

The Building Biology Survey according to the

# STANDARD OF BUILDING BIOLOGY TESTING METHODS

SBM-2008

The Standard gives an overview of the physical, chemical and biological 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 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. Any risk reduction is worth striving for.

Between 1987 and 1992, BAUBIOLOGIE MAES developed the *Standard of Building Biology Testing Methods*, the accompanying *Building Biology Evaluation Guidelines for Sleeping Areas* and additional testing details on behalf and with the support of the *Institut für Baubiologie und Ökologie Neubeuern IBN*. Scientists, medical doctors and colleagues also offered their support. The *Standard* was issued for the first time in May 1992. The most current *Standard* SBM-2008 is the seventh edition and was published at the beginning of 2008. Since 1999 a 10-member expert commission assists in maintaining and updating the *Standard*, including the *Guidelines* and specific testing protocols. The current members of the commission are as follows: Dr. Dipl.Chem. Thomas Haumann, Dipl.Ing. Norbert Honisch, Wolfgang Maes, Dipl.Ing. Helmut Merkel, Dr. Dipl.Biol. Manfred Mierau, Uwe Münzenberg, Rupert Schneider, Peter Sierck, Dipl.Chem. Jörg Thumulla, Dr.Ing. Martin H. Virnich.

## 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 prominent **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 prominent **harmonics**

### 3 RADIOFREQUENCY 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 high frequency electromagnetic **power density** ( $\mu\text{W}/\text{m}^2$ ) as well as identification of dominant RF **sources** and low frequency **signals** (pulse, periodicity, modulation...)

### 4 DC 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 DC MAGNETIC FIELDS (Magnetostatics)

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

Measurement of **geomagnetic field distortion** as **spatial deviation** of magnetic flux density ( $\mu\text{T}$ , metal/steel) or **temporal fluctuation** of magnetic flux density ( $\mu\text{T}$ , current) as well as **compass deviation** ( $^\circ$ )

### 6 RADIOACTIVITY (Gamma Radiation, Radon)

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

Measurement of **equivalent dose rate** (nSv/h, %) as well as **radon concentration** ( $\text{Bq}/\text{m}^3$ )

### 7 GEOLOGICAL DISTURBANCES (Geomagnetic Field, Terrestrial Radiation)

Sources: currents and radioactivity in the earth; local disturbances caused by faults, fractures, underground water courses...

Measurement of earth's **magnetism** (nT) and earth's **radiation** (ips) and its prominent **disturbances** (%)

### 8 SOUND and VIBRATION (Airborne and Solid Sound)

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

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

## **B INDOOR TOXINS, POLLUTANTS, INDOOR CLIMATE**

### **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) such 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, cleaners...

Measurement of **volatile organic compounds** ( $\mu\text{g}/\text{m}^3$ , ppm) as acrylates, aldehydes, aliphates, alkanes, alkenes, alcohols, amines, cycloalkanes, esters, ethers, glycols, halogens, hydrocarbons, isocyanates, ketones, cresols, phenols, siloxanes, terpenes and other aromatic or organic compounds (VOC)

### **3 PESTICIDES** and other Semi-Volatile Organic Compounds (SVOV)

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

Measurement of **semi-volatile organic compounds** (mg/kg, ng/m<sup>3</sup>) as biocides, insecticides, fungicides, wood preservatives, 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** (mg/kg) such as heavy metals and metal compounds, 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** (/l,  $\mu\text{g}/\text{m}^3$ , /g, %)

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

Source: moisture damage, building materials, ventilation, heating, furnishings, breathing, static electricity, 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** (/cm<sup>3</sup>) 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 **molds** that can or cannot be cultured, their spores and fragments (/m<sup>3</sup>, /dm<sup>2</sup>, /g) as well as their metabolites (MVOC, mycotoxins...)

### **2 YEASTS** and their Metabolites

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

Measurement and identification of **yeasts** (/m<sup>3</sup>, /dm<sup>2</sup>, /g) and their metabolites

### **3 BACTERIA** and their Metabolites

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

Measurement and identification of **bacteria** (/m<sup>3</sup>, /dm<sup>2</sup>, /g, /l) and their metabolites

### **4 DUST MITES** and other Allergens

Sources: dust mites, their feces and metabolites, mold growth, hygiene, house dust, pets, building moisture, ventilation, environment...

Measurement and identification of **mite number** and **feces**, **pollen**, **grasses**, **animal hair** (/m<sup>3</sup>, /g, %)

Additional measurements, inspections and surveys are also part of the Standard e.g. light quality, illuminance level and UV exposure, potable water quality testing for toxic and microbial contamination, testing of building materials, furniture 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 construction.

The Standard also includes the Building Biology Evaluation Guidelines for Sleeping Areas, which have been developed specifically for long-term risks and the sensitive time of regeneration or sleep, as well as additional testing conditions and explanations, which specify and describe the methods and analyses in more detail.

The Standard of Building Biology Testing Methods SBM-2008 was translated from German into English by Katharina Gustavs in June 2008.

Supplement to the Standard of Building Biology Testing Methods SBM-2008

# 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 building biology experience and knowledge 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 Concern** 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 Concern** As a precaution and especially with regard to sensitive and ill people, remediation should be carried out whenever it is possible.

**Severe Concern** 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 Concern** 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 achieving. Reference 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-2008, Page 1

<b>No</b> Concern	<b>Slight</b> Concern	<b>Severe</b> Concern	<b>Extreme</b> Concern
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## A FIELDS, WAVES, RADIATION

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

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

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, general 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, childhood leukaemia: 10-20 V/m; nature: < 0.0001 V/m

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

<b>Flux density</b> in nanotesla	<b>nT</b>	<b>&lt; 20</b>	<b>20 - 100</b>	<b>100 - 500</b>	<b>&gt; 500</b>
in milligauss	<b>mG</b>	<b>&lt; 0.2</b>	<b>0.2 - 1</b>	<b>1 - 5</b>	<b>&gt; 5</b>

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 fluctuations of the magnetic field, data logging needs to be carried out - especially during nighttime - and for the assessment, the 95<sup>th</sup> percentile is used.

DIN/VDE: occupational 5 000 000 nT, general 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 RADIOFREQUENCY RADIATION (High Frequency, Electromagnetic Waves)

<b>Power density</b> in microwatt per square meter	<b>µW/m²</b>	<b>&lt; 0.1</b>	<b>0.1 - 10</b>	<b>10 - 1000</b>	<b>&gt; 1000</b>
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Values apply to single RF sources, e.g. GSM, UMTS, WiMAX, TETRA, Radio, Television, DECT cordless phone technology, WLAN..., and refer to peak measurements. They do not apply to radar signals.

More critical RF sources like pulsed or periodic signals (mobile phone technology, DECT, WLAN, digital broadcasting...) should be assessed more seriously, especially in the higher ranges, 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 in the lower ranges.

Former Building Biology Evaluation Guidelines for RF radiation / HF electromagnetic waves (SBM-2003): pulsed < 0.1 no, 0.1-5 slight, 5-100 strong, > 100 µW/m² extreme anomaly; non-pulsed < 1 no, 1-50 slight, 50-1000 strong, > 1000 µW/m² extreme anomaly

DIN/VDE: occupational up to 10 000 000 µW/m², general up to 1 000 000 µW/m²; ICNIRP: up to 10 000 000 µW/m²; Salzburg Resolution / Vienna Medical Association: 1000 µW/m²; BioInitiative: 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 < 0.000001 µW/m²

#### 4 DC ELECTRIC FIELDS (Electrostatics)

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

Values apply to prominent 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 10000 V; synthetic flooring, laminate: up to 20000 V; TV screens: up to 30000 V; nature: < 100 V

#### 5 DC MAGNETIC FIELDS (Magnetostatics)

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

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 67900  $\mu\text{T}$ , general 21200  $\mu\text{T}$ ; USA/Austria: 5000-200000  $\mu\text{T}$ ; MRI: 2-4 T; earth's magnetic field: across temperate latitudes 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 (Gamma Radiation, Radon)

	%	< 50	50 - 70	70 - 100	> 100
<b>Equivalent dose rate increase</b> in percent	%	< 50	50 - 70	70 - 100	> 100

Values apply in relation to local background levels: Germany on average 0.8 mSv/a (100 nSv/h). At substantial deviations from this mean background radiation, the reference ranges for the equivalent dose rate increase need to be decreased accordingly.

Radiation Protection Germany: general 1 mSv/a additional exposure, workers 20 mSv/a; BGA: general 1.67 mSv/a; USA federal law: general 5 mSv/a, workers 50 mSv/a; Germany background: < 0.6 mSv/a (< 70 nSv/h) north, > 1.4 mSv/a (> 165 nSv/h) south, Black Forest, Bavaria

	Bq/m <sup>3</sup>	< 30	30 - 60	60 - 200	> 200
<b>Radon</b> in becquerel per cubic meter	Bq/m <sup>3</sup>	< 30	30 - 60	60 - 200	> 200

EU: 400 Bq/m<sup>3</sup> (old buildings), 200 Bq/m<sup>3</sup> (new buildings); Radiation Protection Germany: 250 Bq/m<sup>3</sup>; Sweden, Canada: 200 Bq/m<sup>3</sup>; US EPA: 150 Bq/m<sup>3</sup>; England: 100 Bq/m<sup>3</sup> (new buildings); WHO: 100 Bq/m<sup>3</sup>; German Radon Protection Act (draft): 100 Bq/m<sup>3</sup>; avg. indoor levels: 20-50 Bq/m<sup>3</sup>, avg. outdoor levels: 5-15 Bq/m<sup>3</sup>; radon mine: 100000 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 (Geomagnetic Field, Terrestrial Radiation)

	nT	< 100	100 - 200	200 - 1000	> 1000
<b>Disturbance of geomagnetic field</b> in nanotesla	nT	< 100	100 - 200	200 - 1000	> 1000
<b>Disturbance of terrestrial radiation</b> in percent	%	< 10	10 - 20	20 - 50	> 50

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

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

## B INDOOR TOXINS, POLLUTANTS, INDOOR CLIMATE

### 1 FORMALDEHYDE and other Toxic Gases

	$\mu\text{g}/\text{m}^3$	< 20	20 - 50	50 - 100	> 100
<b>Formaldehyde</b> in microgram per cubic meter	$\mu\text{g}/\text{m}^3$	< 20	20 - 50	50 - 100	> 100

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 reference value 'normal': 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: 60  $\mu\text{g}/\text{m}^3$ ; immediate danger 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)

	$\mu\text{g}/\text{m}^3$	< 100	100 - 300	300 - 1000	> 1000
<b>VOC</b> in microgram per cubic meter	$\mu\text{g}/\text{m}^3$	< 100	100 - 300	300 - 1000	> 1000

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

Allergenic, irritating or odor-intensive individual substances or compound classes need to be assessed more critically, especially harmful or carcinogenic air pollutants.

Federal Environment Agency Germany: 200-300  $\mu\text{g}/\text{m}^3$ ; Seifert BGA: precautionary threshold 200-300  $\mu\text{g}/\text{m}^3$ ; Molhave: 200  $\mu\text{g}/\text{m}^3$ ; AGÖF target value: 100  $\mu\text{g}/\text{m}^3$ ; nature: < 10  $\mu\text{g}/\text{m}^3$ ; AGÖF 'normal' values: toluene 12  $\mu\text{g}/\text{m}^3$ , xylene 5  $\mu\text{g}/\text{m}^3$ , benzene 1.7  $\mu\text{g}/\text{m}^3$ , ethylbenzene 2  $\mu\text{g}/\text{m}^3$

### 3 PESTICIDES and other Semi-Volatile Organic Compounds (SVOV)

	air	ng/m <sup>3</sup>	< 5	5 - 25	25 - 100	> 100
<b>Pesticides</b> e.g. PCP, lindane, permethrin, chlorpyrifos, DDT, dichlofluaniid...	wood, material	mg/kg	< 1	1 - 10	10 - 100	> 100
	dust	mg/kg	< 0.5	0.5 - 2	2 - 10	> 10
	material with skin contact	mg/kg	< 0.5	0.5 - 2	2 - 10	> 10
	dust	mg/kg	< 0.5	0.5 - 2	2 - 5	> 5
<b>PCB</b>	dust	mg/kg	< 0.5	0.5 - 2	2 - 5	> 5
	dust	mg/kg	< 0.5	0.5 - 2	2 - 10	> 10
<b>Fire Retardants</b>	chlorinated	mg/kg	< 0.5	0.5 - 2	2 - 10	> 10
	halogen-free	mg/kg	< 5	5 - 50	50 - 200	> 200
<b>PAH</b>	dust	mg/kg	< 0.5	0.5 - 2	2 - 20	> 20
<b>Plasticizers</b>	dust	mg/kg	< 100	100 - 250	250 - 1000	> 1000

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

Values for dust apply to typical mixtures of substances. Values for adsorbed plasticizers in dust (sum total: x 2); PCB according to LAGA. PAH according to EPA.

Decree of prohibition of PCP (Germany): 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>; AGÖF reference value 'normal' for dust: PCP 0.3 mg/kg, permethrin 0.5 mg/kg, TCEP 0.5 mg/kg; PAH benzo(a)pyren < 0.2 mg/kg, DEHP 400 mg/kg

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

Indoor concentrations of particulate matter, fibers or dust should be below the common, uncontaminated outdoor concentrations. Asbestos should not at all be detectable in indoor air, house dust and on indoor surfaces.

Former building biology reference 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); EPA: 25 µg/m<sup>3</sup> (< 2.5 µm); VDI: 75 µg/m<sup>3</sup>; TA: 150 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: 10 000 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...)

Relative humidity in percent	% r.h.	40 - 60	< 40 / > 60	< 30 / > 70	< 20 / > 80
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Carbon dioxide in parts per million	ppm	< 600	600 - 1000	1000 - 1500	> 1500
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MAK: 5000 ppm; DIN: 1500 ppm; VDI: 1000 ppm; USA (occupational/classrooms): 1000 ppm; unventilated bedroom after one night or classroom after a one-hour lesson: 2000-4000 ppm; nature in 2008: 380 ppm, in 1985: 330 ppm; annual increase: 1-2 ppm

Small air ions per cubic centimeter air	/cm <sup>3</sup>	> 500	200 - 500	100 - 200	< 100
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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

Air electricity in volt per meter	V/m	< 100	100 - 500	500 - 2000	> 2000
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DIN/VDE: occupational 40 000 V/m, general 10 000 V/m; nature: ca. 50-200 V/m, foehn: ca. 1000-2000 V/m, thunderstorm: 5000-10 000 V/m

## C FUNGI, BACTERIA, ALLERGENS

### 1 MOLDS and their Spores and Metabolites

The combination of different diagnostic methods that take the specifics of each situation into account and the pooling of diverse results and observations maximizes especially in the case of mold problems the analytical certainty and makes it possible to identify sources and reach meaningful assessments, e.g. investigations of air, surfaces, dust, materials and cavities by culturing on agar, using microscope identification for non-culturable species and mold fragments, toxicological analyses, measurements of indoor air climate and humidity/moisture levels...

The mold **count** in indoor air should be less compared to the ambient outdoor environment or to uncontaminated comparison rooms. Mold **types** in indoor spaces should be **very similar** to those outside or uncontaminated comparison rooms. Particularly, **critical** or toxigenic molds should **not** be detectable or only minimally. Any **sign, suspicion** or indication of a potential mold problem should be investigated: visible mold growth - the larger, the more critical, moisture-indicating molds, mycotoxins and other metabolites, cold surfaces - thermal bridges, constantly high air humidity and material moisture, construction and moisture damage, problematic construction details, odors, building history, ill-health symptoms, results of environmental medicine investigations...

Former building biology reference 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 for 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)

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) needs to 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: < 50/m<sup>3</sup> very low, < 200/m<sup>3</sup> low, < 1000/m<sup>3</sup> medium, < 10 000/m<sup>3</sup> high, > 10 000/m<sup>3</sup> very high. See 'Schimmelpilz-Leitfaden' by Environment Agency (Germany) for assessment details.

### 2 YEASTS and their Metabolites

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

### 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 should not be detectable or only minimally, neither in indoor air or on material surfaces, neither 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. During a mold investigation, bacteria should also be considered and vice versa, they often occur together.

Since the Building Biology Evaluation Guidelines are first of all based on experience, not all subcategories have a reference range (yet). They are regularly revised and updated as new knowledge becomes available.

In addition to the Standard of Building Biology Testing Methods and the Building Biology Evaluation Guidelines, there are Building Biology Testing Conditions and Explanations that describe the technical and analytical procedures in more detail.

The Standard of Building Biology Testing Methods, the accompanying Building Biology Evaluation Guidelines for Sleeping Areas and additional testing details were developed by *BAUBIOLOGIE MAES* on behalf and with the support of the Institut für Baubiologie+Ökologie Neubeuern IBN between 1987 and 1992 and first published in May 1992. Scientists, medical doctors and colleagues also offered their support. The most current version SBM-2008 is the 7<sup>th</sup> edition. Since 1999 a 10-member expert commission assists in maintaining and updating the Standard and its Guidelines.

The Building Biology Evaluation Guidelines SBM-2008 were translated from German into English by Katharina Gustavs in June 2008.