA} Normalised impact sound pressure level in the room, field measurement; level corrected by the standard absorption area of the room.

L'_{nT} Standardised impact sound pressure level: sound pressure level in the room corrected by the standard reverberation time T; field measurement.

b) Indices characterising the impact sound insulation performance of the floor

Impact sound pressure levels are single values, calculated by adjusting the measured curve to a reference curve defined in EN- ISO 717:2. They are identified by the letter 'w', meaning weighted:

$L_{n,w}$ Weighted normalised impact sound pressure level; laboratory measurement.

L'_{nAw} Weighted normalised impact sound pressure level in the room corrected by the standard absorption area of the room; field measurement.

$L'_{nT,w}$ Weighted standardised impact sound pressure level corrected by the standard reverberation time T; field measurement.

Unlike airborne sound insulation, the impact sound insulation is quantified by measuring the sound pressure level in the receiving room, rather than a difference in levels between rooms. Thus, a lower weighted sound pressure level represents a higher level of requirements for impact sound insulation.

A4.1.3 Sources of requirements for acoustic performance

Building regulations contain detailed requirements for acoustic performance in Denmark, England and Wales, France, the Netherlands, and Norway. All refer to national standards, which in turn refer to European-International standards (EN ISO). Current legislation or relevant parts of current legislation, together with relevant national standards is listed in Table A4.1.

In Belgium there are no specific requirements in federal legislation but *CWATUP*, the development code in Wallonie, enables the regional government to issue regulations on acoustic qualities. In practice, the acoustic performance of buildings in Belgium (Wallonie) relies on the implementation of national standards, which are occasionally tested in court cases. Revisions to the national standards have been expected for some time.

The building regulations in Germany (Hesse) and Sweden only give general performance requirements for acoustic performance. Each relies on national standards to give levels that are deemed to comply with the requirements.

A4.1.4 Acoustic parameters

Each country refers to national standards for definitions and methods of measurement. Most have incorporated international standards, but even where the national standards refer to the same international standards, they adopt slightly differing acoustic parameters (see Table A4.2).

A recent European norm, *EN 12354*[3], gives methods of calculation to evaluate the acoustic performance of buildings from the performance of elements.

3 *EN 12354-1:2000, EN 12354-2:2000, EN 12354-3:2000, EN 12354-4:2000: Building Acoustics - Estimation of acoustic performance of buildings from the performance of elements: Part 1: Airborne sound insulation between rooms; Part 2: Impact sound insulation between rooms; Part 3: Airborne sound insulation against outdoor sound; Part 4: Transmission of indoor sound to the outside.*

Table A4.1 Current requirements for noise protection in dwellings

	Latest edition of noise protection regulations	Relevant sections for general needs housing	National standards referred to in legislation
Belgium			
Federal	—	—	—
Wallonie	*Code wallon de l'Aménagement du territoire, de l'Urbanisme et du Patrimoine* (AERW du 14 mai 1984; last amended AGW du 10 juin *1999).*	SECTION IV: Urban Regulations; CHAPTER I: Regional urban regulations: Article 76: 5.	*NBN S01-400 (1977) Acoustique – Critères d'isolation acoustique.* *NBN S01-401 (1987): 'Valeur limites des niveaux de bruit en vue d'eviter l'inconfort dans les batiments' (in-situ).* *NBN S01-402 (1991) Acoustique – Niveaux caractéristiques des bruits d'environnement.*
	[The recommendations in NBN S01-400:1977 will soon be replaced by indices that are "more coherent in terms of both European legislation and psycho-acoustics" (www.bbri.be/antenne_norm). Although the Belgian NBNs do not have the status of legislation, Courts consider the standards in cases of complaint.]		
Denmark	*Building Regulations BR-95* (1995).	Part 9 Resistance to the passage of sound. 9.1 General. 9.2 Domestic buildings, hotels, nursing institutions etc.; 9.2.1 Airborne sound insulation; 9.2.2 Impact sound pressure level; 9.2.3 Reverberation time; 9.2.4 Noise level. Appendix 4 Measurement of sound insulation in buildings and of building elements.	*DS/EN ISO 140 (1998) Akustik. Lydisolationsmålinger i bygninger og af bygningselementer.* *DS/EN ISO 717-1(1997) Akustik. Vurdering af lydisolation i bygninger og af bygningsdele.* *DS/ISO 1996 (1983 & 1991) Akustik. Måling og beskrivelse af ekstern støj. Del 1: Grundlæggende størrelser og fremgangsmåder [environmental noise].*
	Building Regulations for Small Dwellings BR-S 98 (1998).	4.4 Resistance to passage of sound [traffic noise]. 7.1.6 Services: general. 9.8 Joined single-family houses: resistance to passage of sound.	*NT ACOU 069 (1988) Doors in buildings: airborne sound insulation.*
England and Wales	*Building Regulations, 2000. Approved Document E: Resistance to the passage of sound* (2003)	E1 Protection against sound from other parts of the building and adjoining buildings. E2 Protection against sound within a dwelling-house etc. E3 Reverberation in the common internal parts of buildings containing flats or rooms for residential purposes.	*BS EN ISO 140: 1998 Measurement of sound insulation in buildings and of building elements.* *BS EN ISO 717 Methods for rating the sound insulation in building elements.*
France	*Code de la Construction et de l'Habitation (CCH).*	*Limitation of internal noise.* R.111-23-1, R.111-23-2 Also, *traffic noise:* R.111-4-1.	*NF S31-057 (1982) Acoustique – Vérification de la qualité acoustique des bâtiments.*
	Arrêté du 30 juin 1999 relatif aux caractéristiques acoustiques des bâtiments d'habitation (Acoustic characteristics of dwellings).		*NF EN ISO 140 (1998).*
	Arrêté du 30 juin 1999 relatif aux modalités d'application de la réglementation acoustique (Methods of application of acoustic regulations).		*NF EN ISO 717 (1997). Acoustique – Évaluation de l'isolement acoustique des immeubles et des éléments de construction.*
	Also: Traffic noise: *Décret n° 95-21 du 9 janvier 1995,* reference to *Loi n° 92-1444 du 31 décembre 1992.*		

	Latest edition of noise protection regulations	Relevant sections for general needs housing	National standards referred to in legislation
Germany *Hesse*	*Hessische Bauordnung (HBO)* (Building Ordinance, State of Hesse) (18 June 2002).	14.2 Noise control.	*DIN 4109 (1989) Schallschutz im Hochbau – Anforderungen und Nachweise; Beiblatt 1 (1989, A1 2001) – Aus führungs-beispiele und Rechenverfahren; Beiblatt 2 (1989) Hinweise für Planung und Ausführung; Vorschläge für einen erhöhten Schallschutz; Empfehlungen für den Schallschutz im eigenen Wohn- oder Arbeitsbereich; Beiblatt 3 (1996) Berechnung von* $R'_{w,R}$ *für den Nachweis der Eignung nach DIN 4109 aus Werten des im Labor ermittelten Schalldämm-Maßes* R_w*; Beiblatt 4 (2000) – Nachweis des Schallschutzes; Güte- und Eignungsprüfung.*
Netherlands	*Bouwbesluit* (Building Decree) (2001)	3.1 Protection against external noise; 3.2 Protection against noise from installations; 3.3 Sound insulation between habitable rooms within one unit; 3.4 Limitation of reverberation; 3.5 Sound insulation between rooms with different user functions. All sections apply only to new buildings.	*NEN 5077 (1991, revised 1992) Geluidwering in gebouwen: bepalingsmethoden voor de grootheden voor luchtgeluidisolatie, contactgeluidisolatie, geluidwering van scheidingsconstructies en geluidniveaus veroorzaakt door installaties.*
Norway	*Tekniske forskrifter til plan- og bygningsloven av 14. juni 1985 nr. 77.* (Technical Regulations under the Planning and Building Act) (1997).	8-4 Building acoustics and vibrations; 8-41 Documentation; 8-42 Protection against noise: 1. General requirements; 2. Airborne sound; 3. Impact sound; 4. Reverberation; 5. Noise from technical installations; 6. Outdoor noise. [NB refers to NS 8175 for levels of requirements.]	*NS 8175 (1997) Lydforhold i bygninger – Lydklasser for ulike bygningstyper* [Also refers to 27 Norwegian Building Research Institute leaflets.]
Sweden	*Boverkets byggregler BFS 1998: 38* (1999).	Chapter 7 Bullerskydd Protection against noise: 7.1 General; 7.2 Dwellings.	*SS 02 52 54 (1)* (1999) *Byggakustik – Mätning av ljudisolering i byggnader och hos byggnadselement; SS 02 52 63 (2)* (1996) *Byggakustik – Mätning av ljudnivå i rum – Fältprovning; SS 02 52 67 (2)* (1998) *Byggakustik – Ljudklassning av utrymmen i byggnader-Bostäder SS ISO 717/1; SS ISO 717/2.*

Titles of European-International standards common to at least two countries:
EN ISO 717-1 (1996) Acoustics - Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation; and EN ISO 717-2 (1996) - Part 2: Impact sound insulation.
EN ISO 140-4 (1998) Acoustics – Measurement of sound insulation in buildings and of building elements - Part 4: Field measurements of airborne sound insulation between rooms; and EN ISO 140-7 (1998) - Part 7: Field measurements of impact sound insulation of floors.

Table A4.2 Acoustic performance: form of requirements

KEY	References: Ref: method and calculation; Ref A: method of measurements; Ref B: rating method			
	Internal noise from equipment	**Airborne sound insulation**	**Impact sound insulation**	**Examples of compliance in primary source**
Belgium *Wallonie*	LAeq (dB(A)), refers to Noise Rating curves NBN 576_11.	Dn, *NBN S01-006:1975. NBN EN ISo 140-4:1998.*	Ln, *NBN S01-008:1975. NBN EN ISo 140-7:1998. NBN EN ISo 717-2:1997.*	No.
	Noise Rating curves are sets of single-number weighting curves, adopted by ISO.			
Denmark	L_{Aeq} (dB(A)) Building Regs for Small Dwellings refers to L_{Aeq}'T (dB) Ref A: *DS/ISO 1996.*	R'_w (dB) Ref. A: *DS/ISO 140 Part 4.* Ref. B: *DS/EN ISO 717-1:1997.*	$L'_{n,w}$ (dB) Ref. A: *DS/ISO 140 Part 7* Ref. B: *DS/EN ISO 717-2:1997.*	*Building Regulations:* Yes, in Appendix 4; also refers to SBI *Direction 172, 173. Building Regulations for Small Dwellings:* No; refers to *SBI Direction 189.*
England and Wales	–	$D_{nTw} + C_{tr}$ (dB). Ref. *A: BS EN ISO 140: 1998 part 4*; Ref B: *BS EN ISO 717: 1997 part 1.* R_w (dB) [for walls within dwellings]. Ref. B: *BS EN ISO 717 : 1997 part 1.*	L'_{nTw} (dB). Ref. A: *BS EN ISO 140: 1998 part 7*; Ref. B: *BS EN ISO 717: 1997 part 2.*	Yes.
France	L_{nAT} (dB(A))	$D_{nT,A}$ (dB) now replaced by D_{nTw} +C. $D_{nT,A,tr}$ (dB) (for extensions; now replaced by $D_{nTw} + C_{tr}$). Ref. A: *NF EN ISO 140-4: 1998 (NF S31-049).* Ref. B: *NF EN ISO 717-1: 1997 (NF S 31-032-1).*	L'_{nTw} (dB) Ref. A: *NF EN ISO 140-7: 1998.* Ref. B: *NF EN ISO 717-2: 1997 (NF S 31-032-2).*	No.

This offers an alternative way to identify the type of separating wall or floor that complies with requirements. As yet none of the countries studied has adopted this method, but it is expected that the German *DIN* standard will soon take account of *EN 12354*.

A4.1.5 Application of requirements

Several countries have developed classification systems that relate types of area or types of housing to a range of requirements for sound insulation. In Belgium, there are four categories, 1 - 4, for protection against environmental noise, which vary with land use. The standards for airborne and impact sound insulation also refer to these categories. Netherlands has an acoustic quality number k to classify the type of dwellings and room. Germany differentiates between block of flats and terraced semi-detached houses. Sweden currently defines four classes of dwellings with differing minimum require-

	Internal noise from equipment	Airborne sound insulation	Impact sound insulation	Examples of compliance in primary source
Germany *DIN 4109*	L_{In} dB(A) L_{Afmax} dB(A) L_r dB(A)$_r$	R'_w (dB). Ref. A: *DIN EN ISO 140-4: 1998.* Ref. B: *DIN EN ISO 717: 1997 Part 1.*	$L'_{n,w}$ (dB). Ref. A: *DIN EN ISO 140-4: 1998.* Ref. B: *DIN EN ISO 717: 1997 Part 2.*	Yes. *DIN 4109 Beiblatt 1*: Construction examples and calculation methods.
Nether-lands	$L_{I;A}$ dB(A)	I(lu) (dB); I(luk) (dB). Ref. A: *NEN-EN ISO 140-4: 1998 (replaces NEN 5077: 1991). Ref. B: NEN EN ISO 717:1997 part1 (replaces NEN 1070: 1976* (Iluk)).	I(co) (dB) *Ref.: NEN 5077:1991. (Ref. A: NEN-EN ISO 140-7:1998. Ref. B: NEN EN ISO 717: 1997 part 2 (replace NEN 1070: 1976).*	No.
	Criteria for the insulation index Ilu (airborne sound = *luchtgeluid*) are calculated from a reference curve similar to that in *ISO 717-1*. However, the index is combined with floor area to give a new criterion I(luk). Criteria for insulation index I_{co} (impact sound = *contactgeluid*) are determined from a reference curve which is only found in *NEN 5077*. The lowest value is the best *IsolatIe-index*.			
Norway *NS 8175*	$L_{A\ eq\ 24h}$, (dB(A)) L_{Amax} (dB(A))	R'_w (dB). Ref. B: EN –ISO DIS 717/1.	$L'_{n,w}$ (dB) Ref. B: EN –ISO DIS 717/1.	No, but given in Norwegian Building Research Institute leaflets.
Sweden	L_{Amax} (dB(A)) $L_{A\ eq\ 24h}$ (dB(A))	R'_w (C, C_{tr}) (dB) with adaptation correction term C50-3150). Ref. A: *SS 02 52 54.* Ref. B: *SS –ISO 717 /1* (see also *SS 02 52 67*).	$L'_{n,w}$ (C, C_{tr}) (dB) with adaptation correction term CI,50-2500. Ref. A: *SS 02 52 54.* Ref. B: *SS –ISO 717 /2* (see also *SS 02 52 67*).	No.

ments: A and B for dwellings with improved or very good acoustic qualities; D for old dwellings, which cannot meet the acoustic qualities of new dwellings. It is expected that a similar system will soon be introduced in Denmark.

Mostly, only minimum requirements are given, but the national standards in both Belgium and Germany give both minimum and recommended levels. The national standards in Belgium is expressed in terms of index A, which gives recommended standards for acoustic comfort, and index B, which gives minimum requirements to protect 'psycho-physiological well-being'. Index A standards are 5dB higher than index B for airborne sound and 3dB for impact sound. In Germany, the differences between general requirements and recommendations vary, between 7-12dB.

A4.2 Protection against noise from installations

This section of the CBD comprises:

- Article 3.6 Performance requirement: protection against noise from equipment
- Article 3.7 Maximum noise level from specified equipment in a user function to a communal / habitable space in a user function on an adjacent plot
- Article 3.8 Maximum noise level from specified equipment to non-shared habitable space of another dwelling on the same plot
- Article 3.9 Permissible difference in maximum characteristic noise levels for alterations or extensions to existing buildings

Belgium, Denmark, France, Germany, the Netherlands, Norway, and Sweden have requirements to limit the noise level generated by equipment in adjacent flats or dwellings, or other parts of the building. There are no specific requirements for protection against noise from equipment in England and Wales.

The countries vary in the range of equipment from which acoustic protection is required. The installations specified in the CBD are: a toilet cistern, tap, mechanical ventilation system, hot water installation, pump or lift. Sweden only mentions 'building services', but other countries variously list heating systems, mechanical ventilation and air conditioning equipment, lifts, transformers, water supply, sanitation and drainage systems, and equipment in common service rooms such as laundries and kitchens. Denmark is unusual in mentioning noise generated by installations to operate windows and sunscreens. Only Norway mentions noise from escalators, commercial refrigerators and production machinery.

There are various situations that may require protection: buildings or parts of buildings on neighbouring lots; neighbouring dwellings or parts of dwellings; dwellings or parts of dwellings; and parts of the same dwelling. It concenrs protection from respectively equipement in a building, a dwelling, common parts of a building and a dwelling.

The CBD requires protection of habitable space from equipment in a user function on an adjacent plot [a neighbouring building], and protection of private habitable space from equipment in another living function on the same plot [a neighbouring dwelling]. The CBD's use of the term 'living function' as meaning parts of buildings that are ancillary to individual dwellings means that the requirements apply when the equipment is in common parts of a building. However, the CBD does not require acoustic protection from equipment within a single dwelling. This is in keeping with the requirements in Belgium, Denmark, Norway, and Sweden, but they use simpler terms for the application of requirements: habitable rooms, bedrooms, places for rest, living rooms, spaces for living, or kitchens.

Table A4.3 Acoustic parameters for limits of sound levels generated by equipment

	Parameter	Definition
Belgium	L_{Aeq} dB(A)	Equivalent continuous A-weighted sound pressure level.
Wallonie	NR	Maximum permissible rise in noise resulting from equipment in the same building, compared to the noise rating curve NR.
Denmark	L_{Aeq} dB	Equivalent continuous A-weighted sound pressure level.
England and Wales	—	—
France	L_{nAT} dB(A)	A-weighted continuous sound pressure level, normalised over a period of time T.
Germany	L_{In} dB	Sound pressure level.
	L_{AFmax} dB(A)	Maximum instantaneous A-weighted sound pressure level with fast time weighting.
	L_r dB(A)	A-weighted sound pressure averaged over the duration of noise exposure. 'Single event' noise; repeated 'single event' noise are taken account when measuring L_r.
Netherlands	$L_{I;A}$ dB(A)	Averaged A-weighted standardised sound pressure level over 5 octave bands 125, 250, 500, 1000, and 2000Hz.
Norway	L_{Aeq24h} dB(A)	Standard equivalent continuous A-weighted sound pressure level normalised to 24 hours.
	L_{Amax} dB(A)	Maximum momentary A-weighted sound pressure level.
Sweden	L_{pA} dB(A)	A-weighted sound pressure level.
	L_{pAFmax} (dB(A))	Maximum A-weighted sound pressure level with fast time weighting.

Only France requires protection against noise from equipment within the same dwelling. France also has different requirements for separate kitchens and for open plan rooms with a kitchen area, the so-called 'American kitchen'. Denmark and Norway limit the noise level from equipment to outdoor areas, in Denmark to a point directly outside windows and to recreation areas such as balconies, and in Norway to play or recreational areas.

The description of limits on sound levels generated by equipment may be broadly categorised as 'standard equivalent continuous A-weighted sound pressure level normalised to a period of time'. The A-weighting simulates the human ear's unequal sensitivity to different frequency sound. However, some countries introduce other parameters to quantify different types of noise equipment, which can cause confusion when comparing requirements.

The CBD specifies a single limit for the permissible noise level from equipment, but the Scandinavian countries vary the limits for different types of noise. Denmark differentiates between noise with or without audible tones or pulses, adding up to 5dB to the measured L_{Aeq} when these characteristics are present. It also requires that up to 3dB should be added to the L_{Aeq} when measured in furnished rooms, because furniture introduces absorption. The German *DIN* standard also includes some specific targets related to the spectrum of noise. Norway and Sweden differentiate between noises of long duration (noise from continuously functioning plant, such as heating, refrigerator or ventilation equipment) and noises of short duration (intermittent noise such as WC flushes, drainage, and lift movements). In Sweden, the distinctions between sound of short duration and long duration in the Swedish regulations will be modified in new regulations. Intermittent sound will not be covered, but requirements for internal noise levels in bedrooms will take account of low frequency noise.

Table A4.4a Protection against noise from installations

	Types of installations	Internal noise level from equipment	
		Situations	**Requirement**
Belgium	External noise. Noise within the building but external to the room to be protected.	Living spaces.	Category 1 $L_{Aeq} \leq 30dB$, Category 2 $L_{Aeq} \leq 35dB$, Category 3 $L_{Aeq} \leq 40dB$ and Category 4 $L_{Aeq} \leq 45dB$ for existing background noise. $L_{Aeq} \geq 27dB$: difference between the noise source and background noise ≤ 6dB.
		Bedrooms.	Category1 $L_{Aeq} \leq 30dB$, Category2 $L_{Aeq} \leq 30dB$, Category3 $L_{Aeq} \leq 35dB$ and Category4 $L_{Aeq} \leq 40dB$ for existing background noise. $L_{Aeq} \geq 27dB$: difference between the noise source and background noise ≤ 3dB.
	NBN S01-400 defines four categories of development areas with differing requirements for sound insulation between dwellings: Category 1: Rural or suburban residential areas; Category 2: Urban residential areas; Category 3: Areas affected by light industries, and housing in commercial areas; and Category 4: Town centres, areas affected by heavy industries and areas within 5 km of an airport. There are also noise limits on technical spaces in dwellings, by reference to Noise Rating criteria (NR):		
		Toilet, in operation; bathroom or kitchen with air extract in operation [i.e. maximum noise level in room containing toilet, or bathroom, or kitchen].	NR ≤ 35; an increase of 5dB when the equipment starts or stops operation is acceptable.

Unlike the other countries, the national standard in Belgium has a two-part limitation on noise from equipment outside the dwelling. In addition to a maximum level for background noise (for instance $L_{Aeq} \leq 30dB$ for a room in a Category 1 development), there are limits on the increase in sound level caused by a noise source outside the dwelling (6dB(A) for day rooms, 3dB(A) for night rooms) which apply when the background noise exceeds a certain level ($L_{Aeq} \geq 27dB$).

The German *DIN* standard is the only one of the measures studied to set different daytime and night-time requirements, which refer to noise from domestic technical installations and from enterprises.

The highest standard is in Germany, for continuous night-time noise from businesses ($L_r \leq 25dB(A)$), but overall most countries require $L_{Aeq} \leq 30dB(A)$ in habitable rooms except Germany (35dB(A)), and Belgium ($L_{Aeq} \leq 33$ - 45dB(A), varying according to the category of development area).

The levels required in the Netherlands vary according to the type of building and the type of room (- 5 or 10 dB for more demanding values; + 5 or 10 dB for less demanding values).[4]

	Types of installations	Internal noise level from equipment	
		Situations	**Requirement**
Denmark		*Small buildings:*	
	Drainage, ventilations, or heating equipment, waste disposal units, etc.	Habitable rooms, kitchens	$L_{Aeq} \leq 30dB$ $L_{Aeq} \leq 25dB$ (momentary sounds such as motors starting or stopping; noise with a pure tone such as whistle from a fan).
	Utility water equipment, installations for operation of windows, sunscreens, etc.	Neighbouring houses	$L_{Aeq} \leq 30dB$
		Multi-storey domestic buildings:	
	Drainage and utility water equipment, lifts, ventilation systems, heating systems, macerators, equipment in common service rooms, e.g. laundry-rooms, kitchens; excludes noise from water installation in utility dwelling itself.	Habitable rooms, kitchens	$L_{Aeq} \leq 30dB$
	Installations in commercial units in domestic buildings.	Habitable rooms	$L_{Aeq} \leq 30dB$
	Heating and ventilation systems, mechanical refuse collection systems etc.	At windows, in recreation areas (balconies, roof terraces, conservatories etc.).	$L_{Aeq} \leq 40dB$
England and Wales	—	—	—

In the Netherlands, the CBD allows a lower standard for building work to adapt or extend existing buildings (+10dB). Lower standards are explained by the difficulty in quantifying flanking transmission in existing buildings. In Denmark, Norway, and Sweden, the general application of requirements to adaptations and extensions prevails, which is a higher standard than in the Netherlands. In France, the requirements only apply to new residential buildings. It is not clear whether requirements apply to extensions and adaptations in Belgium or Germany.

4 Advice from an acoustics consultant in the Netherlands.

Table A4.4b Protection against noise from installations

	Types of installations	Internal noise level from equipment		
		Situations	Requirement	
France *Arrêté 30.6.99*	Heating or air-conditioning unit.	Principal rooms	L_{nAT}	≤ 35dB(A)
		Kitchens	L_{nAT}	≤ 50dB(A)
	Heating appliance unit operating at minimal power.	Principal room open plan with kitchen	L_{nAT}	≤ 40dB(A)
	Mechanical ventilation installation at minimum setting.	Principal rooms	L_{nAT}	≤ 30dB(A)
		Kitchens of each dwelling	L_{nAT}	≤ 35dB(A)
	Common equipment, such as lifts, heating plant, transformers, pumps, soil pipes.			
	Individual appliance in a dwelling.	Principal rooms	L_{nAT}	≤ 30dB(A)
		Kitchens	L_{nAT}	≤ 35dB(A)
Germany *DIN 4109*	Water and waste water installations.	Living room, bedroom	L_{In}	≤ 35dB(A)
	Noise from business activities, plants.		L_{AFmax}	≤ 30dB(A)
			L_r	≤ 35dB(A) (06.00 to 22.00)
				≤ 25dB(A) (22.00 to 06.00)
				+10dB(A) for brief peaks
Netherlands	Flush toilets, taps, mechanical ventilation systems, hot water equipment, equipment to increase water pressure, lifts.	Habitable area of user function on adjacent plot.	Characteristic sound level $L_{I;A}$	≤ 30dB(A) (new build)
		Non-shared habitable area of another living function on the same plot.	$L_{I;A}$	≤ 40dB(A) (adaptation or extension of existing buildings)
Norway *NS 8175*	Lifts, escalators, fans, sanitary appliances, air conditioning plants, installations for service or commercial purposes: washing machines (common laundry rooms), refrigeration machines (shops), production machinery (industry) etc. Noise from use and running of indoor car parks.	Bedrooms, rooms for occupation (excluding storage rooms, toilets, bathrooms, hallways and corridors).	$L_{A\ eq\ 24h}$	≤ 30dB(A)
			L_{Amax}	≤ 32dB(A)
		Also, limits on noise nuisance from equipment to outdoor areas intended for recreation or play.	L_{Amax}	≤ 40dB(A)
Sweden *SS 02 52 67 (2)*	Building services.	Sounds not from within same dwelling: Bedrooms, living rooms in non residential premises		
		- Sound of long duration	L_{pA}	≤ 30dB(A)
		- ound of short duration	L_{pAFmax}	≤ 35dB(A)
		Kitchens		
		- Sound of long duration	L_{pA}	≤ 35dB(A)
		- Sound of short duration, not	L_{pAFmax}	≤ 40dB(A)
		- from within same dwelling		
	Sounds of short duration include sound due to pressure pulses or flow of water in water supply and drainage installations, impulse sound due to the starting and stopping of lifts; sounds of long duration include sound from ventilation plants, refrigerator compressors, heat pumps.			

Table A4.5 Sound insulation between rooms within one 'user function'

	Situations	Airborne sound	Impact sound
Belgium	–	–	–
Denmark	–	–	–
England and Wales	New internal walls and floors within dwelling-houses, flats and rooms for residential purposes new-built or formed by material change of use).	R_W dB ≥ 40dB	–
France	–	–	–
Germany *DIN 4109*	Floors and stairs within houses (except detached houses) and flats on two storeys.	–	$L'_{n,W}$ ≤ 53dB
Netherlands	Between habitable rooms in same dwelling. Excludes open plan rooms on same storey and adjacent rooms linked by doorway.	Min. characteristic insulation indices: I_{lu} ≥ - 20dB (new build) [D_{nTA} = 31dB] I_{lu} ≥ - 30dB (adaptation or extension of existing buildings) [D_{nTA} = 21dB]	I_{co} ≥ - 20dB (new build) [D_{nTA} = 31dB] I_{co} ≥ - 30dB (adaptation or extension of existing buildings) [D_{nTA} = 21dB]
Norway	–	–	–
Sweden	–	–	–

A4.3 Sound insulation between habitable rooms within one unit

This section of the CBD comprises:
- Article 3.11 Performance requirement: protection against excessive noise within the same dwelling
- Article 3.12 Minimum characteristic insulation indices between rooms within the same dwelling
- Article 3.13 Permissible difference in minimum characteristic insulation indices for alterations or extensions to existing buildings

Of the countries studied, only the Netherlands has requirements for both airborne and impact sound insulation between rooms in the same dwelling, but Germany has requirements for impact sound insulation in flats with two storeys, and England and Wales introduced requirements in 2003 for airborne sound insulation of internal walls and floors. The levels of requirements cannot be directly compared due to the use of different parameters.

A4.4 Sound insulation between rooms in different user functions

This section of the CBD comprises:
- Article 3.17 Performance requirement: limitation of noise nuisance between user functions
- Article 3.18 Minimum characteristic insulation indices for airborne and contact noise between spaces in adjacent user functions on different plots

- Article 3.19 Minimum characteristic insulation indices for airborne and contact noise between spaces in adjacent user functions on the same plot. Exemptions for noise transmission to circulation space on the same plot, and between shared common rooms.

The CBD limits airborne and impact sound transmission between neighbouring user functions both between different plots and between user functions on the same plot. There are also requirements concerning airborne and impact sound transmission between dwellings in each of the other countries.

A4.4.1 Acoustics parameters

Each country refers to national standards for definitions and methods of measurement. Most have incorporated international standards, but even where the national standards refers to the same international standards, they adopt slightly differing acoustic parameters. The criteria used in the Building Decree are different from those in other countries and can only be understood by reference to the national standard, *NEN 5077*. Instead of direct expressions of a standardised level difference (D_n) or sound reduction index (R) for sound transmission, it has, until recently, used indices which refer to specific rating curves peculiar to the Netherlands. However, the European-International rating curve was recently adopted. The same comments apply to Belgium.

Although most countries refer to measurements in conformity to *EN ISO 717:1997*, comparisons are complicated by the varying use of spectrum adaptation terms. For instance, the parameter describing standardised level difference in France incorporates the adaptation terms C for pink noise and C_{tr} for traffic noise. Although C_{tr} is intended to take account of traffic noise or noise from a nightclub, England and Wales uses C_{tr} for party walls, in order to take account of low frequency sound transmission.[5]

The acoustic parameters used in Denmark, Germany, Norway and Sweden (R'_w), and in England and Wales ($D'_{nTw} + C_{tr}$), France ($D'_{nTw} + C_{tr}$; $D_{nT,A}$) are defined in European standards. Most of the countries using R'_w are now in the process of introducing, or are discussing the introduction of correction terms for both airborne and impact sound insulation. It is expected that R'_w will be replaced by D'_{nTw} in the *DIN* standard.

5 The use of C_{tr} in England and Wales to limit low frequency noise transmission through party walls and floors has been criticised for reducing protection from medium and high frequency noise. For instance, 'New building regulations will actually lower standards' published at www.rics.org/ricscms/bin/show?class=News&template=/includes/shownews.html&id=4456 reports on unpublished research by the Building Performance Centre, Napier University presented at an Institute of Acoustics meeting, November 2002.

A4.4.2 Comparison of requirements for airborne and impact sound transmission

Direct comparisons of requirements for airborne and impact sound transmission can be made between Denmark, Germany, Norway and Sweden which use the same criteria and method of measurements. The levels of requirements for airborne sound transmission between dwellings in Germany (for dwellings in multi-storey buildings), Norway and Sweden are similar ($R'_w \geq$ 55dB), but the requirement in Germany for walls between houses is slightly higher ($R'_w \geq$ 57dB). The lowest of these comparable requirements is in Denmark ($R'_w \geq$ 52-53dB).

Standardised level differences are used in England and Wales, Netherlands and France. The parameters used in the Netherlands and France appear comparable ($I_{lu} = D_{nTw}+C = D_{nT,A}$), but England and Wales uses a different spectrum adaptation term. The level of requirements in France are higher than those in Netherlands (for example airborne sound transmission between rooms: France $D_{nT,A}$ [= $D_{nT,w}+C$] ≥ 54dB; $I_{lu} \geq$ 0dB @ $D_{ntw}+C \geq$51).

There are various features of requirements peculiar to only two or three of the countries studied: Denmark, England and Wales, and Sweden set different levels of airborne sound insulation requirements for walls and floors; Denmark and Germany take account of the effect of doors; and Denmark and France set higher levels of requirements for airborne sound insulation for dwellings next to commercial premises.

The highest standard for maximum impact sound pressure level is in Germany ($L'_{n,w} \leq$ 46-48dB) and the lowest levels of requirements are in Sweden ($L'_{n,w} \leq$ 58-64dB). The standard in France ($L'_{nTw} \leq$ 58dB) is higher than in England and Wales ($L'_{nTw} \leq$ 62dB).

There are differing requirements for joined houses and adjacent flats in Denmark, Germany (for airborne sound for walls), and Sweden. The levels of requirements are higher for houses than flats.

There are requirements to limit airborne sound transmission from common circulation spaces to dwellings in Belgium, Denmark, France, Norway, and Sweden and Germany. There are no similar specific requirements in England and Wales or the Netherlands. Only France has specific requirements to limit sound transmission from garages to dwellings.

In the Netherlands, there are lower levels of requirements for both adaptations and extensions to existing buildings (-10dB), which are used due to the difficulty in quantifying flanking transmission in existing buildings. In England and Wales, slightly lower standards are specified for dwelling-houses and flats formed by material change of use (-2dB); this includes a material change of use whereby the number of rooms for residential purposes is increased. In France, the limits on noise levels from external sources in habitable rooms and kitchens apply to extensions. For Denmark, Norway, and Swe-

Table A4.6a Sound insulation between spaces with different user functions

	Airborne sound insulation		Impact sound	
	Situations	**Requirements**	**Situations**	**Requirements**
Belgium	For dwellings and dwellings in multi-storey buildings:		Between dwellings in multi-storey buildings:	
	- from common circulation to bedroom	Dn ≥ Category I	- from kitchen/bathroom/ playroom to bedrooms - from bathroom/playroom to living room	Ln ≥ Category I
	- from common circulation to living room	Dn ≥ Category II	- between bedrooms - from bedroom to living room/ kitchen	Ln ≥ Category II
	- from common circulation to kitchen	Dn ≥ Category III	- from bedroom to living room	Ln ≥ Category II
	- from common circulation to play room	Dn ≥ Category III	- from bedroom/living room/ kitchen/bathroom/playroom to kitchen	Ln ≥ Category III
	NBN S01-400 defines four categories with differing requirements for protection against environmental noise, which are also applied to sound insulation between dwellings: Category I: rural or suburban residential areas; Category II: Urban residential areas; Category III: Areas affected by light industries, and housing in commercial areas; and Category IV: Town centres, areas affected by heavy industries and areas within 5 km of an airport. NBN S01-401 has charts relating values to categories, but they are difficult to interpret. A range of values is given, corresponding to classes A (recommendations for acoustic comfort) and B (minimum requirements).			
Denmark	Multi-storey residential buildings			
	Between dwellings and:		Habitable rooms and kitchens in	
	- other dwellings, common spaces	$R'_w \geq 52$dB (walls) $R'_w \geq 53$dB (floors)	surrounding dwellings and common spaces, from:	
	- noisy premises *	$R'_w \geq 60$dB	- floors, decks, roof terraces, access corridors, staircases, common corridors > 2.5 m²	$L'_{n,w} \leq 58$dB
	- common rooms	$R'_w \geq 32$dB (doors)	- balconies, floors, and decks in bathrooms, WCs > 2.5 m²	$L'_{n,w} \leq 63$dB
			- floors, decks in noisy premises	$L'_{n,w} \leq 48$dB
	* Premises producing particularly disturbing noise include boiler-rooms, laundries, banqueting rooms, hobby-rooms, business premises, workshops, restaurants.			
	Joined houses:			
	- between houses, between houses and common spaces	$R'_w \geq 55$dB (walls)	habitable rooms and kitchens, from:	
			- floors, decks, staircases	$L'_{n,w} \leq 53$dB
	- between dwellings and common spaces	$R'_w \geq 32$dB (doors)	- bathrooms, WCs > 2.5 m²	$L'_{n,w} \leq 58$dB

	Airborne sound insulation		Impact sound	
	Situations	**Requirements**	**Situations**	**Requirements**
England and Wales	Tests on four pairs of rooms:			
	- separating walls (dwelling-houses), floors and stairs (flats, rooms for residential purposes)	$D'_{nTw} + C_{tr} \geq 45dB$ (purpose built) $D'_{nTw} + C_{tr} \geq 43dB$ (formed by material change of use)	- separating floors and stairs (dwelling-houses, flats, rooms for residential purposes)	$L'_{nTw} \leq 62dB$ (purpose built) $L'_{nTw} \leq 64dB$ (formed by material change of use)
	- separating walls (rooms for residential purposes)	$D'_{nTw} + C_{tr} \geq 43dB$ (purpose built or formed by material change of use)		
	- internal walls and floors (within dwelling-houses, flats and rooms for residential purposes)	$R_w \geq 40dB$ (purpose built or formed by material change of use; laboratory values)		
France		[NB: $D_{nT,A} = D_{nT,w+C}$]		
	Between place in dwelling (except garage) and room in another dwelling:		For all floors and walls in rooms except for balconies and loggias not immediately above an habitable room; for stairs in buildings having a lift, technical/service spaces.	
	- principal rooms	$D_{nT,A} \geq 54dB$		
	- kitchens, bathrooms	$D_{nT,A} \geq 51dB$		
	Between common internal circulation spaces and room in dwelling in building:			
	- principal rooms separated by landing door	$D_{nT,A} \geq 40dB$		
	- principal rooms in other situations	$D_{nT,A} \geq 53dB$		
	- kitchens, bathrooms separated by landing door	$D_{nT,A} \geq 37dB$		
	- kitchens, bathrooms in other cases	$D_{nT,A} \geq 50dB$		
	Between individual or communal garage and room in other dwelling:			
	- principal rooms	$D_{nT,A} \geq 55dB$		
	- kitchens, bathrooms	$D_{nT,A} \geq 52dB$		
	Between activity spaces and room in other dwelling:			
	- principal rooms	$D_{nT,A} \geq 58dB$		
	- kitchens, bathrooms	$D_{nT,A} \geq 55dB$		

Table A4.6b Sound insulation between spaces with different user functions

	Airborne sound insulation		Impact sound	
	Situations	**Requirements**	**Situations**	**Requirements**
Germany	Separating walls between houses	$R'_w \geq 57dB$	Between dwellings	$L'_{n,w} \leq 48dB$
	Walls between neighbouring flats	$R'_w \geq 53dB$	Between dwellings in multi-storey buildings	$R'_w \leq 55dB$
	Between dwellings in multi-storey buildings		$L'_{n,w} \leq 46dB$	
			From common space and stairs	
			- dwellings	$L'_{n,w} \leq 53dB$
			- dwellings in multi-storey building	$L'_{n,w} \leq 58dB$
	Floors between neighbouring flats; passages, cellars, under bath/WC.	$R'_w \geq 54dB$	Floors between neighbouring flats; passages, cellars, under bath/WC	$L'_{n,w} \leq 53dB$
	Walls of stairwells	$R'_w \geq 52dB$	Stairs in stairwells in multi-family housing	$L'_{n,w} \leq 58dB$
Netherlands	From a closed room to a habitable area:	New build:	From a closed room to a habitable area:	New build:
	- in adjacent user function on another plot (except light industrial or unspecified user function)	$I_{lu} \geq 0dB$ [$\approx D_{ntw}+C \geq 51$]** Adaptations, extensions:	- in adjacent user function on another plot (except light industrial or unspecified user function)	$I_{co} \geq 5dB$ [$\approx L'_{n,w}+C_I \leq 54dB$]** Adaptations, extensions:
	- in adjacent living function on the same plot* (except between common rooms serving the same user functions).	$I_{lu} \geq -10dB$ [$\approx D_{ntw}+C \geq 61$]**	- in adjacent living function on the same plot* (except between common rooms serving the same user functions).	$I_{co} \geq -5dB$ [$\approx L'_{n,w}+C_I \leq 64dB$]**
	From a closed room to a closed room that is not a habitable area:	New build:	From a closed room to a closed room that is not a habitable area:	New build:
	- in adjacent user function on another plot	$I_{lu} \geq -5dB$ [$\approx D_{ntw}+C \geq 46dB$]** Adaptations, extensions:	- in adjacent user function on another plot	$I_{co} \geq 0dB$ [$\approx L'_{n,w}+C_I \leq 59dB$]** Adaptations, extensions:
	- in adjacent living function on the same plot* (except transmission to circulation space, or between common rooms serving the same user functions).	$I_{lu} \geq -15dB$ [$\approx D_{ntw}+C \geq 44dB$]**	- in adjacent living function on the same plot* (except transmission to circulation space, or between common rooms serving the same user functions).	$I_{co} \geq -10dB$ [$\approx L'_{n,w}+C_I \leq 69dB$]**

* Insulation of adjacent user functions on the same plot only applies to dwellings.

** Approximate equivalent values calculated using ISO 717 part 1 and ISO 717 part 2: $I_{lu} \approx D_{ntw} + C - 51dB$; $I_{co} \approx 59 - L'_{n,w} + C_I$.

	Airborne sound insulation		Impact sound	
	Situations	**Requirements**	**Situations**	**Requirements**
Norway	Between individual dwelling units; between communal areas (stairs lobby, corridors, etc.) and dwellings.	$R'_w \geq 55dB$	Between individual dwelling units; from communal areas (stairs lobby, corridors, etc.) to dwellings.	$L'_{nw} \leq 53dB$
	Between commercial areas, car parks and dwellings.	$R'_w \geq 60dB$	From commercial areas, car parks to dwellings.	$L'_{nw} \leq 48dB$
			From toilet, storage areas, balconies etc. to a dwelling unit.	$L'_{nw} \leq 58dB$
Sweden	Between spaces outside dwelling and dwelling.	$R'_w + C_{50\text{-}3150} \geq 52dB$ (wall) $R'_w \geq 53dB$ (floor)	In habitable rooms from stairway, corridor, access balcony.	$L'_{nw}+C_{I,50\text{-}2500} \leq 64dB$
	Between dwellings, contiguous single family houses.	$R'_w \geq 55dB$	In habitable rooms from other space outside dwelling.	$L'_{nw}+C_{I,50\text{-}2500} \leq 58dB$
	Multi-storey blocks.	$R'_w+C_{I,50\text{-}3150} \geq 39dB$		
	Between spaces inside interior entrance doors and stairway/ corridor, between dwelling and access balcony.			

den, it appears that the general application of requirements to adaptations and extensions prevails. If this is true, these are higher levels of requirements than in other countries.

In Belgium, the description of recommended criteria in the national standards is difficult to understand, due to its reference to categories of development and inclusion of both recommended and minimum levels. Although there are charts relating values to the categories of development, we found them too difficult to interpret with confidence.

A4.4.3 Implementation of requirements

The achievement of the intended level of acoustic performance relies on careful workmanship. Pre-completion testing of completed buildings is the only reliable way to highlight any defects in workmanship that would prejudice performance, but it is an expensive method of implementation. The Dutch Building Decree does not require such testing.

Denmark requires pre-completion testing. However, often less than half of the new buildings are tested.[6]

In England and Wales, *Approved Document E* 2003 introduced requirements for pre-completion testing of insulation against sound from adjoining dwellings and other parts of the building, on a sampling basis. Requirements apply to both new building and houses, flats or rooms for residential purposes formed by a material change of use. Testing is not required for controls on sound insulation within a dwelling or reverberation in the common parts of flats. However, the introduction of testing for new houses and flats has been delayed until January 2004, in order for the House Builders Federation to develop 'Robust Standard Details' which "*must provide consistently good performance, and so will not need routine testing*". If successful, the regulations will be amended to allow the details to be used as an alternative to testing.[7]

Pre-completion testing is not required in any of the other countries studied. For instance, in Norway compliance may be proved "*either by design of the construction works in accordance with generally accepted specifications to ensure satisfactory acoustic conditions, or by verifiable analyses and/or calculations proving that the other specifications ensure satisfactory acoustic conditions*".[8]

It appears that, in practice, noise control in housing usually relies on the use of constructions that are known to satisfy the requirements, or certificated building systems, but these do not guarantee as-built performance. Some

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6 Conversation with Delta, Danish acoustics consultants.

7 Announcement by Chris Leslie, the Minister responsible for Building Regulations, reported in: House Builders Federation (2002) *Robust Standard Details Programme: Background Information.*

8 Technical Regulations under the Planning and Building Act 1997: § 8-41 Documentation.

countries offer examples of wall and floor constructions which fulfil the requirements, but only in supporting documents. The most extensive range of examples is given in *Approved Document E* in England and Wales. It also gives 'points to watch' for each type of construction, such as the need to fill masonry joints with mortar. Examples are also given in the *DIN* standard in Germany, and in supporting documents in Denmark and Norway. Such constructions are usually acceptable without tests, but in Denmark, the local authority is allowed to stipulate pre-completion testing. We did not identify examples of suitable constructions in Belgium, France, the Netherlands, or Sweden. In those countries designers presumably rely on certification of materials or components that comply with the requirements, which are publicised by manufacturers.

Whether or not there are examples of constructions that comply with regulations, there is generally no specific limitations on the choice of materials, except in Germany where there is a prohibition on materials with poor acoustic properties.

England & Wales, France and Germany have systems of labelling to describe certain aspects of the performance of buildings, but it appears that only France has a label for the acoustics quality of new or converted buildings. The labelling agency *QUALITEL* first makes a study based on calculations and requirements, then undertakes field measurements on at least 25 per cent of the completed buildings. Award of the *Confort Acoustique* label confirms that the field measurements accord with the levels of requirements in the building regulations.[9]

A4.4.4 Conclusions

Noise control is a topic that is relatively impenetrable to non-experts, indeed the analysis relied on the interpretation of requirements by a specialist consultant. Except for the *Approved Document* in England and Wales, the building regulations studied do not offer information about noise control that can be easily assimilated by designers and it appears that the design standards are increasingly the domain of specialists.

Differences between acoustic parameters represent an impediment, not only to comparative analysis, but to the harmonisation of standards and international construction practice. Acoustic performance is one of six essential requirements of the Construction Products Directive, but the comparative analysis highlights considerable variety in the form of requirements. Although most countries refer to EN-ISO standards, there are important dif-

9 Information for building professionals: www.qualitel.org/pro/methode/acoustique_interieure.html; information for consumers: www.qualitel.org/acoustique.

ferences in the criteria used, including differences in the methods of measurement (laboratory or field).

All the countries studied use the same EN-ISO standards for measements of airborne and impact sound insulation, but then apply a different reference curve or a different spectrum adaptation term. Belgium and the Netherlands use indices that are not used in any of the other countries, although they are gradually adapting to EN-ISO 717. In the Netherlands, although requirements are expressed in a very different way to other countries, the levels of requirements can be compared to EN-ISO standards through a calculation process, and are soon to be revised in line with those standards.

It is not clear whether there is any practical advantage in one method of measurement and rating over any other, but there is at least one significant practical implication of differences between acoustic parameters. Low frequency components of sound are an important feature of domestic noise nuisance, but are only considered in England and Wales, France, and Sweden. However, there is disparity in the parameters used. France uses the adaptation term C, which includes low-frequency noise, but England and Wales uses C_{tr}, which was intended to account for traffic noise. Forthcoming legislation in Sweden, Norway, Denmark, and Germany is expected to introduce the adaptation term C.

All countries use EN-ISO standards for measurement. Most countries specify levels of requirements within the Building Regulations or associated guidance documents, but Germany (Hesse) and Sweden only give general performance requirements and rely on national standards to give levels that are deemed to comply with the requirements. In Belgium there are no specific requirements in federal legislation and the acoustic performance of buildings relies on the implementation of recommendations in the national standards.

It is difficult to compare levels of requirements, but many of the differences between countries in levels of requirements up to 3dB would probably be barely perceptible. The greatest differences in levels of requirements are those for impact sound. Few requirements for airborne sound transmission can be directly compared but it appears that there is a much narrower range of requirements. Where differences arise, they concern party walls between rooms with different functions.

There is some variation between countries in the scope of requirements. Only England and Wales, the *DIN* standard in Germany, and the Netherlands set requirements for acoustic protection between rooms within the same dwelling. The most notable shortcoming is the lack of specific requirements regarding noise from equipment, in England and Wales.

Many countries are currently in the process of updating the building regulations. For instance, the *DIN* standard in Germany is expected to take account of *EN 12354* and to adopt D'_{nTw} instead of $R_{w.}$

Pre-completion testing is the most demanding implementation procedure

but this is comparatively rare. It appears that in practice, noise control in housing usually relies on the use of constructions that are known to satisfy the requirements or certificated building systems, but these do not guarantee as-built performance. Even in England and Wales, the only one of the building regulations studied to include mandatory testing, the house-building industry is being allowed to develop standard details as a potential alternative to testing.

Noise control in the countries studied offers a striking example of the disparity between the intention of performance requirements, as encouraging design freedom, and their implementation in practice, using standard constructions. Reliance on standard constructions is only officially acknowledged by the examples of such constructions in *Approved Document E* in England and Wales, and in the *DIN* standard in Germany. In other countries designers must rely on certificated manufacturers' details. In future, *EN 12354* may be adopted as a way to justify the choice of construction.

Appendix 5 Noxious materials and substances from the ground

A5.1 Introduction

This chapter follows the structure of two sections in the Building Decree:
- 3.15 Limitation of the use of noxious materials
- 3.16 Limitation of the penetration of noxious substances or radiation from the ground

These sections address two of the factors that affect the quality of the indoor climate.[1] Health can be affected by materials used in construction that emit or release contaminants, and by dangerous substances in the ground, including radiation, that diffuse into buildings.

Countries vary in the way they present the controls on noxious materials and contaminants from the ground. The Building Decree requirements are in a chapter on environmental health issues, including drainage, ventilation, water supply and protection against vermin. However, the sections are isolated, and do not refer to related issues that influence air quality. In contrast, the Scandinavian countries set such requirements in a broader context. In Denmark, they are in a section on 'Indoor Climate', and in Sweden, controls are given in the air quality section of a chapter on 'Hygiene, Health and the Environment'. In Norway, requirements are in a section on 'Environment and Health', with the use of materials and protection from radon gas in a sub-section on 'Indoor Climate', and precautions against other noxious substances from the ground in 'Outdoor Climate'.

Sections 3.15 and 3.16 are unusual within the Building Decree because they do no more than state performance requirements and enable the issue of requirements by ministerial decrees. They do not list the materials or substances for which there are controls. Ministerial regulations are now assembled in *Regeling Bouwbesluit*[2] and include requirements concerning the use of formaldehyde and asbestos.

A5.2 Requirements for the limitation of the use of noxious materials

This section of the Building Decree comprises:
- Article 3.106 Performance requirement: limitation of use of noxious materials

1 There are a number of other factors that affect the indoor climate, but they are not analysed here. These include: products of combustion by heat-producing appliances; moisture of construction, penetrating moisture, moisture generated in everyday activities; the quality of exterior air; ventilation and air circulation; and temperature.

2 *Regeling Bouwbesluit* (2003), published at www.vrom.nl/Docs/wonen/REGELING_bouwbesluit.pdf.

Table A5.1 Limitation of the use of noxious materials

	General	Controlled materials	
Belgium	No requirements identified.		
Denmark	Prohibition of emission of gases, vapours, particles or ionising radiation. Recommendations: *Reference to SBI Reports no. 232 and 233: Indoor climate labelling of building products* *Houses:* *Reference to SBI Direction 189 for Danish Indoor Climate Labelling of Building Products.*	Formaldehyde:	1) controlled use of wood-based boards with binders that emit formaldehyde. 2) controlled use of foamed urea and formaldehyde; prohibition of uses other than insulation of external wall structures. Recommendations: *Max. concentration of formaldehyde [for given-ventilation rates, temperature, relative humidity]: 0.15 mg/m^3. Notes acceptable binders for wood-based boards Reference to inspection and approval scheme for wood-based panels.*
		Asbestos:	Prohibition of indoor use. General prohibition of asbestos, reference to *Ministry of Labour Order no. 660, 24 September 1986, amended 11 December 1992.*
		Mineral wool:	Coating, covering, encapsulation or sealing of materials containing mineral wool (surfaces in contact with indoor climate).
		Fly ash, clinker from coal firing:	Min. 200 mm gravel cover, weight 300 kg/m^2. Recommendations: *Residuals from coal firing: can contain radioactive substances. Reference to National Building and Housing Agency Instruction sheet, 21 Feb 1992* where children are present.
England and Wales		Formaldehyde:	Protection from urea formaldehyde cavity insulation, limitation of use to masonry inner walls, suitable for foam filling; reference to BS 5617 and 5618.
		Asbestos:	No requirements in Building Regulations. The *Asbestos (Prohibition) Regulations 1985* banned import, supply or use of blue and brown asbestos, an amendment in 1999 banned white asbestos.*

* "The law does not require people to remove existing asbestos in buildings, as this can create more risks to health than leaving it where it is." (Health and Safety Executive Press Release C054:99 - 23 November 1999)

	General	Controlled materials	
France		Formaldehyde:	Precautions for injection of urea-formaldehyde foams in housing. Max. concentration from an individual wall: 0.2 parts per million.
Decrêt 06.05.88 *Arrêté 06.05.88*			
Decrêt 07.02.96 *Arrêté 07.02.06* *Circs. 19.07.96,* *08.01.97, 25.09.98.*		Asbestos:	Other legislation forbids fabrication, import, sale of products containing asbestos. Existing buildings: Removal of asbestos quilts, thermal blankets, false ceilings. Level of exposure for workers. Schedule for action determined according to age of building. Refers to rules for removal, grants for removal in Decrêt no. 96-7, 7.02.96, circ. 19.7.96.
Arrêté 12.07.99 *Circs. 30.08.99,* *DGUHC 99-58 30.08,* *DGS 99/533 14.09*		Lead:	Existing buildings: Presence of surfaces containing lead must be reported to occupants. Avoid degradation, dampness, spreading dust. Remedial work for occupied buildings, especially buildings where children are present.
Germany *Gefahrstoff-Verordnung* (Dangerous Substances Act)	Design, construction, equipment to avoid danger or damage by chemical, physical or biological influences.	*Formaldehyde*:	Max. emission of wood products in pieces of furniture: 0.1 ml/m³.
Netherlands	Limitation of presence of substances hazardous to health, including ionising radiation. (Applies to new building and refurbishment, adaptation and extensions of existing buildings.)	Requirements may be issued by ministerial decree about the use of materials from which toxic or irritating substances or ionising Radiation may emanate. Reference to Nuclear Energy Act.	
Regeling Bouwbwsluit		*Max. concentration of formaldehyde:* 120 µg/m³. *Max. concentration of asbestos particles:* 1000 ve/m³. Methods to determine concentrations; conditions.	
Norway	Building materials should not emit pollutants to the indoor air in quantities that are known to be hazardous regarding health and irritation. According to the use of the room, indoor air should not causehealth hazards for occupants.		
Sweden	Emission of gases and particles from elements of structure and surface materials shall not prejudice health,for given air flow rates. Ventilationdesigned to remove airborne emissions from building materials.	Ducts and other components of ventilation systems shall not be made of, or treated with, materials which may release contaminants into the indoor air. General recommendation: *Products emitting low levels of pollutants should be selected in the first instance.*	

- Article 3.107 Issue of requirements by ministerial decree
- Article 3.108 Application to work on existing buildings

Various building materials can present a danger to health:
- by emitting contaminants, such as formaldehyde;
- by releasing dangerous particles when disturbed, such as mineral wool and asbestos;
- when ingested by children, such as paints containing lead; or
- by emitting radiation, such as clinker from coal firing.

Most countries control the use of such materials, but few give requirements for specific materials.

There are controls on the use of materials that emit formaldehyde in building regulations in Denmark, England and Wales, and France, in federal legislation in Germany, and ministerial regulations in the Netherlands. Concentrations of formaldehyde are described variously in terms of milligrams per cubic metre (mg/m^3), parts per million, and millilitres per cubic meter (ml/m^3). The standard for permissible concentrations of formaldehyde appears to be much lower in the Netherlands (120 mg/m^3) than in Denmark (0.15 mg/m^3), but it appears unlikely that they are using the same methods of measurement.

There are controls on the use of asbestos in building regulations in Denmark, England and Wales, and France, and ministerial regulations in the Netherlands. In addition to a ban on the use of asbestos in France, there are requirements for its safe removal from existing buildings, in contrast to England and Wales where it is considered that removal may present greater danger than leaving it in place.

France also addresses the danger to children of lead in paints, and has requirements for remedial work to occupied buildings, especially buildings where children are present. There may be similar requirements in other countries, indeed controls are long established, with Great Britain, Sweden and Belgium first restricting the use of lead paint in 1926, but the requirements are not included in building regulations.

Denmark also has specific requirements for the use of mineral wool and ash and clinker from coal firing. There are general performance requirements that may cover such substances, in the Netherlands, Norway and Sweden, and in federal legislation in Germany. No detailed comparisons can be made because detailed requirements in Denmark are given by secondary reference. There are no requirements in Belgium or England and Wales.

A5.3 Requirements concerning dangerous substances from the sub-soil

This section of the Building Decree comprises:

- Article 3.110 Performance requirement: limitation of risk of penetration of noxious substances or radiation from the sub-soil
- Article 3.111 Issue of requirements by ministerial decree
- Article 3.112 Application to work on existing buildings

There are some substances found in the sub-soil that can diffuse into buildings and build up dangerous concentrations. Contaminants can pass into buildings by diffusion and convection through foundations, ground supported floors, suspended floors and the external walls of underground spaces.

Two substances are commonly identified that prejudice health and safety in housing: radon, a radioactive gas; and methane gas, found in landfill sites and gasworks. Former industrial sites may also be contaminated by other noxious substances used in manufacturing processes.

Radon is produced by the decay of radium, itself a decayed form of uranium, which is found in small quantities in all soil and rocks. Levels of radon vary between areas and there may be different levels even between neighbouring buildings. Radioactive decay of radon forms particles called 'radon daughters', which can cause lung cancer. Radon rises from the ground into the air and enters buildings because internal air pressure is usually lower than pressure in the ground below. Outdoors, radon is diluted and poses negligible risk, but dangerous concentrations can build up in enclosed spaces.

Radon levels are measured in Bequerels per cubic metre (Bq/m^3). The average background level of radon found in the UK is 20 Bequerels/m^3; the average concentrations in housing in France were found to be 66 Bq/m^3; in Belgium concentrations are higher in the south than the north, with averages of 40 Bq/m^3 in Flanders, 80 Bq/m^3exposure in Wallonie. However, local levels of radon can be much higher, for example an average of 100-150 Bq/m^3 is found in certain areas of France. One of the highest average levels of radon is in Sweden, 108 Bq/m^3.

There are requirements to prevent the penetration of radon gas to building interiors in Denmark, England and Wales, Norway, and Sweden. In France, a ministerial circular (1999) offers guidance, in anticipation of legislation, but no legislations had been published by 2002. In Germany, there are no requirements in the building regulations for Hesse, but *DIN 25706-1* and *–2* address radon and recommendations are issued by a government office for radiation protection. The Netherlands has a general limitation on penetration of radiation from the ground. In England and Wales, protection is only required in high-risk areas, identified in a geological survey of radon potential. There are no mandatory requirements in Belgium, but in Wallonie a mandatory ventilation norm refers

Table A5.2 Limitation of the penetration of radiation from the ground

	General, limits	Strategies
Belgium	No mandatory norms. *Recommendation: action for levels of 200 Bq/m³ in new housing, 400 Bq/m³ in existing housing.*	Recommendations: *Impermeable plastic membrane between ground and slab, good ventilation, especially cellars and underground garages. Ventilation norm NBN D 50-001 Dispositifs de ventilation dans les bâtiments d'habitation (mandatory for Wallonie under arrêté du Gouvernement Wallon du 15 février 1996) refers to CSTC (mars 1999) Note d'Information Technique 211: Le radon dans les habitations : mesures préventives et curatives. Funding available in Wallonie for measures against radon. Action strongly advised for Ardennes area.*
Denmark *Building Regulations; Building Regulations for small dwellings*	*Max. annual mean radon content:* 200 Bq/m³. Recommendations: *Also, existing buildings; simple measures for 200-400* Bq/m³; *more effective improvements for > 400 Bq/m³.*	Building structures in contact with subsoil shall be made airtight. Recommendations: *Air tightness strategies: use of concrete; careful, uniform, crack-free construction; sealing around penetrating pipes and ducts. Reference to National Building and Housing Agency & Danish Building Research Institute 'Radon in Dwellings'; and National Building and Housing Agency 'Radon – guidance on protective measures for new buildings.'*
England and Wales	Reference to Building Research Establishment (BRE) (1999) document B*uilding Regulations 211, Radon: guidance on protective measures for new dwellings:*	
	'Action level': recommends work if annual mean radon content: 200 Bq/m³.	BRE guidance describes: design of damp-proof membrane (DPM) in floor to link with cavity tray; sealing of penetrations of DPM; radon sumps for area with high radon levels; maps of British Geological Survey of geological radon potential. Free radon measurements to existing homes, offered if 5% chance of home being above action level. All applications for new dwellings must be accompanied by a geologicalassessment of the site to ensure that there are no local conditions which make protection necessary.

to advice on radon and subsidies are available for anti-radon measures.

A common strategy to protect against radon is to create airtight and impermeable structures below ground and at ground level. Air tightness and impermeability require careful attention to detail and it is difficult to compare standards because detailed requirements are given by reference to secondary sources. However, it is worth noting that the tactics to exclude radon gas are different in Denmark and England and Wales: Denmark relies on careful detailing of concrete construction, England and Wales on the continuity of a damp proof membrane. France suggests the alternative options of mechanical ventilation and a sub-floor sump for radon drainage; these are also mentioned in England and Wales, but as measures for particularly high concentrations of radon.

There are limitations on the acceptable level of radon in buildings, with similar requirements in Denmark for small dwellings, in England and Wales, France, Norway, and Sweden (annual mean radon concentration ≤ 200 Bq/m^3), with lower standards for existing buildings in Denmark and France (≤ 400 Bq/m^3, with a level of 1000 Bq/m^3 justifying urgent action). These lev-

	General, limits	Strategies
France	No legislation (at Sept 00), but strategies discussed in ministerial circular published in *REEF: Circulaire n° 99-46 du 27 janvier 1999.*	
	Recommendations: *Max. radon concentration:* *200 Bq/m³ (new build);* *400 Bq/m³ (existing).*	Recommendations: *Circular identifies 27 Départements with radon levels exceeding 100Bq/m³, where corrective action must be undertaken for buildings admitting the public, but does not state strategies for domestic buildings. Corrective action for existing buildings with levels > 400 Bq/m³; buildings with levels > 1000 Bq/m³ should be closed. Consumer advice.*
Germany Bundesambt für Strahlenschutz (Government office of radiation protection)	No requirements in HBO, Hesse. *Recommendations: max. standard average annual concentration of radon: 250 Bq/m³.*	*Recommendations: simple measures to reduce concentrations 250 – 1,000 Bq/m³ (e.g. changed use of rooms, ventilation or sealing of obvious radon entrance-openings); redevelopment if total concentration over a specified interval exceeds 15,000 Bq/m³.*
Netherlands	Limit exposure of users to radiation from the ground.	Requirements may be issued by ministerial decree for conditions of construction of building elements which constitute a partition with the ground or with an underfloor void, and any relevant parts of other structures. (Applies to new building and refurbishment, adaptation and extensions of existing buildings.)
Norway	Max. annual mean radon content: 200 Bq/m³.	Constructions close to the ground must be executed in such a way that no pollution from the ground - particularly moisture and radon - can penetrate the building and damage the health of the occupants.
Sweden	*Max. annual mean radon content:* 200 Bq/m³. Also *max. gamma radiation*: 0.5 mSv/h in rooms where persons are present other than occasionally.	–

els reflect the guidance of the Commission of the European Communities.[3] The recommendation issued in Germany by the government office for radiation protection sets a lower standard (≤ 250 Bq/m³).

Several countries address the issue of remedial action for excessive radon levels found in existing buildings. Action does not need to be related to building projects. There are various websites that give advice on remedial action.[4]

There are requirements to prevent the penetration of contaminants from landfill and other waste and industrial sites in Denmark, England and Wales, and Norway. This is also covered by the performance requirements in the Netherlands and Sweden. Only England and Wales specifically mentions methane gas. We have not identified any specific requirements in Belgium, France, or Germany (Hesse).

3 90/143/Euratom (1990). As well as setting standards for mean annual concentration of radon in buildings, this requires the identification of areas of high concentrations, and programmes of public information.

4 Examples of guidance on measures to reduce radon levels are given at www.cstb.fr and www.bre.co.uk/radon.

Table A5.3 Limitation of the penetration of noxious substances from the ground

	General, limits	Strategies
Belgium	None identified.	None identified.
Denmark	Landfill, other waste disposal, gasworks, contaminated industrial sites:	
Building Regulations; Building Regulations for small dwellings	Contaminants must not cause an unhealthy or unsafe indoor climate	Airtight and impermeable structures if ground not completely decontaminated. Local authorities can stipulate other measures in special cases. *Reference to Act on Waste Depositories; Act on Environmental Protection. (REC)*
England and Wales	Protection from landfill gas and methane: Methane: < 1% by volume.	General guidance on exclusion and dispersal of methane. Reference to BRE (1991) *Construction of new buildings on gas-contaminated land* BR 212.
France	None identified.	None identified.
Germany *Hesse*	None identified, apart from general requirement to avoid danger or nuisance from chemical, physical or biological influences.	
Netherlands	Limit exposure of users to noxious substances from the ground.	Requirements may be issued by ministerial decree for conditions of construction of building elements which constitute a partition with the ground or with an underfloor void, and any relevant parts of other structures. (Applies to new building and refurbishment, adaptation and extensions of existing buildings.)
Norway	Contaminated land, e.g. former gas works and other industrial land:	Polluted soil to be removed, waste and polluted soil must be treated with care. Local environmental agencies must be alerted if pollutants are discovered during excavations.
Sweden	No contaminants in indoor air which give rise to negative health effects or unpleasant smells.	

A5.4 Conclusions

These topics are not always controlled by building regulations, but by other types of legislation and we cannot be certain of having identified the controls in each country. The most commonly controlled materials or substances are formaldehyde, asbestos, radon and methane gas.

The Building Decree's formulation, of generalised requirements with reference to ministerial regulations, is unhelpful because it does not identify the materials or substances for which there are controls. The Bouwbesluit_online website could have hyperlinks to the relevant regulations, which are given elsewhere on the VROM website.

VROM does not give advice on action to counter the risk of radon emissions, unlike other countries. A performance standard concerning radiation has been developed, but its potential inclusion in the Building Decree is controversial. Opponents assert that it is superfluous, due to the nature of the geology of the Netherlands, and would represent an unnecessary administrative burden. It is interesting that, even with EU guidance on radon levels, the strategies for dealing with radon vary between countries, presumably as the result of differences in construction techniques.

Appendix 6 Daylight

A6.1 Introduction

The structure of this chapter is based on one section of the Converted Building Decree:
- 3.20 Daylight

The CBD uses the term 'daylight openings' as a catch-all description of windows, glazed areas, roof lights and any other transparent part of the building envelope. Most countries simply refer to windows or glazed areas.

A6.2 Requirements for daylight openings

This section of the CBD comprises:
- Article 3.133 Performance requirement: sufficient daylight penetration
- Article 3.134 Equivalent daylight area
- Articles 3.135-6 Requirements for existing buildings

There are requirements for the provision of daylight openings, in habitable rooms in Belgium (Wallonie), Denmark, France, the Netherlands, and Sweden. The performance requirement in Norway, for adequate daylight in habitable rooms and kitchens, is qualified by allowing some rooms to be lit indirectly, but it does not specify which rooms.[1]

Apart from specifications for the size of windows that relate to ventilation and fire safety, there are no requirements in England and Wales.

The requirements in the Netherlands apply to kitchens, but of the other countries only Denmark requires daylight openings in kitchens. Specific permission for kitchens without windows, but with some other means of ventilation, is given in Germany (Hesse). It is unclear whether the requirements in Belgium (Wallonie), France, and Sweden[2] apply to kitchens. None of the countries studied has requirements for daylight in sanitary accommodation.

Of the countries studied, only the Netherlands uses the term 'equivalent daylight area' (EDA), but it is similar to the measure of the total area of glaz-

1 In Norway there is a requirement for a view but there is no explanation of when this applies. Also, indirect lighting is permitted. At least one room in a dwelling will always have the possibility of direct light, normally the living room. Kitchens and bathrooms may be indirectly lit, and often are, particularly in small, two-room dwellings. Bedrooms can be indirectly lit, but this is very rarely done. The conclusion is that it is acceptable for two or three rooms to be indirectly lit. See plan:

2 In Sweden, many requirements apply to 'rooms where persons are present other than occasionally,' but it is not clear whether this includes kitchens.

Table A6.1a Daylight, size of windows for daylighting, other limits on windows

	General provision	Minimum equivalent daylight area or size of windows	Minimum size of windows for other reasons	Maximum size of windows for energy conservation
Belgium *Wallonie* *Arr. 11-02-99* *Critères de Salubrité des Logements:* Subsidy standards: *Annexe II*	Definition of habitable room excludes areas with total absence of natural light.	Total glazed areas ≥ 1/12 floor area (habitable room). ≥ 1/8 (dayrooms) ≥ 1/10 (night rooms, dormer windows) ≥ 1/12 (overhead openings).	–	–
Denmark	Window to each habitable room and separate kitchen.	Size, orientation and sun-shading to achieve appropriate summer temperatures, avoid problems of direct solar radiation.	–	22% of building's heated floor area; larger windows allowed in maximum permissible heat loss method; no restrictions in maximum permissible heat demand method.
England and Wales	–	–	Fire safety: windows for emergency egress: min. openable area: 0.33 m^2, 0.45 x 0.45 m. Ventilation: window openings: 1/20 floor area (habitable rooms, bathrooms)	22.5% total floor area, for elemental U value approach, but no limits for target U-value or energy rating methods of calculation.
France	Principal rooms: an opening and transparent surfaces, facing exterior or onto glazed volumes with opening to exterior.	–	60% glazing (collective housing) or 80% (individual dwellings), must not be covered courtyards.	–

	General provision	Minimum equivalent daylight area or size of windows	Minimum size of windows for other reasons	Maximum size of windows for energy conservation
Germany	At least one habitable room with adequate sunlight. Kitchens, cooking alcoves, bathrooms, WCs without windows allowed if ventilated.	Habitable rooms: 'necessary windows' to give adequate daylight and ventilation.	Fire safety: openings and windows designed to be an escape route min. 0.9 x 1.2 m; max. 1.2 m above, 1 m distant from floor edge.	–
Hesse				
1993 revision	Prohibition of only north-facing habitable rooms.	Necessary windows: min. 1/10 floor area. Habitable rooms in basements: windows to provide area min. 0.5 m up to 1 m from external walls, receiving light at 45°.		
2002 revision	–	Windows: min. 1/8 floor area.		
Netherlands	Sufficient penetration of daylight. Equivalent daylight area must not include indirect daylight through openings in internal partitions from habitable room, WC, bathroom or technical space.	*Min. equivalent daylight area for habitable space:* 10% floor area * *Habitable room:* 0.5 m². Reference to NEN 2057.	–	–
	* Calculation discounts obstruction of openings by off-plot structures or obstructions, and daylight openings < 2 m from boundary or centre of public road, water or open space. *Min. obstruction angle a:* 25°, for each segment.			
Norway	Adequate daylight in rooms for continuous occupation (living rooms, bedrooms, kitchens, work places, eating spaces). View to the outside. Some rooms can be lit indirectly via glazed openings to other rooms or through skylights.	1% daylight factor (measured in the middle of the room from the window wall, 1 m from the side wall and 0.8 m above the floor). Refers to Swedish Standards for methods of measurement.	–	–
Sweden	Satisfactory access to direct daylight (rooms where persons are present other than occasionally). Access to direct sunlight.	*General recommendations: Min. area of glazing: 10% floor area; more if elements of structure or other buildings obscure daylight by more than 20°. Reference to SS 91 42 01 (1).*	–	–

ing relative to floor area used in Sweden. Both Sweden and the Netherlands take into account the obstruction of daylight, but in different ways. Requirements in Belgium (Wallonie) and Germany (Hesse) do not take account of such obstruction and express requirements in terms of the minimum proportion of daylight openings to floor area.

The recommendation in Sweden (10%, but more if obstructed by more than 20°) is a slightly higher standard than the requirement in the Netherlands (10% EDA for habitable space), because it considers obstruction by other buildings, whereas the Dutch requirement discounts off-plot structures and the obstruction of daylight openings close to boundaries. The requirements in Germany (Hesse) were raised in 2002 (frame measurement of essential windows 1/8 floor area). The highest standard is in Belgium (Wallonie) (area of glazing 1/8 floor area).

However, the Netherlands also has a different requirement for the EDA of habitable rooms (0.5 m^2), rather than habitable space, which represents a low standard for larger rooms.

A6.2.1 Other requirements for daylight and the size of openings

Only Norway specifies levels of daylight to be achieved, requiring a Daylight Factor of 1% at the working plane, mid-way into the room, towards the side walls. This is a reasonably high standard, but it is not possible to compare it with the requirements expressed as size of openings because the calculation considers the configuration as well as the size of rooms and windows. Also, the application of this requirement is unclear.

The size of daylight openings can also be influenced by requirements for energy conservation. This is always one of many variables considered in the calculation of energy performance, but some other methods of compliance with energy conservation requirements specify the maximum size of daylight openings. Such methods are found in Denmark and England and Wales (elemental U-value method). Denmark has a slightly more restrictive standard (22% of heated floor area). None of the mechanisms studied discusses the contribution of adequate day lighting to the reduction in CO_2 emissions due to reduced demand for artificial lighting.

Only Sweden requires access to direct sunlight and only Denmark addresses the issue of nuisance from sunlight, related to the size, orientation and sun-shading of windows. Germany (Hesse) used to limit the orientation of windows, prohibiting apartments with only north-oriented habitable rooms, but this requirement was removed in 2002.

A6.3 Conclusions

The regulation of 'daylight openings' is clearly considered to be of importance in each of the countries studied, except for England and Wales. However, the nature of requirements is relatively unsophisticated and would not necessarily provide an appropriate standard of daylighting.

Each of the countries except England and Wales requires daylight openings in habitable rooms. Only Denmark and the Netherlands definitely require separate kitchens to have daylight openings, whilst only Germany (Hesse) gives specific permission for kitchens without daylight openings. The requirements for the size of daylight openings are not directly comparable, with Sweden and the Netherlands considering the obstruction of daylight in addition to the crude relationship of the size of windows to floor area. Even these are different measures, with the Dutch calculation discounting off-plot obstructions, unlike Sweden.

Only Norway sets targets for the level of daylighting, expressed in terms of the daylight factor, which takes into account the configuration of the room and its windows. However, it also allows the possibility of indirectly lit rooms.

Only Denmark and Sweden address issues of sunlight. Germany (Hesse) used to address orientation as an amenity, rather than an energy conservation issue, but in 2002 the requirements to avoid dwellings with all habitable rooms facing north were deleted.

The Building Decree requirements for daylighting sit uncomfortably between sections on the supply of hot water, and rooms for the storage of harmful substances. As in other countries, provision of daylighting appears to be regarded as a basic amenity, with standards little advanced beyond habitability conditions. It is surprising that such requirements continue to be included in building regulations.

It might be more appropriate to link requirements for daylighting with energy performance. As insulation standards improve, the use of electricity for lighting represents an increasing proportion of household energy use, so that regulations to promote adequate levels and distribution of daylighting could make a contribution to the limitation of CO_2 emissions. The use of sufficiently high targets for daylight factor might encourage careful consideration of the location of windows and configuration of rooms.

Appendix 7 Accessibility

A7.1 Introduction

This section considers provisions to promote accessibility for disabled people in general needs housing. It does not consider requirements for specialised accommodation, such as sheltered or supported housing for elderly or disabled people.

Requirements for accessibility are given in the following sections of the Dutch Building Decree:

- 4.2 Accessible sector
- 4.3 Free Passage
- 4.4 Accessibility

It also has sections on toilet compartments and bathrooms:

- 4.7 Toilet compartments
- 4.8 Bathrooms

which include requirements for accessible toilets and bathrooms.

It has a separate section for the characteristics of ramps:

- 2.6 Ramps

which is grouped with sections on 'Bridging differences in heights' and 'Stairways' (see 2-04 Stairways and Ramps).

This format is quite different from other countries, where requirements tend to follow a tour from outside the building to common spaces, and in some cases to individual dwellings.

A central concept of the Building Decree is not found in other countries: the 'accessible sector', meaning an area of an block of flats or a large residential building, such as a home for older people, that must provide a certain level of accessibility.

There are many accessibility issues that are not covered by the Building Decree and, together with the format of requirements and the 'accessible sector' concept, it is difficult to construct a comparative study. However, like the others, this chapter follows the structure of the Building Decree but adds sections to discuss other issues. It starts with a discussion of the objectives, form, and application of requirements.

A7.1.1 Objectives of accessibility requirements

The *European Concept for Accessibility*[1] *(ECA)* defines accessibility as follows: "*Accessibility is a basic feature of the built environment. It is the way in which houses, shops, theatres, parks and places of work can be reached and used. Accessibility enables people to participate in the social and economic activities for which the built environment is intended.*"

Three strategies are commonly identified in design guidance which respond to the needs of people who use wheelchairs:

- Visitability means that people who use wheelchairs can visit the dwelling, socialise, and use the WC. This usually equates to an accessible approach to the entrance, into entrance level rooms, and an entrance level WC. The ECA states that "*Every visitor must be able to use the facilities appropriate to his visit in an independent and equal fashion*", and emphasises that the external environment of pavements, road crossings, and external ramps, must meet visitability requirements, as part of the public domain.
- Adaptability means that the dwelling is designed so that it could easily be adapted to be lived in by someone who uses a wheelchair. It offers visitability plus the potential to make at least an accessible WC / shower room and bedroom. The ECA offers examples of adaptable provision: "*if the staircase in the original design of the home is wide enough, a stair lift could be installed. Also, if the bathroom has sufficient space, a change in the position of fittings, e.g., the WC and bath, can be achieved*".
- Accessibility means that the dwelling could be lived in by someone who uses a wheelchair; it goes beyond visitability to offer a useable WC/shower-room, access to a bedroom or sleeping alcove, and space to manoeuvre in the kitchen. However, this does not mean that the dwelling is equipped to a full wheelchair standard, which is usually tuned to the individual needs of the occupant.

The building regulations for the countries studied rarely state which approach is taken, and sometimes mix the different levels. For instance, in England and Wales heights for accessible power sockets are given in addition to visitability requirements. In some cases, exemptions mean that even visitability is not fully achieved.

None of the countries specifically describes standards for ambulant people with mobility impairments, except for negotiable stairways (see Appendix 1 'Stairways and ramps'). However, many of the provisions that assist people who use wheelchairs also help people who walk with a frame or crutches, or

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1 Central Coordinating Commission for the Promotion of Accessibility (1996). This publication was funded by the European Commission and is the successor to the European Manual for Accessibility.

who need assistance for everyday tasks. Such provisions include wide corridors and doorways, space in kitchens and bathrooms, and accessible power sockets. There are also relatively few provisions related to people with sensory impairments.

None of the countries studied uses the terminology of the World Health Assembly's *International Classification of Functioning, Disability and Health*.[2]

ICF refers to 'activity limitations' and 'participation restrictions':

- Activity limitations: the difficulties an individual may have in executing activities.
- Participation restrictions: the problems an individual may experience in involvement in life situations.

The *ICF* avoids the negative terms 'impairment' and 'disability', but this analysis uses such terms because they are current in regulations.

A7.1.2 Form of accessibility requirements

Accessibility requirements are either treated as a separate issue in building regulations, or integrated with other topics.

The urban code in Belgium (Wallonie) and the building regulations in England and Wales, and France each contain a section on accessibility requirements, and the Building Decree in the Netherlands has sections on accessibility requirements and a further section with paragraphs on accessibility requirements. Germany (Hesse) has only a brief requirement, for the provision of barrier-free dwellings, in a section of general requirements for dwellings.

In Denmark, Norway and Sweden, provisions to promote accessibility are integrated within several topics. Integration may help to reduce the sense of 'special' provision, but (as in the case of Norway) it does not necessarily mean that the requirements demand high standards.

A7.1.3 Application of requirements

One of the main differences between countries lies in the application of requirements. Generally, a distinction is made between provision for blocks of flats and for single-family houses, but sometimes there is a difference in levels of provision for low-rise and taller buildings, the number of dwellings in a building, and in the Netherlands for the floor area of buildings other than blocks of flats. Beyond that, requirements may only apply to parts of buildings, as in the Netherlands.

In the Netherlands, accessibility requirements are given for dwellings in a

2 World Health Assembly (2001).

block of flats, for caravans, and for other dwellings. For some provisions, 'other' dwellings are subdivided by floor area (less than or more than 500 m^2), which in practice distinguishes between single family houses and large residential buildings, such as sheltered accommodation for older people. Many requirements apply to the 'accessible sector' which is required in large residential buildings other than blocks of flats, with a usable area > 500 m^2. Other countries may have requirements for specialist accommodation which includes some degree of supported housing, but it is not possible to make direct comparisons with the Dutch requirements for large residential buildings which are defined on the basis of floor area, rather than tenure or the services provided. Therefore, in this chapter, requirements for large residential buildings are noted in the tables but are not discussed.

It is considerably more onerous to achieve visitability or accessibility for an estate of houses than a block of flats. Relatively few regulations include requirements for houses. The Netherlands goes further than Belgium (Wallonie), France, and Germany (Hesse) in having some controls on single-family houses. However, it does not achieve a visitability standard for houses, unlike Denmark, England and Wales, and Sweden, although all of these have some reduced requirements for access on sloping sites.

In the Netherlands, there are some visitability requirements for all dwellings (for the 'free passage' of entrances, entrances to rooms, and circulation spaces), or for all dwellings except caravans (for differences in the height of adjoining surfaces, and the height of thresholds). Although the Building Decree requires free passage for the entrance to a toilet, it does not have any other requirements for a visitable toilet in houses < 500 m^2.

In Denmark, there are requirements for an accessible approach to blocks of flats, 'joined' single-family houses, and houses where part is used for a business at home. The requirement for level access at the entrance can be waived for detached houses built for the owner's own use, rather than for sale or for rent, or houses on hilly sites. Inside the dwelling, the requirements are at a standard somewhere between visitable and accessible.

In England and Wales, the requirements are written primarily from the point of view of two-storey, single family houses, the predominant form of housing. 1999 legislation introduced a visitability standard, but a stepped approach is allowed for houses on sloping sites.[3] Requirements apply to all new houses (including self-build for owner occupation).

In Norway, only adaptability requirements, for toilets and access routes, apply to houses.

The most substantial controls on houses are the requirements in Sweden,

3 This exception is allowed for shallow plot gradients (greater than 1 in 15). If a stepped access is allowed, an 'unavoidable' step instead of an accessible threshold is also allowed.

where all buildings must be accessible, although there are reduced requirements for buildings comprising one or two dwellings.

Each country has at least visitability requirements for blocks of flats, but with some exceptions in Germany (Hesse), and England and Wales. Requirements are not necessarily mandatory for all the flats in a block. The application of requirements for individual dwellings in blocks of flats is usually linked to the provision of lifts, but this is not always directly stated.

In the Netherlands, all dwellings are subject to requirements for free passage, and limits on differences in heights of floors and thresholds. Further requirements apply to the 'accessible sector' which is required in larger blocks of flats (see A7.2.1). Requirements for lifts, access to dwellings, and free passage mean that all the dwellings in a building with an accessible sector are visitable. There are also adaptability requirements, for the future installation of a lift in smaller blocks of flats that are not required to have an accessible sector.

Unlike each of the other countries, in Belgium (Wallonie), there is no clear separation of requirements for residential buildings and public buildings, which results in high standards of requirements for the common parts of blocks of flats. It appears to require lifts to all storeys, which implies that all dwellings must be visitable.

In Denmark, visitability provision inside dwellings is mandatory, but accessible approaches are only required to ground floor dwellings and to lifts. Lifts are required for buildings with three or more storeys. Thus, an otherwise visitable upper floor flat in a two-storey building would be unreachable because there was no lift, but all the flats would be visitable in a three-storey building.

In England and Wales, the requirements only apply to dwellings on the ground floor and on storeys served by lifts, but there are no requirements to install lifts. Exemptions from accessible approaches are allowed for buildings on sloping sites. Theoretically this applies to the entrance to a block of flats, but it is not known whether this is allowed in practice. In mixed use developments, any shared areas are subject to the accessibility regulations for non-domestic buildings.

In France, there are some visitability requirements for all dwellings, but these do not include a visitable WC. There are further adaptability requirements for dwellings on the ground floor and on storeys served by lifts. Lifts are usually required for buildings with four or more storeys.

In Germany (Hesse), most requirements only apply to barrier free dwellings, which must be provided on one storey in buildings with more than two dwellings.[4] The building order *(HBO)* relies on *DIN 18025 Part 2: Barrier free*

4 The 2002 revision of the *HBO* extended the requirement for barrier-free dwellings (formerly buildings with more than three dwellings.

design for detailed requirements, an accessibility standard.[5] However, there are potentially significant exemptions, because barrier-free dwellings need not be provided in areas of difficult terrain, or where disproportionate additional expense would be incurred to install a lift that is not otherwise required. Thus the standard of provision relies of the interpretation in practice of these exemptions.

In Norway, the requirements only apply to buildings with common parts and with at least four dwellings. In larger buildings where a lift is required, there must be an accessible route to the entrance door of all dwellings. However there are also adaptability requirements: for a future accessible WC, for all dwellings; and for buildings with common access to less than four dwellings, for plans to demonstrate how access could be achieved.

Only Sweden requires that all dwellings in blocks of flats must be accessible, but for two-storey buildings, there need only be provision for the future installation of a lift. Also, standards for the accessibility of certain rooms are slightly different for flats on one storey and those with two or more.

Accessibility requirements apply to alterations or extensions to existing housing as well as new buildings in Belgium (Wallonie), Denmark, France, the Netherlands, Norway and Sweden. In Germany (Hesse) it is not stated whether accessibility requirements apply to extensions and here it is assumed that they do not. There are no requirements for extensions or material changes of use in England and Wales.

In the Netherlands, the requirements concerning the accessible sector and free passage apply to wholesale renovations of buildings. Also, it is not stated, but it is implied that the existing building standards can be allowed for work on existing buildings that does not constitute wholesale renovation, if it is either technically impossible or economically unfeasible to adopt the new building standards. The Building Decree has further requirements for existing buildings which may be applied under the *Woningwet* (Housing Law) to deficient housing. This is unique amongst the countries studied.

In Denmark, the requirements apply to extensions and alterations, but some specified lower standards are allowed if the local authority considers that the full requirements would demand substantial alteration of the building. In France, requirements apply to renovations and extensions to existing buildings. In Norway, the requirements apply to both new construction and other projects that requires planning permission or a building permit. Local authorities may make exceptions in 'special circumstances'; the central authority has recently urged local authorities to be less lenient, believing that exceptions were being granted too frequently and too easily. In Sweden, the

5 *DIN 18025 Part 1* gives requirements for housing for wheelchair users. There is a useful illustrated guide to both parts of *DIN 18025* at www.nullbarriere.de/18025_beweg.htm.

Table A7.1a Application of accessibility requirements - new housing

KEY: □ no significant requirements ◆ some requirements
● most requirements only apply to some dwellings ■ most requirements apply to most or all dwellings

	Houses	Blocks of flats	Application of requirements
Belgium *Wallonie*	□	◆	*Code Wallon de l'Aménagement du Territoire, de l'Urbanisme et du Patrimoine (CWATUP)*: Accessibility of approaches and common parts of blocks of flats; lifts to all floors that cannot be reached by ramps. No federal requirements.
Denmark	■	■	Blocks of flats: direct access or access route to ground floor dwellings and lifts. Joined houses: access and approach to entrances and open places, level access at entrance. Detached houses: level access at entrance, but possible exemption for houses built for owner's own use and for special topographical factors, except if part of the house is used for a home business. All dwellings: Visitable corridors and doors to all rooms on entrance level of dwelling; visitable bathroom/WC at entrance level of dwellings plus visitable kitchen.
England and Wales	■	●	Access to, and use of building; access to habitable rooms and WC. Some exemptions from level access for dwellings on sloping sites. Lifts not required for blocks of flats (only access for ambulant disabled people required). Local plans may require accessible housing but should not impose detailed accessibility standards. Exemptions for student halls of residence not equipped as self-contained accommodation.
France	□	■	*Decrêt no. 78-1167 9.12.78, Arrêté 24.12.80, Arrêté 21.9.82, Circulaire 4.10.82.* Collective housing only [blocks of flats]. Additional requirements for dwellings on ground floor and floors served by lifts include design for future adaptations to provide usable kitchen, bedroom or sleeping space, bathroom and WC.
Germany *Hesse* 2002	□	●	Application of requirements for provision of barrier free dwellings on one storey of buildings with > 2 dwellings. Provision of lifts in buildings > 13 m. Exemptions for areas of difficult terrain, or where disproportionate expense would be incurred to provide a lift that is not otherwise needed. [Details of barrier free design in *DIN 18025 Part 2.*]
Netherlands	◆	●	Provision of 'accessible sector' in houses or blocks of flats > 500 m^2 or blocks of flats with floor of habitable space > 12.5 m, or usable area > 3,500 m^2 > 1.5 m above ground. Requirements for accessible entrance for all dwellings except caravans, and for 'free passage' around all dwellings.
Norway	◆	●	All requirements apply to buildings with common entry to more than 4 dwellings, but some apply only to buildings with more than 4 storeys and common entry to more than 12 dwellings, including provision of accessible dwellings on ground floor. Adaptability requirement for WCs for all dwellings, for access to buildings with common access to less than four dwellings.
Sweden	■	■	All buildings containing dwellings must be accessible, all dwellings usable. Some reduced requirements for access to single family or two family dwellings in difficult terrain; and for buildings with less than 3 storeys.

Table A7.2 Application of accessibility requirements – existing buildings

KEY: □ no significant requirements ◆ some requirements
● most requirements only apply to some dwellings ■ most requirements apply to most or all dwellings

	Houses			Blocks of flats			Application of requirements
	Extensions	Conversions etc.	Existing buildings generally	Extensions	Conversions etc.	Existing buildings generally	
Belgium *Wallonie*	□	□	□	■	■	□	CWATUP does not specifically mention whether accessibility requirements apply to work to existing buildings, but it may be assumed because an planning permit is required for the reconstruction or adaptation of an existing building to create at least two dwellings, studios, or flats, including extensions.
Denmark	■	■	□	■	■	□	Requirements apply to extensions, alterations, and changes of use, but some specified reduced standards are allowed if local authority considers full requirements would require substantial alteration of the building. Reduced standards for width of common stairs and circulation spaces, clear space in kitchens and bathrooms if room suitably organised for its intended use. Exemptions may be allowed from the provision of lifts in adaptations or conversions of existing buildings.
England and Wales	□	●	□	□	●	□	Applies to new build or buildings demolished leaving only external walls. Requirements do not apply to material alterations or extensions to dwellings, but the pre-existing level of accessible facilities must not be prejudiced by materials alterations or extensions.
France	■	■	□	■	■	□	Requirements apply to renovations and extensions.
Germany *Hesse*	□	□	□	□	□	□	No requirements identified
Netherlands	◆	◆	◆	■	■	◆	Requirements for accessible sector and free passage apply to wholesale renovations at the same standard as new build, without exemption. Requirements for accessibility (in *Bouwbesluit*, Section 4.4) do not apply to existing buildings. Standards for new buildings also apply to other work to existing buildings, but lower standards may be allowed for free passage if new standards are not technically or financially feasible.
Norway	□	□	□	■	■	□	Requirements apply equally to extensions and conversions. Local authorities may make exceptions in 'special circumstances'.
Sweden	■	■	□	■	■	□	Mandatory provisions apply to extensions.

mandatory requirements apply to extensions.

England and Wales is an exception because requirements do not apply to extensions. Also, requirements do not apply to a material change of use to form dwellings, unless the original building has been demolished to leave only the external walls, in which case the subsequent rebuild is treated the same as a new build. Any building work must not worsen the pre-existing level of accessibility, but there is no need to improve accessibility when making material alterations, or extending a dwelling.

A7.2 Accessible sector, new buildings

The 'Accessible sector' section in the Building Decree requires that new buildings shall be accessible to wheelchair users, but its requirements only apply to larger buildings. All requirements also apply to full renovations of buildings, without exemption. This section of the Building Decree comprises:

- Article 4.4 Provision of the accessible sector
- Article 4.5 Circulation space in the accessible sector
- Article 4.6 Differences in height
- Article 4.7 Lift cage dimensions
- Article 4.8 Distance between dwelling entrance and lift

A7.2.1 Provision of accessible sector

The Netherlands is unique in requiring provision of an 'accessible sector' in residential buildings or blocks of flats with user area > 500 m^2 or blocks of flats with the floor of a habitable space > 12.5 m, or usable area > 3,500 m^2 at 1.5 m above ground level.[6] In practice, this means blocks of flats with at least 5 storeys or with at least 100 occupants. The Building Decree does not specify the size of the accessible sector or its location. In practice, this is probably similar to a requirement for visitable ground floor dwellings, but a comparative analysis is not possible because no other country uses floor area or storey height to define the application of requirements.

A7.2.2 Circulation space in the accessible sector

The Building Decree has further requirements that relate to the accessible sector that are not directly comparable to requirements in other countries. However, there are requirements for access to parts of buildings or dwellings

6 The Building Decree explanatory notes confirm that calculation of usable area therefore discounts the area of dwellings on the ground floor.

Table A7.3 Accessible sector

	Provision of accessible sector	Circulation space, blocks of flats with an accessible sector
Netherlands	Blocks of flats or other residential buildings > 500 m². Blocks of flats with floor of habitable space > 12.5 m. Blocks of flats with usable area > 3,500 m² at 1.5 above ground.	Common circulation areas must be in the accessible sector. Direct access to all areas in the accessible sector from adjoining terrain or via a route that passes only through the accessible sector and not through a non-habitable space of another user function.

that are susceptible to comparison when taken in conjunction with those for free passage (see Section A7.3.1)

A7.2.3 Bridging differences in height

Article 4.6 of the Building Decree has requirements for the provision of lifts, dimensions of lift cars, and the distance between an entrance to a dwelling and a lift, which all apply to the accessible sector. Subsequent sections have requirements for the width and height of lift doors, for turning space in front of the lift, and for provisions to allow the future installation of a lift in blocks of flats that are not required to have an accessible sector. Unlike many other countries it does not have requirements for access to lift controls, for the use of lifts by people with sensory impairments, or for the movement of lifts. As an alternative to the provision of a lift, the Building Decree allows the provision of a ramp for changes of level within the accessibility sector. The requirements for the characteristics of ramps are given separately, in Articles 2.38 – 2.45 (see 2.04 'Stairways and Ramps').

There are requirements for the provision of lifts in Belgium (Wallonie), Denmark, France, Germany (Hesse), the Netherlands, Norway, and Sweden. There are no longer any requirements in England and Wales. In the Netherlands, lifts must be installed in any multi-story residential building required to have an accessible sector; this is defined relative to floor area or height. In Belgium (Wallonie), requirements apply to any floor that cannot be reached by a ramp, but specifications in Denmark, France, Germany (Hesse), Norway, and Sweden are based on the number of storeys in the building or the height of storeys containing habitable rooms. There are requirements for characteristics of lifts in England and Wales, but provision is not mandatory. France is the only country to allow exemptions or reductions in requirements for buildings on difficult terrain.

In the Netherlands, the provision of an accessible sector and therefore the provision of lifts are mostly related to floor area and cannot be compared with other countries that relate provision to the number of storeys. However, the requirement for an accessible sector in buildings with a floor above 12.5 m translates as a requirement for lifts in blocks of flats ≥ 5 storeys. Disregarding other requirements for the future installation of lifts (see section 10.4.2), the highest standards for the provision of lifts are in Belgium (Wallonie) which requires lifts in all blocks of flats, and in Sweden (buildings ≥ 3 storeys). The lowest standard, where requirements are given, is in Germany

Table A7.4 Lifts: requirements in Building Decree 'Accessible sector'

	Provision of lifts	Min. dimensions of lift cars
Belgium *Wallonie*	Access without assistance by lift or platform lift for floors that can't be reached by ramps.	1.1 x 1.4 m (width x depth).
Denmark	Buildings ≥ 3 storeys. Possible exemption for adaptations or conversions.	Reference to *DS 1125*: class I/630 and *Ministry of Labour Orders No. 626, 627* [not analysed].
England and Wales	Reasonable provision for disabled people to visit occupants who live on any storey. However, a lift may not always be provided.	0.9 x 1.25 m (width x depth) or other dimensions suitable for unaccompanied wheelchair user.
France	≥ 4 storeys; exemption or reduced requirements for difficult terrain.	1.0 x 1.3 m (width x depth).
Germany *Hesse* 2000	At least one 'barrier free' lift suitable to carry stretchers, wheelchairs, heavy loads: buildings with top floor surface of storey containing habitable room ≥ 13 m. Exemption for topmost storey and basement if especially difficult to construct. See also Table 9.8.	1.1 x 2.1 m (usable area for transport of stretcher). 1.1 x 1.4 m (usable area for wheelchairs).
Netherlands	New buildings and full renovations: Lift or ramp for differences in height > 0.02 m between floors in accessible sector. Lift for differences in height > 0.02 m between floor of private habitable space of flat and floor at entrance to accessible sector (blocks of flats, residential buildings > 500 m² required to have an accessible sector). See also Table 9.8.	1.05 m x 1.35 m (lift between floors in accessible sector). 1.05 m x 2.05 m (lift between flat and entrance to accessible sector).
Norway	> 4 storeys, common entry to > 12 dwellings.	1.1 x 1.4 m (width x depth).
Sweden	≥ 3 storeys; one lift with space for a stretcher: > 4 storeys; additional lift: > 10 storeys. See also Table 9.8.	To accommodate a person in an outdoor wheelchair and a helper (at least one lift, if required for access to dwellings). *General recommendations: Ref. to SS 76 35 20 (1)*

(Hesse) (floor surface of highest storey with a habitable room ≥ 13 m, with some exemptions for topmost and basement storeys).[7]

In the Netherlands, the requirement for provision of lifts applies to full renovations of existing buildings. In Denmark, the requirement applies to adaptations and conversions, but exemptions are allowed where it is proven to be impractical. There is no specific mention in other countries of the provision of lifts in existing buildings.

There are specifications for the internal dimensions of lift cars in Belgium (Wallonie), England and Wales, France, Germany (Hesse), the Netherlands (for buildings required to have an accessible sector), Norway, and a performance requirement in Sweden. In Denmark, most requirements for lifts are given by reference to a secondary source, which was not analysed. The performance

7 The 2002 revision of the *HBO* replaced an even earlier lower requirement, for lifts in buildings with more than five habitable storeys above ground floor.

requirement in Sweden is the highest standard because it requires access for an electrically powered outdoors wheelchair and space for a helper.

The requirement in the Netherlands is slightly smaller (1.05 x 2.05 m, lift between flat and entrance to accessible sector) is presumably intended to allow transport of a stretcher, as in Germany (Hesse) (1.1 x 2.1 m). The Netherlands has a further standard for other circumstances 1.05 x 1.35 m (lift between floors in accessible sector), which is slightly smaller than the standard common to Belgium (Wallonie), Germany (Hesse), and Norway which may be considered adequate for a smaller manual wheelchair (1.1 m wide x 1.4 m deep).[8]

The requirement in France (1.0 x 1.3 m) falls short of these standards. The lowest standard, where requirements are given, is in England and Wales (0.9 x 1.25 m), which is intended for an unaccompanied wheelchair user and is only a little wider than the dimensions given in France for the space required for an occupied wheelchair (0.75 x 1.25 m).

The Netherlands is unique in limiting the distance between a dwelling entrance and a lift in an accessible sector (90 m).

A7.3 Free passage

The 'Free passage' section of the Building Decree applies to all dwellings, but caravans are only subject to the requirements for entrances. All requirements apply to both new buildings and to full renovations of buildings, without exemption. This section includes:

- Article 4.11 Entrances: width and height
- Article 4.12 Circulation spaces: width, turning circles

A7.3.1 Application of requirements

The Building Decree requirements for free passage determine the parts of the building that are accessible and, taken together with the requirements for an accessibility sector, these requirements can be compared with statements in other countries of the parts of buildings that are to be accessible, or the application of similar requirements.

In addition to the requirements for accessibility sectors, the Building Decree requires 'free passage' of entrances which apply to all dwellings. It gives requirements for free passage of areas outside dwellings in blocks of flats, as well as the dwellings themselves.

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8 The *European Concept for Accessibility (ECA)* states that these dimensions are adequate for a person in a wheelchair and an accompanying person.

Table A7.5 Accessibility of parts of the building

	Access to parts of buildings or dwellings	Routes within blocks of flats
Belgium *Wallonie*	—	Accessible route from access route to lift and spaces within the building; applies to public or private access routes and pedestrian spaces in common parts of blocks of flats.
Denmark	Access to each habitable room, kitchen, visitable bathroom/WC (entrance level) [by implication from requirements for accessible doors and corridors].	Level access to ground floor dwellings, and to any lifts. Ramp for any change of level ≥ 0.35 m (common access routes).
England and Wales	Access within entrance or principal storey to habitable rooms and room containing a WC; sufficiently wide for convenient circulation by a wheelchair user.	Access into entrance level flats (level or ramped approaches).
France	Ground floors, storeys served by lifts: adequate dimensions and configuration for wheelchair access to kitchen/ kitchen alcove, living room, bedroom/ bed alcove, WC, bathroom/shower room.	Accessible continuous route to lifts, common spaces, dwellings.
Germany *Hesse 2002*	Barrier-free dwellings: access to living and sleeping areas, a toilet, a bath, and the kitchen or cooking alcove.	If a lift is required: it must give access to all habitable storeys but exemption allowed for basement and top-most storey if difficult to construct. Barrier-free access to lift from all dwellings and common circulation.
DIN 18025	Circulation spaces large enough for wheelchair users. Manoeuvring space at swing and sliding doors.	Access without steps to one storey of housing, if necessary via ramp or lift. Provision for future installation of a ramp or lift to access other storeys within dwellings or common facilities.
Netherlands	All areas in the accessible sector (buildings required to have an accessible sector). Free passage of entrances to: one habitable space, habitable room, toilet, bathroom, and if applicable, to a shared storage room for household refuse, a lift, and to any room giving access to such spaces (all dwellings).	A common circulation space in a block of flats required to have an accessible sector must be in the accessible sector.
Norway	One storey accessible from the common entry (buildings with common entry to more than four dwellings). Accessible continuous route to lifts and dwellings implied (buildings where lifts are required).	
Sweden	Buildings containing dwellings to be accessible and usable; also laundry rooms, other buildings and jointly used premises. Dwellings on one storey: access to all rooms. All dwellings: entrance level WC, bed alcove, dining space, cooking facilities, place for 3-piece suite, storage.	Usable circulation spaces, sufficient space for unassisted handling of a electric outdoor wheelchair.

Access to common circulation spaces at ground level is specified or implied for each country. Access to other common spaces is required in Belgium (Wallonie), France, the Netherlands, and Sweden. Access to dwellings for each storey accessed by a lift is required in France, Norway, and Germany (Hesse).

It is also implied by the performance requirements in Denmark and Sweden, and by requirements for the provision of lifts in Belgium (Wallonie) and the Netherlands.

There are requirements for access to specified parts of dwellings (rather than buildings) in England and Wales, France, Germany (Hesse), the Netherlands, and Sweden. Requirements in both England and Wales and the Netherlands for access to specified parts of dwellings do not include sleeping spaces and therefore constitute visitability standards, but they are high standards in the sense that they apply to single family houses as well as flats. In France, access is required to all the main facilities in dwellings on the ground floor or storeys served by a lift. Sweden, requires access to all rooms for dwellings on one storey, but for dwellings on more than one storey, gives functional requirements only for spaces on the entrance level.

The *DIN* standard in Germany also requires provision for a ramp or lift to reach any other levels within barrier free-dwellings.

The extent of access within dwellings is not always stated directly. In Denmark, the requirements for doorways and corridors imply access to all habitable rooms, the kitchen, and a visitable bathroom or toilet at entrance level. In Norway, the requirement of provision for future adaptations to provide an accessible toilet implies that there should be access to that toilet. There are no requirements for access inside dwellings in Belgium (Wallonie).

A7.3.2 Free passage: width

The Building Decree has a single value for the width of entrances, which is the same as the minimum width for circulation spaces. It is the only country to use the term 'entrance', rather than door or doorway.

Each country has specifications for either the clear opening width of doorways or the width of the structural opening, from which a typical clear opening width can be deduced. There are specifications for clear opening width in Belgium (Wallonie), England and Wales, France (for entrance doors), the *DIN* standard in Germany, the Netherlands, and general recommendations in Sweden. There are specifications for the width of structural openings in Denmark, France and Norway. The description of requirements in Denmark is confusing.[9]

The highest standards for entrance doors is the *DIN* standard in Germany (0.9 m clear opening); the lowest standard is in England and Wales (0.775 m). The highest standard for internal entrances/doorways is in the Netherlands (0.85 m, all dwellings); Belgium (Wallonie) has a similar standard, but it only

9 There seem to be two ways of describing door widths. For accessible doors, the width is described as 9M, 'the modular designation for a door with an outside width (casing measurement)' of about 0.9 m. For upper storeys in houses, width is described as 'a door casing with inside width' of at least 0.7 m.

Table A7.6 Entrances: width of openings

	Min. clear opening width	Min. structural opening width
Belgium *Wallonie*	0.85 m (external and internal).	–
Denmark	–	0.9 m * (outside doors, porch, halls, corridors, one door to habitable rooms, kitchen, visitable bathroom/WC); 0.8 m (non-entrance storey in 2-storey flat if visitable bathroom/WC on entrance storey); 0.7 m upper storeys in houses or conversions.
	* Described as 9M, the modular designation for a door with an outside width (casing measurement) of about 0.9 m. For upper storeys of houses, width described is 'door casing with an inside width of 0.7 m'.	
England and Wales	Entrance doors: 0.775 m Internal doors: – head on approach: 0.75 m from 0.9 m corridor – not head-on approach: 0.75 m in 1.2 m corridor 0.775 m in 1.05 m corridor 0.8 m in 0.9 m corridor	–
France	*0.83 m (for structural opening 0.9 m)* 0.77 m (for structural opening 0.8 m)	0.9 m (entrance doors) 0.8 m (internal doors, access doors in common areas to spaces < 30 m²)
Germany *DIN 18025:2*	0.9 m (entrance to building and to dwelling) 0.8 m (internal)	–
Netherlands	0.85 m (clear width, entrances to habitable space, habitable room, WC, bathroom, common refuse room, lift, associated circulation; all dwellings)	–
Norway	–	1 m (entrance, common circulation)
	[The thickness of insulated doors and door frames results in clear opening widths of only 0.8 m.]	0.9 m (all rooms to which a wheelchair user may need to have access) *
	* Described as 9M (see note for Denmark). No clarification of the type of room is given.	
Sweden	*General recommendations: 0.8 m (entrance and corridor doors, openings along passageways).*	–

applies to doors on the access route in common parts of blocks of flats. The lowest standards, where requirements for internal doors are given, are for upper storeys in Denmark (0.7 m structural opening). In England and Wales the basic requirement is low (0.75 m), but consideration is given to the configuration of the corridor and door, so that doorways must be wider if the approach is not head-on and the corridor is narrow (0.8 m clear opening for a 90∞ turn from a 0.9 m corridor).

A7.3.3 Free passage: height

The Netherlands has a unique requirement for the height of entrances. This requirement addresses an issue of universal design: the accessibility of buildings to tall people. The Building Decree explanatory notes comment that

Table A7.7 Entrances: height of openings

	Min. clear opening height	Other requirements for height of routes
Belgium *Wallonie*	–	Public or private access routes and pedestrian spaces in common parts of blocks of flats: 2.2 m, free of obstacles.
Denmark	–	–
England and Wales	–	–
France	–	–
Germany	–	–
Netherlands	2.3 m (clear height, entrances to habitable space, habitable room, WC, bathroom, common refuse room, lift, routes to those spaces; all dwellings).	–
Norway	–	Avoidance of collision by sufficient height of roof overhangs, other overhanging or movable parts of the building, including stairs, landings, doorways. External access free of obstacles, projecting signs hazardous to sensory impaired people.
Sweden	–	Design to limit risk of injury due to collisions. Doors, stairs, columns, projecting parts of buildings sited and designed to prevent collision; if this cannot be done, marking or signage of obstacles that can be noticed by persons with impaired sight. Design of low balconies (< 2.2 m above footpath) so that they can be noticed by people with impaired sight.

the standard has been increased (from 2.1 m to 2.3 m) in recognition of the increasing height of the population.[10] As noted in the chapter on Stairways and Ramps, the Netherlands also requires 2.3 m headroom above stairways, but other countries only require 2 m.

However, there are broader requirements in other countries for the height of routes, which are intended to limit the risk of collisions with parts of buildings. Only Belgium (Wallonie) specifies the height of pedestrian routes (2.2 m), a slightly lower standard than the one for doorways and stairways in the Netherlands, but of wide application to both external and internal routes. The performance requirement in Norway, to make overhanging parts of buildings sufficiently high to avoid collisions, does not specify dimensions. In Sweden, there is a wide-ranging requirement for design to limit the risk of collisions. There is also a requirement related to the height of balconies, but it does not proscribe low height projections.

10 The Dutch are the tallest nation in the world: the average Dutch man measures 1.845 m. Steenbekkers, L.P.A. (1998).

A7.3.4 Circulation spaces: width, turning circles

The Building Decree has a general standard for the width of circulation spaces in all dwellings except caravans (0.85 m) and a different standard for common circulation spaces (1.2 m). There is also a higher standard for common circulation in existing buildings, which is intended to allow people in wheelchairs to be accompanied (1.25 m). This standard would not apply to full renovations, but to other work to existing buildings. It also has requirements for the dimensions of turning spaces (1.5 x 1.5 m) in blocks of flats: near an entrance, beside the lift doors, and, if necessary, at some point within a circulation space to allow a wheelchair user to turn and exit the building.

There are specifications for the dimensions of common circulation spaces in Belgium (Wallonie), Denmark, France, the Netherlands, the *DIN* standard in Germany, and general recommendations in Sweden. In, there is no limit on the width of corridors but a requirement for provision of a turning space. In England and Wales, there are no specific requirements for common spaces but these may be inferred from performance requirements for the entrance level as being equal to those for corridors within dwellings. There is a performance requirement in Norway, but no clue to dimensions. Apart from France, there are no requirements concerning the configuration and dimensions of corridor junctions and lobbies, although they are implied by the requirement in France for the horizontal carriage of a stretcher. The highest standards for common circulation is in Belgium (Wallonie) (1.5 m, public or private access routes and pedestrian spaces in common parts of blocks of flats). The *DIN* in Germany has a similar standard (1.5 m), but in Hesse this applies only to buildings required to contain barrier-free dwellings. The minimum requirements in England and Wales appear to represent the lowest specified standard (0.9 m, 0.75 m obstructed), but wider corridors are required at any 90° turns into doorways, related to the clear opening width of the doorway.

There are specifications for the minimum dimensions of circulation spaces within dwellings in the requirements in Denmark, England and Wales, France, the *DIN* standard in Germany, the Netherlands, and general recommendations in Sweden. In Norway, there are no dimensional specifications, but the adaptability requirement to provide an accessible WC implies access to that WC. The highest standard is in Denmark (1.3 m access spaces, 1 m upper storeys, access to entrance level bathrooms). Both Denmark and England and Wales recognise that straight routes require less space than routes with turns into doorways, by specifying different corridor widths, but Denmark has higher standards. The lowest standard is in the Netherlands (0.85 m).

There are requirements for turning spaces in common circulation spaces in Belgium (Wallonie) (1.5 m diameter), and the Netherlands (1.5 x 1.5 m, if a turn is needed to reach adjacent terrain). In Sweden, the performance requirement for access for an outdoor wheelchair except in single rooms in

Table A7.8 Circulation spaces: width and turning spaces

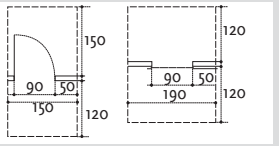
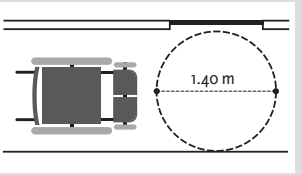
	Min. dimensions of circulation spaces		
	Common	**Within dwellings**	**Turning space**
Belgium *Wallonie*	1.5 m, but 1.2 m obstructed width allowed if obstacles < 0.5 m long and no other obstacle within 1.5 m.	–	1.5 m diameter (at doors to exits, corridors, lobbies). –
Denmark	1.3 m (porches, halls, corridors, similar access rooms on habitable floors); 1 m (corridors without room or cupboard doors at sides; storey other than entrance storey in 2-storey flats if [visitable] bathroom/WC on entrance storey; upper floors in houses; may be allowed for alterations or conversions in existing buildings)		–
England and Wales	Entrance or principal storey: dimensions related to clear opening of doorways and direction of approach: head on approach: 0.9 m 0.75 m door; not head-on approach: 1.2 m 0.75 m door; 1.05 m 0.775 m door 0.9 m 0.8 m door. Min. obstructed width: 0.75 m, max length of obstruction 2 m; obstruction must not prevent turns into or out of a room.		–
France	0.9 m Entrance lobby: 1.4 m deep clear space so that wheelchair user can open and close door. Entrance to building: 1.4 m deep x 1.2 m wide.	0.9 m 1.2 m (perpendicular access, accessible dwellings on ground floor and storeys served by lift).	Space needed for occupied wheelchair: 0.75 m x 1.25 m [Ø 1.5 m turning circle only applies to adaptability of kitchens, bathrooms, bedrooms].
Germany *DIN 18025:2*	1.5 m (width). 1.5 x 1.5 m deep space at opening side of door swing, or 1.9 x 1.2 m space both sides of sliding doors.	1.2 m (width and length), 0.9 m (obstructed). 	1.5 x 1.5 m (turning space by lift doors, at ends of ramps).
Netherlands	1.2 m (common circulation space, blocks of flats). 1.25 m (common circulation space, existing buildings).	0.85 m (all dwellings except caravans).	1.5 x 1.5 m (blocks of flats: near at least one entrance; also in common circulation space if turn needed to reach adjoining terrain).
Norway	Circulation spaces suitable for people with mobility impairments (blocks of flats with common entry to more than 4 dwellings and buildings where lifts are required) [no dimensions or references to other sources].	– [No specification but adaptability requirement to provide an accessible WC implies accessible circulation.]	General requirement Ø 1.4 m. 
Sweden	*General recommendations: 1.3 m (width) 0.8 m (obstructed); same specifications for ramp in corridor as for usable pathways.*		*General recommendations: Ø 1.5 m outdoor wheelchair, Ø 1.3 m indoor wheelchair.*

Table A7.9 Free passage: lifts

	Min. lift door opening	Min. space in front of lift doors
Belgium *Wallonie*	0.9 m (clear door opening)	Clear manoeuvring space 1.5 m by door at call button.
Denmark	Min. standard of lift, by reference to *DS 1125*: class I/630 [not analysed].	Clear width of space in front of doors: 1.3 m.
England and Wales	0.8 m (doorway opening)	1.5 x 1.5 m
France	0.8 m (doorway opening).	Requirement for carriage of stretcher has implications for size of space in front of doors.
Germany		
Hesse 2002	0.9 m (door opening)	Adequate space to manoeuvre.
DIN 18025:2	0.9 m (door opening)	1.5 x 1.5 m (space in front of doors).
Netherlands	0.85 m (clear width) 2.3 m (clear height)	1.5 x 1.5 m (turning space adjacent to lift doors).
Norway	One lift must be accessible. Reference to *NS 3800*. [By inference: 0.8 m.]	[By inference: 1.4 m diameter.]
Sweden	*General recommendations:* *0.8 m (door opening); Ref. to SS 76 35 20 (1).*	*General recommendations:* *Ref. to SS 76 35 20 (1).*

dwellings would mean that a turning space would be required for some layouts (general recommendation: diameter 1.5 m). The *DIN* standard in Germany has requirements for turning spaces at the ends of ramps and by lifts (1.5 x 1.5 m), and also requires a manoeuvring space at the opening side of swing doors (1.5 x 1.5 m, including door swing). In Norway, turning circles are used to satisfy performance requirements for 'sufficient space,' which are significantly smaller than in other countries (diameter 1.4 m). There are no specific requirements for their provision, but one section has a diagram requiring sufficient space in front of entry doors to allow accessibility for a wheelchair user. In France there are adaptability requirements for turning circles, but in rooms not circulation spaces. There are no requirements for turning spaces in Denmark, or England and Wales.

A7.3.5 Free passage: lifts

The requirements for free passage apply to lifts. Similar requirements are given separately in other countries and it is convenient to group them in a separate table.

Accessible entry to lifts relies on both the opening width of doors and manoeuvring space at landings in front of the doors. Some countries have dimensional specifications for both of these: Belgium (Wallonie), England and Wales, Germany (*DIN* standard), and the Netherlands. In France, only opening width is specified but the requirement for the carriage of a stretcher has implications for manoeuvring space. Norway requires at least one accessible lift; no dimensions are given, but reference is made to a national standard. Apart from reference to an *SS* standard, the general recommendation in Sweden only includes dimensions for opening width.

The highest standards for the clear opening width of lift doors are in Belgium (Wallonie) and Germany (0.9 m). The Netherlands requirement (0.85 m) falls midway between this and the lowest standards, in England and Wales, France, Sweden, and probably Norway (0.8 m).

There are dimensional specifications for manoeuvring space in front of lift doors in Belgium (Wallonie), Denmark, England and Wales, Germany (*DIN* standard), and the Netherlands. There is no specific requirement in France, but the requirement for movement of a stretcher would impose some requirement on manoeuvring space. In Norway and Sweden, there are only references to national standards. Belgium (Wallonie) and Denmark only specify the width of the space (1.5 m), but England and Wales, the *DIN* standard in Germany and the Netherlands specify both width and depth (1.5 x 1.5 m).

A7.4 Accessibility, new buildings

This section of the Building Decree includes:

- Article 4.17 Differences in height at entrances to dwellings and blocks of flats
- Article 4.18 Differences in height at entrances to accessible sector
- Article 4.19 Provision for the future installation of a lift

Some of the requirements in the 'Access' section apply to all dwellings apart from caravans, some only apply to blocks of flats. There is no mention of the application of these requirements to existing buildings.

A7.4.1 Difference in height of surfaces and thresholds at entrances

The Building Decree 4specifies a single limit for the differences in height between adjoining surfaces and for threshold upstands (0.02 m), which applies to the entrances to dwellings, to blocks of flats, and to the accessible sector. It reinforces the requirement that a lift or ramp is required to bridge differences in height > 0.02 m between floors in an accessible sector, but it also means that entrances to single family houses are visitable.

Most countries limit the height of thresholds but do not specify limits on the relative heights of internal floors and adjoining terrain or common circulation spaces. There are requirements for access without steps in Denmark, and performance requirements for level access in Norway and Sweden. The performance requirement in Sweden, for a usable entrance for an electrically powered wheelchair, is the highest standard. In England and Wales, accessible thresholds are required except on sloping sites where a stepped approach is allowed, in which case a step at the entrance is allowed (0.15 m).

There are specified limits on the height of thresholds in Denmark for

blocks of flats, in France, the Netherlands, Norway and in the *DIN* standard in Germany. In Denmark, level access is required for houses, but no height of threshold is specified. In England and Wales, detailed requirements are given in a separate document.[11]

In Sweden, the performance requirement of access for an outdoors wheelchair applies, but there is no recommendation for the height of thresholds. The highest standards are in France and the Netherlands (0.02 m); there are slightly lower standards in Denmark and Norway (0.025 m).

A7.4.2 Provision for installation of a lift

The Building Decree requires provision for the future installation of a lift in buildings where an accessible sector is not required.[12] There are similar requirements in the *DIN* standard in Germany and in Sweden, but the application of requirements varies. Provision in Germany applies to buildings required to have barrier-free dwellings, which probably has the same effect in practice as the requirement in the Netherlands. The requirement in Sweden is of much wider application, to buildings not required to have lifts but which has dwellings that cannot be reached from ground level.

A7.5 Toilet compartments and bathrooms

The Building Decree sections on toilet compartments and bathrooms include accessibility requirements which apply to buildings required to have an accessible sector. There are also dimensional requirements for toilets and bathrooms in other situations which are basic space standards and are not intended to achieve visitability. These sections of the Building Decree include:

- Articles 4.35-4.38 Provision, location, dimensions of toilet compartments
- Articles 4.40-4.44 Requirements for existing buildings
- Articles 4.46-4.49 Provision, location, dimensions of bathrooms
- Articles 4.51-4.54 Requirements for existing buildings

Some countries do not have separate requirements for toilets and bathrooms and it is not always possible to make a direct comparison.

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11 Guidance on thresholds in England and Wales is very detailed and offers different ways to deal with the problem of ingress of water. This interest probably reflects the preponderance of individual houses, where this issue is more critical than for a common entrance to an block of flats.

12 The Building Decree notes explain that the space for future installation of a lift may be inside or outside the user function [i.e. inside or outside dwellings or the residential area of the building], at a point where it can be installed without conflict with other building regulations, such as provision of daylight to rooms.

Table A7.10 Access: difference in height of floors, thresholds, provision for future installation of lifts

	Difference in height of floors, requirements for entrances	Max. threshold	Provision for future installation of lifts
Belgium *Wallonie*	–	–	–
Denmark	No steps.	Blocks of flats: 0.025 m Houses: none specified.	–
England and Wales	Accessible threshold if level or ramped approach. Also for stepped approach unless step unavoidable, max. 0.15 m. Refers to separate guidance: Department of the Environment, Transport and the Regions (1999) *Accessible thresholds in new housing: Guidance for house builders and designers* : *DETR (1999): Design, detailing and dimensions of drainage channels at entrance.*	*Height of sill above landing: 0.005-0.010 m plus max. height of threshold unit 0.015 m. Design of sill, internal transition unit.*	–
	Alternatives can be used, demonstration by ergonomic testing.		
France	–	0.02 m	–
Germany *DIN 18025:2*	–	0.02 m, all doors	Provision for addition of a ramp or lift for step-free access to other storeys within dwellings and common facilities (buildings with barrier free dwellings).
Netherlands	Max. 0.02 m difference in height between floor at entrance and adjoining land or common circulation space (at least one entrance to all dwellings except caravans; to accessible sector; to block of flats).	0.02 m (at least one entrance to all dwellings except caravans, and at least one entrance to block of flats; between floor in accessible sector and adjacent floor, terrain or ramp).	New buildings: installation space for lift in block of flats with entrances to dwellings at height > 3 m [i.e. buildings ≥ 2 storeys]; installation space to serve each storey, provide for lift cage min. 1.05 x 2.05 m.
Norway	Difference in level between internal floor and entrance landing as small as possible.	0.25 m; chamfered profile.	–
Sweden	Usable entrances, sufficient space to handle an electrically powered outdoor wheelchair.	–	Provision for future installation of lift or lifting device: < 3 storeys with dwellings that cannot be reached from ground level.

A7.5.1 Provision, location, and dimensions of toilet compartments

The visitability or accessibility of toilets varies with the amount of space available for manoeuvre and the relative positions of the toilet, hand basin, and manoeuvring space. The Building Decree specifies provision of a universally accessible toilet compartment in the accessible sector. It does not

require visitable toilets in individual dwellings, although it requires free passage for doors to toilet compartments.

There are accessibility or visitability requirements for toilet compartments in England and Wales, Germany (Hesse), the Netherlands, and Sweden; for space in bathrooms in Denmark and the *DIN* standard in Germany; and adaptability requirements in France and Norway. The requirements in Denmark, England and Wales, and Sweden apply to the entrance level of individual houses as well as flats. In Belgium (Wallonie) there is no requirement for accessible provision, but dimensions are given that would apply if a toilet was provided. In Norway, there must be provision for the future installation of an accessible WC, but the requirement is seldom (if ever) enforced except in blocks of flats.

The Netherlands gives dimensional requirements for the size of toilet compartments in terms of width, depth, height and area. It has two levels of requirements for new dwellings, one for a universally accessible toilet in an accessible sector (1.65 x 2.2 m), the other is a requirement for small dwellings in blocks of flats that is not intended to achieve any level of accessibility (0.9 x 1.2 m). There is also a set of lower standards for existing buildings. The only other description of room size is a general recommendation in Sweden for the size of a compartment for toilet and hand-basin (1.7 x 1.9 m). Although this is smaller than the accessible toilet in the Netherlands, it is required for all new housing, and thus represents a higher standard. Only the Netherlands specifies a minimum ceiling height for toilets.

Other countries do not specify the size of the room, but give critical dimensions for use of the toilet. There are requirements for the minimum space in front of sanitary equipment in Denmark and the *DIN* standard in Germany, and for dimensions relative to the toilet bowl in England and Wales. There are also requirements in France to provide for the future adaptation of ground floor flats and flats on storeys served by a lift, comprising turning space between sanitary appliances and clear space adjoining the toilet. Requirements in England and Wales, and the *DIN* standard in Germany are accompanied by diagrams. The requirement in England and Wales could be satisfied by a room 1.5 m deep x 0.9 m wide for frontal access or 0.85 m wide for oblique access.[13] The diagram provided does not include a hand-basin, although the text requires that it should be positioned so that it does not impede access. The regulations acknowledge that the wheelchair will not be accommodated within the compartment. The activity spaces required in Denmark (1.1 m deep), France (0.8 x 1.3 or 1.5 m diameter space between sanitary appliances), and the *DIN* standard in Germany (1.2 x 1.2 m) would produce a

13 The form of this requirement is suited to single-family houses where, typically, a ground floor toilet would be installed in the space under the stairs or in a utility room adjoining the kitchen.

Table A7.11 Provision and dimensions of toilets and bathrooms

	Provision of accessible toilet compartments and bathrooms or shower rooms	Dimensions of toilet compartments and bathrooms or shower rooms
Belgium *Wallonie*	–	If toilets are provided in common parts of blocks of flats: 1.8 x 2.2 m; with 1.1 m space to one side of centre-line of bowl, in line with doorway.
Denmark	At least one bathroom with toilet: clear space in front of washbasin, toilet, bath, shower and bidet. *Guidance: reference to SBI Direction 98: Housing for everyone.*	Clear space: 1.1 m. Smaller spaces may be allowed for adaptations.
England and Wales	Provision of toilet in entrance storey of dwelling or principal storey if entrance storey contains no habitable rooms. No stairs between toilet and habitable rooms in that storey.	Min depth clear space in front of toilet bowl: 0.75 m. Frontal access: min width from centreline to side walls: 0.45 m (both sides); wheelchair approach to within 0.4 m of front of toilet. Oblique access: min width from centreline to side walls: 0.4 m (side opposite door), 0.45 m (side adjacent to door); edge of door opening setback 0.25 m parallel to front of toilet.
France	Dwellings on ground floors, storeys served by lift adaptable by simple work (without affecting structure or common shafts or decreasing number of rooms); includes provision of a usable toilet and bath or shower room.	Provision for future adaptations: Ø 1.5 m turning space between sanitary appliances, clear of door swing, space 0.8 m x 1.3 m beside/in front of WC, clear of door swing.
Germany		
Hesse	Toilet, bath accessible by wheelchair (dwellings required to be barrier-free).	–
DIN 18025	–	*Bathrooms*: min. space in front of sanitary equipment: 1.2 x 1.2 m.

	Provision of accessible toilet compartments and bathrooms or shower rooms	Dimensions of toilet compartments and bathrooms or shower rooms
Netherlands	At least one universally accessible toilet compartment - located in the accessible sector (buildings > 500 m²); - located in the dwelling, or accessible from dwelling entrance via shared habitable rooms or rooms in the dwelling (dwellings < 50 m² in block of flats with accessible sector). At least one universally accessible bathroom - residential buildings > 500 m²; - blocks of flats with dwellings without bathrooms and required to have accessible sector.	Universally accessible toilet compartment: 1.65 x 2.2 m, 2.3 m high. Also: non-accessibility requirements: - for one toilet compartment: 0.9 m x 1.2 m, 2.3 m high (flat < 50 m²) 0.6 m wide, 0. 64 m² area, 2 m high (existing buildings). Universally accessible bathroom: 2.2 x 2.2 m, 2.3 m high. Also: non-accessibility requirements: - for one bathroom: 0.8 m wide, 1.6 m² area, 2.3 m high, but 2.6 m² area for bathroom containing toilet (residential buildings > 500 m², flat < 50 m² in block of flats with accessible sector); 0.6 m wide, 0.36 m² area, 2 m high, but 1 m² area for bathroom containing toilet (existing buildings).
	Building Decree explanatory notes refer to Dutch Federation of Handicapped Associations (1998, 3rd edition) *Handbook for accessibility* for the design of universally accessible toilet compartments and bathrooms.	
Norway	Capable of simple* future adaptations to install a WC that can be used by people with mobility and orientation impairments; future solutions to be demonstrated on drawings. [* 'Simple' may mean building works such as removing a wall or providing a soil pipe in a room that is large enough to accommodate an accessible WC.]	–
Sweden	At least one sanitary accommodation to enable a person sitting in an indoor wheelchair to use the toilet. At least one usable sanitary accommodation designed to allow adaptation to provide room for a helper and a separate shower cubicle.	*General recommendations:* *Design dimensions, reference to SS 91 42 21 (4); includes toilet with hand-basin 1.7 x 1.9 m; turning circle: Ø 1.3 m for indoor wheelchair.*

much more visitable toilet, depending on the location of the hand-basin and any other sanitary equipment. The highest space standard is in the Netherlands, for a universally accessible toilet, but it is possible to fulfil this requirement by a single, shared facility in large residential buildings and the accessible sector of blocks of flats. Also, the Building Decree does not include requirements to ensure that the room is usable by wheelchair users.

A7.5.2 Provision, location, and dimensions of bathrooms

The Building Decree requires universally accessible bathrooms in large residential buildings and any block of flats that must have an accessible sector but has dwellings without bathrooms. Only the Netherlands specifies the size of the room (2.2 x 2.2 m), rather than the size of activity space. Denmark specifies the depth of activity space in front of the washbasin, toilet, bath, shower and bidet (1.1 m).[14]

Germany (Hesse) requires a bathroom to be accessible by a wheelchair in those dwellings required to be barrier-free, and *DIN 18025:2* specifies the size of space in front of sanitary equipment (1.2 x 1.2 m). The only other requirements relating to bathrooms or shower rooms are provisions for future adaptations: in France, for a usable bath or shower, and in Sweden for adaptation of a toilet compartment to incorporate a separate shower compartment, with room for a helper. The space standard in the Netherlands is high, but the application of the requirements means that it is a much lower level of provision than in Denmark, France, the *DIN* standard in Germany, or Sweden, where requirements apply to individual dwellings.

The Netherlands has a further set of standards for shared bathrooms (0.8 m wide, 1.6 m^2 area, 2.3 m high, but 2.6 m^2 area for bathroom containing toilet), but these are not intended as accessibility standards and could not incorporate sufficient manoeuvring space to be visitable. There is also a set of lower standards for existing buildings.

A7.6 Other accessibility issues

The Building Decree does not address a number of accessibility issues that are controlled in other countries, or does not regulate issues to the same level of detail. The accessibility or visitability of housing relies on a great many details and it is possible to evaluate the standards required by the Building Decree by considering additional requirements in other countries.

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14 This may not allow a wheelchair to turn in a single movement, but a three-point turn may be possible if the space is 1.4 m long.

A7.6.1 Routes to the building

In the Netherlands, there is no consideration of accessible car parking, or routes outside the building.

The key issues for car parking are the provision of accessible spaces and the dimensions of such spaces, in particular the width of manoeuvring space to the side of the car. There clearest requirements for both the provision and dimensions of accessible parking spaces are in Belgium (Wallonie) (2%, 3.3 m wide) and France (5%, 3.3 m wide including 0.8 m manoeuvring space). Also, in Norway, the Guidebook to the Building Regulations recommends at least one space near the building (5.0 x 3.8 m). The recommendation in Norway is the highest standard in terms of the size of the parking space, and is meant to apply to all buildings, but in practice it would not be applied to single family houses. In Denmark, there are requirements for a 'suitable' number of accessible car parking spaces for non-detached houses with reference to a secondary source, and for blocks of flats, but no dimensional requirements are given. In Sweden, there only need be the possibility of providing an accessible waiting or parking space and no dimensions are given. Even so, there is a precise specification of the maximum distance of an accessible space from a dwelling (25 m). There are no requirements for the provision, location or dimensions of accessible parking spaces for housing in England and Wales, Germany (Hesse), or the Netherlands.

There are requirements for accessible routes:

- to houses and blocks of flats in Denmark, England and Wales, and Sweden, but for ground floor dwellings in Sweden, it is only necessary to ensure that an entrance ramp can be built in future;
- to blocks of flats in Belgium (Wallonie), Denmark, France, and Germany (Hesse);
- to buildings with common entry to at least four dwellings in Norway; plans for smaller buildings must show how accessible access can be achieved in future.

Some countries allow exemptions for sloping sites. In Denmark, only level access at the entrance is required for detached houses, rather than an accessible route from the public roadway. Exemptions from this are allowed for an owner's own house on a hilly site. However, accessible routes are required for all houses in which part is used for a home business. In England and Wales, exemptions are allowed for 'steeply sloping' plots: for plot gradients over 1:15, only provision for ambulant disabled people is required, in the form of limited flights of gentle steps. This exemption, which applies to blocks of flats as well as houses, means that the requirements in England and Wales represent the lowest standard. Sweden allows exemptions for single-family and two-family houses on difficult terrain, but does not define a measure of difficulty.

Table A7.12 Car parking, general requirements for routes to buildings

	Accessible car parking: provision, min. dimensions	General requirements: routes to buildings
Belgium *Wallonie*	1 dedicated accessible place + 1 further space per 50 places, level surface, signed. Min. width 3.3 m. Direct proximity to building entrance.	Access route from road and parking area.
Denmark	A suitable number of parking spaces for use by disabled people.	Blocks of flats: direct access to each dwelling or from a common external and internal access route. Adjust changes of level in 'access area' [outside the entrance] or with a ramp. Level access to ground floor dwellings, any lifts. *Recommendations by reference to DS Manual 105: Outdoor areas for all – Planning and design – Guidelines for providing access for disabled persons.*
	Joined single-family houses: a suitable number of parking spaces for use by disabled people. *Reference to DS Accessible Outdoor Environment – Direction on Planning and Design for Accessibility for All.*	Joined houses, houses with home business: accessible route from public road to entrance to buildings and open spaces, design for people with reduced mobility, impaired sight and hearing. Detached houses, with no part used for a home business: level access at entrance doors, adjust changes of level in access area.
England and Wales	–	Access to principal entrance from point of alighting from car into house or entrance level flats. Stepped approach 'to suit ambulant disabled people' allowed on 'steeply sloping' plots.* * 'Steeply sloping' plot: plot gradient of more than 1 in between pont of access from a car and finished floor level.

Some of the other countries also have requirements for the characteristics of accessible routes, including pathways and ramps. In the Building Decree, ramps are not grouped with the accessibility sections, and characteristics of ramps are discussed in Appendix 1 'Stairways and Ramps.' Issues that are not addressed in the Netherlands are cross-slope, quality of surfaces, and size of openings in floor grids or gratings on ramps (see Table A1.11). Sometimes the characteristics of ramps also apply to pathways.

A7.6.2 Lifts: controls, door opening, stopping tolerances, signals

There are further factors which affect the safe and easy use of lifts by people with mobility impairments: the location of controls, stopping tolerances (the size of the gap between the lift and the landing floors)[15] and door opening

15 On-site testing has found that the size of the gap between the lift car and the landing floor, in terms of both the width of the gap and the height of the change in level, is of major importance for wheelchair users and people with impaired vision. Site testing has shown that differences in height of 0.03 m occur surprisingly often.

	Accessible car parking: provision, min. dimensions	General requirements: routes to buildings
France	5% accessible 3.3 m (overall width), 0.8 m (space to side)	Accessible continuous route to collective housing.
Germany *DIN 18025: Part 2*	1.5 m (width of space to one side)	Access without steps to houses* and to one storey of the building, if necessary via ramp or lift. Possibility of addition of ramp or lift to achieve access without steps to other storeys, to all areas of dwelling and communal facilities.
	* *DIN 18025 Part 1* includes houses, but in Hesse applies only to one storey of a block of flats.	
Netherlands	–	–
	[Accessibility requirements only apply to entrances and internal circulation].	
Norway	Min one parking space for people with impaired mobility, near the building, 5.0 x 3.8 m. *(Guide book to the Building Regulations)*. [This applies to all buildings, but there is no specific mention of dwellings. In practice, this would not be enforced for single family houses with parking space on private ground.]	Accessible and usable by people with mobility impairments and orientation impairments * (buildings with common entry to more than 4 dwellings). Adaptations for accessible access in future to be shown on plans (buildings with common entry to less than 4 dwellings). * [i.e. Cognitive, hearing and visual impairments.]
Sweden	Possibility of providing a waiting or parking place; max. 25 m from an accessible entrance.	Buildings containing dwellings to be accessible; usable path between waiting or parking place and a usable entrance. For ground floor dwellings, accessibility is satisfied if an entrance ramp can be easily constructed at a later date. Exemptions for one- or two-family dwellings if difficult terrain.

and closing intervals. Belgium (Wallonie), England and Wales, France, and Norway consider some of these issues. In Denmark and Norway, detailed requirements are made by reference to secondary sources, which were not analysed.

Each has requirements for the location of lift controls. Wallonie reflects the possible conflict between accessibility and child safety, with a requirement that the 'stop' button should be at a height of 1.3 m.

There are requirements for stopping tolerances in Belgium (Wallonie), and France, designed to limit differences in height between the floor surfaces of the lift car and landing.

The only specifications of door opening and closing intervals, which relate to the speed at which people move, are in England and Wales.

There are some further visual and acoustic requirements for lift controls and signals which relate to the needs of people with sensory impairments, in Belgium (Wallonie), England and Wales, the *DIN* standard in Germany, and Sweden. There are also requirements for tactile signals in England and Wales, and the *DIN* standard in Germany. Only the *DIN* standard in Germany mentions handrails inside lifts.

Table A7.13 Controls, lift behaviour, other requirements for lifts

	Lift controls: reach from a wheelchair	Control of lift movement	Other requirements
Belgium *Wallonie*	Height of call button, telephone, control buttons: 0.8 - 0.95 m. Control buttons arranged horizontally.	Mechanism for level arrival of lift at storeys.	To be kept unlocked, but without prejudice to security rules. Visual and acoustic signalling of lift stops at landings; visual and audible lift calls and controls; lift telephone with a visual signal; a second set of Braille control as well as a set at a lower level intended for wheelchair users.
Denmark	Min. standard of lift, by reference to DS 1125: class I/630 [not analysed]. *Reference to Ministry of Labour Orders No. 626, 627.*		
England and Wales	Height of landing and car controls: 0.9 m – 1.2 m; min distance from front wall: 0.4 m.	*Min. 'dwell time' before doors close:* 5 secs, or 3 secs with electronically operated override.	Visual and acoustic signalling of lift stops at landings; tactile indication of the storey at landings; visual notification that the lift is answering a landing call; tactile indication of the floor selected.
France	Max. height of controls: 1.3 m; controls to side of car.	Max. stopping tolerance: 0.02 m.	–
Germany *DIN 18025:2*	–	–	Dimensions of hand rails, control tablet. Tactile control devices, acoustic signals if necessary (over 3 storeys).
Netherlands	–	–	–
Norway	Height of lift controls: 0.9-1.1 m. Reference to *NS 3800* and to Norwegian Building Research Institute information sheets for detailed specifications.	–	At least one lift accessible to orientation impaired people; easy to use controls and signals.
Sweden	—	—	Visual and acoustic signalling of lift stops at landings.

A7.6.3 Entrances to buildings and to dwellings

As well as consideration of clear opening width for the passage of a wheelchair and the height of thresholds, the independent use of entrance doors is affected by the size of adjacent manoeuvring space, including space beside the opening edge of the door; and by the ease of use of handles or locks.

There are specific requirements for the dimensions of landings at entrances in Denmark, France, the *DIN* standard in Germany, and recommendations by secondary reference in England and Wales.[16]

The requirements in Denmark only apply to blocks of flats and to houses with a home business. In Norway, there are differing requirements in two sections on stairways and doorways, which apply to entrances that must be accessible. The highest standard is the performance requirement in Sweden, which requires sufficient space to manoeuvre an outdoors wheelchair.

16 Department of the Environment, Transport and the Regions (1999).

Table A7.14 Dimensions and slope of entrance landings

	Min. dimensions of entrance landings	Max slope of entrance landings
Belgium *Wallonie*	–	–
Denmark	Blocks of flats, houses with home business: 1.5 x 1.5 m, measured from hinged side of door; or 1.5 m x 1.7 m along facade (outward opening door). No requirement for other houses.	Blocks of flats: Horizontal, level with floor inside. Houses: Level; also at doors to terraces, balconies.
England and Wales	Refers to separate guidance, DETR (1999). *0.9 m wide x 1.2 m deep for head-on approach; 1 m wide for side approach.* *Alternatives to recommendations can be used, demonstration by ergonomic testing.*	*1:40 – 1:60*
France	1.4 m deep (beyond door swing)	Level
Germany *DIN 18025:2*	1.5 x 1.5 m (opening towards user); requirements for clear space on terraces and at ends of ramp may also be relevant.	Max. lengthwise slope: 3% [1:33]; Max. cross-slope: max 2% [1:50].
Netherlands	–	–
Norway	No direct requirements but: a) Requirements for stairways: Landings at entrances to apartments required to be usable by wheelchair users: 1.4 m wide and large enough to use door. b) Requirements for moveable parts of buildings: Width varies with width of door and direction of travel, may be calculated from requirements for clear space beside door. Door opening in direction of travel: 1.4 m deep x door width + 0.3 m wide; door opening towards user: 1.8 m deep x door width + 0.5 m wide. Also: *Min. distance from doorway to opposite wall:* 1.4 m (door opening in direction of travel); 1.8 m (door opening towards user).	–
Sweden	–	–

Norway has a requirement for the minimum space between a doorway and an opposing wall, which probably relates to the size of door lobbies.

The requirements in Denmark and France concerning the slope of landings at entrances are simply for a level surface, but in England and Wales a maximum gradient is recommended by reference to a secondary source. The *DIN* standard in Germany is the only measure to directly specify gradients for slopes and cross-slopes at entrances. Denmark is alone in applying requirements for level access to terrace and balcony doors as well as the entrance.

A7.6.4 Use of doors and doorways

Manoeuvring space beside the opening edge of doors allows a wheelchair to move to one side as the user reaches for the handle. This is particularly important when the door swings towards the chair. This measure has considerable implications for the size of circulation spaces and is rarely addressed.

Table A7.15 Use of doorways

	Clear space beside opening edge	Other requirements for doors and doorways
Belgium *Wallonie*	0.5 m	Use of revolving doors alone not allowed.
Denmark	0.5 m if door opens towards user (common access routes).	Reference to *DS 1028: Single-leaf interior doors*.
England and Wales	–	Outward opening doorway to WC on entrance or principal storey. Doorway positioned to enable wheelchair users to access WC; for oblique access, edge of door opening setback 0.25 m parallel to front of WC.
France	–	Circulation to accommodate a stretcher carried horizontally; stretcher dimensions 2.29 m (+/– 0.005 m) x 585 mm (+/– 0.002 m). [General requirement, separate from accessibility requirements.]
Germany *DIN 18025:2*	–	Turning space (manually operated doors). Doors must not open into WCs and bathrooms.
Netherlands	–	–
Norway	Common access routes (blocks of flats with common entry to > 4 dwellings), dwelling entrances (blocks of flats): 0.3 m (door opening in direction of travel); 0.5 m (door opening towards user).	–
Sweden	Sufficient space to open and close doors from a wheelchair (usable doors). *General recommendations: Reference to SS 91 42 21 (4), wich relates clear space to the depth of adjacent space, e.g. 0.25 m for 1.8 m, 1.1 m for 1.2 m (internal doors).*	Usable doors in circulation spaces. Usable doors in one-storey dwellings: at least one entrance door, door to each room including kitchen, one sanitary accommodation, balcony or patio. Handles and locks positioned and designed for use by functionally impaired persons. *General recommendations: Swing doors that people can see through.*

There are direct requirements for clear space beside the opening edge of doors on common access routes in blocks of flats in Belgium (Wallonie), Denmark, and Norway (0.5 m, doors opening towards user). The requirements in Norway only apply to buildings required to be accessible, but it also requires clear space for doors opening in the direction of travel (0.3 m). The performance requirement in Sweden applies to any door required to be usable, which applies to doorways inside one storey dwellings as well as common circulation spaces. The associated SS standard gives a range of dimensions related to the depth of the adjacent space (e.g. 0.25 m for 1.8 m, 1.1 m for 1.2 m).

In England and Wales, there is a limit on the relative location of the edge of the door opening and the toilet bowl, and a requirement for outward opening toilet doors. The *DIN* standard in Germany allows either outward-opening or sliding doors.

The only requirement for the ease of use of handles, control devices, and locks is in Sweden. None of the requirements addresses the weight of doors or the force needed to open them.

Table A7.16 Size of living rooms, bedrooms, kitchen

	Living room, bedroom	Kitchen
Belgium *Wallonie*	–	–
Denmark	*Guidance: reference to SBI Direction 98: Housing for everyone.*	Kitchen: clear space 1.1 m in front of workplaces and cupboards. Smaller spaces may be allowed for adaptations, if rooms are suitably arranged for intended use. *Guidance: reference to SBI Direction 146: Kitchens for the disabled.*
England and Wales	–	–
France	Ground floors, storeys served by lift: dwellings adaptable by simple work (without affecting structure or common shafts or decreasing number of rooms) to provide a usable kitchen/kitchen alcove, living room, bedroom/bedroom alcove. Future adaptations: bedrooms: Ø 1.5 m turning space, 0.9 m passage to 3 sides of a double bed.	Future adaptations: 1.5 m passage between appliances, fittings and walls.
Germany *DIN 18025:2*	Min. access spaces: 1.2 m (beside bed); 0.9 m (in front of fitted furniture).	Kitchens: min. space in front of kitchen appliances: 1.2 m; 0.9 m in front of fitted furniture.
Netherlands	–	–
Norway	–	–
Sweden	Accessible to a person in an indoor wheelchair (dwellings on 1 storey). Dwellings designed and equipped so that people with diminished mobility abilities can use them. Usable common rooms. Space for manual or small electrically powered indoor wheelchair. *General recommendations: Turning circle: Ø 1.3 m for indoor wheelchair.*	

A7.6.5 Size of living rooms, bedrooms, and kitchens

The Building Decree has requirements for the size of toilets and bathrooms and space standards for other rooms that are intended to increase amenity rather than accessibility. Some other countries have requirements for living rooms, bedrooms, or kitchens, that are expressed in terms of turning space or access space. In France, there are requirements for the future adaptation of dwellings on ground floors and storeys served by flats, which have implications for the size of rooms.

The only accessibility requirements for the size of living rooms or bedrooms are in France, the *DIN* standard in Germany, and in Sweden. In France, provision for future adaptations must be made in bedrooms (to allow Ø 1.5 m turning space, 0.9 m passage to three sides of a double bed). This is probably the highest standard. The *DIN* standard in Germany, which in Hesse applies to the barrier free dwellings required on one storey, gives the minimum width of a space to the side of a bed (1.2 m) and a more general requirement for space in front of furniture (0.9 m). In Sweden, the performance requirement means that a turning space for an indoors wheelchair is required in all rooms for dwellings on one storey (general recommendation: 1.3 m diameter).

There are requirements for kitchens in Denmark, the *DIN* standard in Germany, and in Sweden. The highest standard is the performance requirement in Sweden, with an associated general recommendation that gives dimensions for a turning circle (1.3 m).

A7.6.6 Other mobility provisions

There are a few other requirements which contribute to the use and enjoyment of housing by people who use wheelchairs. These are found in the requirements in Belgium (Wallonie), Denmark, England and Wales, France, and the *DIN* standard in Germany.

Only Belgium (Wallonie) mentions garage doors, requiring that they should be sliding rather than swing-balanced, or kerb drops, for access routes that form pavements.

Denmark mentions boot-scraper gratings at entrances (blocks of flats: no unfixed scraper gratings; houses: no un-recessed boot-scrapers) and France prohibits brush doormats.

There are restrictions on the location of controls, in England and Wales (switches and sockets 0.45-1.2 m), and the *DIN* standard in Germany (height of controls: 0.85 m; radiator valves 0.4-0.85 m; controls located at least 0.5 m from return walls).

Only France limits the size of openings, such as gratings, and height of projections (0.02 m, pathways to buildings, dwellings, lifts, parking places, common spaces). The edges of the projections must be rounded or chamfered.

The *DIN* standard in Germany has a number of other requirements: for turning space on balconies and other types of private outdoor areas (1.5 x 1.5 m); specifications for the minimum area of balconies (4.5 m^2); an intercom with door opener near the entrance of each dwelling; anti-slip, anti-static floor mats at entrances; working height of cooker, worktop, and sink; and space beneath toilets and basins to allow the approach of a wheelchair.

A7.6.7 Other considerations of universal design

Generally, there is relatively little consideration of people with sensory impairments. Some requirements have already been noted: for safety on stairways (see Section A1.3.6 Other requirements for stairways), and for the use of lifts (see Section A7.6.2 Lifts: controls, signals).

The requirements for headroom under projecting parts of buildings (see Section A7.3.3: Free passage: height) may be relevant to people with visual impairments, but they are primarily aimed at tall people.

There are also requirements for contrast marking of glass in Denmark, Germany, Norway, and Sweden. In England and Wales the requirements[17] do not apply to housing. Also, in Denmark, areas of glazing must either be designed and dimensioned to avoid risk of injury, or guarded.

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17 Requirements given in DTLR (1998) *Building Regulations: Approved Document N - Glazing - safety in relation to impact, opening and cleaning.*

There are few way-finding requirements: The *DIN* standard in Germany requires tactile marking of storey numbers and route directions on stairways. Norway requires that access, circulation spaces and lifts are clearly marked, recommending a variation in paving at the start of the access path and in front of the entrance to the building.

Belgium (Wallonie) has requirements for the detection of obstructions by people with visual impairments: for ground level skirts below projecting fittings such as letter boxes and telephones[18], and for the size and visibility of car parking bollards. There is also a limit on the projection of a door opening onto accessible routes.[19]

In Denmark, headspace in kitchens is required, at the front edge of workspaces and cupboards (2 m).

Norway requires the lighting of external access routes, but does not specify a level of illumination. It also appears to consider the spatial requirements of people with guide dogs, requiring that access to dwellings is large enough for sensory disabled people, but there is no indication that this requirement is practised with that understanding in mind.

There is very little mention of people with other types of impairments, and only in the most general terms. In Denmark, the 'greatest possible consideration must be given to people with reduced mobility or impaired sight or hearing' if it is not possible to provide a lift in an adaptation or conversion, but there is no explanation of what this means. Norway frequently refers to people with orientation impairments, a term that encompasses cognitive, hearing and visual impairments, and Sweden mentions people with hearing impairments, but again seems to have no requirements other than visual lift signals. Sweden is alone in specifying consideration of the needs of 'people who become easily confused', but does not offer any explanation of how to satisfy this requirement.

A7.7 Comparison with the European Concept for Accessibility (ECA)

Unlike some other countries, the Building Decree does not refer to any secondary sources for design guidance, such as a national standard or advice by research bodies. Although the Building Decree explanatory notes refer to the *Accessibility manual* of the Federation of Dutch Councils of Disabled People as the source of dimensions for an accessible toilet compartment, it does not

18 This is similar to the intention of the requirement in max 0.3 m high space under overhangs onto walkway.

19 It is difficult to understand this requirement: "*La porte transversale de ce cheminement ne dépasse pas 2 centimètres par mètre*" *(CWATUP, Art 415.)*.

recommend reference to the manual for detailed design. Surprisingly, it also does not refer to the *European Concept for Accessibility*, which was initiated in Utrecht in 1987 by a conference organised by the Dutch Council of the Disabled.

This section explores the use of the *European Concept for Accessibility (ECA)* as a possible benchmark for accessibility standards by comparing its approach and requirements with those of the countries studied.

The *ECA* specifies dimensions and other quantitative requirements, states various qualitative requirements, and introduces each topic with a brief explanation. It has requirements for:

- Horizontal movement: widths; turning space; headroom; level surfaces; means of orientation and warning;
- Vertical movement: ramps; lifts; steps and stairways;
- 'Various activities': use of doors; operating, reaching and holding; sitting; perceiving information.

The *ECA* does not differentiate between standards for housing and non-domestic buildings. It has a single standard for most measures, apart from the width of circulation space and the steepness of stairs and ramps. In other words, it proposes that accessibility has many absolute requirements, no matter the situation.

Primarily, the *ECA* is concerned with visitability. It does not describe a full accessibility standard, for individual dwellings appropriate to wheelchair users, without adaptation. Also, it does not demonstrate any adaptability requirements. However, it has some broader requirements in the sections on 'Operating, reaching and holding' and 'Perceiving information' that exceed visitability.

The following tables compare the *ECA* criteria with the requirements in the countries studied, including those for vertical movement (see 2:04 Stairways and ramps).

The table should be viewed with some caution:

- Although standards in some countries may be higher than the *ECA*, the application of the standards may mean that they are of relatively less significance. For instance, Belgium (Wallonie) has very high standards for the width of circulation spaces, but they do not apply to single family housing.
- The absence of a requirement does not necessarily represent a low standard. For instance, if there is no requirement for the width of narrowed parts of walkways it means that the minimum width of the walkway applies throughout, which is a high standard. Similarly, if there is no requirement for space to turn at doorways, this does not matter if the minimum width of the walkway is sufficiently generous.
- Some requirements are expressed in a different manner that does not allow direct comparison, but may offer a similar standard of amenity.

Table A7.17a Comparison with European Concept for Accessibility (ECA)

Key									
high	country standard higher than ECA								
low	country standard lower than ECA								
equal	country standard equal to ECA								
–	no dimensional requirement								
ECA criteria		**Belgium** *(Wallonie)*	**Denmark**	**England and Wales**	**France**	**Germany**	**Netherlands**	**Norway**	**Sweden** *(Gen. recommend.)*
Min. width of walkway									
0.9 m (people never pass one another)		–	high	equal	equal	high	low	–	*high*
1.2 m (people pass each other occasionally)		high	high	low	low	high	equal	–	*high*
The *ECA* has further standards: 1.5 m (people pass each other regularly); 1.8 m (people pass each other continually). These are probably not relevant to housing. However, the requirements for common circulation in Belgium (Wallonie) and the *DIN* in Germany equal the first of these higher standards.									
Min. width at narrowing in walkway									
0.85 m, narrowing ≤ 0.3 m long		high	–	low	–	high	low	–	*low*
Space for 90° turn into porch/door opening									
passage width + opening width ≥ 2 m		high	–	low	equal	–	–	high	–
Max. speed of movement									
0.5 m/sec		–	–	high	–	–	–	–	–
Min. turning space, walkways with dead end									
1.4 x 1.4 m (90°)		–	–	low *	–	–	–	–	–
1.7 x 1.4 m (180°)		–	–	–	–	–	–	–	–
Ø 1.5 m (90°, 180°, 360°)		equal *	–	–	–	equal**	high	low	–
Ø 1.8 m (180°, 360°, electric or other wheelchair)		–	–	–	–	–	–	–	*low*
* Only requirements for space beside doorways.									
** Only shows head on approach to doorways.									
Min. headroom									
2.2 m walkway		equal	–	–	–	–	high	–	–
2.1 m doorways ≤ 0.3 m deep		–	–	–	–	–	high	–	–
Level surfaces									
Max. 0.02 m openings in surface of walkways		–	–	–	equal	–	–	–	–
Max. 0.005 m projections in walking surface		–	–	–	low	–	–	–	–
Max. 0.02 m difference in floor levels without need for special provisions		–	–	–	–	–	equal	–	–
Various activities [Use of doors]									
min. 0.85 m clear door opening		equal	low	low	low	high*	equal	low	*low*
* Higher standard for entrances, lower standard for internal doors									
max. 30 N opening resistance		–	–	–	–	–	–	–	–
min. 1.15 m wide passage, door approached from the side		high	high	low	high	– *	– **	high	–
* No mention of doors approached from the side but high standard of requirements for width of corridors.									
** No mention of doors approached from the side. Common corridors sufficiently wide but low standard for width of private corridors.									
min. 0.2 m space at lock side of door (front approach to door)		high	high	–	–	–	–	high	*high*
min. 1.4 m = space at lock side of door + depth of space beyond door swing (front approach to door)		low	low	–	–	–	–	low	*high*
min. 1.4 m wide passage to use car door		low	–	–	low	high	–	equal	–

Table A7.17b Comparison with European Concept for Accessibility (ECA)

Key

high	country standard higher than ECA
low	country standard lower than ECA
equal	country standard equal to ECA
–	no dimensional requirement

ECA criteria	**Belgium** *(Wallonie)*	**Denmark**	**England and Wales**	**France**	**Germany**	**Netherlands**	**Norway**	**Sweden** *(Gen. recommend.)*
Ramps								
Max. 1:12 (8%) gradient, ramp up to 0.15/0.175 m high *	low	high	equal	high	low/ high+	equal	high	*equal*
* The reason for these alternative limits is not explained in the ECA document published on the internet.								
+ Low building regulations standard; high DIN standard.								
Max. 1:20 (5%) gradient, ramp up to 0.5 m high	low	equal	low	equal	low	low	equal	low
Lifts								
Min. 1.4 deep x 1.1 m wide floor area of lift	equal	–	low	low	equal	low	equal	–
Min. 1.2 deep x 0.9 m wide floor area for staircase lift	–	–	–	–	–	–	–	–
Min. 3,500 N hoisting power of lift	–	–	–	–	–	–	–	–
Min. 2,500 N hoisting power of staircase lift	–	–	–	–	–	–	–	–
180°, 1.1 m wide space in front of lift door	high	high*	high	? **	high	high	high*	–
* ECA diagram is unclear. The reference to 180° may mean a turning space 1.4 x 1.7 m.								
** Non-accessibility requirement for space to manoeuvre a stretcher, dimensions only given for stretcher.								
Steps and stairways								
Max. 0.15/0.175 m height of tread* [riser]	low	low/ equal	equal *	equal *	low	low	low/ equal	–
* The reason for the alternative limits is not explained in the ECA document published on the internet, so it is not possible to make precise comparisons.								
Depth of tread 0.63 – 2H [0.33 – 0.28]	low	low	low	low	low	low	low	low
Nosing ~ 15° angle	–	–	low	–	–	–	–	–
0.7 – 0.9 m height of handrail [Another section gives 0.9 m for height of handrail]	–	equal *	equal **	–	–	equal **	equal *	–
* Single value within ECA range.								
** Given that the optimum height of handrails varies with individuals it is not possible to state whether a different height is a higher or lower standard.								
Min. 0.3 m handrail at start and end of stairway	high	–	equal	–	–	–	–	–

Table A7.17c Comparison with European Concept for Accessibility (ECA)

Key		Belgium *(Wallonie)*	Denmark	England and Wales	France	Germany	Netherlands	Norway	Sweden *(Gen. recommend.)*
high	country standard higher than ECA								
low	country standard lower than ECA								
equal	country standard equal to ECA								
–	no dimensional requirement								
ECA criteria									
Means of orientation and warning									
min. 0.05 m upstand defining a walkway		–	–	–	–	high*	low*	–	–
max. 0.3 m high space under overhangs onto walkway		high	–	–	–	–	–	–	–
0.6 m deep marked area to give warning for objects in walkway		–	–	–	–	–	–	–	–
* Only requirements for edge guarding of ramps (see Stairways and Ramps).									
Operating, reaching and holding									
0.9 – 1.1 m height for door handle, light switch, public phone, lift control panel		–	–	low	–	high	–	–	–
0.4 – 1.35 m height for coat hooks, book shelves, etc.		–	–	–	–	–	–	–	–
0.35 m distance from corner to operate a switch		–	–	–	–	high	–	–	–
0.9 m height of handrail [Stairway section states 0.7 – 0.9 m]		–	equal *	equal *	–	–	equal *	equal	–
0.04 – 0.05 m diameter handrail		–	–	–	–	equal *	–	–	–
0.045 distance between handrail and surrounding elements		–	–	–	–	–	–	–	–
0.45 – 0.5 m height for sitting		–	–	–	–	–	–	–	–
0.8 m height for working surface		–	–	–	–	–	–	–	–
min. 0.7 m height space under working surface		–	–	–	–	–	–	–	–
min. 1 m wide x 1.2 m deep transfer space in toilet (oblique, frontal, lateral)		–	high	–	low	–	–	–	–
min. 1.7 wide x 1.4 m deep turning space in toilet, changing room, shower cubicle [overlaps bowl]		–	–	–	high	low	–	–	low
min. 1 m space from centre-line of toilet bowl for transfer and/or assistance		high	–	low	–	–	–	–	–
Perceiving information									
1.05 – 1.95 m clear line of vision, standing		–	–	–	–	–	–	–	–
1.5 m height for information at 'reading distance'		–	–	–	–	–	–	–	–
0.6 – 1.45 m clear line of vision when sitting		–	–	–	–	–	–	–	–
Contrast between information and background (text, switches, door handles)		–	–	–	–	–	–	–	–
Colour coding for symbols: blue information; green safety; yellow risky; red danger/emergency		–	–	–	–	–	–	–	–
Size of symbols related to reading distance: 0.25 m high, < 10 m distant; 0.4 m high, < 20 m distant; 0.75 high, < 50 m distant		–	–	–	–	–	–	–	–
Detectible information for partially sighted and deaf people, such as tactile marking of switches, audible information over intercom, amplification.		equal *	equal *	–	–	equal *	–	equal *	equal *
* The ECA requirement is generalised, with examples of provision; this table reflects any provision for people with sensory impairments.									

Some subjects addressed by *ECA* are of more relevance to non-domestic buildings and to public roadways. We cannot guarantee that our analysis, based on the requirements for housing in the Netherlands, has correctly recorded such subjects. For instance, we did not identify any requirements for the tactile marking of objects along walkways.

The comparison demonstrates the problems of harmonisation, even in this relatively recent field of legislation. There is striking divergence from the *ECA*, not only in terms of standards, but in the scope of accessibility legislation. The scatter of asterisks indicate that the expression of requirements also varies, so that direct comparisons are not always possible. Of course, what is not revealed by this comparison are a few items that are addressed in one or two countries, but are not included in the *ECA*.

The variation in dimensional specifications is probably the most surprising feature of the comparison. One can speculate on the reasons for such differences: variations in the design of wheelchairs between the countries studied; variations in ergonomic research; the heritage of earlier legislation; consideration of construction or land costs; or the influence of interest groups on government policy.

A couple of *ECA* standards are particularly high: none of the countries matches its standards for gently rising stairways and less than half meet the standard for clear door opening widths.

Some other *ECA* standards are particularly low: for clear space in front of lifts, and for clear space at the lock side of doors.

There are several differences in the expression of requirements. For instance, building regulations tend to specify turning circles or squares, rather than turning rectangles; few use calculations for the proportions of space at doorways, or for the relationship between the height and depth of stair treads.

Some *ECA* subjects are rarely specified, such as projections and openings in the surfaces of paths, headroom of pathways and doorways, or the angle of stair nosings. Others are clearly not thought to be suitable subjects for building control, such as the hoisting power of lifts.

A7.8 Conclusions

There is striking divergence from the *European Concept for Accessibility*, not only in terms of standards, but in the scope of accessibility legislation. The expression of requirements also varies, so that direct comparisons are not always possible.

The Netherlands has generally lower standards of accessibility requirements than Sweden, Denmark, or England and Wales, and a lower standard for blocks of flats than France, or the *DIN* standard in Germany. Only Belgium

(Wallonie) and Norway have lower standards. The limited application of requirements in the Building Decree, the lack of some requirements, and the form of expression of others mean that the accessibility or visitability of environments and dwellings is not guaranteed.

Various requirements apply only to the accessible sector that is required in large blocks of flats and residential buildings. The concept of an 'accessible sector' seems a convoluted way to state the application of requirements. It would be much more straightforward to require accessible flats and common spaces on certain storeys, such as ground floors and floors reached by lifts. Smaller blocks of flats are exempt from the requirement for an accessible sector, which seems a wasted opportunity. For instance, a stepped change of level of up to 0.21 m would be allowed within the entrance storey of a block of flats with an area less than 500 m^2, and with the tallest storey less than 12.5 m high. Also, the requirement for provision of lifts is a low standard.

One notable omission in the Netherlands is the lack of controls on the accessibility of externals routes to buildings, even though it requires visitable entrances. Although it has requirements for the width of corridors and doorways, they would not guarantee that it would be easy to manoeuvre into rooms and there is no requirement that rooms should be usable by people in wheelchairs. It requires one accessible toilet and bathroom in large blocks of flats and residential buildings, but it does not require a visitable entrance level toilet in either individual flats or single family houses.

The expression of requirements in relation to the space needed to perform an activity, rather than absolute dimensions of spaces, is of particular relevance to accessibility. Although the Building Decree specifies fairly generous dimensions for an accessible toilet compartment and its doorway, the resulting room could be poorly arranged and difficult to reach, because there is no specification of the critical dimensions for the location of fittings or turning space, or of manoeuvring space at doorways.

Belgium (Wallonie) has fairly high standards for the common parts of blocks of flats, including provision of lifts to all storeys that cannot be reached by ramps, but it does not have any requirements for dwelling interiors, or for single family houses.

Denmark has relatively high standards for blocks of flats and somewhat lower standards for houses. It goes a little beyond visitability standards for flats, but does not quite achieve accessibility (for instance, the space required in bathrooms and kitchens does not allow a wheelchair to turn). Houses must be visitable, but there are exemptions for detached houses built by owner occupiers.

The requirements in England and Wales are written from the point of view of houses, but also apply to flats. Dimensional standards are not particularly high, but requirements include an entrance level toilet and specifications for the heights of sockets and switches. Although the application of require-

ments to houses as well as flats is a relatively high standard, there are signification exemptions because a stepped approach may be allowed on sloping sites. Also, many flats are exempted because there is no requirement for the provision of lifts.

There are some high standards in France, largely thanks to adaptability requirements, but they apply only to flats on ground floors and on storeys reached by lift.

The *DIN* standard in Germany sets high standards, but under the Building Order in Hesse, barrier-free dwellings are only mandatory for one storey of buildings containing more than two dwellings.[20]

In Norway, most requirements apply only to buildings with more than four flats and do little more than address issues of access to dwellings. It is the only country that does not specify or recommend dimensions for circulation spaces. The only requirement for the interior of houses is for the future installation of an accessible WC.

Overall, the highest mobility standards should be generated by the performance requirements in Sweden, for: access using an electrically powered outdoor wheelchair, or provision for such access, to entrances and in circulation spaces; and access using an indoor wheelchair within rooms on the entrance storey. These appear to constitute a nearly comprehensive accessibility and usability standard for dwellings on one storey and the entrance storey of other dwellings. Some provisions are left to future adaptations: provision for the installation of lifting equipment in two-storey blocks of flats, and for adaptable sanitary accommodation to accommodate a helper and a separate shower compartment (both particularly high standards). It is the only country to consider the assisted use of sanitary accommodation. However, there are some shortcomings in the Swedish requirements. Dwellings with direct access from ground level need only be furnished with the possibility of building a ramp to the entrance at a later date, which constitutes a low standard for external access. The turning circle for an indoor wheelchair is smaller than turning spaces specified in other countries, but it applies only to rooms within dwellings, which are rarely addressed in other countries.

None of the countries studied has particularly extensive standards of provision for visual impairment,[21] but the Netherlands has the fewest requirements, apart from France.

Diagrams are rarely used to explain accessibility requirements, but are often used in secondary sources, such as national standards and design guid-

20 The *DIN* standard is also mandatory in Hesse for all dwellings in receipt of subsidy (*Sozialer Wohnungsbau*), under the *Technische Wohnungsbaurichtlinien* (Technical Guidelines for the Construction of Housing).

21 A model of requirements that address the needs of people with visual impairments is given in the Swiss national standard *SN 521 500*.

ance by research or specialist organisations. Of the measures studied, only *Approved Document M* in England and Wales, and *DIN 18025* in Germany include diagrams to highlight critical dimensions.

Appendix 8 Dimensions of habitable space and habitable rooms[1]

A8.1 Introduction

This chapter is based on two sections of the Building Decree:
- 4.5 Habitable space
- 4.6 Habitable rooms

In these sections, the Netherlands tries to avoid associating the sub-division of space with specific functions, but it also has requirements for specific rooms in later sections. Of these, only one is considered in this chapter, because it has implications for the size of a habitable room:
- 4.15 Installation space for a sink and space for a cooking appliance

The other sections, which are not analysed are:
- Toilet rooms
- Bath rooms
- Common storage space for domestic waste
- Storage space for bicycles
- 4.12 Meter space
- 4.13 Lift shafts
- 4.14 Lift machine rooms
- 4.16 Installation space for a space-heating appliance
- 4.17 Installation space for water heating appliance

The formulation of requirements for the subdivision and dimensions of space are considerably different in the Building Decree from those in other countries. The order of the following analysis is slightly different to the order of the paragraphs in the Building Decree, because it makes it easier to construct a comparative analysis.

A8.2 Habitable space

Section 4.5 of the Building Decree requires the provision of habitable space related to the characteristic activities of a dwelling:
- Article 4.20 Performance requirement: provision of habitable space.

1 The Building Decree uses the terms *verblijfsgebied* and *verblijfsruimte*, which are not in everyday use. A literal translation would be 'staying area' and 'staying room', but this analysis translates the term *verblijfsgebied* as 'habitable space' and *verblijfsruimte* 'habitable room', used in the same way as in *Approved Document B*: "*a room used, or intended to be used, for dwelling purposes, including a kitchen or kitchen alcove, but not a bathroom*".

A8.2.1 Characteristics of dwellings

In order to understand the definition of habitable space, it is necessary to consider the spaces that are deemed to be characteristic of dwellings. The Building Decree gives the definition in the explanatory notes. The characteristic activities of the 'living' function are sitting, cooking, eating and sleeping. Thus, in the Netherlands, habitable space includes kitchens but excludes bathrooms, WCs, and circulation spaces, the sizes of which are controlled in other sections. It also includes a proportion of any designated shared habitable area. It excludes areas outside flats such as storage areas and stairways. The definition of the 'living' function does not include storage and the only mention of storage in the Building Decree is for shared storage rooms for household refuse.

Apart from the Netherlands, only Denmark and Sweden define the characteristics of dwellings. The requirement in Sweden is the most extensive, including a dining space, a space for homework, a place near the entrance for outdoor clothes, and storage space, as well as more basic requirements for habitable rooms, a kitchen, and sanitary accommodation. For other countries that have space standards, the characteristic spaces can be deduced from the inclusion of spaces in the definition of measurement of habitable area (see also Table A8.3). In Germany (Hesse) the definition of characteristics of dwellings was reduced in the 2002 revision to a requirement for sanitary facilities and storage.

A8.2.2 Sub-division of space

Section 4.5 of the Building Decree has requirements for the sub-division of space, and the relationship of spaces:

- Article 4.21 Proportion of area of habitable space to total usable area
- Article 4.22 Access from entrance to habitable space

In the Netherlands there is, uniquely, a minimum requirement for the proportion of habitable area relative to usable area (55%). This is a different type of concern from the subdivision of common and individual spaces in collective dwellings in Belgium (Wallonie). The Building Decree also allows for a limited proportion of the habitable space to be provided in the form of shared habitable space.

The Netherlands has basic requirements for the relationship of spaces. Access from the dwelling entrance to habitable space should be via dedicated circulation space, and without passage via a toilet, bathroom or plant room. The only other requirements for the sub-division of interior space are in Denmark and Sweden. Denmark and Sweden address the issue of open planning. In Denmark, kitchen areas may be open plan with living rooms. Sweden spec-

Table A8.1 Characteristics of dwellings, measurement of habitable area

	Characteristics of dwellings	Measurement of habitable space
Belgium *Wallonie*	–	*Habitable area of dwelling:* usable area of habitable rooms, including area of stairways on each level. Excludes halls, corridors, sanitary provision, storage rooms, cellars, uninhabitable attics or extensions, garages, places for professional use.
Denmark	Dwellings must have habitable rooms, a kitchen, and sanitary accommodation.	–
England	–	–
France	–	*Habitable area:* excludes stairways, uninhabited roof spaces, cellars, basements, outhouses, garages, terraces, balconies, loggias, external drying rooms, verandas, glazed volumes for solar gain or acoustic insulation, common spaces, other ancillary spaces.
Germany		
Hesse 1993	Each dwelling must have at least one habitable room, a kitchen or cooking alcove, a secondary room including storage room, bath with bath tub or shower, toilet. Common space for buggies, bikes, play equipment (buildings with dwellings on upper storeys); drying areas; laundry room if washing machines cannot be used in dwellings (buildings > 2 dwellings).	Discount areas with ceiling height < 1.5 m.
Hesse 2002	Each dwelling must have a bathroom with bath tub or shower, toilet. Storage for baby buggies and bicycles, in addition to adequate storage in each dwelling (buildings with > 2 dwellings).	Net area [used to classify buildings] discounts area of basements. Discount areas with ceiling height < 1.5 m.
Netherlands	Characteristic activities of the 'living' function: sitting, cooking, eating and sleeping.	–
Norway	–	–
Sweden	Dwellings must comprise: a room for personal hygiene, a room for everyday social contact, a room for sleep and rest, a kitchen, a dining space in or near the kitchen, a space for homework, a place near the entrance with space for outdoor clothes, and spaces for storage. Instead of rooms, a separable part of a room with a window may be provided for social contact, sleep and rest, or cooking, i.e. designed to allow separation by means of walls. In 1-person dwellings, either the part of a room for sleep and rest, or the part of a room for cooking, need not be separable.	

ifies which functions may be accommodated in a separable part of a room, instead of requiring a separate room, but it does not specify the combination of functions. The lack of requirements in other countries suggests that open planning is acceptable.

A8.2.3 Dimensional requirements for habitable space

Section 4.5 of the Building Decree specifies dimensions for habitable space:

- Article 4.21
  - Area of total habitable space of each living function
  - Width and length of one habitable space
- Article 4.24
  - Area of other habitable spaces
  - Width of other habitable spaces
  - Ceiling height of all habitable spaces

The Netherlands does not specify the minimum total size of a dwelling[2] and only France does so.[3] However, there are requirements for the size of substantial areas of the dwelling in Belgium (Wallonie) and the Netherlands. Unfortunately, the definition and measurements used in Belgium (Wallonie) and the Netherlands do not allow direct comparisons. The calculation in Wallonie includes the area of an internal stairway but the Netherlands excludes stairways. In both Belgium (Wallonie) and France, requirements for the area of habitable space are related to occupancy, but the definitions of habitable space and methods of measurement are different, so again, direct comparisons are not possible. Sweden has a performance requirement for the size of a dwelling, but does not specify dimensions. There are no requirements for the size of a dwelling in the building regulations of Denmark, England[4] and Wales, Germany (Hesse), or Norway.

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2 Although the Netherlands does not specify the minimum total area, this may be deduced from two requirements in Article 4.21. The Building Decree notes explain: "*Activities that are characteristic of living are sitting, cooking, eating and sleeping. Apart from the fact that 55% of the usage area must be present as habitable area for this, the second paragraph sets a minimum area of 24 m² for the habitable area of the dwelling. Practical research has shown that the smallest possible space needed for the performance of activities characteristic of living by one person is 24 m²*". The combination of these requirements suggests that, discounting the possibility that some of the habitable space is shared space outside individual dwellings, the minimum usable area per dwelling should be 43.6 m².

3 In France, there are also regulations to control the description of the size of properties. *Loi n° 65-557 du 10 juillet 1965* requires that offers of sales of flats must state the floor area, measured in conformity with *Décret n° 97-532 du 29 mai 1997*. A purchaser may demand a price reduction if the area is more than 5% smaller than the stated size.

4 In England, there are also no space standards in either of the fitness standards for human habitation or for houses in multiple occupation (Sections 604 and 352, *Housing Act 1985* as amended by Schedule 9 of the *Local Government and Housing Act 1989*).

Table A8.2 Sub-division of space, relationship of spaces

	Sub-division of space	Relationship of spaces
Belgium *Wallonie*	Collective dwellings: requirements for total area of habitable rooms for individual use, for collective use.	–
Denmark	–	Kitchen may be connected with the living room or, in dwellings < 50 m², may be a kitchenette.
England	–	–
France	–	–
Germany *Hesse*	–	–
Netherlands	Habitable area ≥ 55% usable area of user function. Max. common habitable area 35% provided there is either min. 24 m² private habitable area, or min. 18 m² private habitable area and one common habitable area min. 18 m².	A habitable space must be accessible from the dwelling entrance, via enclosed private spaces, without passing through a WC, bathroom or technical room. A shared habitable space may be accessed from the dwelling entrance via enclosed common circulation space or enclosed private space.
Norway	–	–
Sweden	–	–

In the Netherlands there is a single requirement for the minimum area of habitable space (24 m²), which the Building Decree notes explain is for a one-person dwelling. No matter whether precise comparisons are possible, it is clear that the standard of a one-person dwelling in Wallonie is lower (20 m², 15 m² for a studio flat). Both are higher standards than in France (14 m²), where habitable space includes many more parts of the dwelling.

The Netherlands specifies minimum dimensions for one habitable space (3.3 x 3.3 m), deemed to be sufficient sitting space for two people. This requirement is the same as for one habitable room. The only other requirements for the dimensions of spaces, rather than rooms, are the fitness standards in Belgium (Wallonie) for the width of façades.

A8.2.4 Comparison with conditions of financing

There are now very few mandatory space standards associated with subsidy, but it is interesting to compare such requirements with general amenity standards. In Belgium (Wallonie) and France, minimum area related to the number of occupants is specified as part of the conditions of use and conditions of financing.

In Belgium (Wallonie), the space standards are included in habitability or fitness criteria which are conditions of permits to rent or used to decide which properties should be improved or demolished. A further, slightly higher set of standards, linked to the number of rooms and type of household, is a condition of government subsidy.

In France, the *Normes Minimales d'habitabilité* is a fitness standard. The use of the higher, more extensive requirements in the *Code de la Construction et de l'Habitation (CCH)* is not explained in either the CCH or associated decrees; they may remain from earlier systems of subsidy. There are some further, higher standards which apply to housing financed with low interest loans.

Table A8.3 Size of dwellings or habitable space in dwellings

KEY: □ not included in measurements ■ included in measurements

	Criterion	Definition of measurements								Requirements
			parts of dwelling interiors included in measurements							
		Calculations	stairs	corridors	store space	living room	bed-rooms	Kitchen	Bath/WC	
Belgium *Wallonie Arrêté 11 fevrier 1999 Critères de Salubrité des Logements.*	Floor space per occupant Habitable area of dwelling: usable area of habitable rooms, measured to internal partitions but 75% of areas with ceiling heights 1.8-2 m, 50% 1-1.8 m; discounts areas < 1 m high. Includes area of stairways on each level. Excludes halls, corridors, sanitary provision, storage rooms, cellars, uninhabitable attics or extensions, garages, places for professional use; also places with usable area < 4 m², width or lengths < 1.5 m, floors > 1.5 m below adjacent ground, places without natural light.	Gross habitable area	■	□	□	■	■	■	□	**Habitable area (m²), no. occupants** 1 2 3 4 5 ... 10 20 28 33 38 43 68 +5 m² per additional occupant. Dwellings with combined living room – kitchen – bedroom: 15 23 28 — Adequate volume, dimensions. Min. interior width between walls or façades: 2.8 m; min. interior width of a sole façade: 3.5 m.
Denmark	—									
England	—									
France *Code de la Construction et de l'Habitation R111-2, elaborated in Décret n° 84-68 du 25 janvier 1984 and Décret n° 97-532 du 23 mai 1997.*	Floor space per occupant Habitable area: excludes area of walls, internal partitions, stairs, stairway enclosures, shafts, window and door recesses, areas with heights < 1.8 m, uninhabited roof spaces, cellars, basements, outhouses, garages, terraces, balconies, loggias, external drying rooms, verandas, glazed volumes for solar gain or acoustic insulation, common spaces, other ancillary spaces. Habitable volume: 33 m³ (per occupant, up to 4 occupants), 23 m³ (each additional occupant).	Net habitable area	□	■	■	■	■	■	■	**Habitable area (m²), no. occupants** 1 2 3 4 5 6 7 14 28 42 56 66 76 86 [extrapolated from requirement for 14 m² per occupant (≤ 4 occupants), 10 m² (per additional occupant.] **Habitable volume (m³), no. occupants** 1 2 3 4 5 6 7 33 66 99 132 155 178 201
Normes minimales d'habitabilité.	Floor space per **occupant**	Net habitable **area**	□	■	■	■	■	■	■	**Habitable area (m²)** 16 9 for a *pièce isolée* (a dwelling without provision for cooking)

	Criterion	Definition of measurements								Requirements
			parts of dwelling interiors included in measurements							
		Calculations	stairs	corridors	store space	living room	bed-rooms	Kitchen	Bath/WC	
Germany	—									
Netherlands	Habitable space, living function	Floor area	□	□	□	■	■	■	□	**Habitable area (m²)** 24 (new buildings) 14 (min. total floor area of habitable rooms, existing buildings) Size of one habitable space: 3.3x3.3 m
	No definition is given for habitable space, but this can be deduced from the following definitions: User surface area: excludes areas occupied by load-bearing construction components, areas with heights < 1.5 m, areas located outside a flat in a block of flats such as a storage room, heating room or staircase. Also, user surface area of a flat in a block of flats is increased by the proportionate part of certain shared rooms allocated to the flat. Habitable space: part of a user function consisting of one or more habitable rooms, adjacent to each other and on the same storey, other than a toilet or bathroom, technical room or circulation space; space for activities characteristic of the living function: sitting, cooking, eating, sleeping. Habitable room: a room in which people stay; includes rooms used for living, eating or sleeping, or a kitchen. Standards are based on research about the smallest possible space needed for the performance of characteristic activities by one person and for minimal seating for two persons (refers to *Living provisions of the Building Decree*, 1988).								
Norway	—									
Sweden	Dwellings shall be sized ... with regard to their long term use and to the number of persons for which they are intended. *General ecommendations: Reference to SS 91 42 21 (4)[which gives functional dimensions but does not specify minimum room sizes or the overall size of dwellings, many dimensions relate to accessibility requirements].*									

Table A8.4 Size of dwellings: conditions of financial incentives: Belgium, France

KEY: □ not included in measurements ■ included in measurements

	Criterion	Definition of measurements							Requirements						
			parts of dwelling interiors included in measurements												
		Calculations	stairs	corridors	store space	living room	bed-rooms	Kitchen	Bath/WC						
Belgium *Wallonie* *Arrêté 11.2.99**	Floor space per household	Gross habitable area	■	□	□	■	■	■	□	Number of occupants: areas for number of rooms					
										1	2	3	4	5	... 10
										1. 24	30	50	56	62	104
										2. 32	38	or	62	68	110
										3. –	44	56	68	74	–
										4. –	–	–	–	80	–
	* Also in *Arrêté 11 fevrier 1999 Critères de Salubrité des Logements: Annex 2: Fixation des critères minimaux d'octroi d'une subvention autre que celles accordées pour des logements destinés aux ménages en état de précarité* [conditions of state subsidy (except for vulnerable households)].														
France Arrêté 1.3.78 *	Floor space per household	Net habitable area	□	■	■	■	■	■	■	1 person	person/dependent	Head of household + no. children/ dependent people			
												+1 =2	+2 =3	+3 =4	+4 =5 +5 =6
										New-build		30	46	60	73	88	99	114
										Existing buildings, acquisition		27	41	54	66	79	89	103
	Arrêté 1 mars 1978: Normes de surface et d'habitabilité des logements financés à l'aide de prêts conventionnés, modified 17 juillet 1984, 25 octobre 1991, 7 novembre 1991, (standards for dwellings financed by low interest bank loans).														

Again, the differences in definition and measurement do not permit comparison of the conditions of financing in Belgium (Wallonie) and France. However a rough comparison can be made with the Building Decree requirement in the Netherlands, which is similar to the conditions for financing of a one-room apartment for one person in Belgium (Wallonie) (24 m^2), but is considerably lower than the standard for a two-room apartment (32 m^2).

There are no direct or indirect requirements for the size of dwellings in England, or Norway. Space standards have never been included in Building Regulations in England, but used to be included in conditions of the government subsidy of social housing.[5] Similarly, Norway has never had statutory requirements, but compliance with standards for overall area, dimensions, and layout of rooms were preconditions for loans from the State Housing Bank.[6]

In Germany (Hesse), there are no requirements in building regulations but the technical guidelines for subsidised housing includes a minimum requirement for the area of rental and common ownership apartments. Although this includes internal circulation space and sanitary provision, it is clearly a

much higher standard (40 m^2, for a one or two-person apartment) than the minimum for habitable area in the Netherlands (24 m^2).

It is possible that space standards are conditions for financing in Denmark, but they are not contained in building regulations. There is no longer any subsidy of housing in Sweden and the conditions of financing do not consider space standards.

A8.3 Habitable rooms

Section 4.6 of the Building Decree sets requirements for 'habitable rooms'. The dimensional requirements in Section 4.6 are as follows:

- Article 4.26
  - Width and length of one habitable room
  - Width of all habitable rooms
  - Ceiling height of all habitable rooms
- Article 4.31
  - Total area of habitable rooms, dwellings in existing buildings
  - Area of one habitable room, dwellings in existing buildings
  - Width of one habitable room, dwellings in existing buildings

Each country except England has some requirements for the size of habitable rooms. In some countries there are further accessibility requirements that have implications for the size of rooms, most notably the performance requirement in Sweden and the adaptability requirements in France. (See Appendix 7 Accessibility)

None of the requirements explicitly refers to the functions of 'bedroom' or 'living room', but these are usually implied. Requirements for the size of rooms are mostly expressed in terms of minimum floor area and ceiling height, but some countries specify a minimum for the width or length of rooms. There are a few differences in definition, terminology and measurement, but an approximate comparison of requirements is feasible.

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5 From 1967 to 1982 new social rented housing in England was required to meet 'Parker Morris' standards, as a condition of subsidy. These offered minimum specifications of floor area relative to the type of dwelling and number of occupants, plus other storage and services standards. The standards were abandoned by the Conservative government in the 1980s as part of its policy to reduce public expenditure on housing. The current use of floor area related to design occupancy as part of the calculation of Total Cost Indicators cannot be considered to constitute space standards due to the imprecision of their description.

6 Until the early 1990s, loans from the State Housing Bank in Norway were subsidised. Although the loans are no longer subsidised, requirements concerning functional arrangement (rather than the size of rooms) are still in place.

The Building Decree definition of habitable space includes kitchens, but there are additional requirements for the size of spaces for a sink and a cooking appliance, which are dealt with in a separate analysis of requirements for kitchens.

A8.3.1 Habitable rooms

The Building Decree specifies the minimum size of one habitable room, not in terms of area but dimensions (3.3 x 3.3 m). The area can be calculated in order to make comparisons with the requirements of other countries, but it is worth noting that the specifications of dimensions is more likely to produce a useful space than a simple requirement for area.

There are requirements for the minimum area of habitable rooms in Belgium (Wallonie), France, and for minimum cubic capacity in Norway. In Denmark, a general performance requirement is refined by a requirement relating area to ceiling height for rooms with sloping ceilings. The requirements for the area of rooms in Germany (Hesse) were removed in 2002. Sweden has performance requirements and recommends reference to a national standard which gives functional dimensions but does not specify minimum room sizes. There are no requirements for the size of habitable rooms in England.

The Netherlands has the highest standard for one room (equal to 11 m^2). Belgium (Wallonie) has a lower standard for a 2-person room (9 m^2).

In the Netherlands there is also a much lower standard for the minimum size of other habitable rooms (5 m^2), which compares unfavourably with low minimum standards in France (7 m^2), and Norway (6.25 m^2, based on 15 m^3 capacity, calculated assuming a ceiling height of 2.4 m). The only lower requirement, in Belgium (Wallonie) (4 m^2), would just about allow space for a single bed and shelving.

Apart from the Netherlands, only Belgium (Wallonie) directly addresses the width or length of habitable rooms. The Wallon standard (width 1.5 m) is much lower than in the Netherlands (width 3.3 m; other habitable rooms 1.8 m).

There are statutory requirements for ceiling height in each country except England. Requirements for ceiling heights were unaltered in Germany (Hesse), even though other dimensional specifications were removed in 2002. The highest standard is in the Netherlands (2.6 m), a response to the increasing height of the population.[7]

Other than England, the lowest overall standards are in Denmark for houses, and in France (2.3 m).

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7 Article 4.24 states that the height of ceilings had been raised from 2.4 to 2.6 m due to the increasing average height of the population. Similarly, the height of doors has been raised from 2.1 to 2.3 m. The Dutch are the tallest nation in the world (see Appendix 7: footnote 9).

Table A8.5 Size of habitable rooms (living room, bedrooms)

	Area, width, length	Ceiling height
Belgium *Wallonie (Arrêté 11.2.99)*	One room with min. habitable area 6.5 m² (1 person), 9 m² (2 person), 12 m² (3 person); definitions for occupancy of bedrooms. Characteristics for habitable rooms: min. area 4 m²; overall width > 1.5 m. Area calculations include 75% of areas with ceiling height 1.8 – 2 m, 50% of areas 1.0 – 1.8 m.	2.4 m (new-build) Also, 2.3 m (rehabilitation, adaptation, rebuild, acquisition).
Denmark	Size and design of rooms suitable for intended use. Min. area 3.5 m² with ceiling height at least 2.5 m (apartment buildings) or 2.3 m (houses). Local authority may require evidence of possible furniture arrangements.	Apartment buildings: 2.5 m. Houses: 2.3 m. For sloping ceilings, calculate average of ceilings ≥ 2 m.
England	–	–
France *(Normes minimales d'habitabilité)*	Average habitable area of principal rooms: 9 m², no room < 7 m².	2.3 m
Germany *Hesse 1993*	Net area, habitable rooms: 10 m²; in the case of dwellings with several bedrooms and living rooms, one room may be 6 m².	Habitable rooms: 2.4 m; habitable rooms in attics: at least half area 2.2 m.
Hesse 2002	–	Habitable rooms: 2.4 m. Cellars and at least half area of attic: 2.2 m.
Netherlands	New build: At least one habitable room: floor area: 3.3 x 3.3 m [= area 11 m²]. Min. dimensions of habitable rooms: area 5 m², width 1.8 m. Existing buildings: min. habitable space: 14 m²; at least one habitable room with min. floor area 7.5 m² and min. width 2.4 m.	2.6 m –
Norway	Net cubic capacity: 15 m³ [Calculated net area: 6.25 m², commonly interpreted as 6.5 m².]	2.4 m (may be lower in parts of rooms)
Sweden	Dwellings shall be sized ... with regard to their long term use and to the number of persons for which they are intended. *General recommendations:* *Design dimensions: reference to SS 91 42 21 (4) [which gives functional dimensions but does not specify minimum room sizes.]*	2.4 m, but may be lower: min. 2.1 m (horizontal ceilings) or 1.9 m (inclined ceilings) in parts of rooms where standing height required for room to be fit for its purpose; 2.3 m (attic or basement rooms, single family houses)

The Netherlands has requirements for the size of rooms in existing buildings (minimum total area of habitable rooms 14 m^2, one habitable room 7.5 m^2, min width 2.4 m). The only other requirement for existing buildings is in Belgium (Wallonie) for ceiling height (2.3 m).

A8.3.2 Spaces for food preparation and washing up

Section 4.15 of the Building Decree has requirements for installation spaces for a sink, and for a cooking appliance, in addition to the requirements for the size of habitable space and habitable rooms.

- Article 4.81 Location of installation spaces for sink and cooking appliance
- Article 4.82 Size of installation spaces for sink and cooking appliance

The Building Decree requires that spaces for a sink and cooking appliance should be provided in the same room. It does not specify the mimimum area of kitchens. These spaces should not intrude into the 3.3 x 3.3 m area of a habitable room defined earlier, and should be set back clear of that area (0.6 m). Given the sizes specified for installation spaces (sink 1.5 x 0.6 m, cooking appliance 0.6 x 0.6 m), this implies that if the sink and cooking appliance were installed in that room, it would have a minimum overall area of 13.4 m^2.

The sink and cooker spaces might be in a smaller room, but the Building Decree does not specify whether this space should be additional to the area required for a smaller room. Simply adding the minimum size for other habitable rooms and the area of the installation spaces would produce a total minimum area of 7.5 m^2. This would be a very high standard, but it is not clear whether this is the intention of the requirement. The formulation of requirements, with specification of installation spaces rather than requirements for the size of kitchens, together with this uncertainty makes it difficult to make a comparative analysis.

There are space standards for kitchens in Belgium (Wallonie), Denmark, and Norway. In Sweden the general performance requirement of fitness for purpose applies. Amongst these countries, the highest standard for the area of kitchens is the calculated value in Norway (6.25 m^2, based on cubic capacity of 15 m^3, assuming a ceiling height of 2.4 m); the lowest is in Belgium (Wallonie) (4 m^2). The requirement in Denmark relates area to ceiling height for rooms with sloping ceilings.

The requirement for the minimum width of habitable rooms applies to kitchens in the Netherlands (1.8 m). The only other requirement for the width of kitchens is in Belgium (Wallonie) (1.5 m).

Requirements of space for equipment and appliances have implications for the dimensions of kitchens, but the only dimensioned requirement for installation spaces is in the Netherlands (sink 1.5 x 0.6 m, cooking appliance 0.6 x 0.6 m). The Building Decree notes explain that the width allowed for the sink

Table A8.6 Size of kitchens

	Minimum area, width, length	Ceiling height
Belgium *Wallonie*	No specific reference to kitchens. Min. characteristics for designation of a space as habitable room: area 4 m²; overall width > 1.5 m.	2.4 (new-build) 2.3 (rehabilitation, adaptation, rebuild, acquisition).
Denmark	Clear space 1.1 m in front of workplaces and cupboards. Min. area 3.5 m² with ceiling height at least 2.5 m (apartment buildings) or 2.3 m (houses). Local authority may require evidence of possible furniture arrangements.	2.5 m. For sloping ceilings, calculate average of ceilings ≥ 2 m. Headroom 2 m at front edge of workplaces and cupboards.
England	–	–
France	Space for a sink in the kitchen.	2.3 m *(Normes Minimales d'habitabilité)*
Germany *Hesse*	–	2.4 m
Netherlands	Installation spaces for a sink and a cooking appliance to be provided in the same habitable room. Exemption if the dwelling is allocated a shared space with a shared sink and cooking appliance. Installation space must not intrude into 3.3 x 3.3 m area of habitable room; front edge of installation space at least 0.6 m distant from that area (new build); must not intrude into minimum 7.5 m² floor area of habitable room (existing buildings). Size of installation spaces: sink 1.5 x 0.6 m; shared sink 2.1 x 0.6 m; cooking appliance 0.6 x 0.6 m (new build); sink 0.7 x 0.4 m; shared sink 1.5 x 0.5 m; cooking appliance 0.4 x 0.4 m (existing buildings).	2.6 m (new build)
Norway	*Net cubic capacity:* 15 m³; may be smaller if part of the living room. [*Calculated net area:* 6.25 m², commonly interpreted as 6.5 m².]	2.4 m (may be lower in parts of rooms)
Sweden	Dwellings sized with regard to long term use, occupancy; a dining space in or near the kitchen. *General recommendations: Design dimensions: reference to SS 91 42 21 (4).*	2.4 m

gives sufficient work space to prepare meals. France requires a sink space, but does not state dimensions.

There are requirements for the ceiling height of kitchens in each country except England. The highest standard for ceiling height is in the Netherlands (2.6 m); the lowest standard, where requirements are given, is for houses in Denmark, and in France (2.3 m).

The Building Decree also, uniquely, contains requirements for installation spaces for sinks and cooking appliances in existing buildings:

- Article 4.84 Location of installation spaces for sink and cooking appliance
- Article 4.85 Size of installation spaces for sink and cooking appliance

The requirements are similar to those for new build, except for the size of installation spaces (sink 0.7 x 0.4 m, cooking appliance 0.4 x 0.4 m). The

smaller standard for the cooking appliance seems unrealistic, given that the new build standard is based on the size of currently available appliances.

A8.4 Conclusions

Floor area is a key determinant of amenity and accessibility, but also influences construction costs, prices and rents. Floor space standards and dimensional requirements may be categorised as a concern for amenity, but this is no longer a central consideration of most European building regulations. Also, the use of minimum space standards as conditions of financing or subsidy has declined in tandem with reductions in public spending on housing.

The sections of the Building Decree on dimensions of habitable space and habitable rooms try to avoid the association of the sub-division of space with specific functions, but later sections give requirements for specific rooms. One of these, on installation space for a sink and space for a cooking appliance, was analysed because it has implications for the size of a habitable room, but the analysis did not include the Building Decree sections on toilet compartments, bathrooms, meter spaces, installation spaces for space-heating or water-heating appliances. Nor did it consider any requirements for circulation spaces and stairways that would affect the size of dwellings, or the sections of the Building Decree that concern the common parts of buildings: storage space for domestic waste, storage space for bicycles, lift shafts, or lift machine rooms.

Despite the liberal concept of 'habitable space' in the Building Decree, which avoids the assumption of cellular planning or function-specific spaces, the Netherlands has more extensive requirements for floor area and dimensions for rooms than any of the other countries studied. Some of the others have requirements for individual rooms, but requirements for the overall floor area of dwellings, for the area of habitable space, or for the arrangement of spaces are comparatively rare. It is particularly interesting to contrast the standards of the Building Decree with the lack of controls in England, both being countries with relatively small dwellings, high land costs, and considerable pressure towards densification.

Space standards might be seen negatively, as an archaic hangover from habitability standards, and a symptom of over-regulation which inflates the cost of housing. A more rational explanation is that these measures are positive indicators of housing quality, which are now lacking in many countries. Some Dutch requirements are particularly noteworthy: those for total habitable space for one-person dwellings, and for one space or room with a clear area of 3.3 x 3.3 m. However, other requirements are less valuable, such as the very low requirement that applies to dwellings in existing buildings for the total area of habitable rooms (14 m^2), given that the Building Decree notes

assert that 24 m^2 is the minimum feasible habitable area for a new build one-person dwelling.

If floor area requirements are worthwhile for one-person dwellings and accepted as a constraint on private house-builders, it seems curious that it does not apply substantial requirements to more of the space in larger dwellings, to promote the sustainability of starter homes and family houses.

It may be argued that the flexibility afforded by higher space standards contributes to the sustainability of housing development, because dwellings are more likely to be suitable for a range of households and a range of physical abilities. However, it is difficult to prove such an assertion because the popularity and long-term success of housing relies on numerous factors, few of which can be influenced by building regulations.

Empirical research would be required to test the validity of specific claims made in the Building Decree. For instance, the Building Decree notes explain that the limit on the proportion of 'habitable area' relative to usable area is intended to ensure a functional design. Given that this requirement is unique, it must be presumed that other countries rely on the working of the market to achieve functional designs, or fail to do so. There is evidence that the removal of controls has resulted in reduced space standards,[8] but it is more difficult to evaluate whether or not the designs are functional. However, it seems sensible to protect the space standards of the housing stock by building regulations, rather than market forces.

8 The abandonment of Parker Morris standards for social housing in England started a decline in space standards which gained further momentum from the competitive allocation of grant introduced along with mixed financing under the 1988 Housing Act. By 1991/92 over half of housing associations were building 5-15% below these standards. (Karn, V. & Sheridan, L., 1994). Later rent controls and decrease in grant rates further increased pressure on space standards in social rented housing (Sheridan, L., 2001).

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Technical requirements

The following schemes identify the primary sources used to compile the analysis (See page 279 and 280).

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	Primary sources	Sources of translations
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Denmark	*Building Regulations* (1995). *Building Regulations for Small Dwellings BR-S 98* (1998).	Official translations
England and Wales	*The Building Regulations 1991: Approved Documents,* e.g. *Approved Document B: Fire safety* (2000)	n/a
France	*Code de la Construction et de l'Habitation (CCH)* [Construction and Housing Code] and associated Lois [laws], Décrets [decrees], Circulaires [ministerial circulars], *Arrêtés* [implementing orders], published in *Recueil des Eléments utiles à l'Exécution des Projets et Marchés de Bâtiments en France (REEF)*, e.g. fire safety requirements: *Arrêté du 31 janvier 1986 relatif à la protection contre l'incendie des bâtiments d'habitation.*	Unofficial translation by Sheridan
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Denmark	Bygningsreglement By- og Boligministeriet m. tillæg 1+2+3 [Building regulations with amendments 1,2,3]:	www.rockwool.dk/tekniskservice/bygbib/br_95/index.htm#top [Rockwool company site] English translation of 1995 regulations without amendments: www.oebm.dk/uk/pub/bygregl/bygregl2.pdf
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The protection of safety and health of their citizens is a major reason for governments to draw up regulations for the built environment. In the course of time other points of departure, such as utility, energy economy, sustainability and economic motives have come to play a part. For these subjects technical requirements are formulated and the procedures for checking building plans against the requirements and issuing the building permits have been laid down in laws.
In search for ingredients for a uniform system of building control in Europe, Delft Technical University (OTB Research Institute for Housing, Urban and Mobility Studies) and the University of Liverpool (School of Architecture and Building Engineering) carried out an international research project into the systems of building regulations, implementation and control and the systems of technical requirements in the Netherlands, England, France, Germany, Sweden, Norway, Belgium and Denmark. This resulted in two books: 'Building regulations in Europe. Part I, A comparison of the systems of building control in eight European countries' (Housing Urban and Planning Studies volume 23) and 'Building regulations in Europe. Part II, A comparison of technical requirements in eight European countries' (this book).

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