STANDARD OF BAUBIOLOGIE METHODS OF TESTING
(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 assesses 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 presented. 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 first published by *Baubiologie Maes* between 1987-1992 in cooperation with the *Institut für Baubiologie und Ökologie Neubeuern IBN*, and with the support of 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* 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 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 and Dr. Martin Virnich.

A Fields, Waves and Radiation

1 AC Electric Fields (ELF)
Measuring the ELF electric **field strength** (V/m), the human **body voltage** in the electric field (mV) as well as the 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 of the ELF **magnetic flux density** (nT or mG), the dominant **frequency** (Hz) as well as the **field line distribution**
Sources: AC current in wiring systems, appliances, transformers, motors, overhead or ground cables, railways

3 Electromagnetic Waves (RF)
Measuring and data logging of the pulsed and non-pulsed high frequency electromagnetic **power density** ($\mu W/m^2$) 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 the **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 the 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 the **equivalent dose rate** (nSv/h, %) and the **radon concentration** (Bq/m^3)
Sources: building materials, stones, tiles, cinders, waste products, devices, ventilation, terrestrial radiation, location

7 Terrestrial Radiation
Measuring the **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 sound conducted through solids)
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

BAUBIOLOGIE MAES, Schorlemerstr. 87 D-41464 Neuss Phone: 02131-43741 Fax: 02131-44127 www.maes.de
IBN, Holzham 25 D-83115 Neubeuern Phone: 08035-2039 Fax: 08035-8164 www.baubiologie-ibn.de
Translated by IBE, 1041A Cleveland Street, Clearwater, FL 33755 Phone: 727 461-4371 www.buildingbiology.net

B Environmental Toxins, Poisons, Indoor Climate

1 **Formaldehyde** and Other Toxic Gases
Measuring **formaldehyde**, ozone and chlorine; industrial pollutants, natural gas, carbon monoxide, nitrogen dioxide and other combustion gases (ppm, µg/m³)
Sources: varnishes, glues, particle board, wood products, furnishings, devices, type of heating, gas leaks, exhaust fumes

2 **Solvents** and Other Volatile Organic Compounds **(VOC)**
Measuring **volatile organic compounds** (ppm, µg/m³) such as aldehydes, aliphates, cycloalkanes, alcohols, amines, aromatic compounds, chlorinated hydrocarbons, esters, ethers, glycols, 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/cm³) such as pesticides, insecticides, fungicides, wood preservatives, fire retardants, plasticizers, pyrethroids, PCBs, PAHs, dioxines
Sources: wood, leather and carpet protections, adhesives, plastics, sealers, moth-proofing agents, pest-control agents

4 **Heavy Metals** and Other Inorganic Toxins
Measuring **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…)
Measuring **dust, number and size of particles**, **asbestos**, and other **fibers** (/cm³, /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, Smells)
Measuring air **temperature** (°C), air **humidity** (% r.h., a.h.), **oxygen** (vol. **%), carbon dioxide** (ppm), **air pressure** (mbar), **air movement** (m/s) as well as **small ions** (/cm³) and **air electricity** (V/m), identification of **odors** and determination of **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 of culturable and non culturable **fungi**, their spores (/m³, /dm², /g) and their metabolites (MVOC and mycotoxins)
Sources: moisture damage, heat bridges, building material, ventilation, air-conditioning, furnishings, environment……

2 **Yeast** and Their Metabolites
Measuring and identifying **yeast-like fungi** (/m³, /dm², /g) and their metabolites
Sources: moist areas, hygiene problems, food storage, garbage, appliances, furnishings, environment

3 **Bacteria** and Their Metabolites
Measuring and identifying **bacteria** (/m³, /dm², /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** (/m³, /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. May we direct your attention to the accompanying **Building Biology Guidelines for Sleeping Areas,** which have been developed especially for monitoring long-term risk and the delicate time of regeneration (sleep)? The focus in the evaluation process is based on experience, prevention and the achievable.

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Supplement to the *Standard of Baubiologie Methods of Testing 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 Fields, Waves and Radiation

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 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; BlmSchV 100,000 nT; US Congress recommendation in 1996: 200 nT; Germany DIN/VDE 0107 (EEG): 200 nT; natural background < 0.0002 nT; Switzerland: 1000 nT (long term occupation); WHO/IARC (2001): 300-400nT are considered potentially carcinogenic for humans

3 Electromagnetic Waves (RF)

Power density in microwatt per sq meter					
Pulsed	$\mu W/m^2$	< 0.1	0.1 – 5	5 – 100	> 100
Unpulsed	$\mu W/m^2$	< 1	1 – 50	50 – 1,000	> 1,000

WHO/ICNIRP 95, 000 $\mu W/m^2$; Germany: DIN/VDE 0848 occupational: 25,000,000 – 100,000,000 $\mu W/m^2$ and general public BlmSchV, WHO/IRPA: 2,000,000 – 10,000,000 $\mu W/m^2$ (depending on frequency); mobile radio tech.: Salzburg Resolution, MD Association, EEG changes 1,000 $\mu W/m^2$ (pulsed); EU Parliament STOA: 100 $\mu W/m^2$; Salzburg County: outside 10, inside 1$\mu W/m^2$; pulsed; USA: ANSI/IEE 6 – 12 W/m^2 (depending on frequency); cell-phone functions: < 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 – 200,000µT; MRI ca. 2 T; earth's magnetic field across temperate latitutes 40 – 50 µT ± 0.1 – 1 µT; magnetic field of eye 0.0001 nT, brain 0.001 nT; heart 0.05 nT

6 Radioactivity (Gamma Radiation and Radon)

Increase of 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; depending on the local surroundings: Germany: average 0.85 mSv/a (100 nSv/h); BGA: general population 1.67 mSv/a;SSK (Radiation Protection Branch in Germany) general population 1.5 mSv/a additional impact and workers 15 mSv/a; if unusual deviation from average background radiation is substantial the frame of equivalent dose rate increase must be reduced.

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, Earth Radiation)

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

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B Environmental Toxins, Poisons, 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: 0.1ppm; Katalyse Institute 0.04 ppm; VDI 1992: 0.02 ppm; natural background 0.002 ppm; irritation of mucuous membranes and eyes 0.05 ppm; smell threshold 0.05 ppm; life threat from 30 ppm

2 **Solvents** and Other Volatile Organic Compounds **(VOC)**

values of **VOC's** in microgram / m^3	µg / m^3	< 100	100 – 300	300 – 1,000	> 1,000

Molhave (1986) 200 µg/m^3; Seifert (BGA 1990) 300 µg/m^3; Gesellschaft für Umweltchemie, Germany GfU (1998) 200 µg/m^3

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

Values for air in nanogram per cubic meter and in milligram per kilogram for 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 (PAK)	**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 x 3); PCB according to LAGA; PAH (PAK) according to EPA; PCP ban in Germany: 5 mg/kg (wood); BGA 1000 ng/m3; ARGE-Bau 100 ng/m3, 1 mg/kg (dust

6 **Indoor Climate** (Temperature, Humidity, CO_2, 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: ocean side > 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; Föhn/thunderstorm ca. 1,000 – 10,000 V/m

C Fungi, Bacteria, Allergens

1 **Molds** (their Spores and Metabolites)

The mold count of air in living spaces should be substantially less compared to the one in the surrounding outdoor environment or in not contaminated rooms. Mold types of indoor air should be very similar to those outside. Particularly toxic species of mold-like fungi such as aspergillus or stachybotrys and yeast-like fungi such as candida, cryptococcus and coliform bacteria should not at all be found in living spaces or in very low quantities. In the event of a suspected microbial infestation indicated by building damages, history of the building, moisture, smells, symptoms of illness, presence of fungi and bacteria an inspection is recommended. Given exposure limits refer to colony forming units (CFU) on building biology agar (YM aniline blue) and culture temperature at 20 – 24 °C as well as to relative low concentrations in the outside air. Climatic, geographic and the hygiene of rooms need to be taken in consideration as well.

Spores CFU per cubic meter air / m^3	< 200	200 – 500	500 – 1000	> 1000
per decimeter surface / 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 ubiquitous fungi can be tolerated up to 500/m^3.

No Anomaly	reflects the optimal natural condition or the common and inevitable 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 potential international guidelines of occupational exposures limits may be reached or even exceeded.

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

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