Supplement to the Standard of Building Biology Testing Methods SBM-2015

BUILDING BIOLOGY EVALUATION GUIDELINES

FOR SLEEPING AREAS

The Building Biology Evaluation Guidelines are based on the precautionary principle. They are specifically designed for sleeping areas associated with long-term risks and a most sensitive window of opportunity for regeneration. They are based on the experience and knowledge of the building biology community and focus on achievability. In addition, scientific studies and other recommendations are also consulted. With its professional approach, building biology testing methods help identify, minimize and avoid environmental risk factors within an individual's framework of possibility. It is the Standard's goal to identify, locate and assess potential sources of risk by considering all subcategories in a holistic manner and implementing the best possible diagnostic tools available with analytic expertise in order to create indoor living environments that are as exposure-free and natural as practicable.

No Anomaly This category provides the highest degree of precaution. It reflects the unexposed natural conditions or the common and nearly inevitable background level of our modern living environment.

Slight Anomaly As a precaution and especially with regard to sensitive and ill people, remediation should be carried out whenever it is possible.

Severe Anomaly Values in this category are not acceptable from a building biology point of view, they call for action. Remediation should be carried out soon. In addition to numerous case histories, scientific studies indicate biological effects and health problems within this reference range.

Extreme Anomaly These values call for immediate and rigorous action. In this category international guidelines and recommendations for public and occupational exposures may be reached or even exceeded.

If several sources of risk are identified within a single subcategory or for different subcategories, one should be more critical in the final assessment.

Guiding Principle:

Any risk reduction is worth aiming at. Guideline values are meant as a guide. Nature is the ultimate standard.

The small print at the end of each subcategory of the Building Biology Standard is meant as a comparative guide, e.g. legally binding exposure limits or other guidelines, recommendations and research results or natural background levels.

	No Anomaly	**Slight** Anomaly	**Severe** Anomaly	**Extreme** Anomaly

A FIELDS, WAVES, RADIATION

1 AC ELECTRIC FIELDS (Low Frequency, ELF/VLF)

Field strength with ground potential in volt per meter	**V/m**	**< 1**	**1 - 5**	**5 - 50**	**> 50**
Body voltage with ground potential in millivolt	**mV**	**< 10**	**10 - 100**	**100 - 1000**	**> 1000**
Field strength potential-free in volt per meter	**V/m**	**< 0.3**	**0.3 - 1.5**	**1.5 - 10**	**> 10**

Values apply up to and around 50 (60) Hz, higher frequencies and predominant harmonics should be assessed more critically.

ACGIH occupational TLV: 25 000 V/m; DIN/VDE: occupational 20 000 V/m, public 7000 V/m; ICNIRP: 5000 V/m; TCO: 10 V/m; US Congress / EPA: 10 V/m; BUND: 0.5 V/m; studies on oxidative stress, free radicals, melatonin and childhood leukemia: 10-20 V/m; nature: < 0.0001 V/m

2 AC MAGNETIC FIELDS (Low Frequency, ELF/VLF)

Flux density in nanotesla	**nT**	**< 20**	**20 - 100**	**100 - 500**	**> 500**
in milligauss	**mG**	**< 0.2**	**0.2 - 1**	**1 - 5**	**> 5**

Values apply to frequencies up to and around 50 (60) Hz, higher frequencies and predominant harmonics should be assessed more critically. Line current (50-60 Hz) and traction current (16.7 Hz) are recorded separately.

In the case of intense and frequent temporal magnetic field fluctuations, the 95th percentile of the data logging records, especially those from nighttime logging, shall be used for the assessment.

DIN/VDE: occupational 5 000 000 nT, public 400 000 nT; ACGIH occupational TLV: 200 000 nT; ICNIRP: 100 000 nT; Switzerland 1000 nT; WHO: 300-400 nT "possibly carcinogenic"; TCO: 200 nT; US Congress / EPA: 200 nT; Bio Initiative: 100 nT; BUND: 10 nT; nature: < 0.0002 nT

3 RADIO-FREQUENCY RADIATION (High Frequency, Electromagnetic Waves)

Power density in microwatt per square meter	**µW/m²**	**< 0.1**	**0.1 - 10**	**10 - 1000**	**> 1000**

Values apply to single RF sources, e.g. GSM, UMTS, TETRA, LTE, WiMAX, Radio, TV, WLAN, DECT, Bluetooth..., and refer to peak measurements. They do not apply to rotating-antenna radar.

More critical RF sources like pulsed or periodic signals (GSM, TETRA, DECT, WLAN, digital broadcasting...) and broadband technologies with pulsed signals/patterns (UMTS, LTE…) should be assessed more seriously, especially at higher levels, and less critical RF sources like non-pulsed and non-periodic signals (FM, short, medium, long wave, analog broadcasting...) should be assessed more generously, especially at lower levels.

Former Building Biology Evaluation Guidelines for RF radiation / HF electromagnetic waves (SBM-2003): pulsed fields < 0.1 no, 0.1-5 slight, 5-

		No Anomaly	Slight Anomaly	Severe Anomaly	Extreme Anomaly

100 strong, > 100 µW/m² extreme anomaly; non-pulsed fields < 1 no, 1-50 slight, 50-1000 strong, > 1000 µW/m² extreme anomaly

DIN/VDE: occupational up to 100 000 000 µW/m², public up to 10 000 000 µW/m²; ICNIRP: up to 10 000 000 µW/m²; Salzburg Resolution / Vienna Medical Association: 1000 µW/m²; Bio Initiative 2007: 1000 µW/m² outdoor; EU-Parliament STOA: 100 µW/m²; Salzburg: 10 µW/m² outdoor, 1 µW/m² indoor; EEG / immune effects: 1000 µW/m²; sensitivity threshold of mobile phones: < 0.001 µW/m²; nature < 0.000 001 µW/m²

4 STATIC ELECTRIC FIELDS (Electrostatics)

Surface potential in volt	**V**	**< 100**	**100 - 500**	**500 - 2000**	**> 2000**
Discharge time in seconds	**s**	**< 10**	**10 - 30**	**30 - 60**	**> 60**

Values apply to conspicuous materials and appliances close to the body and/or to dominating surfaces at ca. 50 % r.h.

TCO: 500 V; damage of electronic parts: from 100 V; painful shocks and actual sparks: from 2000-3000 V; synthetic materials, plastic finishes: up to 10 000 V; synthetic flooring, laminate: up to 20 000 V; CRT TV screens: up to 30 000 V; nature: < 100 V

5 STATIC MAGNETIC FIELDS (Magnetostatics)

Deviation of flux density (metal/steel) in microtesla	**µT**	**< 1**	**1 - 5**	**5 - 20**	**> 20**
Fluctuation of flux density (current) in microtesla	**µT**	**< 1**	**1 - 2**	**2 - 10**	**> 10**
Deviation of compass needle in degree	**°**	**< 2**	**2 - 10**	**10 - 100**	**> 100**

Values for the deviation of the flux density in µT apply to metal/steel and for the fluctuation of the flux density to direct current.

DIN/VDE: occupational 67 900 µT, public 21 200 µT; USA/Austria: 5000-200 000 µT; MRI: 2-4 T; earth's magnetic field: Europe, USA, Australia 40-50 µT, equator 25 µT, north/south pole 65 µT; eye: 0.0001 nT, brain: 0.001 nT, heart: 0.05 nT; animal navigation: 1 nT; 1 µT = 10 mG

6 RADIOACTIVITY (Alpha, Beta and Gamma Radiation, Radon)

Count resp. **equivalent dose rate increase** in percent	**%**	**< 50**	**50 - 70**	**70 - 100**	**> 100**

Values apply in relation to local background levels, at least to 0.8 mSv/a or 100 nSv/h (average in Germany); at much higher background levels, the guideline ranges for the equivalent dose rate increase need to be decreased accordingly.

Radiation Protection Germany: public 1 mSv/a additional exposure; EU building materials: 1 mSv/a additional exposure; occupational 20 mSv/a; USA federal law: public 5 mSv/a, occupational 50 mSv/a; Germany north: < 0.6 mSv/a (< 70 nSv/h), south up to 1.4 mSv/a (165 nSv/h)

Radon in becquerel per cubic meter	**Bq/m³**	**< 30**	**30 - 60**	**60 - 200**	**> 200**

EU reference level (EU-BSS 2013): 300 Bq/m³, EU recommendation (new construction): 200 Bq/m³; BfS Germany: 100 Bq/m³; Sweden, Canada, England (new construction): 200 Bq/m³; US EPA: 150 Bq/m³; WHO: 100 Bq/m³; average indoor levels: 30-50 Bq/m³, 1-2% > 250 Bq/m³; average outdoor levels: 5-15 Bq/m³; radon mine: 100 000 Bq/m³; lung cancer risk increase by 10 % for each 100 Bq/m³; Bq/m³ x 0.027 = pCi/l

7 GEOLOGICAL DISTURBANCES (Earth's Magnetic Field, Terrestrial Radiation)

Disturbance of earth's magnetic field in nanotesla	**nT**	**< 100**	**100 - 200**	**200 - 1000**	**> 1000**
Disturbance of terrestrial radiation in percent	**%**	**< 10**	**10 - 20**	**20 - 50**	**> 50**

Values apply in relation to the natural earth's magnetic field and the earth's natural background of gamma or neutron radiation.

Natural fluctuation of the earth's magnetic field: temporal 10-100 nT; magnetic storms / solar eruptions: 100-1000 nT; decrease per year: 20 nT

8 SOUND WAVES (Airborne and Structure-born Sound)

Currently, specific Building Biology Guideline Values for sound or vibrations are not yet available. For first exposure recommendations during sleep and other details, consult the accompanying Building Biology Testing Conditions and Instructions.

9 LIGHT (Artificial Lighting, Visible Light, UV and Infrared Light)

Currently, specific Building Biology Guideline Values for light are not yet available. For first recommendations regarding electromagnetic fields, light spectrum, spectral distribution, light flicker, illumination level, color rendition, color temperature, ultrasound... and other details, consult the accompanying Building Biology Testing Conditions and Instructions.

B INDOOR TOXINS, POLLUTANTS, INDOOR CLIMATE

1 FORMALDEHYDE and other Toxic Gases

Formaldehyde in microgram per cubic meter	**µg/m³**	**< 20**	**20 - 50**	**50 - 100**	**> 100**

MAK: 370 µg/m³, BGA: 120 µg/m³; WHO: 100 µg/m³; AGÖF guidance value: 30 µg/m³; VDI: 25 µg/m³; irritation of mucous membranes and eyes: 50 µg/m³; odor detection threshold: ~ 50 µg/m³; immediately dangerous to life: 30 000 µg/m³; nature < 2 µg/m³; 100 µg/m³ = 0.083 ppm

2 SOLVENTS and other Volatile Organic Compounds (VOC)

VOC in microgram per cubic meter	**µg/m³**	**< 100**	**100 - 300**	**300 - 1000**	**> 1000**

Values apply to the sum total of all volatile organic compounds (TVOC) in indoor air.

Allergenic, irritating, or odorous individual substances or compound classes need to be assessed more critically; this applies especially to hazardous or carcinogenic air pollutants such as benzenes, naphthalene, cresols, styrene...

German Federal Environment Agency: 300 µg/m³; Seifert BGA: precautionary threshold 200-300 µg/m³; Molhave: 200 µg/m³; AGÖF normal value a) sum total: 360 µg/m³, b) individual substance (examples): acetaldehyde 20 µg/m acetone 42 µg/m³, benzene 1 µg/m³, ethylbenzene 1 µg/m³, naphthalene < 1 µg/m³, phenol < 1 µg/m³, styrene 1 µg/m³, toluene 7 µg/m³, m,p-xylene 3 µg/m³, alpha-pinene 4 µg/m³; delta-3-carene 1 µg/m³, limonene 4 µg/m³; nature: < 10 µg/m³

For the assessment of odorous substances, see AGÖF Guideline "Gerüche in Innenräumen" (Odors in Indoor Air).

			No Anomaly	Slight Anomaly	Severe Anomaly	Extreme Anomaly

3 PESTICIDES and other Semivolatile Organic Compounds (SVOC)

Pesticides		Air	ng/m³	< 5	5 - 25	25 - 100	> 100
E.g. PCP, lindane, permethrin, chlorpyrifos, DDT, dichlofluanid…		Dust	mg/kg	< 0.2	0.2 - 1	1 - 10	> 10
		Wood, material	mg/kg	< 1	1 - 10	10 - 100	> 100
		Material with skin contact	mg/kg	< 0.5	0.5 - 2	2 - 10	> 10
Fire Retardants	Chlorinated	Dust	mg/kg	< 0.5	0.5 - 2	2 - 10	> 10
	Halogen-free	Dust	mg/kg	< 5	5 - 50	50 - 200	> 200
Plasticizers		Dust	mg/kg	< 100	100 - 250	250 - 1000	> 1000
PCB Sum total of LAGA		Dust	mg/kg	< 0.5	0.5 - 2	2 - 5	> 5
PAH Sum total of EPA		Dust	mg/kg	< 0.5	0.5 - 2	2 - 20	> 20

Values in nanogram per cubic meter (air) and in milligram per kilogram (material, wood, dust), respectively.

As a rule, values for dust apply to secondary contamination, not primary contamination (that is, not to directly vacuumed, treated sources, surface areas and materials).

German PCP Prohibition Ordinance: 5 mg/kg (material); PCP Guideline: 1000 ng/m³ (air), target value:100 ng/m³; ARGE-Bau: 100 ng/m³ (air), 1 mg/kg (dust); PCB Guideline: 300 ng/m³ (target value); PCB target value for remediation in NRW (Germany): 10 ng/m³; acute health hazard: 3000 ng/m³; toxic waste disposal: 50 mg/kg; AGÖF normal value for dust (examples): PCP 0.3 mg/kg, lindane 0.1 mg/kg, permethrin 0.5 mg/kg, chlorpyrifos 0.1 mg/kg, DDT / DDD / DDE > 0.1 mg/kg, dichlofluanid 0.1 mg/kg, tolylfluanid < 0.1 mg/kg, TCEP 0.5 mg/kg; PAH benzo(a)pyren < 0.2 mg/kg, DEHP 400 mg/kg

As an additional assessment tool, see "AGÖF-Orientierungswerte für mittel- und schwerflüchtige Stoffe im Hausstaub" (AGÖF Guidance Values for Semivolatile Compounds in House Dust), which is currently under review.

4 HEAVY METALS and other Similar Toxins

Building Biology Guideline Values for heavy metals are not yet available.

For an assessment tool, see "AGÖF-Orientierungswerte für mittel- und schwerflüchtige Stoffe im Hausstaub" (AGÖF Guidance Values for Semivolatile Compounds in House Dust), which is currently under review.

5 PARTICLES and FIBERS (Fine Particulate Matter, Nanoparticles, Asbestos, Mineral Fibers...)

Indoor concentration levels of particulate matter, fibers or dust should be below the common, uncontaminated outdoor concentration levels. In indoor air, on surfaces or in house dust, asbestos should not be detectable or only at extremely low levels.

Former building biology guideline values for asbestos fibers, SBM-2000: < 100 no, 100-200 slight, 200-500 strong, > 500/m³ extreme anomaly

Asbestos fibers in air - BGA: 500-1000/m³; TRGS target: 500/m³; EU: 400/m³; WHO: 200/m³; outdoor air: 50-150/m³; clean air region: 20/m³; Particulate matter in air (annual avg.) - BImSchV: 40 µg/m³; EU: 50 µg/m³ (< 10 µm), 25 µg/m³ (< 2.5 µm); EPA: 25 µg/m³ (< 2.5 µm); VDI: 75 µg/m³; Alps 3000 m: 5-10 µg/m³; rural: 20-30 µg/m³; urban: 30-100 µg/m³; indoor with tobacco smoke: > 1000 µg/m³; smog warning: 800 µg/m³

6 INDOOR CLIMATE (Temperature, Humidity, Carbon Dioxide, Air Ions, Air Changes, Odors...)

Relative humidity in percent	% r.h.	40 - 60	< 40 / > 60	< 30 / > 70	< 20 / > 80
Carbon dioxide in parts per million	ppm	< 600	600 - 1000	1000 - 1500	> 1500

MAK: 5000 ppm; DIN: 1500 ppm; VDI: 1000 ppm; German Federal Environment Agency: 1000 ppm; USA (occupational/classrooms): 1000 ppm; unventilated bedroom after one night or classroom after a one-hour lesson: 2000-4000 ppm; nature in 2015: 400 ppm, in 2008: 380 ppm, in 1985: 330 ppm; annual increase: 1-2 ppm

Small air ions per cubic centimeter air	/cm³	> 500	200 - 500	100 - 200	< 100

Note: In indoor air, high levels of air ions may indicate radon.

Nature by the sea: > 2000/cm³; clean outdoor air: 1000/cm³; rural: < 800/cm³; urban: < 700/cm³; industrial areas/traffic: < 500 /cm³; indoor with static electricity: < 300/cm³; indoor with tobacco smoke: < 200/cm³; smog < 50/cm³; continuous decrease of air ions over past years/decades

Air electricity in volt per meter	V/m	< 100	100 - 500	500 - 2000	> 2000

DIN/VDE: occupational 40 000 V/m, public 10 000 V/m; nature: ~ 50-200 V/m, foehn: ~ 1000-2000 V/m, thunderstorm: 5000-10 000 V/m

C FUNGI, BACTERIA, ALLERGENS

1 MOLDS and their Spores and Metabolites

In indoor environments **mold growth** should not be visible to the naked eye or a microscope. Contamination with **mold spores** or **mold metabolites** should not exist either. The mold **count** in indoor air, on surfaces, in house dust, in cavities and in materials… should be lower compared to ambient outdoor air or uncontaminated comparison rooms. Mold **types** in indoor spaces should be **very similar** to those outside or in uncontaminated comparison rooms. Particularly **critical** molds, e.g. toxigenic or allergenic molds, or those thriving at 37°C body temperature, should **not** be detectable or only minimally. Constantly high levels of material moisture or air humidity as well as cool surface temperatures should be avoided because they promote mold growth.

Any **sign**, **suspicion** or indication of a potential microbial problem should be investigated: visible mold growth such as discoloration and mold spots, odors typical of microorganisms, moisture-indicating mold species, construction and moisture damage, problematic construction details, hygiene aspects, excessive exposure from outside, old damage, building history, on-site inspection, ill-health symptoms of occupants, environmental medicine results...

For further building biology assessment tools of indoor air, surface areas, dust, MVOC, water activity, moisture... and other parameters, consult the additional information, testing conditions and explanations in the Building Biology Testing Conditions and Instructions.

For more detailed assessments and data, see "Schimmelpilz-Leitfaden" (Mold Guideline) and "Schimmelpilzsanierungs-Leitfaden" (Mold Remediation Guideline) by Umweltbundesamt (German Federal Environment Agency).

Former building biology guideline values for molds, SBM-1998 through SBM-2003 (using YM Baubiologie Agar at a culture temperature of 20-24 °C, colony forming units CFU): in the air < 200 no, 200-500 slight, 500-1000 strong, > 1000/m³ extreme anomaly (values refer to indoor air when outdoor reference levels are relatively low, below 500/m³); on surfaces: < 20 no, 20-50 slight, 50-100 strong, > 100/dm² extreme anomaly (values refer to surfaces that are subject to common and regular cleaning practices).

Molds in indoor air - WHO: Pathogenic and toxigenic fungi are not acceptable in indoor air; from 50/m³ of a single fungal species, the source(s) must be identified; a mixture of common fungi typical for a given location (e.g. Cladosporium) can be tolerated up to 500/m³. Senkpiel/Ohgke: Indoor concentrations that are over 100/m³ above the outdoor air indicate a problem. EU statistics for apartments (CEC, Commission of European Communities): < 50/m³ very low, < 200/m³ low, < 1000/m³ medium, < 10 000/m³ high, > 10 000/m³ very high. US OSHA (United States Occupational Safety and Health Administration): > 1000/m³ = contamination / microbial damage. AIHA (American Industrial Hygiene Association): > 1000/m³ = "not a typical" situation; indoor concentration levels clearly above outdoor levels = indoor source exists. Netherlands (Association of Health Care Professionals): > 10 000/m³ mixed or > 500/m³ potentially hazardous species = health hazard. Finland (Ministry of Health): < 500/m³ in winter, < 2500/m³ in summer = maximum in residential spaces.

2 **YEASTS** and their Metabolites

Yeasts should **not** or only minimally be detectable in indoor air, on surfaces and materials or in areas of hygiene, bathrooms, kitchens and food storage. This applies especially to **critical** yeasts like Candida or Cryptococcus.

3 **BACTERIA** and their Metabolites

The level of bacteria in indoor air should be within the same range or **below** outdoor air or uncontaminated comparison rooms. Especially **critical** bacteria such as certain Pseudomonas, Legionella, Actinomycetes species... should not or only minimally be detectable, neither in indoor air or on material surfaces, nor in drinking water or in areas of hygiene, bathrooms or kitchens. Any **sign** of a potential bacterial contamination should be investigated: high material moisture, water damage, hygiene and fecal problems, foul odors typical of bacteria... During a mold assessment, bacteria should also be considered and vice versa; they often occur together.

4 **DUST MITES** and other Allergens

Building Biology Guideline Values for dust mites and allergens are not yet available.

In addition to the Standard of Building Biology Testing Methods and the Building Biology Evaluation Guidelines for Sleeping Areas, there are also Building Biology Testing Conditions and Instructions available that describe the technical and analytical testing procedures in more detail and suggest first recommendations regarding exposure levels.

Since the Building Biology Guideline Values are first and foremost based on experience, not all subcategories offer a value (yet). The Guideline Values are revised and updated regularly as new knowledge becomes available.

In occupational settings and especially in sensitive areas where people spend extended periods of time on a regular basis, exposure levels should be kept as low as possible. In occupational settings and others, the guiding principle of building biology should apply: Any risk reduction is worth aiming at; feasibility is the first priority.

For the assessment of occupational exposure levels, other regulations, recommendations and findings may apply, such as TCO or US-Congress / EPA (ELF electric/magnetic fields, static electricity), Bio Initiative Working Group, EU Parliament STOA or BUND (RF radiation), EU, WHO or Federal Office for Radiation Protection (radioactivity, radon), AGÖF (pollutants)..., partly also UBA (mold, pollutants, carbon dioxide...), VDI (pollutants), ARGE-Bau (pesticides), LGA Baden-Württemberg (mold)...

This original three-part Building Biology Standard has been the basis of building biology testing practices and precautionary assessments since 1992. Now it is also being used internationally. This Standard with its Evaluation Guidelines and Testing Conditions also forms the basis of the work of the Verband Baubiologie VB (Building Biology Association), which has been established in 2002.

The Building Biology Standard with its Evaluation Guidelines for Sleeping Areas plus its Testing Conditions, Instructions and Additions has been developed by *BAUBIOLOGIE MAES* at the request and with the support of the Institut für Baubiologie + Nachhaltigkeit IBN (Institute of Building Biology + Sustainability IBN) between 1987 and 1992. Colleagues and medical doctors have also offered their support. It was first published in 1992. Since 1999 experienced building biology professionals with the support of independent scientists from physics, chemistry, biology and architecture, as well as experts from analytical laboratories, environmental health care professionals and other experts have helped shape the Building Biology Standard with its Evaluation Guidelines and Testing Conditions. This current SBM-2015 is the eighth update, which was released in May 2015.

Building Biology Standard, Evaluation Guidelines and Testing Conditions were translated from German into English by Katharina Gustavs, Canada.

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