ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804

<table>
<thead>
<tr>
<th>Owner of the Declaration</th>
<th>Deutsche ROCKWOOL Mineralwoll GmbH &amp; Co. OHG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programme holder</td>
<td>Institut Bauen und Umwelt e.V. (IBU)</td>
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<td>Publisher</td>
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<tr>
<td>Declaration number</td>
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<td>ECO EPD Ref. No.</td>
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<td>Issue date</td>
<td>18/12/2012</td>
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<tr>
<td>Valid to</td>
<td>17/12/2017</td>
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</table>

Stone wool insulation materials in the high bulk density range
Deutsche ROCKWOOL Mineralwoll GmbH & Co. OHG

www.ibu-epd.com / https://epd-online.com
1. General Information

Deutsche ROCKWOOL Mineralwoll GmbH & Co. OHG

Programme holder
IBU - Institut Bauen und Umwelt e.V.
Panoramastr. 1
10178 Berlin
Germany

Declaration number
EPD-DRW-20120113-IBC2-EN

This Declaration is based on the Product Category Rules:
Mineral insulating materials, 07.2014
(PCR tested and approved by the SVR)

Issue date
18/12/2012

Valid to
17/12/2017

Owner of the Declaration
Deutsche ROCKWOOL Mineralwoll GmbH & Co. OHG
Rockwool Straße 37 - 41
45966 Gladbeck
Germany

Declared product / Declared unit
1 m³ unfaced and uncoated synthetic resin-bonded stone wool (= rock wool) insulation material produced by ROCKWOOL in the high bulk density range of 121 kg/m³ to 250 kg/m³. Moreover, the environmental impacts of 7 facings are presented on the basis of 1 m² in the Annex.

Scope:
The Life Cycle Assessment is based on the life cycle of unfaced and uncoated synthetic resin-bonded stone wool produced by ROCKWOOL. The LCA results of the facings are listed in the Annex. The stone wool is produced in the plants in Gladbeck, Neuburg and Flechtingen in which production data was recorded for 2008 and complemented by generic data for the facings in 2015. The Life Cycle Assessment therefore represents all of the stone wool produced by ROCKWOOL. This document is a translation from German into English. It is based on the original declaration EPD-DRW-20120113-IBC2-DE. The owner of the declaration shall be liable for the underlying information and evidence; the IBU shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.

Verification
The CEN Norm /EN 15804/ serves as the core PCR
Independent verification of the declaration according to /ISO 14025/

[ ] internally  [x] externally

2. Product

2.1 Product description / Product definition
Definition of mineral wool (stone wool and glass wool) in accordance with the /EU Guideline 97/69/EC/ and the German hazardous substances legislation (/ChemVerbotsV/ and /GefStoffV/): Man-made mineral fibres comprising vitreous (silicate) fibres with random orientation with a content of oxides of sodium, potassium, calcium, magnesium and barium greater than 18% by weight.

Stone wool insulation materials are fibre insulation materials. The essential components are stone wool thermal insulation fibres, monofilament synthetic mineral fibres of non-crystalline structure extracted from a silicate melt. The mean fibre diameter is 3-6 μm. The fibres can be up to several centimetres in length.

The unfaced and uncoated synthetic resin-bonded stone wool insulation materials described in this declaration are produced in the form of slabs, mats or rolls in the high bulk density range (121 up to 250 kg/m³). The products are supplied in thicknesses of 20 to 350 mm, e.g. as pressure-resistant slabs, non-crush double-layered slabs or highly compressible felts and rolls.

ROCKWOOL products are produced in the three plants in Gladbeck, Neuburg and Flechtingen. Averages were formed on the basis of the production volumes at the plants. The unfaced and uncoated stone wool products do not display any differences in terms of the production process or production technology.

For certain applications, the insulation materials are provided with a functional facing on one or both sides.
Environmental Product Declaration Deutsche ROCKWOOL – Stone wool insulation materials in the high bulk density range

For the placing on the market of the product in the EU/EFTA (with the exception of Switzerland) Regulation (EU) No. 305/2011 (CPR) applies. The product needs a Declaration of Performance taking into consideration /EN 13162:2012+A1:2015/ (Thermal insulation products for buildings - Factory made mineral wool (MW) products – Specification) respectively /EN 14303:2015/ (Thermal insulation products for building equipment and industrial installations - Factory made mineral wool (MW) products – Specification) and the CE-marking. For the application and use the respective national provisions apply.

2.2 Application

- All areas of application in accordance with /DIN 4108-10/ for walls, ceilings and roofs with the requirements specified there for heat and sound insulation and mechanical properties.
- Building equipment (insulation of heating and hot-water pipes).
- Technical insulation (insulation of pipelines, district heating pipelines, boilers and apparatuses).
- Industrial processing (air-conditioning ducts, fire doors, prefabricated house elements and chimney systems).
- Fire safety elements (fireproofing for wiring and elements for steel structures).

2.3 Technical Data

- Declared value of thermal conductivity $\lambda_{D}$ as per /DIN EN 13162/: 0.032 to 0.048 [W/m∙K]
- Design value of thermal conductivity $\lambda$ as per general construction approval: 0.032 to 0.048 [W/m∙K]
- Water vapour diffusion resistance value according to /EN 12086/ $\mu = 1$
- Water vapour diffusion equivalent air layer thickness $= \mu \times$ component thickness in [m] (this would be 1 for a thickness of 1 m)
- Bulk density as per /DIN 1602/: 121 up to 250 kg/m³
- Compressive stress as per /EN 826/: 5 to 70 kPa
- Sound absorption coefficients $\alpha_s$ depending on the frequency as per /DIN EN ISO 354/ are listed in the data sheets for the corresponding products, e.g. RAF noise absorption panel (30 mm panel with 200 mm air space):

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_s$</td>
<td>0.34</td>
<td>0.73</td>
<td>0.93</td>
<td>0.81</td>
<td>0.92</td>
<td>0.94</td>
</tr>
</tbody>
</table>


2.4 Delivery status

Stone wool insulation materials are available in various lengths and widths as mats, blankets, slabs, ropes and mouldings, with thicknesses of up to 350 mm being possible.

Bulk density: 121 up to 250 kg/m³

2.5 Base materials / Ancillary materials

The raw materials are the naturally occurring rocks diabase or basalt (27-50% by weight) and cement-bound blocks (50-73% by weight). This is supplemented by max. 3.5% DM binder (urea-modified phenol formaldehyde resin with glucose), max. 0.2% aliphatic mineral oil and max. 0.1% bonding agent (aminosilane). No other auxiliaries or additives are used for the unfaced/uncoated products.

The base materials/ancillary materials of the facings are:

<table>
<thead>
<tr>
<th>Facing</th>
<th>$g/m²$ (one-sided)</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>glass fleece</td>
<td>100 g</td>
<td>glass fibres, binder</td>
</tr>
<tr>
<td>glass silk</td>
<td>102 g</td>
<td>glass fibres, binder</td>
</tr>
<tr>
<td>mineral fleece</td>
<td>346 g</td>
<td>glass fibres, mineral based primer, binder</td>
</tr>
<tr>
<td>mineral based primer</td>
<td>250 g</td>
<td>silicic emulsion</td>
</tr>
<tr>
<td>aluminium sandwich foil</td>
<td>94.8 g</td>
<td>aluminium foil, glass fabrics, PE foil</td>
</tr>
<tr>
<td>anorganic fiber-reinforced coating based on magnesium oxide</td>
<td>5450 g</td>
<td>magnesium cement, glass fibres</td>
</tr>
<tr>
<td>RockTect facing</td>
<td>145 g</td>
<td>PP fibres, thermoplastic elastomer ether ester (TEES)</td>
</tr>
</tbody>
</table>

2.6 Manufacture

Both diabase or basalt and concrete blocks are melted using coke in a cupola furnace at approx. 1,400-1,500°C and spun into fibres in a roller spinning process. Fluxing agents (mineral oils) and binder (urea-modified phenol formaldehyde resin) are then immediately sprayed on in an aqueous solutions. The binder serves to ensure bonding and dimensional stability while the fluxing agent minimises dust and ensures water repellence. The bonding agent also contained in the aqueous solution supports adhesion of the binder to the fibres. The raw wool is deposited on conveyor belts in negative-pressure collecting chambers. The uncured material is then continuously discharged and fed into hardening furnaces in which air at 200-300°C is sucked through the wool mass, leading the binders to cross-link to form thermostets. This process can be followed by applying facings or the mat is quilted with a wire mesh. However, these processes are not addressed in this declaration.

Finally, the product is shaped by sawing. The waste air volume arising during production is mechanically filtered and largely afterburned thermally. The heat content is used for pre-heating the blast air by heat exchangers. The dust separated is re-used as a raw material.

Process water is cleaned internally and largely returned into the process.
Quality assurance:
Internal and external monitoring in accordance with approval no. Z 23.15-1468 and CE marking in accordance with European regulations.
For technical insulation products as per VDI 2055, corresponding to Keymark, corresponding to AGI Q 132.
All products according to RAL-GZ 388.
Quality management system in accordance with /DIN EN ISO 9001/.

2.7 Environment and health during manufacturing

Health protection during manufacturing:
In Germany, the following specific guidelines apply for mineral wool insulation materials:
- Ban on the production and use of biopersistent fibres (German Dangerous Substances Order, Annex II, No. 5)
- Ban on placing biopersistent fibres on the market (German Chemicals Prohibition Order, No. 23 of the Annex to Sec. 1)

Apart from the statutory requirements, no other special measures are required.

Environmental protection during manufacturing:
The specific guidelines of the German Technical Instructions on Air Quality Control ("TA Luft"), section 5.4.5.2.1 apply (regulations governing total dust and phenol/formaldehyde for pre-existing plants).
- Air: Waste air generated during production is cleaned in accordance with statutory regulations.
- Water/Soil: No contamination of water or soil occurs. Production-related waste water is treated internally and returned to the production process.
- Noise measurements have shown that all values measured inside and outside the production facilities are below the standards applicable in Germany. Noise-intensive plant components such as the defibration unit are encapsulated appropriately by structural measures.

2.8 Product processing/Installation
Recommendations on product processing depend on the respective product and system and are described in the specific brochures and data sheets (available at www.rockwool.de).

2.9 Packaging
Wooden pallets and PE shrink foil serve as packaging materials. Foil packaging is disposed of by Interseroh AG, Cologne.

2.10 Condition of use
No changes arise in material composition during use, except in the case exceptional impacts (see 2.13).

2.11 Environment and health during use
Mineral wool fibre dust indoors:
As is the case with all types of dust, the release of mineral-fibre dust can cause skin and eye irritation, irritation of the respiratory tract and allergic reactions. Rougher fibres and/or fibre fragments can have a mechanical effect on the eyes, throat and skin. The general principles of industrial hygiene should be observed to avoid such temporary and reversible symptoms, as when handling non-fibrous dust.
Insulation materials produced by Deutsche ROCKWOOL Mineralwoll GmbH Co. OHG are not covered by the scope of Annex II, No. 5 of the Dangerous Substances Order and section 23 of the Annex to Sec. 1 of the Chemicals Prohibition Order. Therefore, they are not subject to the ban on production and use of fibrous dusts assessed as carcinogenic at the workplace.
According to UBA Text 30/94 "Studies of indoor
pollution by fibrous fine dust from installed mineral wool products", the concentration of mineral wool fibre dust in interior areas is

- not usually increased during the use phase if thermal insulation has been installed correctly; this presumes that the insulation material being clearly segregated from the interior (e.g. thermal insulation on the outer wall or thermal insulation behind a vapour-proof barrier and cladding made of gypsum plasterboard, wooden panels or similar);
- usually only moderately increased if the mineral wool products are fitted in such a way that they are in a direct air exchange with the interior; this is the case mainly in rooms with suspended (acoustic) ceilings without functioning trickle protection;
- in individual cases significantly increased (up to several thousand fibres per cubic metre of room air), such as in case of structural defects or designs which do not comply with the state of the art, or temporarily in the case work being done on components containing mineral wool products.

Formaldehyde and VOC emissions:
Formaldehyde and VOC emissions can cause health problems such as headaches, nausea or irritation of the mucous membranes which is why care should be taken to use low-emission construction materials. The formaldehyde and VOC emissions determined for the declared unfaced stone wool products are below the detection and/or limit values; no carcinogens were detected. Use can therefore be classified as harmless (see section 7.4).

2.12 Reference service life
When used correctly, the service life of ROCKWOOL stone wool is unlimited according to current scientific findings, and only limited by the service life of the components and/or building as a whole. Insulation performance persists in full throughout the entire service life. Insulation performance is only impaired by exceptional impacts (see 2.13) and damage to the structure.

2.13 Extraordinary effects

Fire
During the use phase, the binding agent can disintegrate in the case of stone wool insulation materials exposed to increased temperatures of above about 200°C over longer periods of time. Stone wool insulation materials are classified in fire rating class A1 (non-combustable) in accordance with DIN EN 13501-1 and DIN 4102. They do not represent a hazard potential as regards smoke development, nor are flaming droplets possible. The melting point of stone wool insulation material fibres is above 1,000°C and the maximum temperature for use is approximately 700°C.

Water
Moisture impairs the insulating characteristics. Mineral wool insulation materials are permeable and can dry out. The insulation material must be replaced after lengthy exposure to water (e.g. flooding).

Mechanical destruction
Not relevant.

2.14 Re-use phase
Stone wool insulation materials are not re-usable. If they contain only stone wool, they can be recycled. Ground mineral wool can also be used as an additive in brick-making.

2.15 Disposal
In the European Waste Catalogue, the waste code for production residue of stone wool insulation materials is 10 11 03 in accordance with the Waste Catalogue Statutory Regulation (AVV); the waste code for building site waste (after use) is 17 06 04 if the waste is of a single grade, and 17 09 04 for mixed waste.

2.16 Further information
Further information on the stone wool insulation materials produced by ROCKWOOL is available on the producer's website: www.rockwool.de.

### 3. LCA: Calculation rules

#### 3.1 Declared Unit
This declaration refers to the life cycle of 1 m³ of stone wool insulation material produced by Deutsche ROCKWOOL Mineralwoll GmbH & Co. OHG. ROCKWOOL products are manufactured in three plants, with averages being formed on the basis of the production volumes. The plants do not display any differences in technology in the production of stone wool. The bulk density of the declared stone wool products ranges from 121 to 250 kg/m³. The averaging results in an average bulk density of 158 kg/m³ for stone wool insulation materials in the high bulk density range for which the following LCA results are shown. These results can be applied to other bulk densities by means of linear scaling.

<table>
<thead>
<tr>
<th>Declared unit</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion factor to 1 kg</td>
<td>0.00633</td>
<td>-</td>
</tr>
</tbody>
</table>

In addition, the environmental profiles of 7 facings, which are based on the specifications given in section 2.5, are presented in the Annex. In order to use the data for the facings, the results for the stone wool products on the basis of 1 m³ have to be recalculated for the desired thickness. Then, the results for the facings per square metre have to be added. The environmental profiles of the facings were calculated for one-sided attachment. In the case of facing on both sides, the environmental impacts of the facings have to be doubled, or added together in the case of different facings. Additional adhesive is not needed for the facing process.
3.2 System boundary
Type of EPD: cradle to grave, with options
The Life Cycle Assessment takes into account the life cycle phases of stone wool production (Modules A1–A3), disposal of the packaging arising during installation (Module A5) and the subsequent-use phase (Modules C2 and C4). Credits based on thermal utilization of the packaging are allocated to Module D. Credits arising from landfilling (Module C4) are also allocated to Module D.
The following individual processes were included in the product stage A1–A3 of production:
- Provision processes concerning preliminary products and energy
- Transporting the raw materials and preliminary materials to the plant
- Production process in the plant including energy inputs, disposal of residual materials arising and emissions
- Production of packaging

The packaging material volumes taken into account involve annual consumption / annual purchase volumes which also cover pallet returns. Emissions and burdens attributable to disposal of packaging are allocated to Module A5.
The disposal of stone wool at the end of life takes into account the transport by truck to a landfill site (C2) as well as final landfilling (C4) with utilisation of landfill gas for generating electricity.

The scope of examination for the facings covers the same modules that are already declared for the unfaced products. As no additional packaging is taken into account for the facing, no environmental burdens or credits result in the modules A5 and D for the facings.

3.3 Estimates and assumptions
In the product system under review, ash and slag from external sources are entered as neutral preliminary products in the Life Cycle Assessment (for making the concrete blocks). These preliminary products are regarded as waste products which do not cost ROCKWOOL anything and are accordingly calculated as inputs without burdens. Only transport to Flechtingen, Gladbeck and Neuburg is taken into account in the Life Cycle Assessment. Relevant recycled materials in the production of stone wool fibres are ash, slag and used anodes, for example. Recycled fuels also serve to cover energy requirements in the cupola furnace. These are used mainly in Flechtingen and are also calculated as neutral, since they are production wastes. Further processing was not considered here, for the moment, on account of the uncertain data basis and the fact that there is only a minor influence on the final results. Assumptions had to be made with regard to NMVOC emissions, for reasons of consistency. According to ROCKWOOL, it can be assumed that all of the VOC emissions measured involve NMVOCs which are also depicted as such in the Life Cycle Assessment software. Measurements for phenol, formaldehyde and VOC (total) are available for two lines at each of the Gladbeck and Neuburg plants. ROCKWOOL was unable to provide any details on VOC (total) for the Flechtingen plant, so that a worst-case approach was used here, on the basis of the values measured in Gladbeck and Neuburg.

The environmental impacts of the facings presented in the Annex are estimated on the basis of their material composition. Other aspects such as transports, production energy, process emissions and production offcuts are not considered. The energy used in the manufacturing process of the facing based on magnesium oxide is estimated.

3.4 Cut-off criteria
All operating data obtained for the Gladbeck, Neuburg and Flechtingen plants was taken into account for the audit, i.e. all of the starting materials used according to the formulations, the thermal energy used, internal fuel and electricity consumption, and all direct production waste, as well as emission measurements. Assumptions were made as regards the transport expenses associated with all inputs and outputs taken into account. Thus, material and energy flows with a share of less than 1% were also taken into account. It can be assumed that the total of all neglected processes does not exceed 5% of the impact categories. Machinery, plants and infrastructure required in the manufacturing process are neglected. It can be assumed that the prescribed cut-off criteria are respected by neglecting the environmental aspects not taken into account for the facings.

3.5 Background data
“GaBi 4” – the software system for comprehensive analysis (/GaBi 4/) developed by PE INTERNATIONAL AG – was used for modelling the life cycle of the stone wool. The data records contained in the GaBi data base are documented in the online GaBi documentation (/GaBi 4 Doku/). The basic data in the GaBi data base was applied for energy, transport, preliminary products and auxiliaries. No data records from other data bases were used. The Life Cycle Assessment was drawn up for Germany as a reference area. This means that, besides the production processes under these conditions, the preliminary stages also of relevance for Germany, such as provision of electricity or energy media, were used. The power mix for Germany with the reference year 2008 is used.

3.6 Data quality
All of the background data records of relevance for production were taken from the GaBi 4 software data base; primary data was supplied by ROCKWOOL. The background and primary data used was last revised less than 4 years ago. It involves industrial data from Deutsche ROCKWOOL Mineralwoll GmbH & Co. OHG which was recorded in the Gladbeck, Neuburg and Flechtingen plants for the year 2008. The data on the provision of preliminary products was taken from the GaBi data base.

For modelling the life-cycle of the facings only standard data records from the GaBi database are used. No primary data collection has been carried out. Information on the formulation was submitted by ROCKWOOL or is based on data from the literature and industry /GaBi Doku/.
The data quality can be regarded as good, since data records which were representative in terms of time, area and technology were available for all processes and preliminary products.

3.7 Period under review

The data in this Life Cycle Assessment for the unfaced and uncoated products is based on primary data concerning the production of stone wool in 2008 by Deutsche ROCKWOOL Mineralwoll GmbH & Co. OHG. The amounts of raw materials, energy, auxiliaries and consumables used are considered as average annual values.

In contrast to the unfaced stone wool products, the material composition of the facings refers to data for the year 2015. The model therefore is based on GaBi database version 2014.

3.8 Allocation

All plant data refers to the declared product. Within the framework of the Life Cycle Assessment, no allocations were carried out as the average stone wool produced is modelled.

Co-product allocation was carried out in the production of stone wool fibres. Pig iron arises during melting of the raw materials and preliminary products in the cupola furnace. Pig iron as a co-product complies with the end-of-waste criteria as per DIN EN 15804. In the Life Cycle Assessment, allocation is done by mass.

Recycled materials entering the product system as inputs are calculated as inputs without burdens, as they consist of waste products. This approach complies with the specifications in the EN 15804 standard. Only their transport to Flechtingen, Gladbeck and Neuburg is taken into account in the Life Cycle Assessment. Relevant recycled materials in the production of stone wool fibres are ash, slag and used anodes, for example. Secondary fuels are used in the cupola furnace; these are also regarded without burdens (see section 3.3).

No other allocations had to be made in this Life Cycle Assessment for the primary data pertaining to the product under review and the facings.

Packaging materials are burned in a waste incineration plant. They are modelled in an input-specific manner in the model. Any emissions occurring are taken into account in the model (Module A5). According to the elementary composition and ensuing calorific values, credits for thermal utilisation are recorded in Module D. Re-used production waste is modelled as closed-loop recycling.

3.9 Comparability

Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to EN 15804/ and the building context, respectively the product-specific characteristics of performance, are taken into account. The GaBi database was applied for energy, transport, preliminary products and auxiliaries. No data records from other databases were used.

4. LCA: Scenarios and additional technical information

The following technical information forms the basis for the declared modules or can be used for developing specific scenarios for a building assessment.

Disposal of packaging during installation (A5)

Packaging materials are incurred on the building site (ROCKWOOL database):
- Wooden pallets: 4.63 kg/m³
- Polyethylene foil: 0.93 kg/m³

End of Life (C2 & C4)

Transport to the landfill site: 50 km, 50% truck utilisation capacity including dry runs.
Landfill with utilisation of landfill gas for generating electricity, due to the organic components of the binding agents.

Module D

Module D contains credits for electricity and thermal energy as a result of thermal utilisation of packaging materials as well as of landfiling stone wool. Both electricity (28%) and heat (72%) are produced during incineration. The plant is based on an overall efficiency of 82%.
5. LCA: Results

The environmental impacts for 1 m³ stone wool with an average bulk density of 158 kg/m³, produced by Deutsche ROCKWOOL Mineralwoll GmbH & Co. OHG, are presented below. The following tables depict the results of the indicators of the estimated impact, input of resources, waste and other output flows in relation to 1 m³ of stone wool insulation material. Modules marked "X" as per /DIN EN 15804/ are addressed.

The environmental impacts and life cycle inventory indicators for the various facings are listed in the Annex.

<table>
<thead>
<tr>
<th>PRODUCT STAGE</th>
<th>CONSTRUCTION PROCESS STAGE</th>
<th>USE STAGE</th>
<th>END OF LIFE STAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material supply</td>
<td>Transport</td>
<td>Manufacturing</td>
<td>Assembly</td>
</tr>
<tr>
<td>Raw material supply</td>
<td>Transport</td>
<td>Manufacturing</td>
<td>Assembly</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>MND</td>
</tr>
</tbody>
</table>

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1 m³ stone wool, 158 kg/m³

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>A5</th>
<th>C2</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global warming potential</td>
<td>[kg CO₂-Eq.]</td>
<td>140.95</td>
<td>11.11</td>
<td>0.67</td>
<td>12.41</td>
</tr>
<tr>
<td>Depletion potential of the stratospheric ozone layer</td>
<td>[kg CFC1-Eq.]</td>
<td>5.07E-6</td>
<td>8.19E-9</td>
<td>1.18E-9</td>
<td>4.04E-6</td>
</tr>
<tr>
<td>Acidiﬁcation potential of land and water</td>
<td>[kg SO₂-Eq.]</td>
<td>1.42E-1</td>
<td>5.64E-4</td>
<td>4.78E-4</td>
<td>3.97E-2</td>
</tr>
<tr>
<td>Eutrophication potential</td>
<td>[kg PO₄₂⁻-Eq.]</td>
<td>0.00E+0</td>
<td>0.00E+0</td>
<td>0.00E+0</td>
<td>0.00E+0</td>
</tr>
<tr>
<td>Formation potential of tropospheric ozone photochemical oxidants</td>
<td>[kg ethene-Eq.]</td>
<td>3.81E-5</td>
<td>3.32E-7</td>
<td>2.26E-6</td>
<td>6.84E-8</td>
</tr>
<tr>
<td>Abiotic depletion potential for non-fossil resources</td>
<td>[kg Si-Eq.]</td>
<td>1.72E-7</td>
<td>5.47</td>
<td>9.33</td>
<td>27.98</td>
</tr>
</tbody>
</table>

RESULTS OF THE LCA - RESOURCE USE: 1 m³ stone wool, 158 kg/m³

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>A5</th>
<th>C2</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable primary energy as energy carrier</td>
<td>[MJ]</td>
<td>195.78</td>
<td>0.04</td>
<td>0.01</td>
<td>1.78</td>
</tr>
<tr>
<td>Renewable primary energy resources as material utilization</td>
<td>[MJ]</td>
<td>22.87</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total use of renewable primary energy resources</td>
<td>[MJ]</td>
<td>218.65</td>
<td>0.04</td>
<td>0.01</td>
<td>1.78</td>
</tr>
<tr>
<td>Non-renewable primary energy as energy carrier</td>
<td>[MJ]</td>
<td>1744.66</td>
<td>5.77</td>
<td>9.38</td>
<td>29.46</td>
</tr>
<tr>
<td>Non-renewable primary energy as material utilization</td>
<td>[MJ]</td>
<td>189.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total use of non-renewable primary energy resources</td>
<td>[MJ]</td>
<td>1933.68</td>
<td>5.77</td>
<td>9.38</td>
<td>29.46</td>
</tr>
<tr>
<td>Use of secondary material</td>
<td>[kg]</td>
<td>5.11</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Use of renewable secondary fuels</td>
<td>[MJ]</td>
<td>4.20</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Use of non-renewable secondary fuels</td>
<td>[MJ]</td>
<td>95.23</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Use of net fresh water</td>
<td>[m³]</td>
<td>0.51</td>
<td>0.01</td>
<td>0.00</td>
<td>0.05</td>
</tr>
</tbody>
</table>

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1 m³ stone wool, 158 kg/m³

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>A5</th>
<th>C2</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous waste disposed</td>
<td>[kg]</td>
<td>4.37E-2</td>
<td>2.28E-1</td>
<td>0.00E+0</td>
<td>5.32E-3</td>
</tr>
<tr>
<td>Non-hazardous waste disposed</td>
<td>[kg]</td>
<td>541.49</td>
<td>0.24</td>
<td>0.08</td>
<td>161.35</td>
</tr>
<tr>
<td>Radioactive waste disposed</td>
<td>[kg]</td>
<td>6.32E-2</td>
<td>9.23E-5</td>
<td>1.47E-5</td>
<td>1.71E-4</td>
</tr>
<tr>
<td>Components for re-use</td>
<td>[kg]</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Materials for recycling</td>
<td>[kg]</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Materials for energy recovery</td>
<td>[kg]</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Exported electrical energy</td>
<td>[MJ]</td>
<td>-</td>
<td>6.81</td>
<td>0.00</td>
<td>5.76</td>
</tr>
<tr>
<td>Exported thermal energy</td>
<td>[MJ]</td>
<td>-</td>
<td>67.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

6. LCA: Interpretation

The total primary energy input across the life cycle of 1 m³ of stone wool is almost entirely dominated by production. During production (Modules A1-A3) of 1 m³ of stone wool, the total use of non-renewable primary energy amounts to about 1934 MJ/m³. The total input of renewable primary energy amounts to 220 MJ per m³ of stone wool.

The input of non-renewable primary energy during stone wool production is primarily determined by the melting process and the energy required for this (coke and thermal energy from natural gas). When considering the direct energy equivalents used in the plants, coke dominates at 60% followed by the energy-media mix as a result of the input of electricity which accounts for 27%, while thermal energy from natural gas contributes 13%.

A further contribution is made by the production of binding agents, which is in turn primarily attributable to the production of phenol and formaldehyde. The input of primary energy for winning and treating other raw materials such as basalt is relatively low. A significant percentage of the raw materials used is accounted for...
by recycled materials which enter the calculation without burdens. The input of renewable primary energy is determined by the production of binding agents and of wooden pallets. The binding agent contains the renewable resource glucose. In the upstream chains of the production of glucose and wood sunshine is required to grow biomass. Another significant contribution is made by the percentage of renewable sources in the power mix (wind power).

Stone wool production involves the use of briquettes, to produce which recycled materials such as ash, dust and slag are used. Apart from coke as the main primary fuel, both renewable and non-renewable recycled fuels are also used in the melting process in the cupola furnace. During the production (Modules A1-A3) of 1 m$^3$ of stone wool, 1.5 m$^3$ water are required, including the upstream chains. Most of this is employed in upstream chains of electricity generation; water is primarily used for cooling purposes in the coal-fired power stations. Direct water consumption in the plant is relatively low.

An analysis of waste volumes is depicted separately for the three main segments: disposed-of, non-hazardous waste (including mining waste, excavation waste, ore treatment residue, municipal solid waste including domestic waste contained therein, and commercial waste), hazardous waste for landfiling and disposed-of radioactive waste.

Non-hazardous waste represents the largest share in the production of stone wool. Excavation waste and mining waste are primarily incurred in the upstream chains associated with coke, and the generation of electricity during extraction of fuels (coke, natural gas etc.). After the use phase, stone wool products are deposited entirely on landfill sites. Radioactive waste arises only in generating electricity in nuclear power plants.

The dominance of the product stage (Modules A1-A3) is apparent in all impact categories which is why this life cycle is given more consideration. Apart from the product stage, the upstream chains associated with the production of packaging foil. Non-recycled materials are mainly used in the upstream chains associated with the production of stone wool. Excavation waste and mining waste are primarily incurred in the upstream chains associated with coke, and the generation of electricity during extraction of fuels (coke, natural gas etc.). After the use phase, stone wool products are deposited entirely on landfill sites. Radioactive waste arises only in generating electricity in nuclear power plants.

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Radioactive waste arises only in generating electricity in nuclear power plants. The dominance of the product stage (Modules A1-A3) is apparent in all impact categories which is why this life cycle is given more consideration. Apart from the product stage (Modules A1-A3), landfiling stone wool has a 7% influence on the POCP, 8% on the GWP and approx. 21% on the EP. Methane arises as a result of landfiling stone wool and conversion of the binding agents which contributes to the POCP and the GWP. Landfiling is also responsible for ammonia emissions in the landfill body as a result of the ammonia component in the binding agent formulation recipe, which contribute to the EP.

The Global Warming Potential associated with the production of stone wool is dominated to more than 90% by carbon dioxide emissions. CO$_2$ is primarily generated during the melting process while converting coke in the cupula furnace. The upstream chains associated with the provision of electricity, as well as the direct emissions in the plant owing to thermal conversion of natural gas, are the other major contributors to the Global Warming Potential. R11 and R114 emissions from the upstream chain associated with the provision of electricity are the main contributors to the Ozone Depletion Potential.

The Acidification Potential associated with the production of stone wool (Modules A1-A3) is dominated to 46% by sulphur dioxide emissions and to 41% by ammonia emissions. SO$_2$ emissions are dependent on the use of coke in the cupula furnace while ammonia emissions arise from the hardening during production which causes ammonia to escape from the binding agent. Dominance of the "Production" sub-system within modules A1-A3 is also indicated by the Eutrophication Potential which is primarily determined by ammonia emissions (65%) but also by nitrogen oxides (25%). Ammonia emissions arise primarily from the application of binding agents and from the hardening of the stone wool. Nitrogen oxides arise as a result of the melting process or can be attributed to upstream chains associated with the provision of electricity. Primarily NMVOC emissions (42%) but also nitrogen oxides (14%) and sulphur dioxide (35%) contribute to the Summer Smog Potential during stone wool production. SO$_2$ is generated mainly during thermal conversion of coke in the cupula furnace. NMVOCs arise at plant level due to the application of binding agents and hardening, as well as in the upstream chains associated with the production of packaging foil. When considering the ADP (elements), the dominance of the upstream chains associated with the provision of raw materials accounts for about 50% within Modules A1-A3. This is attributable to the use of gypsum in cement production. Cement is used for manufacturing briquettes. The use of various ores in the upstream chains associated with production and in the production of binding agents (copper ore, zinc ore etc.) is also apparent.

Interpretations of the ADP (fossil) indicator are similar to those concerning the input of non-renewable primary energy. The overall data quality can be regarded as good for the modelling of ROCKWOOL stone wool. Corresponding consistent data records were available in the GaBi data base for all of the relevant preliminary products and auxiliaries used. The data used was last revised less than 10 years ago.

The production data involves up-to-date primary data on the ROCKWOOL plants in Gladbeck, Flechtingen and Neuburg from 2008. The amounts of raw materials, energy, auxiliaries and consumables used are considered as average annual values in the plants under review.

Specific GaBi processes were available for all components of the formulation. Assumptions were only made for the missing NMVOC emissions for the FLE 8 line which are reflected in the Summer Smog Potential. Other environmental indicators are affected only minimally (Global Warming Potential) or not at all by this data gap. A worst-case approach based on the values of the other RW lines was employed here. In reality however, the value can be higher or lower than this assumed value and therefore cause higher or lower results for the Summer Smog Potential.

There are therefore limits to the interpretation of the Summer Smog Potential results in the EPD. The credits resulting from the use of landfill gas have a less than 1% influence on the results in the impact categories reviewed. The assumed mass allocation of iron ore in the cupula furnace has a less than 2% influence on the results.
The extent of these fluctuations cannot however be quantified until primary data is available for several years. The excess produced can nevertheless permit the assumption that the declaration for production year 2008 is more of a worst-case scenario.

Depending on the facing and thickness or density of the stone wool panel the influences of the facing on the environmental impact can be quite relevant. The analysis shows that the environmental impact of the facing correlates strongly with the weight of the facing. The anorganic, fibre-reinforced facing on a magnesium-oxide basis, being far the heaviest facing (5.45 kg/m²), also causes the greatest environmental impacts among the facings.

In order to reflect the broad range of stone wool thicknesses and facings with respect to the environment, the environmental profiles of the facings are shown in the Annex. They can be linked with the environmental profiles of the stone wool products by individual module (A1-A3, A5, C2, C4 and D). In this case, it is important to recalculate the results relative to 1 cubic metre for the stone wool panel to the desired thickness, and then add the results for facings per square metre.

### 7. Requisite evidence

#### 7.1 Biopersistence
**Measuring agency / Date:** RCCLtd, Wölfstrasse 4, CH-4414 Füllingsdorf, Switzerland, May-Dec. 1999
**Process:** Examination of the biopersistence of artificial mineral fibres following intratracheal instillation in rats
**Result:** RAL quality mark GZ-388 certificate awarded on 2 May 2007
Evidence of conformity with the quality and test specifications of Gütegemeinschaft Mineralwolle e. V. dated 14 February 2001
See also www.mineralwolle.de

#### 7.2 Radioactivity
**Measuring agency / Date:** Materials Testing Office North Rhine-Westphalia on 21 Sept. 1999
**Process:** Gamma spectroscopic analysis of three stone wool samples
**Result:** Stone wool insulation material: radium-226 = 26-70 Bq/kg, radium-228 = 25-65 Bq/kg, thorium-228 = 29-70 Bq/kg
The nuclides are naturally-occurring radioactive substances; no artificial radioactive substances were found.

#### 7.3 Leaching
**Measuring agency / Date:** Umweltlabor ACB GmbH, test certificate dated 2 Feb. 2012
**Process:** Determining the eluate values in accordance with DIN EN 12457-4 conforming to the Landfill Statutory Regulation (DepV) of 27 April 2009 and 2003/33/EC
**Result:** On the basis of the results, stone wool insulation materials are to be allocated to Landfill Class II in accordance with the Landfill Statutory Regulation of 27 April 2009. In individual cases, waste may be allocated to Landfill Class I by agreement with the responsible authorities.

#### 7.4 Formaldehyde and VOC emissions
**Measuring agency / Date:** Eurofins Product Testing A/S Smedeskovvej 38, DK-8464 Galten, Denmark; ongoing tests
**Process:** Testing the product emissions by the AgBB/DIBt method
**Results:** Carcinogens were not detected after 3 and 28 days. Total VOC (“TVOC”) after 3 days were below the assessment limit of 10 mg/m². Total VOC (“TVOC”) after 28 days were below the assessment limit of 1 mg/m². Total SVOC after 28 days were below the assessment limit of 0.1 mg/m². A rating value of R below the limit of 1 was achieved for the VOC individual substances with more than 5 μg/m² determined after 28 days. The total of VOC individual substances without LCI (NIK) value after 28 days was below the assessment limit of 0.1 mg/m². The formaldehyde concentration after 28 days was below the assessment limit of 120 μg/m².

#### 7.8 Quality and safety criteria

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride - DIN EN ISO 10304-2 (D 20)</td>
<td>1.14</td>
<td>mg/l</td>
</tr>
<tr>
<td>Chromium, total - EN ISO 11885 E22</td>
<td>&lt; 0.05</td>
<td>mg/l</td>
</tr>
<tr>
<td>Cyanides, easily released - DIN 38405-D 13-2-3</td>
<td>&lt; 0.002</td>
<td>mg/l</td>
</tr>
<tr>
<td>Dissolved organic carbon (DOC) - DIN EN 1484</td>
<td>19.0</td>
<td>mg/l</td>
</tr>
<tr>
<td>Copper - EN ISO 11885 E22</td>
<td>&lt; 0.005</td>
<td>mg/l</td>
</tr>
<tr>
<td>Molybdenum - EN ISO 11885 E22</td>
<td>&lt; 0.005</td>
<td>mg/l</td>
</tr>
<tr>
<td>Nickel - EN ISO 11885 E22</td>
<td>0.011</td>
<td>mg/l</td>
</tr>
<tr>
<td>Phenol index - DIN 38409-H 16-2</td>
<td>&lt; 0.005</td>
<td>mg/l</td>
</tr>
<tr>
<td>Mercury - DIN EN 1483 (E 12-2)</td>
<td>&lt; 0.0001</td>
<td>mg/l</td>
</tr>
<tr>
<td>Selenium - EN ISO 11885 E22</td>
<td>&lt; 0.005</td>
<td>mg/l</td>
</tr>
<tr>
<td>Sulphate - DIN EN ISO 10304-2 (D20)</td>
<td>1.97</td>
<td>mg/l</td>
</tr>
<tr>
<td>Zinc - EN ISO 11885 E22</td>
<td>&lt; 0.4</td>
<td>mg/l</td>
</tr>
<tr>
<td>Total content of dissolved matter - DIN 38409 H1</td>
<td>74</td>
<td>mg/l</td>
</tr>
</tbody>
</table>

### 8. References

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DIN EN ISO 14025:2011-10: Environmental labels and declarations — Type III environmental declarations — Principles and procedures

EN 15804
EN 15804:2012-04+A1 2013: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products

Product Category Rules for Building Products, Part B: Requirements on the EPD for mineral insulating materials www.ibu-epd.de

AgBB: Evaluation scheme for VOC from building products; procedure for health-related evaluation of emissions of volatile organic compounds (VOC and SVOC) from building products, as of July 2004
AVV: Waste Catalogue Statutory Regulation of 10 December 2011 (Bundesgesetzblatt Part BGBI. I, p. 3379), last amended by Article 5, paragraph 22 of the Act of 24 February 2012 (Bundesgesetzblatt Part I, p. 212)
BauBG: Instructions entitled "Handling mineral wool insulation materials (glass wool, stone wool)" published by the Bau-Berufsgenossenschaften, Frankfurt a.M.
UBA-Text 30/94: Federal Environmental Agency (pub.): "Tests on indoor pollution caused by fibrous fine dust from installed mineral wool products"; UBA text 30/94, Umweltbundesamt, 1994, Berlin
Chemicals Prohibition Order (ChemVerbotsV): 14 October 1993, "Statutory Regulation on banning and restricting the circulation of hazardous substances, preparations and products in accordance with the Chemicals Act"
GaBi 4: Software and data base for comprehensive analysis. LBP, University of Stuttgart and PE International, 2011
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DIN EN 12457-4:2003-01 Characterisation of waste — Leaching; Compliance test for leaching of granular waste and sludge — Part 4: One-stage batch test at a liquid-to-solid ratio of 10 l/kg for materials with particle size below 10 mm (with or without particle size reduction); German version EN 12457-4:2002