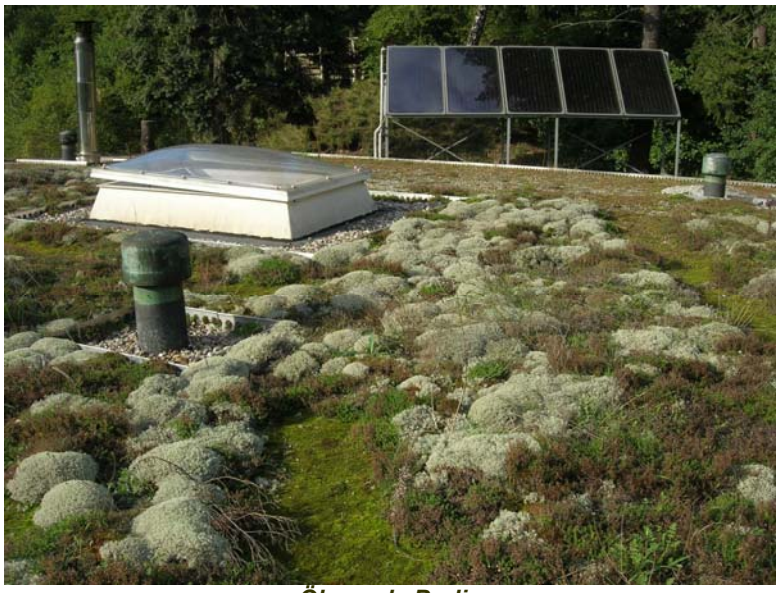

Ökowerk, Berlin

COMPARISON BETWEEN THE GERMAN (FLL), AUSTRIAN AND SWISS GREEN ROOF DIRECTIVES/GUIDELINES

Hanna Waldbaum

On behalf of Livingroofs.org

FOREWORD

Over the last few years there has been much discussion about the establishment of a British Guideline for Green Roofs. Most of the leading companies in the UK use the German Guidelines, known as the FLL, as the benchmark for their products. And quite rightly the whole scale adoption of the German Guideline is generally what has been proposed in the UK. However I have spent a number of years attending meetings of the European Federation of Green Roof Associations and in discussion with colleagues from the continent it became apparent that there were minor differences between the German, Austrian and Swiss Guidelines. I wanted to known what these differences were and whether we could pick positive elements from each to help establish a British Guideline.

Livingroofs.org commissioned Hanna Waldbaum to translate and compare the three guidelines. This comparison is in no way meant to have a preference to anyone of the Guidelines but allow us to make informed decisions.

The German FLL started work on green roofs in 1982 and refined and reviewed the guidance regularly since then.

The Swiss were the first to award firms for best practice in 1999 followed by the Austrians in 2002.

This document is in no way a full translation of the three guidelines. The 2002 FLL can be purchased in English but sadly the Swiss and Austrian are only available in German.

I hope that this short paper enriches any discussions regarding the establishment of a British Standard, which should be based on the best practice of years of work on the continent and should respect and acknowledge the FLL, VfB and SFG.

Dusty Gedge
Livingroofs.org
President European Federation of Green Roof Associations
www.efb-greenroof.eu

General notes

For the sake of brevity the documents compared in this summary will be referred to as **FLL**, **Austrian** and **Swiss** respectively; **GR** stands for green roof(s).

The word 'Richtlinie' which features in all three document titles translates as 'Guideline' (Collins Dictionary, 1997) though they have the status - more imperatively - of 'Directives'.

Tables, figures and page numbers refer to the original documents unless otherwise stated.

The Guidelines can obtained:

FLL can purchased at www.fll.de

The Austrian Guidelines can be obtained by contacting office@gruendach.at

The Swiss Guidelines are only available from www.sfg-gruen.ch

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SUMMARIES

GERMAN DIRECTIVE (FLL)

The German '*Richtlinie für die Planung, Ausführung und Pflege von Dachbegrünungen'* or *'Dachbegrünungsrichtlinie'* is issued by the *Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau.*

The FLL was started in 1982 as 'Principles for Green Roofs' and renamed 'Directive' in 1990. There have been several revisions since then and the 2002 version has been translated into English in 2004 as 'Guideline for the Planning, Execution and Upkeep of Green Roof Sites' .

The FLL is referred to in both the Austrian and Swiss directives; it is the most comprehensive of the three.

The purpose of the FLL is to ensure the good image of green roofs by setting high standards and stressing the importance of the aspects of planning, execution and maintenance being considered together.

The FLL deals in great detail with technical requirements and standards of execution. It contains instructions for construction methods, use of suitable materials and plants for roofs, terraces and platforms. Expected water retention values and run-off coefficients are tabled. Requirements for every single element used in the layered superstructure are detailed and testing methods prescribed.

Compliance with the FLL is not compulsory but it can be a legal requirement in a building contract. It is recognised as the standard work on GR in Germany and it forms the basis of GR standards in many countries around the world.

The **FLL** starts with 2 ½ pages of German building standards (DIN) and additional rules referred to in the Guideline.
Of the quoted thirty one DIN standards:

- 2 deal with structural issues,
- 9 with waterproofing,
- 2 with fire resistance of materials,
- 4 with drainage issues,
- 1 with drinking water supply,
- 5 with accessibility,
- 2 with soil testing, and
- 6 with agricultural / horticultural methods

The latest updated version, published in March 2008 was prompted by changes in German waterproofing standards. It also takes into account updated values for design loads and water retention of building materials. The most important changes refer to the substrate layer; notably, a single

layer intensive GR has been introduced as a result of market trends. The distinction is now made between single layer (simple) and multiple layer intensive or extensive GR. The amount of maintenance required depends on the choice of plants rather than the number of layers in the GR superstructure. In addition the test methods have been refined and expanded. The preface states that there is scope for more discussion about the standard regarding root barriers (DIN EN 13948) as it does not deal with resistance to rhizomes; the applicability of CE labels on materials used in drainage layers is also being questioned.

The 2008 version of the FLL (not yet available in English) contains a number of additions to the 2002 (English 2004) text, more detailed tables and some even stricter requirements. Here are just two examples:
(Chapter numbers refer to the English FLL 2002)

Chapter 5.4 'Structural requirements / Protection against corrosion' has an additional paragraph: (Note: in German the word *sintering* is used, as it relates to furring, rather than rust)

> "*The use of recycled crushed concrete or gravel containing calcareous material is not permitted in drainage layers, protective strips or as design features as this could cause blockage of the drainage system."*

Chapter 5.10.2 'Protection against slipping and shearing / Requirements' have changed:

> *"Roofs with slopes greater than 15°* [previously 20°] *require structural anti-shear protection…"*

Some of the information has been taken out of the text section, updated, expanded and put into three appendices:

1. Tables specifying loads, water retention of layers, depths, etc;
2. Tables of testing methods for substrates and drainage materials
3. The testing of root barriers for resistance to root penetration.

Warranty periods for the layered superstructure and technical installations have been extended from 2 years (FLL 2002) to 4 years (FLL 2008).

After two chapters of descriptions and definitions of types of GR, their functions and their effect on the environment follow two chapters of standards and requirements regarding construction (methods and materials). The next three chapters are devoted to the layered GR superstructure, detailing the requirements for efficient water management and every aspect concerning drainage and filtering. A chapter on the physical and chemical requirements of substrates is followed by three chapters regarding permissible types of vegetation and their maintenance. A short chapter on erosion prevention and a paragraph on warranties follow.

The last chapter is devoted to testing and controlling and contains six reference tables:
- (Tab.7) Characteristics of materials used in drainage layers;
- (Tab.8) Characteristics of substrates;
- (Tab.9) Required physical properties of materials used in drainage layers;
- (Tab.10) Required physical properties of materials used in substrates for multi-layered intensive GR;
- (Tab.11) Required physical properties of materials used in substrates for multi-layered extensive GR;
- (Tab.12) Required physical properties of materials used in substrates for single layer extensive and intensive GR.

There are three appendices.

Appendix 1

Table 13 lists values for loads (in kN/m^2 and kg/ m^2) and the water absorption capacity of various materials used in GR layers.
Tables 14 and 15 give loads for saturated substrates, vegetation mats / seed mats and reservoir layers and Table 16 lists loads for vegetation layers used in extensive, intensive and simple intensive GR.

Appendix 2

Methodology for the testing of substrates and drainage materials used in GR (October 2006)

There is a 5-page table listing the required tests to establish their physical characteristics (grain size, weight by volume, water content, absorption and adsorption capacity, permeability, air content, pH value) and chemical components (salt, organic matter, nutrients, foreign matter).
This is followed by detailed descriptions of the methodology and formulae.

Appendix 3

Methodology for the testing of root barriers for resistance to root penetration (1999 issue, updated 2002/2007).

Tests are done over a 2-year period with *Pyracantha coccinea* and *Agropyron repens* and over a 4-year period with *Alnus incana* and *Agropyron repens.*

The FLL method sets a higher standard than DIN standard EN 13948 in that it includes tests for resistance to rhizomes.

SWISS DIRECTIVES

The Swiss *'Gründachrichtlinie für Extensivdachbegrünungen'* consists of two different booklets and they will be referred to by their publishing dates :

Swiss 1999 deals with water management and vegetation (*'Wasserhaushalt und Vegetation'*); **Swiss 2002** deals with the certification for quality assurance and with ecological performance (*'Labelvergabe und Ökobilanz'*). Both booklets deal exclusively with extensive green roofs.

Swiss (Part 1) 1999

1. General Remarks

This guideline (revised in January 2007) intended for planners and professionals in the field, defines the minimum quality requirements for extensive GR and methods for their verification. It covers water management (storage and drainage of precipitation) and vegetation (variety of plant species and degree of covering). Quality is determined by ecological as well as economical criteria.

GR intended for verification by **Swiss 1999** are expected to use only eco-friendly materials as defined by Swiss Confederation laws regarding waterways, the environment, nature, materials and planning. Therefore the verification of materials used is not part of this guideline.
Tests may only be conducted by expert laboratories and institutes recognised by the issuing organisations of this guideline.

2. Requirements and Definitions

Table 2.1 (Revision of table on page 5) of tests and requirements
(page, figure and table numbers as in **Swiss 1999 ,** with figures revised 17 January 2007 shown in bold))

No	Test	Requirement	Remarks
1	Water capacity of permeable layers available to plants	**≥50 Vol %** (was ≥60Vol%)	When saturated
2	Usable field capacity	**≥25Vol %** (as per Fig.1 p.6) (was ≥20Vol%)	Volume of water available to plants
3	Vegetation		
3a	In general	-well rooted -robust	Visual inspection
3b	Coverage	After two vegetation periods: -min 75% of test area evenly covered -max 30% of total number of plants in test area to be of a single species	-using a test frame (see Fig on p.11) - by visual inspection: counting
3c	For GR with a multitude of species	After two vegetation periods: -min 20 varieties of wild herbs **(no longer excl. sedums)** -min 40 plants of one species per 1000m^2 (number proportionally reduced for smaller areas)	- by visual inspection: counting. These numbers to be guaranteed to be present after 3 years Qualifying suppliers must have a portfolio of successful GR.

Figures 1, 2 and 3 (p.6 and 7) refer to field capacity (nFK) and air capacity (LK) requirements for extensive GR in relation to average precipitation in Switzerland.
Note: LK+nFK=rWK is measured in L/m^2

New minimum (loose) substrate depths required since Feb 2007:
- 13cm with an rWK of 55 L/m^2 where precipitation per annum is <800mm
- 11.5cm with an rWK of 50 L/m^2 at 800-1000mm
- 10cm with an rWK of 45 L/m^2 at 1000-1200mm
- 9cm with an rWK of 40 L/m^2 at >1200mm precipitation.

Water management
The criteria relating to water management on GR are: to provide sufficient water to the plants; to enable the retention of an additional volume of water in case of increased precipitation: and to cause a delay in run-off. These characteristics depend on water retention dynamics (see Figures 1 - 3) and the depth of the GR superstructure. Tests carried out over a number of years have shown that adherence to the figures given in the Directive resulted in all three criteria being met, e.g. a run-off delay of 30 minutes which is acceptable in residential drainage systems.

Vegetation
This guideline requires the use of a large variety of indigenous plant species that are suitable for extensive GR to provide valuable ecological compensation. The main criterion is the degree of coverage, which relies on the use of appropriate quality substrates; appropriate layering of the superstructure; and good quality, suitable plant material. Chemical profiles (pH, carbonate content etc.) are not required here. A good level of coverage gives optimal protection to the underlying roof membrane.

3. Test performance

This chapter deals with practicalities of the tests; what they are and how they are performed.

Test Nr.1: Water and air (LK) capacity of permeable layers relevant to plants
Test Nr.2: Usable field capacity (nFK)

These two tests are done under laboratory conditions, using a sample of the layered GR superstructure inside a cylinder (as shown in Fig. 4 on p.9). The contents are weighed dry (=g3), saturated with water (=g1), and drained (=g2). The result is (LK+nFK=rWK expressed in L/m^2)
The formulae are shown on page 10 of the booklet.

Test Nr.3b: Vegetation Coverage.

This is done in situ between 20th and 30th October after the second vegetation period, using the point-square method (p.11) by means of a 1m long frame that is placed in 4 random positions per 25m^2 of GR. It is a means of calculating the percentage of area covered with vegetation.

4. Test Report

The test report must indicate:
- Descriptions of the layers that make up the superstructure;
- Thickness / depth of each layer;
- Undertaken tests and their results;
- Dates of tests and signature of tester and name of laboratory.

The **Appendix**

A.1 contains a glossary of terms used in GR and highlights the advantages of professional services. There is also a paragraph on substrates stating maximum contents of soluble carbonates (6g/l) and nitrogen (60mg/l) and optimum pH values (6.5-8.5).

It concludes with
A.2 Bibliography (p.14) and the names and functions of the authors of this booklet as well as the names of the five issuing organisations (p.15)

The issuing authority is a consortium of 5 organisations:
SFG Swiss Association of Building-Greening Specialists
SSIV Swiss Association of Welders and Plumbers
SVDW Swiss Roof and Wall Association
VERAS Swiss Association of Waterproofing and Asphalt Enterprises
VSG Association of Swiss Landscape Gardeners

Swiss (Part 2) 2002

1. Awarding of label

This booklet sets the standards for eco-systems and materials as required for certification, offering advice on cost efficient quality implementation and control methods. The SFG awards these certificates to promote the ecological qualities of extensive GR which include the use of eco-friendly materials and minimal transport. It also requires compliance with Swiss environmental laws.

It caters for the needs of the Swiss GR market. For all questions relating to construction the SFG recommends the FLL and also recognises quality assurance according to European Federation (EFB) standards.

Applicants
Participating green roof system suppliers must declare their acceptance of the conditions set out in **Swiss 1999** and **Swiss 2002** in writing. When all criteria are met, the certificate / label *'Dachbegrünung Qualität nach SFG*' is awarded within one month. The 'label receiver' is awarded a certificate and given stick-on labels for business use.

Implementation of Quality Control
The SFG retains the right to inspect the awarded GR systems and their installation. It will check that the layered superstructure, its components and their origin are true to what has been declared. Material samples will be taken for laboratory testing followed by written reports. Apart from the coverage test (see 3b in Table 2.1 above) the inspection can take place within two months from installation of the GR.

Cost
The awarded company bears the cost for the installation of the label (500 SFR for **Swiss 1999** tests and approx. 3500 SFR for **Swiss 2002** tests) and pays an annual fee of 2000 SFR.

The quality control (up to three times a year) is paid for by the SFG.

SFG Regulations
These are given in writing and are irrevocable.
If controls reveal a default a warning may be issued.
Two such defaults result in the withdrawal of the label.
To regain the label the whole label awarding procedure must be repeated.

Figure 1 (p.3) shows the relation between the SFG, the applicant L, the controller K and the ombudsman O.

2. Ecological performance (*Ökobilanz*)

This is a means of improving the ecological quality of systems by pointing out their weaknesses and their optimum ecological potential.

2.2 Basic requirements (**)

The GR system is tested for its whole life environmental performance from source to sink using an internationally agreed Eco-indicator Method. The result is expressed in Eco-indicator points, giving a numerical value to each system, thus enabling comparisons between systems.
The ecological performance is calculated using "EMIS" software developed at Zurich University (*ETH Zürich*) and INFRAS.

Figure 2 (p.8) illustrates the life cycle of GR systems:

[Sourcing ➔Transport ➔ Production of component ➔Transport ➔Construction / maintenance / deconstruction ➔Transport ➔ Disposal] ➔➔
Emissions / Use of resources (e.g. CO, NO,…) ➔➔➔
Weighting / Eco-indicator ➔➔➔➔
Effect (e.g. Green house gas emissions, acidity…) measured in Eco-indicator points.

2.3 Assessment criterion (**)

Based on real systems, a GR system with a negative impact on the environment of 1.300 Eco-indicator points per m^2 is used for reference (See Fig. 3 on p.10; based on 'Eco-indicator 99, Hierarchist'). This value may change in accordance with new environmental research.
GR systems that exceed this value are not awarded the SFG label. The figure limits the use of inferior system components and allows for a reasonable amount of transportation.

(**) Further details obtainable from:
Seecon GmbH, Dr. Johannes Heeb
CH - 6110 Wolhusen
00 41 490 4081(tel)
00 41 490 7074 (fax)
e-mail: johannes.heeb@seecon.ch

2.4 Testing procedure (*Prüfverfahren*)

Applicants must submit the following data (which are treated confidentially by the SFG):
- Type of material, numbers of, and weights;
- Content of recycled material;
- Origin;
- Means of transport;

- Details of substrates;
- Declaration of acceptance of SFG conditions (see chapter 1).

In addition applicants have to submit
- A section to scale, through the GR system; and
- Two completed forms (see 3.1 and 3.2 in the appendix).

Detailed guidance for filling in form 3.1 (Materials and logistics) is given on page 9 and an example of a completed form is on page10 (Tab.1).

Testing is carried out by laboratories / institutes licensed by the SFG.
Applicants are notified of the result (whether the label criterion of 1.300 Eco-indicator points has been fulfilled). They are also given a detailed analysis showing weaknesses and improvement potential and the effect each process has on the final eco-performance. The analysis forms the basis for ecological optimisation of GR systems.

2.5 Sample case (*Fallbeispiel*)

The headings in Tab. 1 'Materials and logistics' are: layer (*Schicht*); thickness (*Dicke cm*); type of material (*Material*); percentage of recycled contents (*Recycling Anteil in %*); weight in kg/m^2 (*Gewicht*); place name and county/country of origin (*Produktionsort*); percentage of part produced there (*Produktionsanteil in %*); means of transport (*Transportmittel*).

Fig.3 shows the ecological performance of the sample GR system.

Tab.2 shows the eco-indicator points per m^2 according to 'Eco-indicator 99 Hierarchist'.

The processes listed in the left column are:
- Production of vegetation mat (mineral wool mat)
- Production of fleece
- Transport
- Fitting, maintenance and de-construction
- Removal

Tab.4 Analysis of weak points in the sample case

The pie chart indicates the following contributions:
- Transport 50%
- Removal 9%
- Production of vegetation mat 13%
- Production of fleece 28%

This case sample shows the transportation of the system components to be the biggest culprit, which suggests choosing more local suppliers. The fact that 60% of transport is done by ship rather than lorry reduces the number of

eco-indicator points enough to keep the total value below the 1.300 threshold. Had all transport been done by road, the sample system would not have passed the SFG label requirements.
Another improvement would be an increase in the recycled content of the vegetation mat.

3. Appendix

The appendix contains the two forms applicants need to complete.

3.1 The form 'Materials and logistics' (p.13.) requests the following information:

layer name / Nr.* (*Schicht Name / Nr.*);
thickness (*Dicke cm*);
type of material (*Material Art*);
percentage of recycled contents (*Recycling Anteil in %*);
weight in kg/m^2 or kg/ m^3 (*Gewicht kg/m^2 bzw. kg/m^3*);
place name and county/country of origin (*Produktionsort Ortsname / Land*);
percentage of part produced there (*Produktionsanteil in %*);
means of transport to…(*Transportmittel bis…*).

*The number refers to the numbering on the accompanying sketch

3.2 The form ' Information on substrate' contains 3 questions:

1. Are there any unnatural materials (e.g. recycled materials) in the substrate? Yes or No
   If yes, what forms of pollution can be expected (e.g. run-off and erosion)
   Proof of solutions to be enclosed
2. Is there any recycled building material in the substrate? Yes or No
   If yes supply information on their chemical composition
3. Any other Information not contained in the information given so far that could have a positive or negative effect on the overall ecological performance

The last page (p.15) lists the members of the work group and supporting organisations.

AUSTRIAN DIRECTIVE

The Austrian Normative Rule (ONR 121131) *'Qualitätssicherung im Grünraum - Gründach - Richtlinien für die Planung, Ausführung und Erhaltung'* 'Quality Assurance for Green Spaces - Green Roofs - Guidelines for their Planning, Implementation and Maintenance'.

The Austrian Standards Institute issued the guidelines in June 2002.

The ONR 121131 complements the 32 Austrian standards (ÖNORM) that are relevant to GR construction. It also points to the **FLL**, the **Swiss** directives and directives from the International Federation of Roofers.

Chapter 2 lists the relevant 32 ÖNORM standards; of these:

- 3 deal with contracts (waterproofing, roof coverings, landscaping)
- 1 with structural issues,
- 2 with waterproofing,
- 2 with synthetic materials used in roof superstructures,
- 4 with geotextiles,
- 2 with sports fields,
- 1 with fire resistance of materials,
- 1 with fixed metal ladders,
- 4 with soil and compost testing,
- 1 with accident prevention,
- 1 with harmful inorganic substances in soil,
- 8 with chemical components in soils,
- 2 with plant material and maintenance

A glossary of terms is given in Chapter 3.

Chapter 4 describes the four GR types that are in use in Austria (intensive, reduced intensive, extensive and reduced extensive) and lists the appropriate plant families for each.

Chapter 5 deals with the prerequisites for GR, i.e. roof slopes; roof types; materials (compatibility between materials and wider environmental impact of materials); condensation issues; weights and loads (Tables 9,10 and 11); wind forces; drainage and run-off coefficients; irrigation (maximum use of rainwater); access and fire precautions.

GR installed on flat roofs $\leq$ 1.8% (1^{o}) must be multi-layered superstructures to allow for efficient drainage. GR on roofs with slopes $\geq$ 5% (3^{o}) need a layered superstructure with higher water storage properties. On roof slopes $\geq$ 9% (5^{o}) all components have to be prevented from slipping.

Chapter 6 details the structural requirements for GR, such as: root resistant waterproofing; prevention of mechanical damage; drainage systems; joints and connections (e.g. between GR and vertical or penetrating structures,

edges and gutters); measures to prevent slippages; barriers / balustrades; paving materials; features (pergolas, ponds, playground structures, etc.).

Chapter 7 describes the requirements for the GR superstructure. It lists the layers and shows two variations, one with a root proof roof membrane and one with a separate root barrier above the roof membrane (Fig.1 on p.18)

Table 1 (p.19) lists the materials / layers used in GR, with their functional uses, some being multi-functional. Table 2 (p.20) lists the required minimum thickness of substrates for various forms of planting (moss, grass, herbaceous, shrubs, trees) in each type of GR (intensive, reduced intensive, etc.) on roofs sloping less than 5% (3^{o}). A footnote refers reduced extensive GR below 8cm substrates to FLL specification.

One of the deciding factors for the choice of GR is the availability of rainwater, its storage and whether additional irrigation is feasible (beyond the initial growing stage).

Chapter 8 deals with all aspects of drainage layers (types of materials, functions and mechanical / chemical requirements)

Chapter 9 deals with all aspects of filter layers / geotextiles (mechanical requirements, plant compatibility and careful installation: with 10 cm overlay)

Chapter 10 deals with substrates (materials, requirements, manufacture and testing methods).

The substrate must be stable, store sufficient water and nutrients for vegetation and only allow surplus water into the drainage layer. At saturation it must contain the appropriate air volume for the intended planting.

Table 3 (p.26) grades the required qualities for substrates for intensive and extensive GR (o insignificant; x required; xx important requirement)

Figures 2, 3 and 4 (pp.27-28) show the permissible percentages of grain sizes (granulometric distribution) in substrates for intensive, multi-layered extensive and single-layered extensive GR respectively.

Table 4 (p.30) lists the required nutrient contents of substrates in mg/l

Chapter 11 Requirements for seeds, plants and vegetation deals with seeds, shoots, perennials, bulbs and rhizomes, shrubs, grass mats and plant mats.

Chapter 12 Cultivation methods, initial care and ongoing maintenance

Table 5 lists the tasks required during the initial growing period for intensive and extensive GR (x when required; xx regularly; o in exceptional circumstances)

In readiness for handover GR are required to provide the following coverage:
- plants and herbs: 60% which must contain minimum 60% of the requested species;
- Sedum extensive: 75%;
- Grass mats: 95%;
- Plant mats: 75%

The counting method employed by the SFG (see Swiss 1999) is to be used.

For ongoing maintenance it is recommended to use expert contractors. Different levels of care are needed for intensive and extensive GR (based on ÖNORM L 1110).

Chapter 13 deals with safety precautions for:
- The stability of trees and shrubs;
- The safety of people;
- Erosion prevention;
- Wind suction.

Chapter 14 Suitability of site for type of vegetation depends on three criteria:
- Local climate (precipitations, wind, sun, temperatures);
- Building-specific factors (orientation, protection from weather and wind, Reflection from other buildings, roof slope, structural strength);
- Plant specific requirements for intensive or extensive planting.

Chapter 15 States the need for suitability tests and subsequent controls

Chapter 16 lists a few disclaimers (damage by animals, walking on growing planting) and general agreements (prevention of falls, provision of access and water outlets, avoidance of sowing GR in summer, maintenance contracts are recommended).

Chapter 17 Requirements for soil mixtures and drainage courses are given in Tables 6 to 11.

Required values for substrates are indicated in
Table 6 (p.40) for intensive GR;
Table 7 (p.41) for multi-layered extensive GR; and
Table 8 (p.42) for single-layer extensive GR

Saturated loads (in kg/m^2 and kN/m^2) are listed in
Table 9 (p.43) for saturated drainage materials;
Table 10 (p.44) for substrates;
Table 11 (p.45) for various forms of planting

Appendix A describes the evaluation model for GR used by the VfB. Points per m^2 are awarded for the layered superstructure that can be penetrated by roots (i.e. the substrate plus the drainage course, if it can store min 15% of its volume in water).

Table A.1 (p.47) shows the types of planting suitable for use with superstructures from 6cm to 150cm depth, and the minimum required number of base points (which is the depth in cm x 10). The division into reduced extensive, extensive, reduced intensive and intensive GR is used.

Table A.2 (p.48) relates the point system to the maximum volume of water that can be stored in the superstructure, i.e. which is available to the plants.
The required volume of water capacity is required to be
25% in reduced extensive GR;
35% in extensive GR;
50% in reduced intensive GR;
55% in intensive GR

Points are deducted if these values are not reached. This can be compensated by increasing the depth of the superstructure.

The minimum required amount of organic matter in substrates is
2% for reduced extensive and extensive GR;
5% for reduced intensive and intensive GR.

Table A.3 (p.48) relates the point system to the number of plant species for extensive GR per area of 10 m^2.
For example an extensive GR planted with grasses and herbs must contain at least 12 different species. One additional point is given for each additional species and 2 points subtracted for missing species.

Table A.4 (p.49)
Intensive GR are assessed for 'green volume' (*Grünvolumen*) rather than number of species. E.g. tall perennials and shrubs should occupy 0.75 m^3 per square metre while lawn only needs to occupy 0.1 m^3
A maximum 'green volume' of 2.5 m^3 is required for intensive GR planted with medium and tall trees. There is no addition or subtraction of points.

Appendix A.3 (pp.49-50) gives a sample case of an extensive GR with a required standard of 80 points. Two variations are shown:

Variation 1. (p.49)
A sedum-moss GR on an 8cm superstructure (= 80 base points) that fulfils all requirements and is given 8 added points for containing 4 additional plant species (total points: 88/ m^2)

Variation 2. (p.50)
A sedum-moss-herb GR on a 10cm superstructure (=100 base points). Its water capacity is 34% vol, which is 1% below requirement, so 4 points are subtracted. It also does not fulfil the required number of species, containing 4 instead of 6. Another 6 points are subtracted. The organic matter content is as required.

100 base points minus10 leave 90 points.
Therefore this variation also fulfils the required standard as the short comings are compensated for by the increased depth.

This point system can be applied to assess all GR systems currently on the market.

COMPARISON (How they differ)

Size and length

The most obvious difference is the size of each document. The FLL 2008 version has 119 A4 pages; the Austrian 2002 Quality Assurance Guidelines is 51 A4 pages long. This is mainly due to the layout, smaller print and narrower line spacing in the Austrian document and the comprehensive appendices in the FLL.

The Swiss Directives of 1999 and 2002 that deal exclusively with extensive green roofs are two A5 size booklets of 15 pages each.

Division into GR types

FLL deals with three types of green roofs:

- Intensive (perennials, grasses, bulbs, annuals, shrubs, lawns, trees)
- Simple intensive (ground covering grasses, perennials, shrubs)
- Extensive (indigenous moss, succulents, herbs, grasses)

In the 2008 version of the FLL has introduced the single layer intensive GR and the distinction is sometimes made between single-layer extensive and intensive and multiple-layer extensive and intensive GR.

The **Austrian** deals with four types of green roofs:

- Intensive (few restrictions on choice of vegetation; high maintenance)
- Reduced intensive (ground cover with grasses, perennials and shrubs)
- Extensive (tough indigenous plants; low maintenance)
- Reduced extensive (thin vegetation layer of sedums / mosses; where appearance is unimportant)

The **Swiss** booklets refer exclusively to extensive green roofs and looking at the SFG website there are no Swiss directives for intensive GR; they point to the FLL.

Building Standards

The **FLL** refers to 31 DIN standards (*Deutsche Industrie Normen*) with emphasis on waterproofing (9) and drainage issues (4).

The **Austrian** refers to 32 ÖNORMs (*Österreichische Normen*) with emphasis on soil quality: chemical components in soil (8), soil testing (4) and inorganic substances in soil (1).

There is no reference to specific **Swiss** Building Standards.

Contents

It must be remembered that the FLL is the most recently revised document (2008), while the Austrian and Swiss (Part 2) date back to 2002. Swiss (Part 1) published in 1999 has been revised in 2007.

A comparison between the tables of contents of the FLL and Austrian directives shows that the Austrian has used the FLL as a model for its own GR standards. The wording is often identical; however, terms sometimes differ according to local usage.

The FLL has two comprehensive appendices that do not feature in the Austrian, dealing with test methods for substrates, drainage materials and root barriers.

The Austrian has developed its own point system which is used to assess the adequacy of a GR. This appears in the appendix.

There is no mention of such a system in Germany.

The Swiss (SFG) award labels on the basis of ecological criteria using Eco-indicator points. Both Swiss booklets deal exclusively with requirements and test methods for high quality extensive GR.

Swiss 1999 concentrates on water management and vegetation in relation to local conditions (climate and plant species).

Samples of the single-layer or multiple-layer GR superstructure are tested in approved laboratories for their suitability as substrates in terms of their air and water capacity.

The degree of coverage of a GR with vegetation is tested in situ after two vegetation periods.

From the information on their website it appears that the SFG does not promote intensive GR.

There is a marked difference between maximum permitted amounts of nutrients in substrates in Germany and Austria as can be seen in the tables below. It appears that Austria has stricter rules.

FLL Tab 6 (p.62)
Nutrient contents in substrates for intensive and extensive GR

Nutrient (mg/l)	N	P_2O_5	K_2O	Mg
Intensive/Extensive	≤80	≤200	≤700	≤200

Austrian Tab.4 (p.30)
Nutrient contents in vegetation substrates

Nutrient (mg/l)	N	P_2O_5	K_2O	Mg
Intensive	60 -120	100 - 200	150 - 250	60 - 120
Extensive	30 - 60	50 - 150	100 - 200	60 - 120

The Swiss 1999 directive prescribes maximum 60mg/l nitrogen (N) for extensive GR and gives no figures for the other nutrients.

There is also a difference in the recommended pH value between the three countries.

Swiss 1999 recommends pH values between 6.5 and 8.5 for substrates;

The FLL allows pH values between 6.0 and 8.5 for multi-layer intensive, and between 6.5 and 8.5 for single-layer intensive and extensive GR substrates; while the Austrian prescribes pH values between 5.5 and 6.5 (max 7.0) for intensive GR, and 6.5 to 8.0 for extensive GR.

The FLL and Austrian have long and detailed tables of permissible properties for substrate and drainage materials where the values differ slightly and it appears that the Austrian directive is more stringent.

Conclusion

The FLL is the most comprehensive and forms the basis of GR directives in Germany and Austria (and many other countries) and is referred to in the Swiss directives. Apart from some of the figures and values the FLL and the Austrian directives are very similar, while the Swiss directive differs in that it deals only with extensive GR, highlighting the importance of its appearance, water management, and the whole life ecological impact of green roofs on the environment.