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BHUTAN STANDARD

Indoor air quality

Draft Bhutan Standard for Indoor Air Quality

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FOREWORD

This Bhutan Standard for Indoor Air Quality was developed by Bhutan Standards Bureau after the draft finalized by the Sustainability and Environment Technical (TC 10) and approved by the Bhutan Standards Bureau Board (BSB Board) on Day Month 2021.

The standard is drafted in accordance with the BSB Rule for Structure and Drafting of Bhutan Standards, 2017. Some of the elements of this standard may be the subject of copyrights. BSB shall not be held responsible for such copyrights. The *annex A* form the normative part of this standard.

This standard is subject to systematic review after five years to keep pace with environmental change, industrial and technological developments. Any suggestions and further information may be directed to the concerned Technical Committee.

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Introduction

Clean air is a basic requirement of life. The quality of air in indoor spaces where people spend a large part of their life is an essential for human well-being. Pollutants emitted from different sources lead to a broad range of health problems and may even be fatal. Therefore assessing and maintaining the pollutants' limit is essential for the health of the occupants.

The purpose of this Bhutan Standard for Indoor Air Quality are to define requirements, sampling and test methods for identified pollutants to ensure permissible limits for human occupancy. This standard provides the uniform basis for the protection of public health from adverse effects of indoor exposure to air pollution. The pollutants considered in this standard are common indoor air pollutants but not limited to; hydrocarbon, halogenated hydrocarbons, inorganic pollutants and particulate matter.

The use of standard remains voluntary and when referenced by regulatory authorities as a basis for legislation, the standards become mandatory.

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BHUTAN STANDARD FOR INDOOR AIR QUALITY

1 Scope

This standard prescribes the requirements, sampling and test methods for Indoor Air Quality suitable for human occupancy. The requirement for biological pollutants is not within the scope of this standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BTS 314:2021 ISO 4226 *Air quality – General aspects – Units of measurements*

BTS 315:2021 ISO 16000-1 *Indoor air- General aspects of sampling strategy*

BTS 316:2021 ISO 16000-2 *Indoor air- Part 2: Sampling strategy for formaldehyde.*

BTS 317:2021 ISO 16000-*5 Indoor air- Part 5: Sampling strategy for volatile organic compounds (VOCs).*

BTS 318:2021 ISO 16000-37 *Indoor air – Part 37: Measurement of PM 2.5 mass concentration*.

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3 Terms and definition

For the purposes of this document, the following terms and definitions apply;

3.1 Acceptable indoor air quality

Air in an occupied space towards which substantial majority of occupants expressed no dissatisfaction and that not likely to contain contaminants at concentration leading to exposures that pose significant health risk.

3.2 Acceptable perceived indoor air quality

Air in an occupied space towards which substantial majority of occupants express no dissatisfaction on the basis of odour and sensory irritation.

3.3 Ambient air

Outdoor air to which people plants, animals or material may be exposed.

3.4 Ambient air quality

State of the ambient air as indicated by the degree of contamination.

3.5 Air pollutant

Any material emitted into the atmosphere either by human activity or natural processes and adversely affecting man or the environment.

3.6 Air pollution

Usually the presence of substances in the atmosphere resulting either from human activity or natural processes, present in sufficient concentration, for a sufficient time and under circumstances such as to interfere with comfort, health or welfare of persons or the environment.

3.7 Halogenated hydrocarbon

Hydrocarbons compound in which at least one hydrogen atom is replaced by halogen (E.g C_2Cl_4 – Tetrachloroethylene)

3.8 Hydrocarbons

Organic compound consisting of only hydrogen and carbon (E.g. C_6H_6– Benzene)

3.9 Indoor air

Air within an enclosed space, e.g., dwelling or public building.

3.10 Indoor air quality

Quality of air inside the enclosed space, described in terms of odour, physical parameters, chemical and biological pollutants.

3.10.1 Description for Indoor Air Quality

The pollutants considered in this standard include hydrocarbon, halogenated hydrocarbon, inorganic pollutant, particulate matter and biological pollutant. For the purpose of households, the pollutants considered are; $PM_{2.5}$, PM_{10}, benzene, formaldehyde, carbon monoxide, naphthalene, nitrogen dioxide, polycyclic-aromatic hydrocarbons (benzo[a]pyrene).

The limits related to individual biological pollutants cannot be specified as the health effects cannot be quantified precisely due to exposure to multiple agents simultaneously. The health risks of biological pollutants could be addressed through appropriate design and management.

The exposure limit prescribed are based on evidences and suspected health effects and an evaluation of human health risks for each pollutants.

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3.11 Inorganic pollutant

Air pollutants which does not have carbon-hydrogen bond (E.g. CO – Carbon Monoxide)

3.12 Particulate matter (PM_x)

Particulate matter suspended in air which is small enough to pass through a size-selective inlet with a 50 % efficiency cut-off at x µm aerodynamic diameter.

3.12.1 PM_1-Particulate matter which passes through a size-selective inlet with a 50 % efficiency cut-off at 1 µm aerodynamic diameter

3.12.2 $PM_{2.5}$ - Particles which pass through a size-selective inlet with a 50 % efficiency cut-off at 2.5 µm aerodynamic diameter

3.12.3 PM_{10} - Particles which pass through a size-selective inlet with a 50 % efficiency cut-off at 10 µm aerodynamic diameter

3.13 Primary pollutant

Air pollutant directly emitted from a source

3.14 Secondary pollutant

Pollutants which may be produced in the atmosphere by physical or chemical processes from primary pollutant or other substances present as the result of emissions from stationary or mobile sources.

3.15 Suspended matter

All particulate material which persists in the atmosphere or in a flue gas stream for lengthy periods because the particles are too small in size to have an appreciable falling velocity.

3.16 Volatile organic compound (VOC)

Organic compound whose boiling point is in the range from (50 °C to 100 °C) to (240 °C to 260 °C)

Note: Boiling points of some compounds are difficult or impossible to determine because they decompose before they boil at atmospheric pressure. Vapour pressure is another criterion for classification of compound volatility that can be used for classification of organic chemicals.

4 Requirements

4.1 Organic and inorganic pollutant

The requirement affecting Indoor Air Quality shall conform to the *Annex A, Table 1.* The limits given in table are based on the exposure to single airborne chemicals through inhalation alone. They do not take account of additive, synergistic or antagonistic effects (except for the combined exposure to sulfur dioxide and particulate matter) or exposure through routes other than inhalation.

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5 Sampling and testing

The sampling strategy to aid the planning of indoor pollution monitoring shall conform to ISO 16000-1 *General aspects of sampling strategy*

5.1 Hydrocarbon

5.1.1 The sampling strategy for determination of formaldehyde shall be carried out in accordance to ISO 16000-2 *Indoor air- Part 2: Sampling strategy for formaldehyde.*

5.1.2 The sampling strategy for determination of volatile organic compounds (except formaldehyde) shall be carried in accordance to ISO 16000-5 *Indoor air- Part 5: Sampling strategy for volatile organic compounds (VOCs).*

5.2 Inorganic pollutants

The sampling and determination of inorganic pollutants shall be carried out with standard methods/ validated test methods.

5.3 Particulate matter

The sampling and determination/measurement of PM_x concentration shall be carried in accordance to ISO 16000-37 *Indoor air – Part 37: Measurement of PM 2.5 mass concentration*.

5.4 Units of measurements

For the purpose of reporting the air quality measurements, ISO 4226 *Air quality – General aspects – Units of measurements* shall be adhered.

Annex A

(Normative)

Table 1. Indoor air quality exposure limit for individual pollutant (Clause 4)

Sl. No.	Pollutant	Exposure limit (µg/m^3)							
		10 min	15 min	30 min	1 hour	8 hours	24 hours	1 week	1 year
	Hydrocarbons								
1	Benzene[a]	No safe level							
2	Toluene	-	-	1000	-	-	-	260	-
3	Styrene	-	-	7	-	-	-	260	-
4	Polycyclic aromatic hydrocarbons[b]	No safe level							
	Halogenated hydrocarbons								
1	Tetrachloroethylene	-	-	-	-	-	250	-	-
2	Trichloroethylene[c]	No safe level							
3	1,2-dichloroethane	-	-	-	-	-	700	-	-
	Other hydrocarbons								
1	Formaldehyde	-	-	100	-	-	-	-	-
2	Naphthalene	-	-	-	-	-	-	-	10

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Table 1 (*Continued*)

	Inorganic pollutants								
1	Ammonia	-	-	-	1400	-	-	-	-
2	Carbon monoxide	-	1×10^5	6×10^4	3×10^4	1×10^4	7×10^3	-	-
3	Nitrogen dioxide	-	-	-	200	-	-	-	40
4	Sulfur dioxide	500	-	-	-	-	125	-	50
5	Ozone	-	-	-	-	120	-	-	-
6	Arsenic[d]	No safe level							
7	Cadmium	-	-	-	-	-	-	-	0.005
8	Manganese	-	-	-	-	-	-	-	0.5
9	Nickel[e]	No safe level							
10	Lead	-	-	-	-	-	-	-	0.5
11	Mercury	-	-	-	-	-	-	-	1
12	*Radon*[f]	No safe level							
	Particulate matter								
1	PM2.5	-	-	-	-	-	25	-	10
2	PM10	-	-	-	-	-	50	-	20

[a] Estimated 6 deaths from cancer in population of 1 million through lifetime exposure of 1µg/m^3

[b] Unit risk for lung cancer for PAH mixtures is estimated to be 8.7×10^{-5} ng/m^3 B[a]P

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[c] Estimated 4,3 deaths from cancer in population of 10 million through lifetime exposure of 1 µg/m^3

[d] Estimated 1500 deaths from cancer in population of 1 million through lifetime exposure of 1 µg/m^3

[e] Estimated 380 deaths from cancer in population of 1 million through lifetime exposure of 1 µg/m^3

[f] Estimated 30 to 60 deaths from in population of 1 million through lifetime exposure of 1 Bq/m^3

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ANNEX B

(Informative)

Particulate Matter PM_1

Particulate Matter (PM) with an aerodynamic diameter less than 1.0 µm have relatively large surface to volume ratio and longer residence time in the atmosphere. It pose a risk to human health because of their adverse effects both on the respiratory and cardiovascular systems. Although PM_1 enters into blood stream and affect biological functions, the standards cannot be set due to limited evidences.

PM_1 affect air quality with potentially negative effects on visibility, agricultural and natural ecosystems, material and cultural heritages. PM_1 also influence the Earth's radiation balance both directly, by scattering and absorbing the in-coming and out-coming radiations, and indirectly, by acting as cloud condensation nuclei (CCN) or ice nuclei (IN), thus changing that way the microphysical structure, the optical properties and the precipitation efficiency of clouds.

The Concentration of PM_1 in the indoor environment strongly depend on parameters such as the room size, relative humidity, air exchange rate, air flow condition and sink effect on surfaces.

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Table 1. Potential sources (not exhaustive) and control measures for PM_1

Source/Cause	Process activity	Products used, sources in a narrower sense	Control measures
Cooking and heating appliances	Combustion process	Biomass, fossil fuels (E.g. Kerosene)	- Vent all fuel fired combustion appliances to the outdoors - Shift clean cooking and heating appliances and fuels - Maintain adequate and proper ventilation
Tobacco	Smoking	Tobacco products (E.g. Cigarettes)	- Designated smoking rooms with proper ventilation
Incense	Burning	Incense products (E.g. Powder and sticks)	- Minimize burning of incense
Reprographic equipment	Printing, scanning, photocopying etc.	–	- Recommended to go paperless

ANNEX C

(Informative)

Asbestos

Asbestos is a naturally occurring mineral fibre popularly used in construction materials due to its thermal resistance, tensile strength and acoustic insulation properties. Exposure to asbestos occurs through inhalation of fibres in air in the working environment and ambient air in the vicinity of point sources.

All asbestos fibre types are hazardous to human health causing asbestosis, lung cancer, mesothelioma, larynx and ovarian cancer. The Occupational Safety and Health Administration (OSHA) established a permissible exposure limit (PEL) of 0.1 fibers/cm^3 over an 8-h period for all fiber types for occupational exposure, however, the limits does not warrant absolute safety. In Bhutan, asbestos are used in Ferro Alloys, Steel Billets and in construction materials (Ministry of Health Report, 2013). Therefore, it is strongly recommended to avoid or replace asbestos containing products with safer substitutes.

The handling and disposal of asbestos containing products shall be carried out following the Occupational Safety Guidelines.

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