

Single-ply roofing membranes made of ECB and FPO/TPO

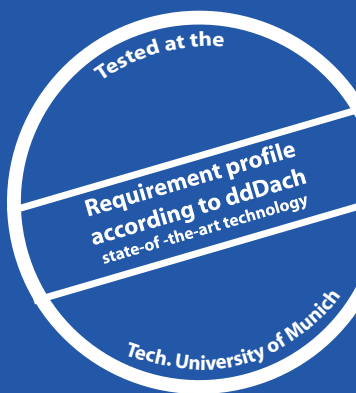
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profile according to ddDach
2005**

Requirement profile for all polymer seals according to ddDach (2005)

1

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A safe and sealed flat roof

2



Roof seals are exposed to a variety of different mechanical, chemical and biological loads and **Just how safe are such seals?** A comparative assessment of various seals (material groups comprising ECB/OCB, EPDM/IIR, EVA-PVC, PIB, PEC, TPO/FPO/OCC, PVC, POLYAMIDE and liquid plastics) was only made possible by practical, standardized tests conducted by W. ERNST (1992, 1999). These tests can assist you in making the right decision.

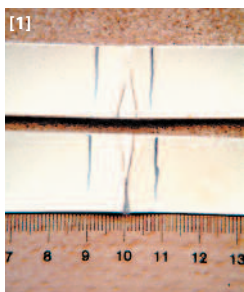
The independent roofing materials expert and Technical author, W. ERNST, makes the following statement on this:

»A fulfilment of all specified, minimum requirements permits the assumption that the sheets are processable in a practical manner, capable of withstanding the loads arising at construction sites, ecologically safe, processable in a suitable manner by fitters, and durable as roof sealing.«.

ERNST (1999, 2003)

A. Foldability at low temperatures

3



Illustrations: [1], [2] low-temperature fracture of a sample; [3] unrolled lengths of various sheets at low temperature

Roof sheets must be processable at construction sites regardless of the prevailing weather.

Due to climate changes, temperatures of below 30 degrees Celsius and below may occur during the winter in Central Europe. These values should be the basis for evaluating standard requirements of roof sealing in order to correctly assess resulting strains (ERNST, 2005).

The verified values for fold edges at low temperature also indicate improved low-temperature flexibility which directly influences processability during adverse, cold seasons. ***The sheets can be unrolled more easily and the welding temperature is lower (energy saving).***

The risk of processing under unfavourable weather conditions is minimized, particularly in the case of detailed workmanship..

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Test according to EN495-5- No fractures or fissures at	ECB plastic sheet	FPO-/TPO plastic sheet
- 30°C	Fulfilled	Fulfilled

B. Resistance to impact

4



Illustrations: [1] metalwork; [2] roofing felt nail; [3] flat roof used for storage

Roof sheets need to be highly resistant to punctures

High mechanical resistance to loads commonly arising at construction sites during processing until acceptance or until application of protective layers means a high degree of security against damage resulting from operations at the construction site.

Accordingly, roof sheets need to be resistant to all loads which normally occur at construction sites.

The sheet thickness of 2mm and the central glass fibre mat minimize the danger of damage during the construction period. Roof surfaces fully exposed to weathering must also be protected against increasingly frequent occurrences of bad weather.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
<ul style="list-style-type: none"> • Test 15 according to EN 12 691 Method A: Solid metal base • 500g falling body • falling height > 700 mm 	ECB plastic sheet (tested to 800 mm)	FPO/TPO plastic sheet (tested to 800 mm)
Resistant	Yes	Yes

C. Resistance to hail



Illustrations: [1] Hailstones; [2] & [3] Damaged sealing membranes

Some of the European regions most affected by strong hailstorms are Southern Germany, Austria, Northern Italy, Savoy, Jura, Alsace and Switzerland.

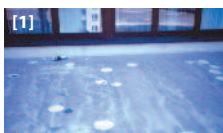
Statistically, every 10 to 15 years one has to expect a disastrous hailstorm.

Based on data gathered in the 70ies, a minimum hail resistance of ≥ 17 m/s for new material was defined in Switzerland. Research results by EMPA showed that aging behavior is an important parameter, which lead to an update of the minimum hail resistance to ≥ 25 m/s to be considered in the Requirement Profile. This value complies with the hail resistance class 3 of the new Swiss "Elementarschutzregister Hagel" (Elementary Safety Register Hailstorm).

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Testing according to EN 13 583	ECB-plastic sheet	FPO-/TPO plastic sheet
> 25 m/s	waterproof	waterproof

D. Resistance to cigarette embers

6



Illustrations: [1] holes caused by cigarette burns in front of a window facade; [2] drops of brazing solder; [3] cigarette butt

Roof sheets must be resistant to fireworks and cigarette embers

To meet deadlines, it is often necessary for several complementary trades to operate concurrently on flat roofs. Welding, soldering, metal sawing and metal grinding frequently need to be performed while sealing is in progress. Concentrated thermal loads exerted by hot metal are a common feature in such situations.

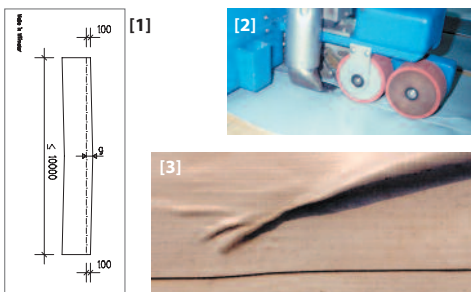
Roof surfaces fully exposed to weathering (in residential areas) need to be resistant to fireworks and cigarettes negligently thrown out of windows and off balconies.

Roof sheets resistant to cigarette embers offer the best possible protection against loads commonly arising at construction sites.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Test according to EN 1399	ECB plastic sheet	FPO-/TPO plastic sheet
Resistant	Yes	Yes

E. Straightness and flatness

7



Illustrations: [1] Straightness and flatness; [2] drift during hot-air welding; [3] creases in the seam

Roof sheets must be installable without the formation of creases using simple and reliable joining techniques.

Straightness(g) and flatness(p) are examined in accordance with EN 1848-2, Section 5.2..

Every sheet is unrolled to a stress-free length of at least 10 m on a flat base at a room temperature ranging between 18°C and 28°C.

According to the principle represented here, the deviation in sheet straightness is the largest measured interval (g) in mm between the edge of the unrolled sheet and path AB.

Straightness (g) and flatness (p) can be examined through visual checks and quality control during sheet production. These parameters are also indicators of processing reliability.

Roof sheets with large deviations tend to exhibit „drift“ during hot-air welding; this results in deficient welding seams (creases).

Requirement according to ERNST	Results obtained by the Tech.Univ. of Munich	
• Test according to EN 1848-2	ECB plastic sheet	FPO-/TPO plastic sheet
Deviation (g) < 30 mm Spacing (p) < 10 mm	Fulfilled Fulfilled	Fulfilled Fulfilled

F. Weldability

8

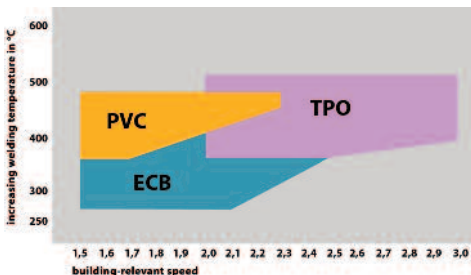


Illustration: Welding range

Source: ERNST, roof sealing and vegetation, part II, page 90

Roof sheets must permit easy welding and optimal joining at the construction site.

The standard defining the weldability of roof sheets is represented in a welding range. The wider this range, the easier it is to weld the corresponding sheet, the more reliable the joining operation, and the more consistent the sealing and evenness of the welded joints.

Essential parameters influencing weldability by means of hot air include:

- Sheet material quality
- Material type
- Substrate
- Ambient temperature
- Moisture content
- Sheet ageing rate
- Type and design of the welding equipment
- Power fluctuations

Hot-air welded joints consisting of homogeneous material are more reliable, and only a roof with tight joints provides its building with durable protection.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Welding range according to ERNST (1999).	ECB plastic sheet	FPO-/TPO plastic sheet
Existent	Yes	Yes

G. Response to application of grease



Illustrations: [1] Sheet sample following an application of grease; [2] flat roof with exterior plant

Roof sheets need to be resistant to grease and oil.

Grease and oil (low-molecular, liquid grease) are of practical significance for the following reasons:

- Grease and oil arise during maintenance of roof plants (elevator, ventilation and air-conditioning equipment, for instance).
- Grease and oil aerosols are present in high concentrations in the exhaust air of industrial plants such as engineering works and chocolate and milk processing factories.
- Kerosene mist arises during operations at airports.
- Ventilation units emitting exhaust air containing grease and oil from kitchens are installed on many roofs.
- Grease and oil also arise as part of operations at construction sites, traffic and gardening activities (for instance, incomplete combustion of exhaust gases from 2-stroke engines).

Material tests do not account for such operational loads. Roof sheets fulfilling the requirement profile ddDach can withstand these loads.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Test according to DIN 16 726 of elongation at break compared with new material:	ECB plastic sheet	FPO-/TPO plastic sheet
< 25% relative	Fulfilled	Fulfilled

H. Response to immersion in warm water

10



Illustrations: [1], [2] temporary accumulation of water; [3] mixture of gravel and accumulated water

Roof sheets must be resistant to heat and water.

Surface temperatures in excess of 50°C can occur on roofs on hot, sunny days.

This process is simulated by the test according to EN 1847, which examines changes in elongation at break compared with new material.

Because water can be expected to accumulate temporarily on most roof surfaces, this standard test at a relatively high temperature of 50°C over a long duration of 16 weeks simulates actual conditions more realistically than the material test.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
<ul style="list-style-type: none"> • Test according to EN 1847, 50°C for 16 weeks. • Elongation at break with respect to new material EN 12311-2 	ECB plastic sheet	FPO-/TPO plastic sheet
< 25% relative	Fulfilled	Fulfilled

I. Response to immersion in limewater



Illustrations: [1] material failure below gravel; [2] low-quality mortar; [3] sintering inside roof drains

Roof sheets must be resistant to limewater.

Limewater immersion test to examine resistance to lime deposits, for instance.

This test was prompted by visible signs of embrittlement on soft PVC roof sheeting covered with gravel.

The roof sheeting was covered by a closed layer of dust and abraded gravel comprising chalky rock. The same sheeting on the adjoining roof covered with vegetation did not exhibit this damage.

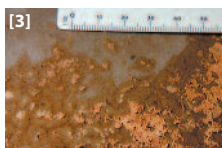
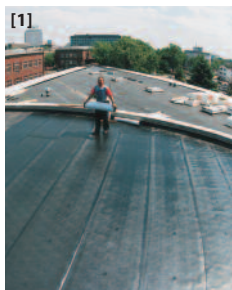
Procedure:

Sheets immersed in limewater for 16 weeks at a room temperature between 50°C.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
<ul style="list-style-type: none"> • Test according to EN 1847 • Elongation at break respect to new material according to EN 12311-2 	ECB plastic sheet	FPO-/TPO plastic sheet
< 25% relative	Fulfilled	Fulfilled

J. Response to immersion in acid solution

12



Illustrations: [1] BASF building; [2] flat roof close to the sea (Sylt); [3] signs of decomposition following exposure to acid

Roof sheets need to be resistant to corrosive chemical elements in the environment.

This test was prompted by signs of partial embrittlement caused by acid rain on roof sheeting in the vicinity of a chimney.

Acidic substances also arise from deposits such as bird droppings, foliage, pollen and their natural decomposition products.

This test is intended to simulate changes in chemical properties under realistic operating conditions in order to assess the quality, stability and resistance of materials and represent the processes taking place in sheet structure under the influence of acids (for instance, emissions from dead roots, humic acid, acid rain, exhaust gases from the chimneys of heating oil combustion units).

Requirement according to ddDach Results obtained by the Tech.Univ. of Munich

• Test according to EN 1847
• Elongation at break with respect to new material EN 12311-2

ECB plastic sheet

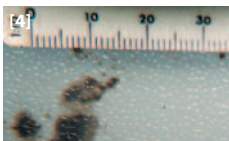
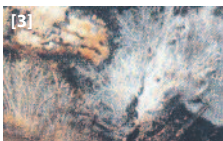
FPO-/TPO plastic sheet

< 15% relative

Fulfilled

Fulfilled

K. Resistance to microorganisms



Illustrations: [1] gravel-covered flat roof; [2] formation of red algae; [3] growth of fungus on the bottom of bituminous sheeting; [4] discoloration on top of the sheeting

Roof sheets must be resistant to biological influences.

Flat roofs are subjected to diverse stresses such as those originating from alkaline substances, algae, microbes etc.

All these factors can affect the material properties of roof sheeting and accelerate its ageing process. The guidelines for flat roofs dated 2003 explicitly state that deposits can serve as breeding grounds for bacteria and microbes. The related material norm only specifies a short-term test. Conditions during this test only partially reflect those actually pertaining to installed roof sheets, especially in the long term. The realistic, long-term test (**32 weeks with age-pre treatment, warm water, 14 days**) employed here is intended especially for simulations of the long-term response of roof sheeting to actual influential factors under laboratory conditions.

Requirement according to ddDsach	Results obtained by the Tech.Univ. of Munich	
• Test according to EN-ISO 846, age-pre treatment, duration 32 weeks	ECB plastic sheet	FPO-/TPO plastic sheet
• Weight loss compared with new material: < 4% relative	Fulfilled	Fulfilled

L. Resistance to hydrolysis



Illustrations: [1] air-conditioning unit on a flat roof; [2] embrittlement of roof sheets; [3] sealed pond on Munich's trade fair premises

Roof sheets must be resistant to hydrolysis.

Hydrolysis is the decomposition of substances by water into their primary products.

In certain circumstances, hydrolysis can produce toxic, water-soluble ingredients which pollute wastewater and the environment.

Hydrolysis can occur through puddles on roofs of an insufficient gradient and fully exposed to weathering, as well as water accumulations on roofs furnished with vegetation.

Resistance to hydrolysis is specified by the guidelines on roof vegetation and needs to be verified if necessary. Material tests according to DIN are not defined for this purpose. Roof sheets complying with the requirement profile according to Ernst are resistant to hydrolysis as defined by this profile.

W. ERNST 1992, 1999

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Test involving a comparison of elongation at break with respect to new material according to EN 12311-2: < 25% relative < 3% change in weight	ECB plastic sheet Fulfilled Fulfilled	FPO-/TPO plastic sheet Fulfilled Fulfilled

M. Resistance to ozone

15



Illustrations: [1] roof covered with vegetation to protect against ultraviolet radiation; [2] solar radiation; [3] unprotected flat roof exposed to ultraviolet radiation

Roof sheets must be resistant to solar radiation and ozone.

A thinning of the ozone layer in the stratosphere (ranging from a height of 10 km to 40 km) lowers the temperature of this region and increases its permeability to reactive UV-B radiation.

Current investigations performed in Europe's mountainous regions show that the intensity of UV-B radiation here has increased notably over the last 15 years.

Steadily increasing road traffic density is resulting in correspondingly greater emissions of nitrogen oxides and hydrocarbons from combustion engines into the atmosphere.

On hot, cloudless summer days, these exhaust gases produce ozone close to the ground. Ozone is not only one of the most toxic gases known, but also has a strong oxidizing effect which can cause premature ageing.

Requirement according to ERNST	Results obtained by the Tech.Univ. of Munich	
• Test according to EN 1844: No fissures on 6-fold enlargement.	ECB plastic sheet	FPO-/TPO plastic sheet
Stage 0	Fulfilled	Fulfilled

N. Thermal ageing

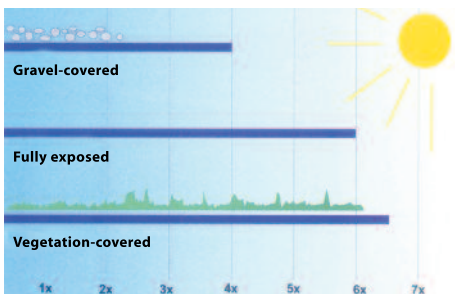


Illustration: Comparison of the durability of equivalent sealing in different configurations

Source: ERNST, roof sealing and vegetation, part II, page 19

Roof sheets must be resistant to ageing.

A knowledge of the properties of a material must include details concerning its ageing pattern. The ageing pattern of any roof sheet is determined primarily by its material quality, a major role being played by the type and grade of the basic materials as well as the manufacturing and finishing processes.

Taking into account all environmental factors acting on a roof sheeting - whether it is fully exposed to weathering, gravel-covered or vegetation-covered - its ageing pattern and long-term durability are determined essentially by:

- **Extraction**
- **Migration**
- **Resistance to hydrolysis**
- **Resistance to microorganisms**
- **Resistance to weathering**
- **Resistance to ozone**

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
<ul style="list-style-type: none"> • Test according to elongation at break (EN 12311-2) with respect to new material • EN 1296 	ECB plastic sheet	FPO-/TPO plastic sheet
<ul style="list-style-type: none"> < 25% relative < 3% change in weight 	Fulfilled Fulfilled	Fulfilled Fulfilled

O. Exposure to UV radiation

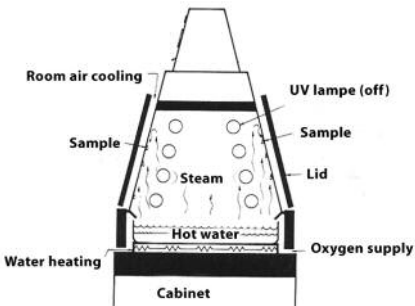


Illustration: Simplified schematic representation of a QUV fast weathering device, Source: Q-Panel company

Roof sheets must be resistant to weathering in the long term.

Weather factors such as solar radiation, temperature, precipitation and atmospheric oxygen lead to a decomposition (ageing) of plastic and bitumen, causing embrittlement and discoloration.

Artificial weathering devices are intended to simulate and intensify real, outdoor climatic factors in order to reproduce ageing processes in time lapse. Global radiation, for instance, is simulated by filtered xenon-arc radiation. The samples are wetted periodically to simulate the stress exerted by rainfall outdoors.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
<ul style="list-style-type: none"> • Test 10 according to EN 1297 (5.000/3.000h) • Change in weight compared with new material • No fissures on 6-fold enlargement 	ECB plastic sheet	FPO-/TPO plastic sheet
< 3%	Fulfilled	Fulfilled
Stage 0	Fulfilled	Fulfilled

P. Fish test



Illustrations: [1] artificial waterfall; [2] temporary accumulation of water; [3] goldfish

Roof sheets must be made of environmentally compatible materials.

The aim of Agenda 21, 1992 is a standardized and ecological approach to modern construction, accounting especially for the protection of soil, water and air as natural fundamentals of living, avoidance of stress on these elements, and an economical use of resources in general. Roofing materials are being subjected to increased scrutiny as regards their ecological and biological construction properties. Measures here include minimization of material consumption and energy consumption during production and transport. Accordingly, ERNST developed the fish test for sealing sheets. This test is used to check whether water-soluble components of installed roof sheeting influence the quality of wastewater, pollution of rainwater by water-soluble substances being undesirable.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Test according to ERNST (1999) and OECD/EEC, tested on: <i>Poecilla reticulata</i> (Guppy) > 24 hours	ECB plastic sheet Fulfilled	FPO-/TPO plastic sheet Fulfilled

Q. Cold contraction

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Illustrations: [1], [2] damage by cold contraction

Roof sheets must undergo contraction tests.

Many years of practical experience have shown that damage to loosely installed roof sheeting often occurs in the cold season.

The reason for this is often tension induced through material contraction resulting from temperature drops. Cold contraction forces act longitudinally and transversely on roof sheeting.

Consequently, the generated forces can exert stress on fixing points and seams.

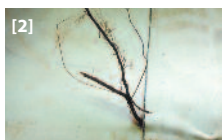
The tensile forces produced in roof sheets at low temperatures in winter, especially if the sheets were installed at high temperatures in summer, cannot be established with the help of standard values in specifications related to the roof sheets.

Accordingly, cold contraction forces acting on roof sheets need to be verified so that they can be accounted for during processing. No standard test of roof sealing has yet been specified for this purpose. Roof sheets complying with the requirement profile according to Ernst fulfil cold contraction criteria taking into consideration applicable processing guidelines.

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Test according to ERNST (1999)	ECB plastic sheet	FPO-/TPO plastic sheet
< 200 kg/m	Fulfilled	Fulfilled

R. Verification of root resistance

20



Illustrations: [1] birch upgrowth; [2];[3] quack grass upgrowth

Roof sheets must be resistant to roots.

Resistance to roots in compliance with EN 14416 (DIN 4062) still has advertising appeal, although the inadequacy of this standard is well known. Explanations are provided in related technical reports.

„To preclude future damage to buildings by roof vegetation, roof sheets are to be tested in accordance with FLL guidelines concerning vegetation. Seed dispersion by wind cannot be prevented, nor is it possible to prohibit blackbirds from dropping cherry seeds on roofs, and the growth of quack grass cannot be controlled.“

Verification of resistance to roots and rhizomes by an FLL test certificate complies with state-of-the-art technology.

W. ERNST (1999)

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
•Verification of root resistance through (since 1999) FLL test certificate	ECB plastic sheet	FPO-/TPO plastic sheet
	Fulfilled	Fulfilled

S. Declaration of ecological features



Illustrations: [1] sealed artificial waterfall; [2] pond sealed with plastic sheets

Roof sheets must be ecologically safe.

Discussions of the ecological features of construction products are gaining steadily in importance.

The SIA (Association of Swiss Engineers and Architects) developed the SIA 493 standard (1997) defining the ecological properties of building materials in order to improve communication between manufacturers and users.

An ecological approach to construction is geared primarily toward making the right decision at the right time during the building process. The greatest freedom in making decisions on ecological aspects is available during the early stage of planning, when environmental goals such as the following ones need to be defined:

- Minimization of energy requirements for structures
- Minimization of material consumption
- Maximization of product durability
- Use of dismantlable and recyclable products
- Use of low-pollution products.

Techniques and details pertaining to such objectives are provided in the declaration of ecological features of building products

Requirement according to ddDach	Results obtained by the Tech.Univ. of Munich	
• Declaration according to SIA 493	ECB plastic sheet	FPO-/TPO plastic sheet
Itemized verification available	Yes	Yes

T. Conclusion

Prerequisites for long-term operational reliability and maintenance of flat roofs are:

- Proper planning of technical and material aspects.
- A call for tenders providing a clear and unequivocal description of the quality of the required roof sheeting.
- Installation by qualified, skilled and experienced personnel.
- Installation in accordance with manufacturers' specifications and technical regulations.
- Annual maintenance.

State-of-the-art criteria for selection of the correct polymer sealing sheets are provided by the requirement profile according to ddDach (2005).

„The ageing of sheets fulfilling all minimum requirements can be assumed to remain within limits which ensure long-term utilization of the sheets.“

ddDach (2005)

Illustration: W. ERNST, roof sealing and vegetation, part 5, page 201.

Code	Requirement Description	Technical Specification / Standard	Value / Percentage
A	Widerstand gegen stehende Belastung	EN 12542	2.700 min
B	Widerstand gegen Abrieb	EN 12543	2.200 g
C	Widerstand gegen UV-Strahlung	EN 12544	2.200 g
D	Widerstand gegen mechanische Beschädigung	EN 12545	2.200 g
E	Widerstand gegen chemische Beschädigung	EN 12546	2.200 g
F	Widerstand gegen biologische Beschädigung	EN 12547	2.200 g
G	Widerstand gegen ...	EN 12548	2.200 g
H	Widerstand gegen ...	EN 12549	2.200 g
I	Widerstand gegen ...	EN 12550	2.200 g
J	Widerstand gegen ...	EN 12551	2.200 g
K	Widerstand gegen ...	EN 12552	2.200 g
L	Widerstand gegen ...	EN 12553	2.200 g
M	Widerstand gegen ...	EN 12554	2.200 g
N	Widerstand gegen ...	EN 12555	2.200 g
O	Widerstand gegen ...	EN 12556	2.200 g
P	Widerstand gegen ...	EN 12557	2.200 g
Q	Widerstand gegen ...	EN 12558	2.200 g
R	Widerstand gegen ...	EN 12559	2.200 g
S	Widerstand gegen ...	EN 12560	2.200 g

U. Colours

23



Black



Grey



Blue



Red



Green



Grey



White



Blue

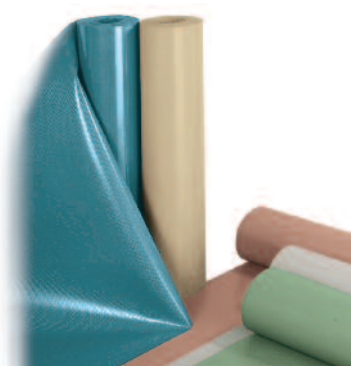


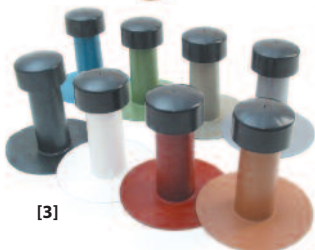
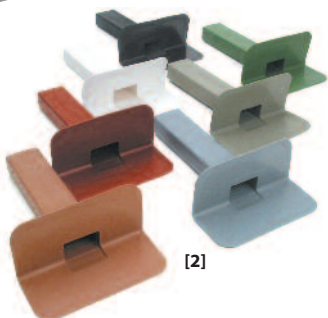
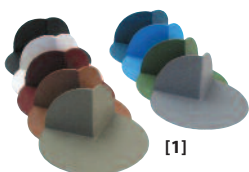
Red



Green

Expedient design can also be appealing, especially in the case of flat roofs whose aesthetics and landscape integration have long been neglected. Whether white, blue, green, red, black or grey, coloured roof sheets are available in a diversity permitting an emphasis of design aspects and affording great conceptual freedom without detracting from the high standards imposed on safety and sealing properties.





Illustrations: [1] exterior angles; [2] water spouts; [3] roof ventilators

A wide range of proven accessories such as moulded articles comprising interior and exterior angles, roof drains, waterstops and bonding plates are available for proper installation and secure, homogeneous welding of roofing and sealing sheets.

You receive roof sealing, accessories and competent advice all from a single source. Maximum reliability and high installation comfort guarantee your success.

W. Insurance for up to 20 years

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Illustration: Sample certificate

LUCOBIT plastic roof sheets made of ECB and/or FPO/TPO can be insured for up to 20 years.

The icing on the cake in terms of safety is provided by flat roof insurance offered by sheet producers. Insurable objects include entire, newly constructed flat roofs and partial, renovated surfaces. A prerequisite for this is the use of LUCOBIT roof sheets made of ECB and/or FPO/TPO and the conclusion of a maintenance contract. Even the entire packet of layers (including substructure and insulation) is insurable on request. The contract has a freely selectable duration of up to 20 years. The sheet manufacturers are to be contacted for the purpose of concluding an insurance contract.

X. Technical literature

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Supplementary and additional technical literature: Roof sealing and vegetation, part III (2002), part IV (2003), part V (2005), and special edition “sealing” published by Fraunhofer IRB. The still current technical books from 1991/1999 and the supplement from 2003 co-authored by W. ERNST, FISCHER, JAUCH and LIESECKE describe presently feasible quality standards and therefore serve to document state-of-the-art technology.

A practical requirement profile for all seals helps improve the safety and durability of roofs. Seals meeting these user-friendly, functional, ecological and sustainable standards are listed.

“The requirement profile for sealings developed by ERNST (1999) and adjusted by ddDach (2005) has been adopted to the European norms. Its wide use contributes to the transparency of the sealing market and is therefore principally recommendable.”(Prof. r.Oswald – Aachener Bausachverständigentage 2005).

We thank ddDach e.V. for the texts, documents and illustrations provided.

No liability is assumed for the correctness of the supplied information or the properties which can be deduced from the requirement profile for the products described in the brochure.



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