Standard of Building Biology Testing Methods SBM-2003

This unique standard gives an overview of the risk factors 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 testing procedures are documented in a final written report. In case potential problems are identified, an effective remediation strategy is recommended.

The various items of the standard deal with environmental factors that can pose a health risk to indoor living. It is the goal of the suggested building biology testing methods to offer a professional and holistic testing protocol according to which achievable reduction or elimination strategies can be developed.

The accompanying ***Building Biology Guidelines for Sleeping Areas*** were pioneered by Baubiologie Maes between 1987-1992 in cooperation with the Institut für Baubiologie und Ökologie Neubeuern IBN, scientists, medical doctors and building biology consultants. The Standard (SBM 92/5) was issued for the first time in May 1992, the fifth revision followed as SBM-2000 in May 2000. The most current Standard is the sixth edition and was published as SBM-2003 in May 2003. Since 1999 an expert panel is responsible for maintaining and updating the ***Standard*** including the ***Guidelines*** and specific testing protocols. The current members of the panel are as follows: Dr. Thomas Haumann, Dipl-Ing. Norbert Honisch, Wolfgang Maes, Dipl.-Ing. Helmut Merkel, Dr. Manfred Mierau, Uwe Münzenberg, Peter Sierck, Dipl.-Chem. Jörg Thumulla, Dr. Martin Virnich.

A Electromagnetic Radiation (EMR)

1 AC Electric Fields (ELF)
Measuring ELF electric **field strength** (V/m), human **body voltage** in the electric field (mV) as well as dominant **frequency** (Hz)
Sources: AC voltage in cable, wiring systems, appliances, walls, floors, beds, high-tension power lines

2 AC Magnetic Fields (ELF)
Measuring and data logging ELF **magnetic flux density** (nT or mG)), dominant **frequency** (Hz) as well as **field line distribution**
Sources: AC current in wiring systems, appliances, transformers, motors, overhead or ground cables, railways

3 Radiofrequency Radiation (Electromagnetic Waves)
Measuring and data logging of pulsed and unpulsed radiofrequency **power density** ($\mu W/m^2$ or nW/cm^2) as well as identifying **ELF modulation**
Sources: radio and TV towers, cellular phone technology, wireless networks, cordless phones, radar, military applications, electronic devices

4 Static Electric Fields (DC)
Measuring **surface potential** of static electricity (V) as well as **discharge time** (s)
Sources: synthetic carpeting, drapes and textiles, vinyl wallpaper, varnishes, laminates, TV or computer screens

5 Static Magnetic Fields (DC)
Measuring static magnetic **flux density** (μT) and **deviation of compass needle** (°)
Sources: steel in beds, mattresses, furniture, appliances, building materials, DC current in street cars

6 Radioactivity (Gamma Radiation & Radon)
Measuring **equivalent dose rate** (nSV/h, %) and **radon concentration** (Bq/m^3)
Sources: building materials, stones, tiles, cinders, waste products, devices, ventilation, terrestrial radiation, location

7 Terrestrial Radiation
Measuring **magnetic field** (nT) and **radioactive radiation** (ips) of the earth as well as the respective **disturbances** (%)
Sources: electric currents and radioactive substances in the earth; disturbances caused by faults, fractures, underground water courses

8 Sound & Vibrations (airborne and solid sound)
Measuring **noise level**, **infrasound**, **ultrasound** and **vibrations** (dB, m/s^2)
Sources: traffic noise, air traffic, train traffic, industry, devices, machines, motors, transformers, sound bridges

B Toxins and Indoor Climate

1 Formaldehyde and Other Toxic Gases
Measured are **formaldehyde**, ozone and chlorine; industrial pollutants, natural gas, carbon monoxide, nitrogen dioxide and other combustion gases (ppm, $\mu g/m^3$)
Sources: varnishes, glues, particle board, wood products, furnishings, devices, type of heating, gas leaks, exhaust fumes

2 Solvents and Other Volatile Organic Compounds (VOC's)
Measured are **volatile organic compounds** (ppm, ng/cm^3) such as aldehydes, aliphates, cycloalkanes, alcohols, amines, aromatic compounds, chlorine hydrocarbons, esters, ethers, glycoles, isocyanates, ketones, terpenes
Sources: paints, varnishes, adhesives, synthetics, particle board, building parts, furniture, cleaners, furnishings

3 Biocides and Other Semi-volatile Organic Compounds (SVOC's)
Measured are **semi-volatile organic compounds** (mg/kg, ng/cm^3) such as pesticides, insecticides, fungicides, wood preservatives, fire retardants, plasticizer, pyrethroids, PCBs, PAHs, dioxins
Sources: wood, leather and carpet protections, adhesives, plastics, sealers, moth-proofing agents, pest-control agents

4 Heavy Metals and Other Inorganic Toxins
Measured are **inorganic substances** (mg/kg) such as heavy metals, metal compounds, salts
Sources: wood preservatives, building materials, building moisture, PVC, paints, glazes, plumbing pipes, industry, environment

5 Particles and Fibers (Dust, Suspended Particles, Asbestos, Other Mineral Fibers)
Measured are **dust, number and size of particles**, **asbestos**, and other **fibers** ($/cm^3$, /l)
Sources: aerosols, smoke, soot, dust, building and insulating materials, heating and air-conditioning and heating systems, insulation, appliances, ventilation, environment

6 Indoor Climate (Temperature, Humidity, CO_2, Air Ions, Odors)
Measured are air **temperature** (°C), air **humidity** (% r.h., a_w), **oxygen** (vol. **%), carbon dioxide** (ppm), **air pressure** (mbar), **air movement** (m/s) as well as **small ions** ($/cm^3$) and **air electricity** (V/m), identification of **odors** and **air exchange rate**
Source: building moisture, ventilation, heating, furnishings, breathing activity, static electricity, electromagnetic radiation, dust, environment

C Fungi, Bacteria, Allergens

1 Molds (Spores and Metabolites)
Measuring and identifying **mold-like fungi** that can or cannot be cultured, their spores ($/m^3$, $/dm^3$, /g) and their metabolites (volatile organic compounds such as MVOC and mycotoxins)
Sources: moisture damage, heat bridges, building material, ventilation, air-conditioning, furnishings, environment

2 Yeasts and their Metabolites
Measuring and identifying **yeast-like fungi** ($/m^3$, $/dm^3$, /g) and their metabolites
Sources: moist areas, hygiene problems, food storage, garbage, appliances, furnishings, environment

3 Bacteria and their Metabolites
Measuring and identifying **bacteria** ($/m^3$, $/dm^3$, /g) and their metabolites
Sources: moisture damage, waste water damage, hygiene problems, food storage, garbage, environment

4 Dust Mites and other Allergens
Measuring **number** and **feces of dust mites, pollen, grasses, animal hair** ($/m^3$, /g, %)
Sources: dust mites and their metabolites, hygiene problems, house dust, humidity, ventilation, environment

The following measurements can also be part of a Building Biology Survey: light quality, lighting intensity and UV exposure, potable water quality, testing of building materials, furniture and other furnishings, as well as for home and wood pests. Please also consult the accompanying ***Building Biology Guidelines for Sleeping Areas*****,** which have been developed specifically for long-term risks and the sensitive time of regeneration or sleep. The main focus of the Building Biology Assessment is based on experience, prevention and the achievable.

Supplement to the Standard of Building Biology Testing Methods SBM-2003

Building Biology Guidelines for Sleeping Areas

The ***Building Biology 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. After thousands of surveys over many years, they have a proven track record and focus on the achievable.

		No Anomaly	Weak Anomaly	Strong Anomaly	Extreme Anomaly

A Electromagnetic Radiation (EMR)

1 AC Electric Fields (ELF)

Field strength in volt per meter	V/m	< 1	1 – 5	5 – 50	> 50
Body voltage in millivolt	mV	< 10	10 – 100	100 – 1000	> 1000

ACGIH (1996) occupational TLV 25,000 V/m; WHO/ICNIRP 5,000 V/m; Germany: DIN/VDE 0848 occupational: 20,000 V/m and general public: 7,000 V/m; MPR 25 V/m; TCO 10 V/m; US Congress recommendation in 1996: 10 V/m; nerve stimulation (RWE) starting at 15 mV; natural background < 0.0001 V/m

2 AC Magnetic Fields (ELF)

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

ACGIH (1996) occupational TLV 1,000,000 nT; Germany: DIN/VDE 0848: occupational 5,000,000 nT and general public 400,000 nT; WHO/ICNIRP 100,000 nT; MPR 250 nT; TCO 200 nT; BImSchV 100,000 nT; US Congress recommendation in 1996: 200 nT; Germany DIN/VDE 0107 (EEG): 200 nT; Switzerland: 1000 nT (long-term exposure); WHO/IARC (2001): 300 - 400 nT are considered potentially carcinogenic for humans; natural background < 0.0002 nT

3 Radiofrequency Radiation (Electromagnetic Waves)

Power density in microwatt per square meter					
Pulsed	$\mu W/m^2$	< 0.1	0.1 – 5	5 – 100	> 100
	nW/cm^2	< 0.01	0.01 – 0.5	0.5 - 10	> 10
Unpulsed	$\mu W/m^2$	< 1	1 – 50	50– 1,000	> 1,000
	nW/cm^2	< 0.1	0.1 - 5	5 - 100	> 100

USA: ANSI/IEE 6 - 12 million $\mu W/m^2$ (depending on frequency); Germany: DIN/VDE 0848 occupational: 25 – 100 million $\mu W/m^2$ and general public BImSchV, WHO/IRPA: 2 – 10 million $\mu W/m^2$ (depending on frequency); Mobile Phone Technology: Salzburg Resolution, Medical Association of Germany, EEG changes: 1,000 $\mu W/m^2$ (pulsed); EU Parliament STOA: 100 $\mu W/m^2$; Salzburg County (Austria): outdoor 10 $\mu W/m^2$, indoor 1$\mu W/m^2$; Sensitivity of mobile phones: < 0.001$\mu W/m^2$; natural background < 0.000001 $\mu W/m^2$

4 Static Electric Fields (DC)

Surface potential in volt	V	< 100	100 – 500	500 – 2000	> 2000
Discharge time in seconds	s	< 10	10 – 20	20 – 30	> 30

MPR and TCO: 500 V; damage of electronic parts: from 100 V; painful shocks and actual sparks from 2,000 – 3,000 V

5 Static Magnetic Fields (DC)

Deviation of flux density in microtesla	μT	< 1	1 – 2	2 – 10	> 10
Deviation of compass needle in degree	°	< 2	2 – 10	10 – 100	> 100

Germany: DIN/VDE 0848 occupational 67,900 μT and general public 21,200 μT;
USA/Austria 5,000 – 200,000 μT; MRI ca. 2 T; earth's magnetic field across temperate latitudes 40 – 50 $\mu T \pm 0.01 – 1 \mu T$; magnetic field of eye 0.0001 nT, brain 0.001 nT; heart 0.05 nT

6 Radioactivity (Gamma Radiation and Radon)

Equivalent dose rate in percent %	< 50	50 – 70	70 – 100	> 100

USA federal law: general population < 5 mSv/a and workers < 50 mSv/a; USA average background 1.3 mS/a; Germany average background 0.85 mSv/a (100 nSv/h) - depending on the local surroundings; BGA: general population 1.67 mSv/a; Radiation Protection Branch Germany (SSK): general population 1 mSv/a, additional exposure and at the workplace 20 mSv/a If deviation from average background radiation is substantial, the percentage range of the equivalent dose rate must be minimized accordingly.

Radon in becquerel per cubic meter Bq/m^3	< 20	20 – 50	50 –200	> 200

EPA recommendation: 150 Bq/m^3; Swedish recommendation: 200 Bq/m^3;
Radiation Protection Branch Germany (SSK): 250 Bq/m^3

7 Terrestrial Radiation (Geomagnetic Field, Geological Disturbances)

Disturbance of geomagnetic field in nanotesla nT	< 100	100 – 200	200 – 1,000	> 1,000
Disturbance of terrestrial radiation in percent %	< 10	10 – 20	20 – 50	> 50

natural fluctuations of the earth's magnetic field: temporal 10 – 100 nT;
local (magnetic storms caused by solar eruptions) 100 – 1,000 nT

B Environmental Toxins & Indoor Climate

1 Formaldehyde and Other Toxic Gases

Formaldehyde in parts per million ppm	< 0.02	0.02 – 0.05	0.05 – 0.1	> 0.1

MAK–threshold value: 0.5 ppm; WHO 0.05 ppm; ACGHI ceiling limit 0.3 ppm; BGA recommendations: 0.1 ppm; Katalyse Institute 0.04 ppm; VDI 1992: 0.02 ppm; natural background 0.002 ppm; irritation of mucous membranes and eyes 0.05 ppm; smell threshold 0.05 ppm; life-threating from 30 ppm

2 Solvents and Other Volatile Organic Compounds (VOC)

VOC in microgram per cubic meter $\mu g/m^3$	< 100	100 – 300	300 – 1,000	> 1,000

Molhave (1986) 200 $\mu g/m^3$; Seifert (BGA 1990) 300 $\mu g/m^3$; Association of Enviornmental Chemistry GfU (1998) 200 $\mu g/m^3$

3 Biocides and other Semi-volatile Compounds (SVOC's)

Sum total in nanogram per cubic meter (air) and in milligram per kilogram (material)

Pesticides	**air**	ng/m^3	< 5	5 - 50	50 – 100	> 100
PCP, Lindane, Permethrin	**wood**	mg/kg	< 0.2	0.2 - 5	5 - 100	> 100
Dichlofluanid, Chlorpyriphos	**dust**	mg/kg	< 0.2	0.2 - 1	1 - 5	> 5
PCB, fire retardants	**dust**	mg/kg	< 0.1	0.1 - 1	1 - 10	> 10
PAH	**dust**	mg/kg	< 0.5	0.5 - 5	5 - 50	> 50
Plasticizer	**dust**	mg/kg	< 100	100 - 250	250 - 500	> 500

Values only for chlorinated fire retardants; values only for plasticizers absorbed by dust (total content times 3); PCB according to LAGA; PAH according to EPA; PCP ban in Germany: 5 mg/kg (wood); BGA 1000 ng/m^3; ARGE-Bau 100 ng/m^3, 1 mg/kg (dust)

6 Indoor Climate (Temperature, Humidity, Carbon dioxide, Air Ions, Odors)

Relative humidity in percent	% r.h.	40 – 60	< 40 / > 60	< 30 / > 70	< 20 / > 80
Carbon dioxide in parts per million	ppm	< 500	500 – 700	700 – 1,000	> 1,000

USA occupational exposure 1,000 ppm; Germany MAK limits 5,000 ppm; nature: rural areas < 360 ppm and urban areas 400 – 500 ppm

Small air ions per cubic centimeter air	/cm^3	> 500	200 – 500	100 – 200	< 100

nature: oceanside > 3,000/cm^3; clean outdoor air 2,000/cm^3; urban areas < 1,000/cm^3; indoor living space with synthetics < 100/cm^3; smog < 50/cm^3

Air electricity in volt per meter	V/m	< 100	100 – 500	500 – 2,000	> 2,000

DIN/VDE 0848: workplace 40,000V/m; general public 10,000 V/m; nature ca. 50 – 200 V/m; foehn/thunderstorm ca. 1,000 – 10,000 V/m

C Fungi, Bacteria, Allergens

1 Molds (Spores and Metabolites)

The **mold count** in the air of living spaces should be substantially less compared to the ambient outdoor environment or non-contaminated rooms. **Mold types** of the indoor air should be very similar to those outside. Particularly **toxic species** of mold-like fungi such as aspergillus or stachybotrys as well as yeast-like fungi such as candida, cryptococcus or coliform bacteria should **not at all be found** in living spaces or at the most in trace amounts. In the event of a suspected microbial infestation - indicated by building damages, history of the building, moisture, odors, symptoms of illness, presence of fungi and bacteria - an inspection is recommended.

Depending on predominant climatic, geographic and indoor-hygienic conditions, the following guideline values serve as a supplement to the definitive assessment criteria listed above as long as the mold concentrations of the outdoor air are rather low, below 500 – 1,000/m^3. Given threshold values refer to colony forming units (CFU) that are cultured on building biology agar (YM anilin blue) at temperatures between 20 – 24 °C and with relatively low outdoor air concentrations below 500 - 1000/m^3.

Spores CFU					
per cubic meter air	/m^3	< 200	200 – 500	500 – 1000	> 1000
per square decimeter surface area	/dm^2	< 20	20 – 50	50 – 100	> 100

WHO: **pathogenic** and **toxigenic** fungi should **not at all be tolerated** in indoor air; if more than **50/m^3** of a single fungal species is found, the source should be identified; a mixture of fungi typical for a given location (e.g. cladosporium) can be tolerated up to 500/m^3.

No Anomaly	reflects the optimal natural condition or the common and invevitable background of our modern living environment.
Weak Anomaly	makes you aware of an imbalance, which following the precautionary principle calls for a remediation in the long term, especially out of consideration for sensitive and ill people.
Strong Anomaly	is not acceptable for the Building Biology Guidelines, but requires remediation in the short term.
Extreme Anomaly	calls for immediate and rigorous action. In this case international guidelines of occupational exposures limits may be reached or even exceeded.

Any attainable reduction is worthwhile to achieve. Nature is *the* ultimate guide.