



**Building Biology  
Institute, Inc**

**BBi  
SBM-2015  
v1**

## Standard of Building Biology Testing Methods



**BRINGING TOGETHER TECHNOLOGY AND DESIGN  
METHODS TO PROVIDE THE INFORMATION  
NEEDED TO CREATE HEALTHY HOMES AND  
WORKPLACES**

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The Holistic Building Biology Survey according to the

# STANDARD OF BUILDING BIOLOGY TESTING METHODS

SBM-2015

The Building Biology Standard gives an overview of the physical, chemical, biological, indoor climate and other risks encountered in sleeping areas, living spaces, workplaces and properties. It offers guidelines on how to perform specific measurements and assess possible health risks. All testing results, testing instruments and procedures are documented in a final written report. In case potential problems are identified, an effective remediation strategy is developed.

The individual subcategories of the Building Biology Standard describe critical indoor environmental influences. With its professional approach, it helps identify, minimize and avoid such factors within an individual's framework of achievability. It is the Standard's goal to create indoor living environments that are as exposure-free and natural as practicable. This holistic approach is accomplished by taking all subcategories into account and implementing all available diagnostic possibilities. Testing, assessment and remediation strategies focus mainly on the building biology experience, precaution and achievability, while taking scientific findings into account. Any risk reduction is worth aiming at.

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

## A FIELDS, WAVES, RADIATION

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

Sources: AC voltage in electrical installations, cables, appliances, outlets, walls, floors, beds, high-tension and other power lines...

Measurement of low frequency electric **field strength** (V/m) and human **body voltage** (mV) as well as identification of dominant **frequency** (Hz) and dominant **harmonics**

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

Sources: AC current in electrical installations, cables, appliances, transformers, motors, overhead and ground cables, power lines, railways...

Measurement and data logging of low frequency magnetic **flux density** (nT) from power grid or railway system as well as identification of dominant **frequency** (Hz) and dominant **harmonics**

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

Sources: cell phone technology, RF transmitters, broadcast, trunked radio systems, line-of-sight systems, radar, military, cordless phones...

Measurement of radio-frequency electromagnetic **power density** ( $\mu\text{W}/\text{m}^2$ ), identification of dominant **frequencies** (kHz, MHz, GHz) or RF **sources** and **signal characteristics** (pulses, periodicity, broadband width, modulation )

### 4 STATIC ELECTRIC FIELDS (Electrostatics)

Sources: synthetic carpeting, drapes and textiles, vinyl wallpaper, varnishes, laminates, stuffed toy animals, TV or computer screens...

Measurement of electrostatic **surface potential** (V) as well as **discharge time** (s)

### 5 STATIC MAGNETIC FIELDS (Magnetostatics)

Sources: steel components in beds, mattresses, furniture, appliances, building materials; DC current from street cars, photovoltaic systems...

Measurement of **earth's magnetic field distortion** as a **spatial deviation** of magnetic flux density ( $\mu\text{T}$ , metal/steel) or as a **temporal fluctuation** of magnetic flux density ( $\mu\text{T}$ , direct current) as well as **compass deviation** ( $^\circ$ )

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

Sources: building materials, stones, tiles, slags, waste products, devices, antiques, ventilation, terrestrial radiation, location, environment

Measurement of radioactive radiation as **count rate** (cps), **equivalent dose rate** (nSv/h) and deviation (%) as well as measurement and long-term data logging of **radon concentration** ( $\text{Bq}/\text{m}^3$ )

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

Sources: currents and radioactivity in the earth; local disturbances caused by faults, fractures, underground watercourses, geological deposits...

Measurement of **earth's magnetic field** (nT) and **radioactive radiation** (ips) and its dominant **disturbances** (%)

### 8 SOUND WAVES (Airborne and Structure-born Sound)

Sources: traffic noise, air traffic, train traffic, industry, buildings, devices, machines, motors, transformers, wind turbines, sound bridges...

Measurement of **noise**, **sound**, **infrasound** and **ultrasound** (dB), **oscillations** and **vibrations** ( $\text{m}/\text{s}^2$ )

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

Sources: incandescent lamps, halogen light, fluorescent tubes, compact fluorescent lamps, LED, screens, displays, VLC data transmission

Measurement of **electromagnetic fields** (V/m, nT), **light spectrum**, **spectral distribution** (nm), **light flicker** (Hz, %), **illumination level** (lx), **color rendering index** (CRI, Ra, R1-14), **color temperature** (K), **ultrasound** (dB)

### 1 FORMALDEHYDE and other Toxic Gases

Sources: varnishes, glues, particle board, wood products, furnishings, devices, heating, gas leaks, combustion, exhaust fumes, environment...

Measurement of **toxic gases** ( $\mu\text{g}/\text{m}^3$ , ppm) as formaldehyde, ozone and chlorine, urban and industrial gases, natural gas, carbon monoxide, nitrogen dioxide and other combustion gases

### 2 SOLVENTS and other Volatile Organic Compounds (VOC)

Sources: paints, varnishes, adhesives, synthetics, building materials, particle board, furniture, coatings, diluents, cleaners...

Measurement of **volatile organic compounds** ( $\mu\text{g}/\text{m}^3$ , ppm) as aldehydes, aliphatics, alcohols, aromatics, esters, ethers, glycols, ketones, cresols, phenols, siloxanes, terpenes and other organic compounds (VOC)

### 3 PESTICIDES and other Semivolatile Organic Compounds (SVOC)

Sources: wood, leather and carpet protections, adhesives, plastics, sealers, coatings, moth-proofing agents, pest-control agents...

Measurement of **semivolatile organic compounds** ( $\text{mg}/\text{kg}$ ,  $\text{ng}/\text{m}^3$ ) as biocides, insecticides, fungicides, wood preservatives, carpet chemicals, pyrethroids, fire retardants, plasticizers, PCBs, PAHs, dioxins

### 4 HEAVY METALS and other Similar Toxins

Sources: wood preservatives, building materials, building moisture, PVC, paints, glazes, plumbing pipes, industry, toxic waste, environment...

Measurement of **inorganic substances** ( $\text{mg}/\text{kg}$ ) as light and heavy metals (aluminum, antimony, arsenic, barium, lead, cadmium, chromium, cobalt, copper, nickel, mercury, zinc), metal compounds and salts

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

Sources: aerosols, airborne particles, dust, smoke, soot, building and insulating material, ventilation and air-conditioning, toner, environment...

Measurement of **dust**, number and size of **particles**, **asbestos** and other **fibers** ( $/\text{l}$ ,  $\mu\text{g}/\text{m}^3$ ,  $/\text{g}$ ,  $\%$ )

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

Source: moisture damage, building materials, ventilation, heating, furnishings, breathing, electric fields, radiation, dust, environment...

Measurement of **air and surface temperature** ( $^{\circ}\text{C}$ ), **air humidity** and **material moisture** (r.h., a.h.,  $\%$ ), **oxygen** (vol. $\%$ ), **carbon dioxide** (ppm), **air pressure** (mbar), **air movement** (m/s) and **air ions** ( $/\text{cm}^3$ ) as well as **air electricity** (V/m), identification of **odors** and **air exchange rate**

## C FUNGI, BACTERIA, ALLERGENS

### 1 MOLDS and their Spores and Metabolites

Sources: moisture damage, thermal bridges, construction defects, building materials, remediation mistakes, air-conditioning, environment...

Measurement and identification of culturable and nonculturable **molds**, their spores and fragments ( $/\text{m}^3$ ,  $/\text{cm}^2$ ,  $/\text{dm}^2$ ,  $/\text{g}$ ) as well as their metabolites (MVOC, mycotoxins...)

### 2 YEASTS and their Metabolites

Sources: moist areas, hygiene problems, food storage, garbage, kitchen appliances, water purification systems, sanitary plumbing systems...

Measurement and identification of **yeasts** ( $/\text{m}^3$ ,  $/\text{dm}^2$ ,  $/\text{g}$ ,  $/\text{l}$ ) and their metabolites

### 3 BACTERIA and their Metabolites

Sources: moisture areas, waste water damage, hygiene problems, food storage, garbage, water purification, sanitary plumbing systems...

Measurement and identification of **bacteria** ( $/\text{m}^3$ ,  $/\text{dm}^2$ ,  $/\text{g}$ ,  $/\text{l}$ ) and their metabolites

### 4 DUST MITES and other Allergens

Sources: dust mites, their feces and metabolites, insects, mold, pollen, hygiene, house dust, pets, scents, moisture, ventilation, environment...

Measurement and identification of **mite number** and **feces**, **pollen**, **animal hair**, **allergens** ( $/\text{m}^3$ ,  $/\text{g}$ ,  $\%$ )

Additional measurements, analyses, inspections, consultations and assessments are also part of the Building Biology Standard, e.g. testing tap and drinking water for toxins and microbial contamination, testing of building materials, furniture, appliances and other furnishings as well as for home and wood pests, also consulting and planning services for respective projects as well as consulting and support during remediation, renovation and construction.

The Building Biology Standard also includes the Evaluation Guidelines for Sleeping Areas, which have been developed specifically for averting long-term risks and protecting the sensitive time of regeneration or sleep, as well as the Testing Conditions, Instructions and Additions, which, among other things, specify and describe the building biology testing methods and analyses in more detail.

The Building Biology Standard with its Evaluation Guidelines and Testing Conditions has been developed by **BAUBIOLOGIE MAES** at the request and with the support of the Institut für Baubiologie + Nachhaltigkeit 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.

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.

Building Biology Evaluation Guidelines for Sleeping Areas  
SBM-2015, Page 1

No Anomaly	Slight Anomaly	Severe Anomaly	Extreme Anomaly
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## A FIELDS, WAVES, RADIATION

**Note:** In North America: Substitute Concern for Anomaly\*\*

### 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 7 000 V/m; ICNIRP: 5 000 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; BioInitiative: 100 nT; BUND: 10 nT; nature: < 0.0002 nT

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

Power density in microwatt per square meter	$\mu\text{W}/\text{m}^2$	< 0.1	0.1 - 10	10 - 1000	> 1000
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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-

100 strong, > 100  $\mu\text{W}/\text{m}^2$  extreme anomaly; non-pulsed fields < 1 no, 1-50 slight, 50-1000 strong, > 1000  $\mu\text{W}/\text{m}^2$  extreme anomaly

DIN/VDE: occupational up to 100 000 000  $\mu\text{W}/\text{m}^2$ , public up to 10 000 000  $\mu\text{W}/\text{m}^2$ ; ICNIRP: up to 10 000 000  $\mu\text{W}/\text{m}^2$ ; Salzburg Resolution / Vienna Medical Association: 1000  $\mu\text{W}/\text{m}^2$ ; Bio Initiative 2007: 1000  $\mu\text{W}/\text{m}^2$  outdoor; EU-Parliament STOA: 100  $\mu\text{W}/\text{m}^2$ ; Salzburg: 10  $\mu\text{W}/\text{m}^2$  outdoor, 1  $\mu\text{W}/\text{m}^2$  indoor; EEG / immune effects: 1000  $\mu\text{W}/\text{m}^2$ ; sensitivity threshold of mobile phones: < 0.001  $\mu\text{W}/\text{m}^2$ ; nature < 0.000 001  $\mu\text{W}/\text{m}^2$

#### 4 STATIC ELECTRIC FIELDS (Electrostatics)

<b>Surface potential</b> in volt	<b>V</b>	<b>&lt; 100</b>	<b>100 - 500</b>	<b>500 - 2000</b>	<b>&gt; 2000</b>
<b>Discharge time</b> in seconds	<b>s</b>	<b>&lt; 10</b>	<b>10 - 30</b>	<b>30 - 60</b>	<b>&gt; 60</b>

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)

<b>Deviation of flux density</b> (metal/steel) in microtesla	<b><math>\mu\text{T}</math></b>	<b>&lt; 1</b>	<b>1 - 5</b>	<b>5 - 20</b>	<b>&gt; 20</b>
<b>Fluctuation of flux density</b> (current) in microtesla	<b><math>\mu\text{T}</math></b>	<b>&lt; 1</b>	<b>1 - 2</b>	<b>2 - 10</b>	<b>&gt; 10</b>
<b>Deviation of compass needle</b> in degree	<b>°</b>	<b>&lt; 2</b>	<b>2 - 10</b>	<b>10 - 100</b>	<b>&gt; 100</b>

Values for the deviation of the flux density in  $\mu\text{T}$  apply to metal/steel and for the fluctuation of the flux density to direct current.

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

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

<b>Count resp. equivalent dose rate increase</b> in percent	<b>%</b>	<b>&lt; 50</b>	<b>50 - 70</b>	<b>70 - 100</b>	<b>&gt; 100</b>
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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)

<b>Radon</b> in becquerel per cubic meter	<b>Bq/m<sup>3</sup></b>	<b>&lt; 30</b>	<b>30 - 60</b>	<b>60 - 200</b>	<b>&gt; 200</b>
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EU reference level (EU-BSS 2013): 300 Bq/m<sup>3</sup>, EU recommendation (new construction): 200 Bq/m<sup>3</sup>; BfS Germany: 100 Bq/m<sup>3</sup>; Sweden, Canada, England (new construction): 200 Bq/m<sup>3</sup>; US EPA: 150 Bq/m<sup>3</sup>; WHO: 100 Bq/m<sup>3</sup>; average indoor levels: 30-50 Bq/m<sup>3</sup>, 1-2% > 250 Bq/m<sup>3</sup>; average outdoor levels: 5-15 Bq/m<sup>3</sup>; radon mine: 100 000 Bq/m<sup>3</sup>; lung cancer risk increase by 10 % for each 100 Bq/m<sup>3</sup>; Bq/m<sup>3</sup> x 0.027 = pCi/l

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

<b>Disturbance of earth's magnetic field</b> in nanotesla	<b>nT</b>	<b>&lt; 100</b>	<b>100 - 200</b>	<b>200 - 1000</b>	<b>&gt; 1000</b>
<b>Disturbance of terrestrial radiation</b> in percent	<b>%</b>	<b>&lt; 10</b>	<b>10 - 20</b>	<b>20 - 50</b>	<b>&gt; 50</b>

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

<b>Formaldehyde</b> in microgram per cubic meter	<b><math>\mu\text{g}/\text{m}^3</math></b>	<b>&lt; 20</b>	<b>20 - 50</b>	<b>50 - 100</b>	<b>&gt; 100</b>
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MAK: 370  $\mu\text{g}/\text{m}^3$ , BGA: 120  $\mu\text{g}/\text{m}^3$ ; WHO: 100  $\mu\text{g}/\text{m}^3$ ; AGÖF guidance value: 30  $\mu\text{g}/\text{m}^3$ ; VDI: 25  $\mu\text{g}/\text{m}^3$ ; irritation of mucous membranes and eyes: 50  $\mu\text{g}/\text{m}^3$ ; odor detection threshold: ~ 50  $\mu\text{g}/\text{m}^3$ ; immediately dangerous to life: 30 000  $\mu\text{g}/\text{m}^3$ ; nature < 2  $\mu\text{g}/\text{m}^3$ ; 100  $\mu\text{g}/\text{m}^3$  = 0.083 ppm

#### 2 SOLVENTS and other Volatile Organic Compounds (VOC)

<b>VOC</b> in microgram per cubic meter	<b><math>\mu\text{g}/\text{m}^3</math></b>	<b>&lt; 100</b>	<b>100 - 300</b>	<b>300 - 1000</b>	<b>&gt; 1000</b>
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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  $\mu\text{g}/\text{m}^3$ ; Seifert BGA: precautionary threshold 200-300  $\mu\text{g}/\text{m}^3$ ; Molhave: 200  $\mu\text{g}/\text{m}^3$ ; AGÖF normal value a) sum total: 360  $\mu\text{g}/\text{m}^3$ , b) individual substance (examples): acetaldehyde 20  $\mu\text{g}/\text{m}^3$ , acetone 42  $\mu\text{g}/\text{m}^3$ , benzene 1  $\mu\text{g}/\text{m}^3$ , ethylbenzene 1  $\mu\text{g}/\text{m}^3$ , naphthalene < 1  $\mu\text{g}/\text{m}^3$ , phenol < 1  $\mu\text{g}/\text{m}^3$ , styrene 1  $\mu\text{g}/\text{m}^3$ , toluene 7  $\mu\text{g}/\text{m}^3$ , m,p-xylene 3  $\mu\text{g}/\text{m}^3$ , alpha-pinene 4  $\mu\text{g}/\text{m}^3$ , delta-3-carene 1  $\mu\text{g}/\text{m}^3$ , limonene 4  $\mu\text{g}/\text{m}^3$ ; nature: < 10  $\mu\text{g}/\text{m}^3$

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

### 3 PESTICIDES and other Semivolatile Organic Compounds (SVOC)

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<b>Pesticides</b>	Air	ng/m <sup>3</sup>	< 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
<b>Fire Retardants</b>	Chlorinated	Dust	mg/kg	< 0.5	0.5 - 2	> 10
	Halogen-free	Dust	mg/kg	< 5	5 - 50	> 200
<b>Plasticizers</b>		Dust	mg/kg	< 100	100 - 250	> 1000
<b>PCB</b> Sum total of LAGA		Dust	mg/kg	< 0.5	0.5 - 2	> 5
<b>PAH</b> Sum total of EPA		Dust	mg/kg	< 0.5	0.5 - 2	> 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/m<sup>3</sup> (air), target value: 100 ng/m<sup>3</sup>; ARGE-Bau: 100 ng/m<sup>3</sup> (air), 1 mg/kg (dust); PCB Guideline: 300 ng/m<sup>3</sup> (target value); PCB target value for remediation in NRW (Germany): 10 ng/m<sup>3</sup>; acute health hazard: 3000 ng/m<sup>3</sup>; 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/m<sup>3</sup> extreme anomaly

Asbestos fibers in air - BGA: 500-1000/m<sup>3</sup>; TRGS target: 500/m<sup>3</sup>; EU: 400/m<sup>3</sup>; WHO: 200/m<sup>3</sup>; outdoor air: 50-150/m<sup>3</sup>; clean air region: 20/m<sup>3</sup>; Particulate matter in air (annual avg.) - BImSchV: 40 µg/m<sup>3</sup>; EU: 50 µg/m<sup>3</sup> (< 10 µm), 25 µg/m<sup>3</sup> (< 2.5 µm); EPA: 25 µg/m<sup>3</sup> (< 2.5 µm); VDI: 75 µg/m<sup>3</sup>; Alps 3000 m: 5-10 µg/m<sup>3</sup>; rural: 20-30 µg/m<sup>3</sup>; urban: 30-100 µg/m<sup>3</sup>; indoor with tobacco smoke: > 1000 µg/m<sup>3</sup>; smog warning: 800 µg/m<sup>3</sup>

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

<b>Relative humidity</b> in percent	% r.h.	40 - 60	< 40 / > 60	< 30 / > 70	< 20 / > 80
<b>Carbon dioxide</b> 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

<b>Small air ions</b> per cubic centimeter air	/cm <sup>3</sup>	> 500	200 - 500	100 - 200	< 100
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Note: In indoor air, high levels of air ions may indicate radon.

Nature by the sea: > 2000/cm<sup>3</sup>; clean outdoor air: 1000/cm<sup>3</sup>; rural: < 800/cm<sup>3</sup>; urban: < 700/cm<sup>3</sup>; industrial areas/traffic: < 500 /cm<sup>3</sup>; indoor with static electricity: < 300/cm<sup>3</sup>; indoor with tobacco smoke: < 200/cm<sup>3</sup>; smog < 50/cm<sup>3</sup>; continuous decrease of air ions over past years/decades

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

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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/m<sup>3</sup> extreme anomaly (values refer to indoor air when outdoor reference levels are relatively low, below 500/m<sup>3</sup>); on surfaces: < 20 no, 20-50 slight, 50-100 strong, > 100/dm<sup>2</sup> 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/m<sup>3</sup> 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/m<sup>3</sup>. Senkpiel/Ohgke: Indoor concentrations that are over 100/m<sup>3</sup> above the outdoor air indicate a problem. EU statistics for apartments (CEC, Commission of European Communities): < 50/m<sup>3</sup> very low, < 200/m<sup>3</sup> low, < 1000/m<sup>3</sup> medium, < 10000/m<sup>3</sup> high, > 10000/m<sup>3</sup> very high. US OSHA (United States Occupational Safety and Health Administration): > 1000/m<sup>3</sup> = contamination / microbial damage. AIHA (American Industrial Hygiene Association): > 1000/m<sup>3</sup> = "not a typical" situation; indoor concentration levels clearly above outdoor levels = indoor source exists. Netherlands (Association of Health Care Professionals): > 10000/m<sup>3</sup> mixed or > 500/m<sup>3</sup> potentially hazardous species = health hazard. Finland (Ministry of Health): < 500/m<sup>3</sup> in winter, < 2500/m<sup>3</sup> 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.

**\*\*Anomaly:** Something that deviates from what is standard, normal, or expected; oddity, peculiarity, abnormality, irregularity, inconsistency, incongruity, aberration, quirk, rarity. Instructors believe that 'Concern' is more meaningful to English speaking clients.

Glossary Term	German	Definition	
<b>µg</b>	µg	micro gram	
<b>ACGIH</b>	ACGIH	American Conference of Industrial Hygienists	
<b>agar</b>	Agar	A gel culture medium based on a seaweed extract, widely used for growing microorganisms in laboratories	
<b>ARGE-BAU</b> Conference of minister of building	ARGE BAU Bauministerkonferenz	The conference of minister of building is a working group for town construction, building and housings responsible Minister and senators of the 16 countries of the Federal Republic of Germany.	
<b>a<sub>w</sub></b>	a <sub>w</sub>		
<b>Becquerel</b>	<b>Becquerel</b>	(symbol Bq) the SI unit of the activity of a radioactive substance. The unit is named after Henry Becquerel, a French physicist, who discovered natural radioactivity in 1896 and together with Pierre and Marie Curie was awarded the Nobel Prize of physics in 1903.	
<b>BGA</b>			
<b>BlmSchV</b>			
<b>Bq/m<sup>3</sup></b>	<b>Bq/m<sup>3</sup></b>	SI unit of the activity of a radioactive substance per cubic meter of air – see also <i>pCi/L</i>	
<b>Building Biology™</b>	Baubiologie™	a branch of science concerned with the holistic interrelationship of humans and their living environment that is rooted in ancient wisdom and based on current scientific knowledge covering all aspects of home, health & habitat; originating in Germany where it is called <i>Baubiologie</i> and first introduced to North America by the International Institute of Bau-biology & Ecology as <i>Bau-biology</i>	
<b>DIN</b>	<b>DIN</b> (Deutsche Industrienorm)	a non-governmental association in Germany concerned with industry standards regarding quality assurance, standardization and environmental protection; founded in 1917	
<b>EEG</b>	<b>EEG</b> (Electrocardiogram)	recording of the changing electrical potentials of brain waves	
<b>EPA</b>	EPA	Environmental Protection Agency	
<b>EU</b>	EU European Union	European Union	
<b>EU-Parliament STOA</b>			
<b>Gauss</b>	<b>Gauss</b>	(symbol G) the former unit of magnetic flux density, which is still in common usage in North America	

Glossary Term	German	Definition	
<b>GfU</b>	GfU Gesellschaft für Umweltchemie	Society for Environmental Chemistry	
<b>ICNIRP</b>	ICNIRP (Internationale Kommission für den Schutz von nicht-ionisierender Strahlung)	(International Commission on Non-ionizing Radiation Protection) an international organization concerned with radiation protection of the non-ionizing portion of the electromagnetic spectrum; founded in 1992	
<b>ips</b>	ips Impressions per second	Measuring the number of impression per second. When measuring radioactivity a Geiger counter is used.	
<b>IRPA</b>	<b>IRPA</b> (Internationale Gesellschaft für Strahlenschutz)	(International Radiation Protection Association) an international health physics society setting international exposure limits for electromagnetic radiation; founded in 1964	
<b>ISM</b>	ISM	an abbreviation for Industrial, Services, Medical; covering various frequency ranges for multiple uses allocated internationally by standards bodies	
<b>Katalyse Institute</b> Köln, Germany	Katalyse Institut	Catalysis Institute for Applied Research	
<b>LAGA</b>	LAGA Länderarbeitsgemeinschaft Abfall	The State (Land) Working Group Waste in Germany	
<b>large ions</b>	<b>Grossionen</b>	are found in high concentrations in polluted air with a diameter up to 0.1 micron (or at least ten times the size of small ions) having a low mobility and disintegrating rather slowly – also referred to as <i>aerosol ions</i>	
<b>mbar</b> millibar	mbar Millibar	A unit of atmospheric pressure equal to 1/1000 of a bar	
<b>mG</b>		milliGauss, a unit of magnetic field flux density (US System)	
<b>micotoxin</b>			
<b>MPR</b>	<b>MPR</b>	an abbreviation for Swedish Board for Technical Accreditation, which set the first low-emission exposure limits for computers	
<b>MRI</b>	Kernspin	magnetic resonance imaging	
<b>mSv</b>	<b>mSv</b> (Millisievert)	( <b>millisievert</b> ) a millionth of Sievert, the SI unit of equivalent dose rate	
<b>mSv/a</b>	<b>mSv/a</b> (Millisievert pro Jahr)	( <b>millisievert per annum</b> ) a millionth of Sievert per year, the equivalent dose rate per year	
<b>µT</b>	µT microTesla	Millionth of a Tesla, a unit of magnetic field flux density	
<b>MVOC</b>		Microbial Volatile Organic Compound	
<b>ng</b>	ng Nanogramm	nano gram	
<b>nT</b>	nT NanoTesla	Billionth of a Tesla, a unit of magnetic field flux density	

Glossary Term	German	Definition	
<b>PAH</b>	PAK	Polycyclic Aromatic Hydrocarbons	
<b>PPM/ PPB</b>	ppm parts per million/ billion	Parts per million/ billion	
<b>pulsed</b>	<b>gepulste (Strahlung)</b>	to produce or modulate electromagnetic waves as pulses- rapid increase and decrease	
<b>RH</b>	r.F relative Feuchte	Relative humidity	
<b>radio frequency radiation (RF)</b>	<b>hochfrequente Strahlung</b>	(RF radiation) electromagnetic radiation that ranges approximately from 30 thousand Hz (kHz) to 300 billion Hz (GHz) including radio and microwaves	
<b>rem</b>	<b>rem</b>	(roentgen equivalent man) a former unit of dose equivalent of absorbed ionizing radiation	
<b>RF also HF</b>	<b>HF</b> (Hochfrequenz)	an abbreviation for radio frequency or high frequency - see also <i>radio frequency radiation</i>	
<b>SI units</b>	<b>SI-Einheiten</b>	(Système International d'Unités) the internationally agreed system of units now in use for all scientific purposes	
<b>Sievert</b>	<b>Sievert</b>	(symbol Sv) the SI unit of dose equivalent of absorbed ionizing radiation. The unit is named after the Swedish physicist Rolf Sievert.	
<b>small ions</b>	<b>Kleinionen</b>	are found in high concentrations in fresh air with a diameter between 0.001 – 0.003 micron, which consist of only a few molecules and therefore are highly mobile and instable - also referred to as <i>cluster ions</i>	
<b>SSK</b>	SSK Strahlenschutzkommission	a German commission for radiation protection	
<b>TCO</b>	TCO (Schwedische Zentralorganisation der Angestellten und Beamten)	an abbreviation of the Swedish Association of Professional Employees, which sets a standard for low-radiation computer systems including ergonomic, ecological and indoor air considerations	
<b>TLV</b>		Threshold Limit Value	
<b>VDE</b>	VDE Verein Deutscher Ingenieure	Association of German Engineers	
<b>WHO</b>	WHO	World Health Organization	