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Technical Rules for Hazardous Substances	Demolition, reconstruction and maintenance work with biopersistent mineral wools	TRGS 521
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The Technical Rules for Hazardous Substances (TRGS) reflect the state of technology, occupational safety and health and occupational hygiene as well as other scientific knowledge for activities involving hazardous substances including their classification and labelling. The

Committee on Hazardous Substances (AGS)

establishes the rules and adapts them to the current state of development accordingly.

The Technical Rules for Hazardous Substances are announced by the Federal Ministry of Labour and Social Affairs (BMAS) in the Joint Ministerial Gazette (GMBI).

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1 Scope

(1) This TRGS 521 applies to the protection of workers and other people during demolition, reconstruction and maintenance work with biopersistent mineral wools (see number 2.3) where fibre dusts classified as carcinogenic are released.

(2) This TRGS describes the protective measures to be taken during demolition, reconstruction and maintenance work with biopersistent mineral wools. It provides the employer with an aid to establishing protective measures.

(3) For activities involving new mineral wool (see number 2.4) the provisions of numbers 4 and 5 of TRGS 500 "Protective measures" shall apply.

(4) The TRGS 521 concretises the requirements for the protection of workers and other people according to Sections 10 and 11 of the Hazardous Substances Ordinance and in particular in its annex III No. 2 "Particulate hazardous substances" and annex IV No. 22 of the Hazardous Substances Ordinance for biopersistent mineral fibres.

(5) Even if the fibre dust concentration at the workplace (50,000 fibres n/m³) as given in number 3.3 is adhered to, it is not possible given the present state of the art

in science to discount a cancer risk. Further measures to reduce the fibre dust concentration are therefore to be aimed at.

2 Definitions

2.1 Wool

Wool describes an unordered accumulation of fibres of different lengths and diameters.

2.2 Mineral wool

(1) The generic term mineral wool is used to cover insulation materials of artificially manufactured stone or glass wools.

(2) Mineral wool consists of artificial mineral fibres which consist of undirected, vitreous (silicate) fibres with a mass content of more than 18 per cent of oxides of sodium, potassium, calcium, magnesium and barium.

2.3 Biopersistent mineral wools

(1) Within the meaning of the present TRGS biopersistent mineral wools are biopersistent artificial mineral fibres according to annex IV No. 22 of the Hazardous Substances Ordinance. The fibre dusts released from biopersistent mineral wools are to be classified as carcinogenic according to TRGS 905 "List of carcinogenic, mutagenic or toxic-to-reproduction substances".

(2) For biopersistent mineral wools the prohibition of manufacture and use according to annex IV No. 22 Hazardous Substances Ordinance has been in force since June 2000. In the case of mineral wool installed prior to 1996 it may be assumed that this is biopersistent mineral wool within the meaning of the present TRGS.

2.4 New mineral wools

The mineral wools of artificial fibres, which have been produced since about 1996 and which fulfil the release criteria of annex IV No. 22 of the Hazardous Substances Ordinance, are known as new mineral wool.

2.5 Demolition work

Demolition work covers the demolition of physical structures, the scrapping of vehicles including ships, the disassembly of plants or equipment etc., including the necessary ancillary work.

2.6 Reconstruction work

Reconstruction work includes the removal of mineral wool insulation materials and where necessary their replacement including the necessary ancillary work.

2.7 Maintenance work

Maintenance work embraces all measures to maintain the target condition (maintenance), to ascertain and assess the actual condition (inspection) and to restore the target condition (repair).

2.8 Disassembly

Disassembly is the largely non-destructive removal of products that may release fibre dusts, in particular within the framework of maintenance work.

2.9 Fibre dusts

Fibre dusts within the meaning of this TRGS are dusts which contain artificial inorganic mineral fibres with a length larger than 5 µm, a diameter smaller than 3 µm and a length-to-diameter ratio which is greater than 3 to 1 (WHO fibres) and hence can be regarded as alveolar.

2.10 Artificial mineral fibres

Artificial mineral fibres (AMF) are fibres manufactured synthetically from mineral resources. In addition to their chemical composition, artificially manufactured fibres, in contrast to natural and ubiquitous fibres, invariably have parallel edges.

2.11 Products

Products within the meaning of this TRGS are substances, preparations and articles.

2.12 Thermal loading

Products made of artificial fibres are subject to thermal load when they are exposed to a temperature which has an adverse effect on the dust formation behaviour. In mineral wool insulation materials this effect normally arises with a thermal load of 200° C upward.

2.13 Dust formation behaviour

The dust formation behaviour describes the characteristic of products with regard to a possible release of fibre dusts and other dusts.

3 Information gathering and risk assessment

3.1 General

(1) Prior to commencement of the work the employer must conduct a risk assessment. The basis of the risk assessment for demolition, reconstruction and maintenance work involving biopersistent mineral wool are numbers 3 and 4 of the present TRGS.

(2) The employer must first establish whether the workers perform activities during which fibre dusts which are classified as carcinogenic may be released. It must be taken into account that these products are articles which were not subject to mandatory labelling when they were placed on the market.

(3) The employer must gather the information needed for the risk assessment when placing on the market or from other accessible sources (e.g. documentation of the construction project owner/client, Gütegemeinschaft Mineralwolle¹⁾ (mineral wool quality association).

(4) In the case of mineral wool products installed prior to 1996 it must be assumed that they are classified as carcinogenic category 2 according to TRGS 905. This classification can only be refuted by an individual verification. This individual verification can be applied for from the Gütegemeinschaft Mineral Wool.

(5) Since 1996 mineral wool products have been manufactured in Germany which are deemed to be harmless. Activities with these products require, alongside the minimum requirements according to TRGS 500, no additional requirements.

(6) If no information is available on the assessment of the mineral wool products – this will normally be the case in practice for work performed on/with installed products – biopersistent mineral wool must be assumed in the assessment. This evaluation is the basis for Tables 1a and 1b.

(7) Since 1.6.2000 biopersistent mineral wool insulation materials may no longer be manufactured, placed on the market and used (annex IV No. 22 GefStoffV²⁾ and Chemicals Ban Ordinance³⁾). Owing to this prohibition of use, activities involving biopersistent mineral wool insulation materials are only permissible in the course of demolition, reconstruction and maintenance work.

¹⁾ GGM Gütegemeinschaft Mineralwolle e.V., Odenwaldring 68, D-64380 Rossdorf bei Darmstadt, see also www.mineralwolle.de

²⁾ Hazardous Substances Ordinance of 23.12.04 (BGBl. I p. 3758)

³⁾ Chemicals Ban Ordinance of 25 June 2003 (BGB. I No. 26)

(8) Owing to the prohibition of use, mineral wool insulation materials which have been disassembled may invariably not be re-installed. The only exemptions from the prohibition of re-installation are biopersistent mineral wool insulation materials removed during maintenance work and for which no or only slight fibre dust exposure is to be expected (see Tables 1a and 1b). The prohibition of use according to annex IV No. 22 of GefStoffV does not contain any requirement to remove existing insulation made of mineral wool.

(9) The risk assessment must be conducted in relation to the specific activities by a person with specialist knowledge. The following points must be considered:

1. Extent and duration of the inhalation exposure,
2. Working conditions and processes including the work equipment and quantity of mineral wool product,
3. Necessary protective measures,
4. Protection against mechanical irritation of the eyes, skin and mucous membranes,
5. Stipulations concerning the effectiveness check of the protective measures taken.

(10) Within the risk assessment the employer must assess the extent, type and duration of exposure of workers. In the case of fibre dusts the concentration is given in fibres n/m^3 (F/m^3).

(11) Measuring results for comparable activities may be referred to in the risk assessment provided the information gathering, measuring procedure and measuring result according to TRGS 402 "Identification and assessment of airborne concentration of hazardous substances in working areas" "Determination and assessment of the risks from activities involving dangerous substances: inhalative exposure" have been recorded.

(12) A check must be made as to whether, for the relevant application, working processes have been selected to ensure that the release of fibre dusts is minimised.

(13) The employer must assess the effectiveness of the protective measures laid down in the risk assessment.

(14) The risk assessment must be documented prior to commencement of the activities. For the activities listed in Tables 1a and 1b a detailed documentation is not necessary.

3.2 Concept of exposure categories

(1) In the risk assessment the employer must identify by workplace measurements the fibre dust concentrations arising during demolition, reconstruction and maintenance work. Activities are assigned to one of three exposure categories which involve concrete state-of-the-art protective measures. This assignment is conducted as a function of the anticipated fibre dust concentrations and the duration and frequency of the activities. When the state-of-the-art measures have been implemented, there result for the exposure categories 1, 2 and 3 the fibre dust concentration ranges

given in number 3.3.

(2) In the Tables 1a "Building construction" and 1b "Technical insulation" selected activities during demolition, reconstruction and maintenance work are compiled. For these activities it is possible to estimate the fibre dust concentration at the workplace on the basis of measuring results obtained. The basis for this estimation is provided by the results of representative exposure measurements by manufacturers, Berufsgenossenschaften (institutions for statutory accident Insurance and prevention) etc. as published in the literature⁴.

(3) Identification of the fibre dust concentration is not necessary if

1. the activities listed in Tables 1a and 1b have been performed by the employer and their effectiveness has been tested or
2. the employer takes all measures of exposure categories 1, 2 and 3 (e.g. for activities not mentioned in Tables 1a and 1b or it is not intended to make use of the possibility to dispense with measures of categories 1 or 2).

(4) Where individual activities not listed in Tables 1a and 1b are to be seen as equivalent by analogy to the activities listed there, the activities can be assigned to an exposure category (justification in the risk assessment necessary).

3.3 Exposure categories and protective measures for biopersistent mineral wool insulation materials

(1) Protective measures for exposure category 1 apply to activities which experience shows do not lead to any fibre exposure, or only very little, taking into account the protective measures described, i.e. where the fibre dust concentration is less than 50,000 fibres n/m³.

(2) Protective measures for exposure category 2 apply to activities which cause little to moderate fibre exposure, taking into account the protective measures described and the nature of the activity, i.e. where the fibre dust concentration is between 50,000 fibres n/m³ and 250,000 fibres n/m³.

(3) Protective measures for exposure category 3 apply to all activities not listed in Tables 1a and 1b and hence according to the state of the art cause a higher fibre dust exposure than 250,000 fibres n/m³.

3.4 Effectiveness check

(1) When implementing the measures assigned to the exposure categories it must be assumed that requirements of the Hazardous Substances Ordinance have been met.

(2) If there is a deviation from these regulations, at least equivalent protective measures must be taken. The deviations must be justified in the documentation of the risk assessment.

⁴ See number 6 "Further regulations and factsheets" especially [10], [20] and [21]

- (3) As a result of the risk assessment methods must also be laid down for checking the effectiveness of the existing protective measures and those still to be taken. It is thus to be ensured that the protective measures reduce the exposure over the period of the activities to the extent required for the safety and health of the workers.
- (4) Technical protective measures, e.g. ventilation and extraction equipment, must be checked regularly with respect to the adequate functioning and effectiveness. This must be done at least once a year for technical equipment (e.g. industrial vacuum cleaners) intended to protect against inhalable dusts. The employer may himself lay down the intervals within the specified framework. The manufacturer's information and other statutory specifications must be complied with here. The result of the inspection must be recorded and documented.
- (5) If measurements are necessary for the identification of the exposure level (fibre dust concentration), only measuring bodies may be engaged who have the necessary specialist knowledge. The measuring results must be recorded and retained by the employer as personnel documents. If there are plant shutdowns, the measuring results must be given to the competent accident insurance institution.
- (6) At the present time there is no health-based occupational exposure level (OEL) for classified fibre dusts of mineral wool insulation materials. With reference to the identified exposure level it is possible to assess whether the state of the art is attained with certain activities involving mineral wool products.

4 Protective measures

4.1. Measures for exposure category 1

- (1) The basic protective measures (Section 8 GefStoffV and TRGS 500) must invariably be taken for activities of exposure category 1. The implementation of these generally applicable minimum standards also ensures protection against mechanical irritation of eyes, skin and mucous membranes from thick fibres.
- (2) Activities involving biopersistent mineral wool at locally and chronologically changing workplaces (e.g. construction sites) must be included on a one-off basis in relation to the specific company and in relation to the construction site in the company's list of hazardous substances.
- (3) The working process must be selected in accordance with the state of the art in such a way that as little fibre dust as possible is released, e.g. nondestructive removal, industrial vacuum cleaner.
- (4) Material removed may not be thrown.
- (5) Swirling dust must be avoided. The workplace must be cleaned regularly.
- (6) Dusts and dust deposits arising may not be blown off with compressed air or swept up dry, but must be taken up using industrial vacuum cleaners (category M) or cleaned up wet.

(7) Waste must be packaged at the place where it is produced in as a dust-tight a fashion as possible or it must be moistened and marked. Closed containers must be used for transport (e.g. barrels, tear-proof sacks, big bags).

(8) In order to lay down the permissible disposal route, wastes must be assigned to the types of waste given in the European Waste Catalogue (EWC). Under the national Waste Catalogue Ordinance (AVV) waste products of biopersistent mineral wool have the waste code 170603*.

(9) In the individual federal states, state-specific regulations apply with respect to waste disposal. The authorities who are competent locally and in terms of specialist concern must therefore be asked concerning the proper form of waste disposal.

(10) The workers should wear loose work clothing and protective gloves of leather or nitrile-coated cotton glove when working. If they have sensitive skin, skin care agents must be used after work.

(11) The workers must be given training on the basis of the working instructions concerning the hazards, rules of conduct and protective measures to be followed when carrying out the activities.

4.2 Measures for exposure category 2

(1) All the measures of exposure category 1 must be implemented. In addition the following measures are necessary.

(2) If it is not possible to prevent the release of fibre dusts they must be completely collected and disposed of at the point of outlet or occurrence by ventilation-related means (e.g. industrial vacuum cleaners) as far as possible.

(3) For cleaning work suitable vacuum cleaners must be used (at least dust class M⁵) or wet cleaning processes must be applied.

(4) It is recommended that, at the request of workers, personal protective equipment (respirators, protective goggles) be made available.

(5) Air extracted from working areas where activities involving fibre dusts of category 2 classified as carcinogenic may not be returned there. As a deviation from sentence 1, air extracted from a working area may be returned there if it has been purified adequately to remove such substances using processes or equipment approved by the authorities or the Berufsgenossenschaften (Institutions for statutory accident insurance and prevention). The air must then be conveyed or cleaned in such a way that these fibre dusts do not pass into the air breathed by other workers. The ventilation systems and in particular the separation installation must be regularly maintained. This assumes

1. a daily inspection,
2. monthly servicing and
3. and annual main inspection

⁵⁾ see DIN EN 60335-2-69 Annex AA. A positive list of tested, dust-removing machines is published regularly in the BIA Maunal, Code 510210.

and as required repair. Written records must be kept of the maintenance work and these must be presented on demand to the inspection authority.

(6) The number of persons exposed must be reduced to a minimum by means of organisational protective measures. Only these persons may have access to the working areas. The working areas must be marked.

(7) The spread of dusts to other working areas must be prevented as far as possible.

(8) Objects or items of equipment that are difficult to clean (e.g. fitted carpets or radiators) should be covered.

(9) Washing facilities must be provided for the workers.

(10) The workers must be offered the possibility of preventive medical examinations.

4.3 Measures for exposure category 3

(1) All measures of exposure categories 1 and 2 must be taken. In addition the following measures are necessary.

(2) The employer must make available to workers personal protective equipment (PPE). Half-face masks with P2 filter or particle-filtering half-face masks FFP2 or filter units with blower TM 1P are suitable as respirators. For overhead work protective goggles must also be provided.

(3) When they have to wear respirators workers must be given occupational medical examinations (e.g. according to G 26 "Respiratory protective equipment").

(4) Workers must be provided with a breathable protective suit type 5 (DIN EN ISO 13982). After use the protective suits must be collected in containers which can be tightly sealed. The employer must organize cleaning or disposal of the protective clothing.

(5) The personal protective equipment provided must be used by the workers. Account must be taken of the limited wearing time for personal protective equipment according to BGR 190.

(6) There must be separate storage facilities available for street clothing and work clothing.

Table 1 a: Activities – building construction area

In the case of activities not given in Tables 1a) and 1b), the measures for exposure category 3 must be applied.

	Activities	Exposure category
1	Work on external walls, inclined roofs or flat roofs	
1.1	Removal of clothing, preliminary brickwork, roof coverings or flat seals with exposure of insulation material	
1.1.1	- without removal of insulation material	1
1.1.2	- with removal/reinstallation ⁶ of insulation material (in the case of work on external walls without workplace encasement with air-impermeable sheeting/tarpaulins, such as by scaffolding cladding with plastic sheets)	2
1.1.3	- with removal/re-installation of less than 20 m ² of the insulation material, e.g. for inspection work or for installation of windows, doors, roof openings (e.g. skylights), outlet vents, antenna masts or similar	1
2	Work on compound thermal insulation systems or comparable systems with exposure of insulation material	
2.1	- with removal/re-installation of insulation material (without workplace encasement using air-impermeable sheets, such as by means of scaffolding cladding with plastic sheets)	2
2.2	- with removal/re-installation of less than 20 m ² of insulation material	1
3	Work on internal walls (partitions, facing plates)	
3.1	- without removal of insulation material	1
3.2	- with removal/re-installation of insulation material	2
3.3	- with removal/re-installation of less than 3 m ² of insulation material, e.g. for installation of switches, doors, sockets, lamps and similar	1
4	Work on ceiling cladding and suspended ceilings	
4.1	Opening of ceiling sections for maintenance and inspection work with removal/re-installation of:	
4.1.1	- caissons with inlaid insulation panels	1
4.1.2	- concealed or insulation panels welded into sheeting which are mounted or fastened to underside of ceiling	1
4.1.3	- unprotected insulation panels or mats which are mounted or inlaid	2
4.1.4	- unprotected insulation panels of less than 3 m ² which are mounted or inlaid	1
4.2	Work in suspended ceiling area, such as laying of cables, leads and pipes in ceilings with mounted	
4.2.1	- protected insulation materials (concealment/covering)	1
4.2.2	- unprotected insulation materials and work in suspended ceiling area	2
5	Work on free-floating screed	
5.1	- without removal of insulation material	1
5.2	- with removal/re-installation of insulation material	2
5.3	- with removal/re-installation of less than 3 m ² of insulation material	1

⁶ Reinstallation is invariably only permissible with activities of the exposure category 1; see number 3.1 section 8 of the present TRGS

Table 1 b: Activities – area of technical insulation

In the case of activities not mentioned in Tables 1a) and 1b) measures of exposure category 3 must be applied.

	Activities	Exposure category
1	Removal/re-installation of encasements or shaped parts, such as metal encasements, without removal of insulation material	
1.1	- with installations or installation parts not subject to thermal load	1
1.2	- with installations or installation parts subject to thermal load	2
2	Removal/re-installation of insulating shaped parts, removable insulations or insulations with encasement, such as caps or hoods, of covers of inspection shafts, of shaped parts of coated fibreglass fabric	
2.1	- with installations or installation parts not subject to thermal load	1
2.2	- with installations or installation parts subject to thermal load	2
3	Removal/re-installation of sound elements (sound capsules, backdrops, housings) with inlays of mineral wool insulation materials and an inner cover of fibreglass fleece, perforated plate or similar	1
4	Removal/re-installation of insulation materials on, for example, piping systems, ventilation ducts and tanks	
4.1	with installations or installation parts subject to thermal load	
4.1.1	- in well ventilated rooms or in the open and removal/re-installation of less than 20 m ² of the insulation material	2
4.1.2	- in well ventilated rooms or in the open and removal/re-installation of less than 1 m ² of the insulation material	1
4.1.3	- in confined and poorly ventilated rooms and removal/re-installation of less than 1 m ² of the insulation material	2
4.2	with installations or installation parts not subject to thermal load	
4.2.1	- in well ventilated rooms or in the open	2
4.2.2	- in the open and removal/re-installation of less than 20 m ² of the insulation material	1
4.2.3	- in well ventilated rooms and removal/re-installation of less than 3 m ² of the insulation material	1
4.2.4	- in confined and poorly ventilated rooms and removal/re-installation of less than 3 m ² of the insulation material	2
4.2.5	- in confined and poorly ventilated rooms and removal/re-installation of less than 1 m ² of the insulation material	1

Table 2: Assignment of exposure category and occupational safety and health measures

Requirement		Exposure category 1	Exposure category 2	Exposure category 3
Statutory basis GefStoffV	Occupational safety and health measure			
Section 7	Information gathering and risk assessment	X	X	X
Section 8 Subs. 2; Annex III No. 2.3	Low-dust working	X	X	X
Section 8 Subs. 2	Low-dust cleaning	X	X	X
Section 8 Subs. 4 and 6	Waste treatment and waste labelling	X	X	X
Section 14 Subs. 1	Working instructions	X	X	X
Section 14 Subs. 2	Training	X	X	X
Section 7 Subs. 8	Inclusion in the company's list of hazardous substances	X	X	X
Section 8 Subs. 2	Organisational protective measures	X	X	X
Section 8 Subs. 2	Selection of suitable work processes	X	X	X
Section 8 Subs. 2	Cover with sheeting where there is lack of cleaning possibilities	-	X	X
Section 9 Subs. 2	Technical measures for fibre dust minimization	-	X	X
Section 9 Subs. 9	Prohibition of smoking and snuff-taking at the workplace. Prohibition of eating.	-	X	X
Section 10 Subs. 2	Respirator and protective goggles for overhead work	-	X ¹	X
Section 10 Subs. 2	Protective suits	-	X ¹	X
Section 10 Subs. 2	Cleaning or disposal of clothing	-	X	X
Section 10 Subs. 2	Washing facilities	-	X	X
Section 10 Subs. 3	Delimitation and marking of working areas	-	X	X
Sections 15 and 16	Preventive medical examination	-	X ²	X
Section 9 Subs. 3	Separate storage facilities for street and work clothing	-	-	X

Explanatory notes for Table 2

X = applies

- = does not apply

¹ = Make available at request of workers² = Preventive medical examination must be offered.

5 Other regulations and factsheets

1. Ordinance on protection against hazardous substances (Hazardous Substances Ordinance - GefStoffV) of 23 December 2004 (BGBl. I p. 3759), Ordinance on safety and health protection in the provision of work equipment and its use at work, on safety in the operation of plants subject to mandatory inspection and on the organisation of workplace occupational safety and health (Plant Safety Ordinance – BetrSichV)“ of 27 September 2002 (BGBl. I p. 3777)
2. Ordinance on workplaces (Workplaces Ordinance – ArbStättV) – of 12 August 2004 (BGBl I p. 2179)
3. Ordinance on safety and health protection on construction sites (Construction Sites Ordinance - BaustellV) of 10 June 1998 (BGBl. I p. 1283)
4. TRGS 402 "Identification and assessment of airborne concentration of hazardous substances in working areas" "Determination and assessment of the risks from activities involving dangerous substances: inhalative exposure"
5. TRGS 500 "Protective measures"
6. TRGS 555 "Working instructions and information for workers"
7. TRGS 900 "Occupational exposure limits"
8. TRGS 905 "List of carcinogenic, mutagenic or toxic-to-reproduction substances"
9. TRGS 906 "List of carcinogenic activities or procedures according to Section 3 Subs. 2 No. 3 GefStoffV"
10. BG Rule: Use of protective clothing (BGR 189)
11. BG Rule: Use of respiratory protective equipment (BGR 190)
12. BG Rule: Operation of work equipment (BGR 500)
13. BG information sheet: Procedures to determine respirable fibres – optical microscopic procedures (BGI 505-31)
14. BG information sheet: Separate determination of the concentration of inorganic fibres in working areas – scanning electron microscopic procedure (BGI 505-46)
15. Rules for safety and health at workplaces with workplace ventilation (BGR 121)
16. List of certified respiratory protective equipment (BGI 693, alt: ZH 1/606) Ordinance on workplaces (Workplaces Ordinance - ArbStättV): Sections 45-47.
17. BGIA work folder: Measurement of hazardous substance; BG/BIA recommendations 1012 X/93 "Insulation in building construction and technical insulation with mineral wool insulation materials" (Note: withdrawn in June 2000)
18. Central Federation of the Industrial Berufsgenossenschaften (HVBG) - Occupational safety and health institute of the Berufsgenossenschaften (BGIA) (ed.), occupational safety and health solutions for selected substances and processes, pp. 126-157; October 2006; Sankt Augustin
19. Central Federation of the Industrial Berufsgenossenschaften (ed.), Occupational health care – Principles of the Berufsgenossenschaften for preventive medical examinations, 3rd edition, Gertner Verlag Stuttgart

20. Handling miner wool insulation materials (glass wool, stone wool), practical instructions of the Berufsgenossenschaft in the construction industry (ed.), retrieval number 341 on the Internet at www.gisbau.de
21. VDI 3469 Sheet 1, edition: white paper 2006, Manufacture, processing of fibrous materials. – Basics; overview
22. VDI 3469 Sheet 6, edition: green paper 2006, Manufacture, processing of mineral wool insulation materials
23. Gütegemeinschaft (quality association) for mineral wool: www.mineral wool.de