Foreword

According to the requirements of Document JIANBIAO [2015] No. 274 issued by the Ministry of Housing and Urban-Rural Development (MOHURD) of the People's Republic of China–"Notice on Printing and Distributing 'the Development and Revision Plan of National Engineering Construction Standards in 2016'". The standard compilation team has compiled this standard after extensive investigation and study, earnest summary of practical experience and extensive solicitation of opinions with reference to relevant international standards and foreign advanced standards.

The main technical contents of this standard include: general provisions, terms and symbols, building materials, survey and designing for building engineering, construction, inspection and acceptance, etc.

The main technical contents revised in this standard are outlined below:

1. Toluene and xylene are added into indoor air pollutants;

2. The classification of decorating materials is refined, and the limit and measurement method of pollutant content (release amount) in some materials are adjusted;

3. The environmental test chamber method and desiccator method for measurement of formaldehyde emission from wood-based panels are retained;

4. The requirements for pollution control pre-assessment and material selection for indoor decoration design are specified;

5. The requirements for the minimum ventilation frequency of class I civil buildings with natural ventilation are specified;

6. The comprehensive radon prevention measures of buildings are improved;

7. More stricter pollution control requirements for the decoration of preschools/nurseries/kindergartens, school classrooms, and student dormitories are specified;

8. The test method for radon concentration in indoor air is defined.

9. The pollutant concentration limit in indoor air is re-determined;

10. The sampling and test method for benzene series and total volatile organic compounds (TVOC) with T-C composite adsorption tubes are added, and the sampling and measurement requirements for indoor air pollutants are further improved and refined.

The provisions printed in bold type in this standard are mandatory ones and must be implemented strictly. This standard is under the jurisdiction of, and its mandatory provisions are interpreted by the Ministry of Housing and Urban-Rural Development. Henan Provincial Academy of Building Research Co., Ltd. is in charge of the explanation of specific technical contents. The relevant options and advice derived from the process of implementing this standard can be posted or passed on to Henan Provincial Academy of Building Research Co., Ltd. (Address: No. 4 Fengle Road, Zhengzhou City, Henan Province, Postcode: 450053).

Chief Development Organizations:

Henan Provincial Academy of Building Research Co., Ltd.

Tihome Construction and Development Co., Ltd.

Co-Development Organizations:

National Center for Quality Supervision and Test of Building Engineering
Chinese Research Academy of Environmental Sciences
Shanghai Zhongcai Engineering Testing Co.,Ltd.
Department of Engineering Physics, Tsinghua University
Tianjin Research Institute of Building Science Co.,Ltd.
Zhejiang Academy of Building Research & Design Co.,Ltd.
Kunshan Construct Engineering Quality Testing Center
Shenzhen Institute of Building Research Co.,Ltd.
Shandong Provincial Academy of Architectural Science Co.,Ltd.
China Academy of Building Research

Chief Drafters:

WANG Xiyuan LIU Hongkui PAN Hong XIONG Wei BAI Zhipeng
ZHU Li MEI Jing DENG Shujuan ZHU Jun ZHANG Jiwen GUO Qiang
YIN Xiaomei LIU Fengdong CHEN Yongliang WANG Qianxue
CHEN Zeguang CHEN Songhua LU Bin BA Songtao

Chief Reviewers:

WANG Youwei WANG Shilong XIE Baoying LI Jinchuan CAO Yang
LI Jian LIANG Jipan LI Shengying LIAN Zhiwei

Chief Translators:

WANG Xiyuan BAI Zhipeng GAO Yao WANG Ronda WU Wenbao
WANG Qianxue LI Yunlong TONY Leung STEPHEN W. Sadler
JI Xuelin BI Minna

Chief Translation Reviewers:

SHI Xiaoming LI Wei CHEN Yunfa CAO Yang ZHANG Yinping
SUN Xiaoyan

Contents

1 General provisions

1.0.1 This standard is formulated with a view to prevent and control indoor environmental pollution from main building materials and decorating materials in civil building engineering, to safeguard human health and public interests, to achieve the goal of advanced technology and economic rationality.

1.0.2 This standard is applicable to the control of indoor environmental pollution in construction, extension, and renovation of civil building engineering.

1.0.3 Indoor environmental pollutants controlled by this standard include radon, formaldehyde, ammonia, benzene, toluene, xylene, and total volatile organic compounds.

1.0.4 The classification of civil building engineering shall meet the following requirements:

1 Class Ⅰ civil buildings shall include residential buildings, residential functional apartments, hospital wards, nursing home facilities for the elderly, preschools/nurseries/kindergartens, school classrooms, student dormitories, etc.

2 Class Ⅱ civil buildings shall include office buildings, shops/department stores, hotels, cultural and entertainment venues, bookstores, libraries, exhibition halls, gymnasiums, public transportation waiting rooms, restaurants, etc.

1.0.5 The main building materials and decorating materials selected for civil building engineering shall meet the requirements of this standard.

1.0.6 Not only the requirements stipulated in this standard for indoor environmental pollution control of civil building, but also those in the current relevant standards of the nation shall be complied with.

2 Terms and symbols

2.1 Terms

2.1.1 civil building engineering

Civil building structural and decorating engineering with construction, extension, and renovation are collectively referred to as civil building engineering.

2.1.2 environmental test chamber

Equipment imitating the indoor environment and used to measure chemical pollutant emissions from decorating materials.

2.1.3 radon exhalation rate from the surface

The radioactivity level of radon atoms released per unit area and per unit time from the surface of the soil or material.

2.1.4 internal exposure index (I_{Ra})

The quotient obtained by dividing the specific activity of the natural radionuclide radium-226 in the main building materials and decorating materials by the specific activity limit value of 200.

2.1.5 external exposure index (I_{γ})

The sum of the quotients obtained by dividing the specific activity of the natural radionuclides radium-226, thorium-232, and potassium-40 in the main building materials and decorating materials by the specific activity limits of 370, 260, and 4 200, respectively.

2.1.6 radon concentration

Radon radioactivity level per unit volume of air.

2.1.7 wood-based panels

Products with wood or non-wood plant fiber as the main raw material, can be further made into a variety of material pieces, either with or without the addition of adhesive and other additives, and which can be layered up and glued to obtain plywood sheets or moulding products. These products mainly include plywood, fiberboard, particle board and its surface decorating board, etc.

2.1.8 wood-plastic composite products

A kind of product made from a certain percentage of wood fiber materials and thermoplastic high molecular polymers. These products mainly include wood-plastic flooring, wood-plastic decorating board, wood-plastic doors, etc.

2.1.9 water-based treatment agents

The agents with water as diluent can be immersed inside the main building materials and decorating materials, improve their performance of flame retardant, waterproof, anticorrosion, etc.

2.1.10 bulk construction adhesive

Adhesives with solvent content or water content within 5% total mass of the colloid.

2.1.11 total volatile organic compounds in the air

The total mass of volatile organic compounds in the air that is measured under the regulated testing conditions of this standard, abbreviated as TVOC.

2.1.12 volatile organic compounds in the material

The gross mass of volatile organic compounds in the material that is measured under the regulated testing conditions of this standard, abbreviated as VOC.

2.1.13 decorating material loading factor

The ratio of total exposure surface area of indoor decorating materials to the net room space volume.

2.2 Symbols

f_i—The mass percentage of the i^{th} material in the total material consumption;

I_{Ra}—Internal exposure index;

I_γ—External exposure index;

I_{Rai}—Internal exposure index of the i^{th} material;

$I_{\gamma i}$—External exposure index of the i^{th} material.

3 Building materials

3.1 Inorganic non-metallic main building materials and decorating materials

3.1.1 The radioactive limits of the inorganic non-metallic main building materials such as sand, stone, brick, solid block, cement, concrete, and concrete prefabricated components used in civil building engineering shall meet the requirements of the current national standard GB 6566 *Limits of Radionuclides in Building Materials*.

3.1.2 The radioactive limits of inorganic non-metallic decorating materials such as stone, building sanitary ceramics, gypsum products, and inorganic powdery bonding materials used in civil building engineering shall be classified in accordance with the requirements of the current national standard GB 6566 *Limits of Radionuclides in Building Materials*.

3.1.3 Where civil building engineering use aerated concrete products and other main building materials such as hollow bricks/hollow blocks with a hollow rate (porosity rate) larger than 25%, etc., the radioactivity limits shall be in accordance with those specified in Table 3.1.3.

Table 3.1.3 The radioactivity limit of aerated concrete products and other main building materials with a hollow rate (porosity rate) larger than 25%

Measurement item	Limit
Radon exhalation rate from the surface [Bq/(m^2·s)]	≤0.015
Internal exposure index (I_{Ra})	≤1.0
External exposure index (I_γ)	≤1.3

3.1.4 The method for measuring the radionuclide content of main materials and decorating materials shall meet the requirements of the current national standard GB 6566 *Limits of Radionuclides in Building Materials*, and the method for measuring radon exhalation rate from the surface shall be in accordance with those specified in Appendix A of this standard.

3.2 Wood-based panels and finishing products

3.2.1 The amount of released free formaldehyde shall be measured, when wood-based panels and finishing products are used indoors as part of civil building engineering.

3.2.2 The environmental test chamber method and the desiccator method can both be used to measure the amount of released formaldehyde from wood-based panels and finishing products. The results from the environmental test chamber method will prevail if the measurements are not consistent with each other.

3.2.3 The amount of released free formaldehyde from wood-based panels and finishing products as measured by the environmental test chamber method shall not be larger than 0.124mg/m^3. The measurement method shall comply with the Appendix B of this standard.

3.2.4 The amount of released free formaldehyde from wood-based panels and finishing products as measured by the desiccator method shall not be larger than 1.5mg/L. The measurement method shall meet the requirements of the current national standard GB/T 17657 *Test Methods of Evaluating the Properties of Wood-based Panels and Surface Decorated Wood-based Panels*.

3.3 Coatings

3.3.1 The free formaldehyde limit in indoor water-based decorative panel coatings, water-based wall coatings, and water-based putties used in civil building engineering shall meet the requirements of the current national standard GB 18582 *Limit of Harmful Substances of Architectural Wall Coatings*.

3.3.2 The free formaldehyde content in the other water-based coatings and water-based putties for civil building engineering shall be measured, and the limits shall be in accordance with those specified in Table 3.3.2, and the method used to measure the amount of free formaldehyde content shall meet the requirements of the current national standard GB/T 23993 *Determination of Formaldehyde Content of Waterborne Coatings—Spectrophotometric Method with Acetylacetone*.

Table 3.3.2 Limits of free formaldehyde in other indoor water-based coatings and water-based putties

Measurement item	Limit	
	Other water-based coatings	Other water-based putties
Free formaldehyde (mg/kg)	≤100	

3.3.3 Where solvent-based decorative panel coatings are used in civil building engineering, the limits of VOC and benzene, toluene+xylene+ethyl benzene shall meet the requirements of the current national standard GB 18582 *Limit of Harmful Substances of Architectural Wall Coatings*. For solvent-based wood coatings and putties, all the same limits above shall meet the requirements of the current national standard GB 18581 *Indoor Decorating and Refurbishing Materials—Limit of Harmful Substances of Solvent-Based Coatings for Woodenware*. For solvent-based floor coatings, these contents shall meet the requirements of the current national standard GB 38468 *Limit of Harmful Substances of Interior Floor Coatings*.

3.3.4 When indoor phenolic antirust coatings, waterproof coatings, fireproof coatings, and other solvent-based coatings are used in civil building engineering, the amount of VOC and benzene, toluene + xylene + ethyl benzene shall be measured after they are mixed according to the maximum dilution ratio specified, their limits shall be in accordance with those specified in Table 3.3.4. The measurement method for VOC content shall meet the requirements of the current national standard GB/T 23985 *Paints and Varnishes Determination of Volatile Organic Compound (VOC) Content—Difference Method*. The measurement methods for benzene, toluene + xylene + ethyl benzene shall meet the requirements of the current national standard GB/T 23990 *Determination of the Contents of Benzene, Toluene, Ethyl-benzene, and Xylene in Coatings by Gas Chromatography*.

Table 3.3.4 Limits of VOC, benzene, toluene + xylene + ethyl benzene in phenolic antirust coatings, waterproof coatings, fireproof coatings, and other solvent-based coatings for indoor use

Coating category	VOC (g/L)	Benzene (%)	Toluene + xylene + ethyl benzene(%)
Phenolic antirust coatings	≤270	≤0.3	–
Waterproof coatings	≤750	≤0.2	≤40
Fireproof coatings	≤500	≤0.1	≤10
Other solvent-based coatings	≤600	≤0.3	≤30

3.3.5 The limits of VOC, benzene, toluene + xylene + ethyl benzene, and free diisocyanate (TDI+HDI) shall meet the requirements of the current national standard GB 18581 *Indoor Decorating*

and Refurbishing Materials—Limit of Harmful Substances of Solvent Based Coatings for Woodenware, when polyurethane coatings and polyurethane putties for wood are used in civil building engineering.

3.4 Adhesives

3.4.1 The limit of free formaldehyde in indoor water-based adhesives used in civil building engineering shall meet the requirements of the current national standard GB 30982 *Limit of Hazardous Substances in Construction Adhesive*.

3.4.2 The limit of VOC in indoor water-based adhesives, solvent-based adhesives, and bulk construction adhesives used in civil building engineering shall meet the requirements of the current national standard GB 33372 *Limit of Volatile Organic Compounds Content in Adhesive*.

3.4.3 The limit of benzene, toluene + xylene, and free toluene diisocyanate (TDI) in indoor solvent-based adhesive and bulk construction adhesive used in civil construction engineering shall meet the requirements of the current national standard GB 30982 *Limit of Hazardous Substances in Construction Adhesive*.

3.5 Water-based treatment agents

3.5.1 For water-based treatment agents used in civil building engineering, including water-based flame retardant (including fireproof coatings), waterproof agents, preservatives, reinforcing agents, etc., the content of free formaldehyde shall be measured, and the limit shall not be larger than 100mg/kg.

3.5.2 The measurement method for free formaldehyde content in water-based treatment agents shall be in accordance with the method of the current national standard GB/T 23993 *Determination of Formaldehyde Content of Waterborne Coatings—Spectrophotometric Method with Acetylacetone*.

3.6 Others

3.6.1 The amount of ammonia released from concrete admixtures in civil building engineering shall not be larger than 0.10%. The measurement method for ammonia release amount shall meet the requirements of the current national standard GB 18588 *Limit of Ammonia Emitted from the Concrete Admixtures*.

3.6.2 The amount of ammonia released from ammonia releasing flame retardant and fireproof coatings, and water-based building waterproof coatings in civil building engineering shall not be larger than 0.50%. The measurement method shall meet the requirements of the current professional standard JG/T 415 *Limit and Test Method of Harmful Substances in Fire-retardant Coating*.

3.6.3 The amount of residual formaldehyde from concrete admixtures which can release formaldehyde in civil building engineering shall not be larger than 500mg/kg. The measurement method shall meet the requirements of the current national standard GB 31040 *Limit of Residual Formaldehyde from the Concrete Admixtures*.

3.6.4 The amount of free formaldehyde released from bonded wood structural materials in civil building engineering shall not be larger than 0.124mg/m^3. The measurement method shall meet the requirements of the Appendix B of this standard.

3.6.5 The amount of free formaldehyde released from curtain and soft package in civil building engineering shall not be larger than 0.124mg/m^3. The measurement method shall meet the requirements of the Appendix B of this standard.

3.6.6 The limit of free formaldehyde in wallpaper (cloth) shall be in accordance with Table 3.6.6. The measurement method shall meet the requirements of the current national standard GB 18585 *Indoor Decorating and Refurbishing Materials—Limit of Harmful Substances of Wallpapers*.

Table 3.6.6 Limits of free formaldehyde in indoor wallpaper (cloth)

Measurement item	Limit		
	Non-woven wallpaper	Woven wallpaper (cloth)	Other wallpaper(cloth)
Free formaldehyde content (mg/kg)	≤120	≤60	≤120

3.6.7 The measurement method of volatile content in PVC coiled floor, wood plastic composite products floor, and rubber plastic flooring materials for civil building engineering shall meet the requirements of the current national standard GB 18586 *Indoor Decorating and Refurbishing Materials-Limit of Harmful Substances of Polyvinyl Chloride Floor Coverings*. The limit shall be in accordance with those specified in Table 3.6.7.

Table 3.6.7 Limits of volatiles in PVC coiled floor, wood plastic composite products floor, and rubber plastic flooring materials

Materials type		Limits (g/m^3)
PVC coiled floor (foaming type)	Glass fiber substrate	≤75
	Other substrate	≤35
PVC coiled floor (non foaming)	Glass fiber substrate	≤40
	Other substrates	≤10
Wood plastic composite products (foamed substrate)		≤75
Wood plastic composite products floor (where the base material is not foamed)		≤40
Rubber and plastic flooring materials		≤50

3.6.8 The measurement methods for the amount of VOC emission, and the free formaldehyde content shall be in accordance with those specified in Appendix B of this standard. The limits of VOC and the free formaldehyde in the carpet and carpet liner for civil building engineering shall be in accordance with those specified in Table 3.6.8.

Table 3.6.8 Emission limits of VOC and free formaldehyde in carpet and carpet liner

Materials type	Measurement items	Limits [$mg/(m^2 \cdot h)$]
Carpet	VOC	≤0.500
	Free formaldehyde	≤0.050
Carpet liner	VOC	≤1.000
	Free formaldehyde	≤0.050

3.6.9 The limit of free formaldehyde, benzene + toluene + ethyl benzene + xylene, and VOC in the indoor wallpaper adhesive and wallpaper (cloth) adhesive of base films for civil building engineering shall be in accordance with those specified in Table 3.6.9. The measurement method for the amount of the benzene + toluene + ethyl benzene + xylene and free formaldehyde shall meet the requirements of the current national standard GB 30982 *Limit of Hazardous Substances in Construction Adhesive*. The measurement method for the amount of VOC shall meet the requirements of the current national standard GB/T 33372 *Limit of Volatile Organic Compounds Content in Adhesive*.

Table 3.6.9 Limits of free formaldehyde, benzene + toluene + ethylbenzene + xylene and VOC in indoor wallpaper (cloth) adhesive

Measurement items	Limits	
	Wallpaper adhesive	Base films
Free formaldehyde (mg/kg)	≤100	≤100
Benzene + toluene + ethyl benzene + xylene (g/kg)	≤10	≤0.3
VOC (g/L)	≤350	≤120

4 Survey and designing for building engineering

4.1 General requirements

4.1.1 For construction, extension of civil building engineering, the radon concentration in the soil of the urban area where the building engineering is located, or the radon exhalation rate from the soil surface, shall be investigated before the design, and the corresponding investigation report shall be submitted. If the measurement of the radon concentration in the regional soil, or the radon exhalation rate from the soil surface has not been carried out, the radon concentration in the soil of the construction site or the soil radon exhalation rate shall be measured, and the corresponding test report shall be provided.

4.1.2 Pollution control measures shall be implemented in indoor decoration design of civil buildings. Pre-evaluation of pollution shall be conducted in decoration design to control the loading ratio and pollutant emission of decoration materials. The assembled decoration is recommended; decoration parts and components should be produced in factory and assembled onsite.

4.1.3 The ventilation design of civil buildings shall meet the requirements of the current national standard GB 50352 *Uniform Standard for Design of Civil Buildings*. The air change flow of civil buildings with central air conditioning shall meet the requirements of the current national standard GB 50736 *Design Code for Heating, Ventilation and Air Conditioning of Civil Buildings*.

4.1.4 The minimum ventilation frequency of class I civil buildings using natural ventilation in hot summer and cold winter areas, cold areas, and severe cold areas shall not be less than 0.5 ACH (Air Changes per Hour). Mechanical ventilation shall be implemented when necessary.

4.2 Radon concentration measurement and resistance on construction sites

4.2.1 The engineering geological survey data of construction, extension of civil building engineering shall include historical data of the soil radon concentration or radon exhalation rate from the soil surface in the urban area where the engineering is located, and the average value of the soil radon concentration or radon exhalation rate from the soil surface.

4.2.2 For civil building engineering that have performed the regional measurement of the radon concentration in the soil or the radon exhalation rate from the soil surface, when the average value of the measurement results of the soil radon concentration is not larger than 10 000Bq/m^3, or the average value of the measurement results of the radon exhalation rate from the soil surface is not larger than 0.02Bq/(m^2·s), and there is no geological fracture structure in the engineering site, the soil radon concentration measurement may no longer be carried out. In other cases, the soil radon concentration of the engineering site or the radon exhalation rate from the soil surface shall be measured.

4.2.3 Where the average soil radon concentration of a civil building engineering site is not more than 20 000Bq/m^3, or the radon exhalation rate from the soil surface is not more than 0.05Bq/(m^2·s), radon prevention may be neglected.

4.2.4 When the soil radon concentration measurement result of a civil building engineering site is

larger than 20 000Bq/m³ and less than 30 000Bq/m³, or the radon exhalation rate from the soil surface is larger than 0.05Bq/(m²·s) and less than 0.10Bq/(m²·s), anti-cracking measures on the ground floor of the building shall be taken.

4.2.5 In case of the soil radon concentration of a civil building engineering site is not less than 30 000 Bq/m³ and less than 50 000Bq/m³, or when the radon exhalation rate from the soil surface is not less than 0.10Bq/(m²·s) and less than 0.30Bq/(m²·s), in addition to the anti-cracking measures on the ground floor of the building, the foundation must be treated according to the first-class waterproofing requirements in the current national standard GB 50108 *Technical Code for Waterproofing of Underground Works*.

4.2.6 In case of the average soil radon concentration of a civil building engineering site is not less than 50 000Bq/m³, or the average soil surface radon exhalation rate is not less than 0.30Bq/(m²·s), comprehensive measures to prevent radon pollution in buildings shall be taken.

4.2.7 Where the average radon concentration in the soil of a class Ⅰ civil building engineering site is not less than 50 000Bq/m³, or the radon exhalation rate from the soil surface is not less than 0.30Bq/(m²·s), the specific activity of radium-226, thorium-232, potassium-40 in the soil of the engineering site shall be measured. Where the soil internal exposure index (I_{Ra}) is larger than 1.0, or the external exposure index (I_{γ}) is larger than 1.3, the engineering site soil shall not be used as engineering backfill.

4.2.8 The method for determining the concentration of radon in the soil of civil building engineering sites, and the method for determining the rate of radon exhalation from the soil surface, shall comply with the provisions of Appendix C of this standard.

4.3 Choice of construction materials

4.3.1 The radiation limits of inorganic non-metallic materials used in interior decoration of class Ⅰ civil buildings must meet the type A requirement in the current national standard GB 6566 *Limits of Radionuclides in Building Materials*.

4.3.2 Inorganic non-metallic materials used in class Ⅱ civil buildings are recommended to meet the type A requirement; when both type A and type B inorganic non-metallic decoration materials are used, the usage of each material shall be calculated as follows:

$$\sum f_i \cdot I_{Rai} \leqslant 1.0 \qquad (4.3.2\text{-}1)$$

$$\sum f_i \cdot I_{\gamma i} \leqslant 1.3 \qquad (4.3.2\text{-}2)$$

Where: f_i—mass percentage of i^{th} material in total material usage (%);

I_{Rai}—internal exposure index of i^{th} material;

$I_{\gamma i}$—external exposure index of i^{th} material.

4.3.3 The content/emission amount of hazardous substances in and/or from decoration materials, such as wood-based panels and its products, coatings, adhesives, water-based treatment agents, concrete admixtures, wallpaper (wall cloth), PVC floor sheets, carpets, etc., shall meet the requirements of Chapter 3 of this standard.

4.3.4 Polyvinyl alcohol-sodium silicate interior wall coatings, polyvinyl formal interior wall coatings, and oil in water (O/W) multicolor interior wall coatings with nitrocellulose as the main resin and xylene as the main solvent, shall not be allowed in the interior decoration of civil buildings.

4.3.5 Polyvinyl formal adhesives shall not be allowed in the interior decoration of civil buildings.

4.3.6 Wood floors and other wood materials used for interior decoration of civil buildings must not be treated with asphalt, coal tar oil type anti-corrosion and moisture-proof treatment agents.

4.3.7 Solvent-based adhesives shall not be used when pasting plastic floor in the interior decoration of class Ⅰ civil buildings.

4.3.8 Solvent-based adhesives should not be used when pasting plastic floor in basements and rooms without direct natural ventilation from outdoors in class Ⅱ civil buildings.

4.3.9 In civil buildings, where an external thermal insulation system is used, environmentally friendly insulation material shall be selected, and the surface shall be tightly sealed. Urea-formaldehyde foam shall not be used as heat insulation material or sound absorption material in interior decoration.

5 Construction

5.1 General requirements

5.1.1 According to the design requirements and the relevant provisions of this standard, the pollutant content of the main building materials and decorating materials, and the pollutant emission therefrom, shall be sampled and tested when the materials enter the construction site.

5.1.2 The sampling method for testing the pollutant content of, or pollutant emission from the decoration materials shall be in accordance with those specified in Table 5.1.2.

Table 5.1.2 Sampling requirements for decorating materials

Materials	Sampling requirements
Natural granite stone and porcelain tile	Where more than 200m^2 of material of the same origin and variety is used, it is necessary to retest the material. Each 5 000m^2 of such material of the same origin and variety shall be treated as a separate sampling group. If the total area of the material is less than 5 000m^2, all the material of the same origin and variety is treated as one sampling group
Wood-based panels (including products made of it)	Where more than 500m^2 of material from the same manufacturer, and of the same variety and specifications is used, it is necessary to retest the material. Material can be divided into sampling groups, each comprising 5 000m^2 of material from the same manufacturer, and of the same variety and specifications. If the total area of the material is less than 5 000m^2, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
Water-based coatings and putty	Material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of the material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
Solvent-based coatings and putty for wood	Polyurethane coatings for wood: material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer. If the total weight of the material is less than 5 tons, all the material from the same manufacturer is treated as one sampling group
	Other types of coatings and putty: material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of the material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
Indoor waterproof coatings	Reactive polyurethane coatings: material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of the material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
	Polymer cement waterproof coatings: material can be divided into sampling groups, each comprising 10 tons of material from the same manufacturer. If the total weight of the material is less than 10 tons, all the material from the same manufacturer is treated as one sampling group
	Other types of coatings: material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of the material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
Water-based adhesives	Polyurethane adhesives: material can be divided into sampling groups, each comprising 5 tons of component A in material from the same manufacturer. If the total weight is less than 5 tons, all the material from the same manufacturer is treated as one sampling group

Table 5.1.2 (continued)

Materials	Sampling Requirement
Water-based adhesives	Polyvinyl acetate adhesives, rubber adhesives, VAE emulsion adhesives and acrylic adhesives: material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of the material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
Solvent-based adhesives	Polyurethane adhesives: material can be divided into sampling groups, each comprising 5 tons of component A in material from the same manufacturer. If the total weight is less than 5 tons, all the material from the same manufacturer is treated as one sampling group
	Neoprene adhesives, SBS adhesive and acrylate adhesive: the material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of the material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
Native adhesives	Epoxy (component A) adhesives: material can be divided into sampling groups, each comprising 5 tons of products from the same manufacturer. If the total weight of material is less than 5 tons, all the material from the same manufacturer is treated as one sampling group
	Silicone adhesive (including MS): material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
Water-based fire retardants, water repellents and preservatives	Material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group
Fire retardant coatings	Material can be divided into sampling groups, each comprising 5 tons of material from the same manufacturer, and of the same variety and specifications. If the total weight of material is less than 5 tons, all the material from the same manufacturer, and of the same variety and specifications, is treated as one sampling group

5.1.3 Main building materials and decorating materials shall not be used in construction where their retest results do not meet the design requirements and the relevant provisions of this standard.

5.1.4 The construction unit shall conduct the construction according to the design requirements and the relevant provisions of this standard, and shall not change the requirements of the design documents without authorization. When it needs to be changed, it shall be processed according to the construction change procedure with confirmation from the original design institution.

5.1.5 Where the same decoration design is repeatedly used in the interior decoration of civil buildings, a model room should be built for testing the concentration of indoor environmental pollutants.

5.1.6 The testing methods for indoor environmental pollutant concentration in the model room shall meet the requirements of Chapter 6 of this standard. When the test results do not meet the requirements of this standard, the reasons shall be found and improvement measures shall be taken.

5.2 On-site examination of building materials

5.2.1 When inorganic non-metallic main building materials and decorating materials used in civil buildings enter the construction site, the construction unit shall examine the radioactive index test reports.

5.2.2 When more than 200m^2 of natural granite stone or porcelain tiles are used in the interior

decoration of civil buildings, the radioactive index shall be tested for each product of each batch, respectively.

5.2.3 When wood-based panel and its products used in the interior decoration of civil buildings enter the construction site, the construction unit shall examine the free formaldehyde emission test report.

5.2.4 When more than 500m^2 of wood-based panels are used in the interior decoration of civil buildings, the free formaldehyde emission shall be tested for each product of each batch.

5.2.5 When water-based coatings and water-based treatment agents used in the interior decoration of civil buildings enter the construction site, the construction unit shall examine the free formaldehyde content test reports for the same batch of the products. When solvent-based coatings enter the construction site, the construction unit shall examine the VOC, benzene, toluene + xylene and ethylbenzene content test reports for the same batch of the products. For polyurethane-type products, free diisocyanate (TDI + HDI) content test reports shall be also required.

5.2.6 When water-based adhesives used in the interior decoration of civil buildings enter the construction site, the construction unit shall examine the free formaldehyde and VOC content test report for the same batch of the products. When solvent-based and pure/native adhesives enter the construction site, the construction unit shall examine the benzene, toluene + xylene and VOC content test reports for the same batch of the products. For polyurethane-type products, free toluene diisocyanate (TDI) content test reports shall be also required.

5.2.7 Wallpaper (wall cloth) used in the interior decoration of civil buildings shall have the free formaldehyde content test report for the same batch of the products, and shall also meet the design requirements and the provisions of this standard.

5.2.8 When the test parameters of the main building materials and decorating materials are incomplete, or the test results are questioned, the materials shall be re-inspected and proved to be in compliance before being used in construction.

5.2.9 When wood-based panel and its products are used in the interior decoration of nurseries/preschool/kindergartens, classrooms and student dormitories, the formaldehyde emission from each batch of each product shall be sampled and tested. The emission of volatile organic compounds from coatings and rubber plastic synthetic materials shall be sampled and tested, and the test results shall comply with the requirements of this standard.

5.3 Requirements for construction

5.3.1 Where anti-radon design measures are applied to civil buildings, the construction technology for special components of the underground works such as deformation joints, construction joints, through-wall pipes (boxes), embedded parts, reserved holes, etc. shall comply with the relevant requirements of the current national standard GB 50108 *Technical Code for Waterproofing of Underground Works*.

5.3.2 Where off-site soil is used as the backfill for class I civil buildings, the specific activity of radium-226, thorium-232, and potassium-40 shall be measured. The internal exposure index (I_{Ra}) of the backfill shall not be larger than 1.0, and the external exposure index (I_γ) shall not be larger than 1.3.

5.3.3 Benzene-containing diluents and solvents such as benzene, industrial benzene, petroleum benzene, heavy benzene and mixed benzene, etc., shall not be used in the interior decoration of civil buildings.

5.3.4 During the interior decoration construction of civil buildings, solvent-based coating operation,

wet operation, suspension dust operation, high noise operation and other polluting construction operation shall be reduced at construction site. Benzene, toluene, xylene and gasoline shall not be used to remove oil and old coatings operation.

5.3.5 Coatings, adhesives, water-based treatment agents, diluents and solvents shall be sealed and stored immediately after use, and the wastes shall be removed from the site immediately.

5.3.6 Organic solvent must not be used to clean construction tools of interior decoration of civil buildings.

5.3.7 For civil buildings in heating regions, the interior decoration should not be constructed during the heating period.

5.3.8 During the decoration construction with light partition walls, coating works, mounting-pasting and soft cover, doors and windows, veneered panels, and ceilings, etc., attention shall be paid to moisture-proofing, and to avoid covering local damp areas.

5.3.9 In the construction of interior decoration, the discharge of condensate water from air conditioning systems shall comply with requirements of the current national standard GB 50736 *Design Code for Heating, Ventilation and Air Conditioning of Civil Buildings*.

5.3.10 In the construction of decoration of civil buildings in use, solvent-based coatings shall not be used without taking effective measures to prevent pollution.

6 Inspection and acceptance

6.0.1 The inspection and acceptance for indoor environmental quality of civil buildings and their interior decoration shall be conducted not less than 7 days after the completion of the project and before the project is delivered for use.

6.0.2 The following documents shall be examined during the inspection and acceptance of civil buildings:

1 Geological investigation reports, test reports of radon concentration in soil or radon exhalation rate from the soil of the project sites, test reports of the natural radionuclides radium-226, thorium-232, and potassium-40 in the soil of project sites with high soil radon.

2 Design and construction documents related to air change flow, and the test reports.

3 Construction drawing design documents and design change documents related to indoor environmental pollution control.

4 Pollutant test reports, entry inspection records and re-inspection reports of the main building materials and decorating materials.

5 Acceptance records and construction records of concealed works related to indoor environmental pollution control.

6 Test reports of indoor environmental pollutant concentration in model rooms (except for those projects without model rooms).

7 Test reports of indoor air pollutants concentrations.

6.0.3 Category, quantity and construction technology of main building materials and decorating materials used in civil buildings shall meet the design requirements and the relevant requirements of this standard.

6.0.4 At the completion and acceptance of civil buildings, the concentration of indoor environmental pollutants must be tested, and the results shall comply with the limits shown in Table 6.0.4.

Table 6.0.4 Concentration limits of indoor environmental pollutants in civil buildings

Pollutant	Class Ⅰ civil buildings	Class Ⅱ civil buildings
Radon (Bq/m^3)	≤150	≤150
Formaldehyde (mg/m^3)	≤0.07	≤0.08
Ammonia (mg/m^3)	≤0.15	≤0.20
Benzene (mg/m^3)	≤0.06	≤0.09
Toluene (mg/m^3)	≤0.15	≤0.20
Xylene (mg/m^3)	≤0.20	≤0.20
TVOC(mg/m^3)	≤0.45	≤0.50

Notes:1. The reported values of indoor pollutant concentrations in the table, except radon, refer to the measured values of indoor pollutant concentrations after deducting the measured background values of pollutant concentrations in the outdoor upwind air.

2. The limiting values of the measured pollutant concentrations in the table are judged by the full numerical comparison method.

6.0.5 At the inspection and acceptance of civil buildings, the air change flow of public buildings with centralized ventilation shall be tested, and the test results shall meet the requirements of design and the current national standard GB 50736 *Design Code for Heating, Ventilation and Air Conditioning of Civil Buildings*.

6.0.6 Radon concentration in the indoor air of civil buildings should be measured by the following methods: pumping electrostatic collection followed by spectrometry, pumping scintillation chamber, pumping pulse ionization chamber, activated carbon box-low background multi-channel gamma ray spectrometer. The uncertainty of the measurement results shall not be larger than 25% (k=2), and the lower detection limit of the method shall not be larger than10Bq/m^3.

6.0.7 The indoor formaldehyde concentration of civil buildings shall be tested using the AHMT spectrophotometric method of the current national standard GB/T 18204.2 *Examination Methods for Public Places Part 2: Chemical Pollutants*.

6.0.8 The use of simple sampling instruments to test the indoor formaldehyde concentration of civil buildings is allowed. Such simple sampling instruments shall be calibrated regularly. When the measuring range is not larger than 0.50μmol/mol, the margin of error shall be within ± 0.05μmol/mol. In case of dispute, the test results of AHMT spectrophotometric method in the current national standard GB/T 18204.2 *Examination Methods for Public Places Part 2: Chemical Pollutants* shall prevail.

6.0.9 The indoor ammonia concentration of civil buildings shall be tested using the indophenol-blue spectrophotometric method of the current national standard GB/T 18204.2 *Examination Methods for Public Places Part 2: Chemical Pollutants*.

6.0.10 The method used to measure benzene, toluene, and xylene in the indoor air of civil buildings shall comply with the requirements of Appendix D of this standard.

6.0.11 The method used to measure TVOC in the indoor air of civil buildings shall comply with the requirements of Appendix E of this standard.

6.0.12 At the inspection and acceptance of civil buildings, the indoor environmental pollutants including radon, formaldehyde, ammonia, benzene, toluene, xylene, and TVOC shall be sampled in representative rooms of each individual building. The number of samples shall neither be less than 5% of the total number of rooms, nor less than 3 rooms for each single building. When the total number of rooms is less than 3, all the rooms shall be tested.

6.0.13 At the inspection and acceptance of civil buildings, if the indoor environmental pollutant concentrations of the model rooms were tested, and all the test results met the requirements of this standard, the number of samples for the rooms that have the same type of decoration design as the model rooms can be reduced by half, and meanwhile shall not be less than 3.

6.0.14 At the inspection and acceptance of nurseries/kindergartens, classrooms, student dormitories and elderly care housing facilities, when testing the indoor environmental pollutants radon, formaldehyde, ammonia, benzene, toluene, xylene, and TVOC, the number of samples shall neither be less than 50% of the total number of rooms nor be less than 20 rooms. When the total number of rooms is not more than 20, all the rooms shall be tested.

6.0.15 At the inspection and acceptance of civil buildings, the number of check points for testing indoor environmental pollutants shall comply with Table 6.0.15.

Table 6.0.15 Required number of check points for testing indoor environmental pollutants

Room area (m^2)	Check points
<50	1
≥50, <100	2
≥100, <500	Not less than 3
≥500, <1 000	Not less than 5
≥1 000	For parts larger than 1 000m^2, add 1 check point for every 1 000m^2 increase. If the increase in area is less than 1 000m^2, add 1 check point for this area

6.0.16 When there is more than 2 check points in the room, the check points shall be adopted diagonal, oblique, or plum-shaped balanced distribution approaches. The test result of the room shall be the average value of the test results from all check points.

6.0.17 At the inspection and acceptance of civil buildings, the sampling position for indoor environmental pollutants shall be 0.8m to 1.5m above the floor of the room and not less than 0.5m from the wall of the room. The check points shall be evenly distributed, avoiding the air ducts and vents.

6.0.18 When testing the concentrations of formaldehyde, ammonia, benzene, toluene, xylene, and TVOC in civil buildings, fixed furniture completed in decoration construction shall be kept in the state in which it is regularly used. Civil buildings with centralized ventilation shall be tested with the regular operation of ventilation system. Civil buildings with natural ventilation shall be tested after the closure of external doors and windows for at least 1h.

6.0.19 When measuring the concentration of radon in the indoor environment of civil buildings, civil building engineering that use centralized ventilation shall be carried out under the normal operating conditions of the ventilation system. Civil building engineering that use natural ventilation shall be carried out 24 hours after the external/outside doors and windows of the room are closed. When a class I building has no overhead floor or underground garage structure, the sampling rate of rooms on the first and second floors should not be less than 40% of the total number of rooms.

6.0.20 Where the indoor radon concentration of class I civil buildings exceeds the standard, in both high thorium areas and high radon areas with soil radon concentration larger than 30 000Bq/m^3, the first-floor room of the building shall be investigated and evaluated for radon-220 pollution, and pollution prevent measures shall be taken according to the situation.

6.0.21 Where the test results of indoor environmental pollutant concentrations for all the sampled rooms meet the requirements of Table 6.0.4 of this standard, the indoor environmental quality of the project shall be determined to be in compliance.

6.0.22 Where the test results of indoor environmental pollutant concentrations do not meet the requirements of Table 6.0.4 of this standard, the number of samples for the non-conforming items shall be doubled, and the non-compliant rooms and the rooms of the same type as the non-compliant rooms shall be included. If the re-test results meet the requirements of Table 6.0.4 in this standard, the indoor environmental quality of the project shall be determined to be compliant. If not, the causes shall be investigated, and measures taken to deal with them until the test results are in compliance.

6.0.23 Where the test results of indoor environmental pollutant concentrations do not meet the requirements of Table 6.0.4 in this standard, the civil buildings must not be delivered and put into use.

Appendix A Measurement of radon exhalation rate from material surfaces

A.1 The instrument directly measures the radon exhalation rate from the surface of building materials

A.1.1 Instruments for measuring radon exhalation rate from the surface of building materials shall include sampling and measurement. The working principle shall be either passive collection type, or active suction collection type. Measuring instruments shall meet the following requirements:

1 The detection limit of a continuous 10h measurement shall not be larger than 0.001Bq/(m^2·s).

2 The uncertainty shall not be larger than 20% (k=2).

3 The calibration of the instrument shall be qualified and within the validity period.

A.1.2 The procedure for measuring radon exhalation rate using a passive collection measurement instrument on the surface shall be carried out according to the following steps:

1 Clean the surface of the material to be tested, secure the gas collection container on a flat surface, and seal the end face of the collector and the surface of the material to be tested. The ratio of the measured surface area (m^2) and the net space volume of the gas collection container of the measuring instrument (m^3) shall be roughly 2:1.

2 The measurement time shall be larger than 1h, and shall be determined according to the radon exhalation rate.

3 The rate of radon exhalation from the surface as measured by the instrument shall be multiplied by the scale factor of the instrument to obtain the rate of radon exhalation from the surface of the material.

4 The measurement temperature shall be within the range of 25℃±5℃, and the relative humidity shall be within the range of 45%±15%.

A.1.3 The steps for determining the rate of radon exhalation from the surface of building materials using an active suction collection type instrument shall be carried out according to the following steps:

1 Preparation of the tested block: The ratio of the surface area (m^2) of the sample under test to the net volume (m^3) of the suction collection container (the suction collection container or the container containing the block under test) shall be approximately 2:1, and the sample surface under test shall be cleaned, ready to measure.

2 Preparation of the measuring device: The suction collection container (or the container enclosing the block under test) shall be connected to the air inlet and outlet of the measuring instrument in place. Before the test, the background radon concentration in the clean air in the air system shall be measured and recorded.

3 The block under test and the measuring device should be placed in place, and the suction collection container (or the container enclosing the block under test) shall be sealed until the end of the measurement.

4 When ready, begin the measurement and start timing. The measurement time shall be more than 2h and less than 10h.

5 The measurement temperature shall be within the range of 25℃±5℃, and the relative humidity shall be within the range of 45%±15%.

6 The radon exhalation rate ε from the surface of the block under test shall be calculated according to the following formula:

$$\varepsilon = \frac{c \cdot V}{S \cdot t} \tag{A.1.3}$$

Where: ε —The rate of radon exhalation from the surface of the block under test [Bq/(m^2·s)].

c —The air radon concentration reported by the measuring device (Bq/m^3).

V—The net volume of the measurement system. That is, the net volume in the suction collection container, which is equal to the volume of the container enclosing the block under test minus the volume of the block itself (m^3).

S—The external surface area of the block under test (m^2).

t —The elapsed time from the beginning of the measurement to the end of the measurement.

A.2 Activated carbon box method for the determination of the rate of radon exhalation from the surface of building materials

A.2.1 The process of preparation for the determination of radon exhalation rate from the surface of building materials using the activated carbon box method shall comply with the requirements of Article A.1.2 of this standard.

A.2.2 The activated carbon measurement method for the determination of the rate of radon exhalation from the surface of building materials shall comply with the relevant requirements of the current national standard GB/T 16143 *Charcoal Canister Method for Measurement ^{222}Rn Exhalation Rate from Building Surface*.

Appendix B Measurement of emission of free formaldehyde and VOC in decorating materials using environmental test chamber method

B.0.1 The volume of the environmental test chamber shall be $0.05m^3 \sim 40m^3$.

B.0.2 The inner surfaces of the environmental test chamber shall be made of inert materials such as stainless steel, glass, etc.

B.0.3 The operating conditions of environmental test chambers shall be in accordance with the following requirements:

1 Temperature: 23℃±0.5℃.

2 Relative Humidity: 50%±3%.

3 Air Change Rate: 1±0.05 ACH (Air Changes per Hour).

4 Air velocity near the surface of samples: 0.1m/s~0.3m/s.

5 The ratio of the sample surface area to the volume of the environmental test chamber for wood-based panel and its products, bonded wood structural materials, wall cloth, curtain and soft cover shall be 1:1; whereas the ratio of the sample surface area to the volume of the environmental test chamber for carpet and carpet liner shall be 0.4:1.

6 Before test, the background concentrations of formaldehyde and VOC in the environmental test chamber shall not be larger than $0.006mg/m^3$ and $0.01mg/m^3$, respectively.

B.0.4 Test Procedures shall be in accordance with the following requirements:

1 Before test, samples shall be placed in a room at (23±1) ℃ and relative humidity 50%±5% for no less than 1d; the distance between samples shall not be less than 25mm; air shall circulate freely over the surfaces of all samples; the air change rate of the constant temperature and humidity room shall not be less than 1 ACH; the formaldehyde concentration of the room shall not be larger than $0.05mg/m^3$, and the VOC concentration shall not be larger than $0.3mg/m^3$.

2 Samples of wood-based panel and its products, bonded wood structural materials, wall cloth, and curtains shall be placed vertically in the center of the environmental test chamber with their surfaces parallel to the air flow direction; the distance between samples shall not be less than 200mm.

3 Carpet and carpet liner samples shall be placed on the bottom of the environmental test chamber face up with the air flow passing through the sample surface evenly.

4 When testing the free formaldehyde emission from wood-based panel and its products, and bonded wood structural materials, measurements shall be taken twice a day with at least 3h interval between each measurement, starting from the second day of the test. If the formaldehyde concentration of the environmental test chamber reaches a stable state (the deviation between the average and the maximum/minimum formaldehyde concentrations of the last 4 measurements is less than 5% or less than $0.005mg/m^3$), the sampling can be stopped; otherwise, take the test result of the 28th day as the final result.

5 When testing the free formaldehyde or VOC emission from carpet, carpet liner, wall cloth and curtain, the samples shall stay in the environmental test chamber for 24h.

B.0.5 The gas sampling system shall be connected to the gas outlet of the environmental test

chamber before sampling.

B.0.6 The sampling volume for the determination of free formaldehyde emission from materials shall be 5L to 20L, and the sampling flow rate shall not be larger than the flow rate of air entering the environmental chamber. The test method shall meet the requirements of AHMT spectrophotometry method in the current national standard GB/T 18204.2 *Examination Methods for Public Places Part 2: Chemical Pollutants*, and the background concentration of the environmental test chamber shall be deducted from the test result.

B.0.7 The sampling volume for the determination of VOC emission from materials shall be 5L to 10L, and the sampling flow rate shall not be larger than the flow rate of air entering the environmental chamber. The test method shall comply with the requirements of Appendix E in this standard, and the background concentration of the environmental test chamber shall be deducted from the test result.

B.0.8 The free formaldehyde or VOC emission from carpet and carpet liner samples shall be calculated according to the following formula:

$$EF = C_s(N/L) \tag{B.0.8}$$

Where, EF—the emission of the material[mg/(m^2·h)].

C_S—the concentration of the environmental chamber(mg/m^3).

N—the air change rate of the environmental chamber(ACH).

L—the ratio of the sample surface area to the volume of the environmental chamber(m^2/m^3).

Appendix C Measurement of radon concentration in soil and radon exhalation rate from the soil surface

C.1 Measurement of radon concentration in soil

C.1.1 The concentration of radon in the soil should be determined by sampling a small amount of soil gas, by an instrument based on electrostatic collection followed by ray detector method, or by the embedded measuring device method.

C.1.2 The performance indicators of the test instrument shall meet the following requirements:

1 The uncertainty shall not be larger than 20% (k=2).

2 The lower detection limit shall not be larger than 400Bq/m^3.

C.1.3 The planning and design data, and the engineering geological survey data of the construction project shall be consulted, and the measurement area scope shall be the same as the geological survey scope of the construction project.

C.1.4 When determining the location of test points within the scope of the engineering geological survey, grids shall be made with an interval of 10m, and each grid point shall be a test point. When encountering large rocks, the deviation can be ±2m, but the number of points shall not be less than 16. The measurement points shall cover the basic construction scope of the single building.

C.1.5 When measuring the radon concentration in a small amount of soil gas using an instrument based on electrostatic collection followed by ray detector method, each test point shall be punched with a special tool, and the depth of the hole should be 500mm to 800mm.

C.1.6 When measuring the radon concentration in a small amount of soil gas using an instrument based on electrostatic collection followed by ray detector method, after the hole is formed, a special sampler with holes on the tip shall be used and inserted into the punched hole. The sampler shall be airtight near the surface, and fresh air from the surface shall not be allowed to penetrate into the hole. The soil gas should be sampled 3 times to 5 times. The first data shall be discarded, and the measured value shall be the average of the remaining measured data.

C.1.7 When using the embedded measuring device method for measurement, the hole shall be formed according to the performance of the instrument and the actual needs of the measurement.

C.1.8 Sampling tests should be carried out between 8:00 to 18:00. On-site sampling tests shall not be carried out on rainy days. When it is rainy, tests shall be carried out 24 hours after the rain. The working temperature shall be −10℃ to 40℃, and the relative humidity shall not be larger than 90%.

C.1.9 Records shall be kept of on-site testing. The content of the records shall include the layout of the test points, the soil type of the hole-forming point, the description of the on-site ground conditions, and the meteorological conditions at the construction site during the 24 hours before the test.

C.1.10 The soil radon concentration test report shall include a description of the sampling test process, the test method, and the results of the soil radon concentration tests.

C.2 Measurement of radon exhalation rate from the soil surface

C.2.1 The instrument and equipment for measuring the radon exhalation rate from the soil surface

shall include sampling equipment and measuring equipment. The shape of the sampling equipment shall be basin-like, and its working principle shall be either passive collection type or active suction collection type. On-site measurement equipment shall meet the following requirements:

1 The uncertainty shall not be larger than 20%.

2 The lower limit of detection shall not be larger than 0.01Bq/(m^2·s).

C.2.2 The measurement procedure shall meet the following requirements:

1 In the measurement construction site, the 20m grid layout points are arranged, and the number of points shall not be less than 16. The soil radon exhalation rate shall be measured at the intersection of the grid points; the working temperature should be −10℃ to 40℃; the relative humidity shall not be larger than 90%.

2 During the measurement, the ground in the vicinity of the sampling point shall be cleaned by removing humus, weeds and stones, the sampler shall be secured on the leveled ground, and the area around the sampler shall be sealed with soil. When ready, start the measurement and start timing (t).

3 During the measurement of the radon exhalation rate from the soil surface, shall meet the following requirements:

1) When using an emission chamber, the seam between the chamber and the surface of the medium shall be sealed.

2) The surface of the measured medium shall be flat, and the volume of the space in the chamber shall not change significantly among measurement points.

3) The measurement duration and other parameters shall be compatible with the measurement sensitivity of the instrument, generally 1h to 2h.

4) The measurement shall be carried out under no wind or breeze conditions.

C.2.3 The radon exhalation rate from the ground surface shall be calculated according to the following formula:

$$R=\frac{N_t\cdot V}{S\cdot T} \tag{C.2.3}$$

Where, R—radon exhalation rate from the ground soil surface [Bq/(m^2·s)];

N_t—the radon concentration in the chamber measured at time T (Bq/m^3);

S—the surface area of the medium covered by the chamber (m^2);

V—the inner volume enclosed by the chamber (m^3);

T—the time elapsed since the start of the chamber measurement (s).

C.3 Survey method of urban regional soil radon level

C.3.1 The arrangement of measuring points shall meet the following requirements:

1 In urban areas, the measurement points shall be arranged on a grid of 2km×2km, and in some small and medium-sized cities, measurement points can be arranged on a grid of 1km×1km. The location of a measurement point may be offset due to terrain, construction, etc., but the offset distance should not exceed 200m.

2 The number of measurement points in each city shall not be less than 100.

3 Topographic (geological) maps and global satellite positioning instruments (BeiDou Navigation Satellite System or GPS) at a scale of 1:50 000 to 1:100 000 or larger should be used to determine the location of the measurement points and mark them on the map.

C.3.2 The investigation method shall meet the following requirements:

1 Before the investigation, a plan shall be made, and measurement instruments and other tools shall be prepared. Instruments shall be calibrated before use. When two or more instruments are used for investigation, the instruments to be used should be calibrated at the same time. The working temperature shall be within the range of −10℃ to 40℃, and the relative humidity shall not be larger than 90%.

2 Measurement point positioning: BeiDou Navigation Satellite System (BDS) or Global Positioning System (GPS) positioning shall be used to determine the position of the measurement point, and a brief description of the geographic location shall be given at the same time.

3 Measurement depth: the survey drilling depth shall be uniformly set at 500mm to 800mm, and the hole diameter shall be 20mm to 40mm.

4 Measurement times: each measurement point shall be measured repeatedly for three times, and the arithmetic mean value shall be taken as the radon concentration at this point. Alternatively, three holes may be drilled in the range of $3m^2$ surrounding each measurement point, and the average value is obtained from these 3 measurements at 3 holes.

5 Other measurement requirements and items that need to be recorded during the measurement process shall comply with Appendix C.1 of this standard.

C.3.3 The quality assurance of the investigation shall meet the following requirements:

1 Before using an instrument, check the stability of the instrument according to the instrument manual.

2 When working with more than two instruments, the consistency of the instruments shall be checked, and the relative standard deviation of the measurement results of the two instruments shall be less than 25%.

3 About 10% of the measuring points shall be selected for recheck measurement, and the recheck measurement results shall be recorded in the original measurement data sheet.

C.3.4 The main content of the survey report on soil radon in urban areas shall include the following contents:

1 Overview of urban geology, soil and radioactive background.

2 Distribution map of measurement points and a description of measurement point arrangement.

3 Introduction of measurement instruments and methods.

4 Description of the measurement process.

5 Measurement results, including original data, average value, standard deviation, etc. If possible, a contour map of urban soil concentration should be drawn.

6 Quality evaluation of the measurement results, including daily stability checks of the instruments, calibration and comparison of the instruments, production of quality monitoring charts for the instruments, etc.

Appendix D Measurement of benzene, toluene, xylene in indoor air

D.0.1 Benzene, toluene and xylene in indoor air shall be collected with an activated carbon sorbent tube or Tenax TA-Carbopack X composite sorbent tube, and analyzed by gas chromatography after thermal desorption, using the retention time to determine the compound, and using the peak area to determine the mass.

D.0.2 Instruments and equipment shall meet the following requirements:

1 Gas sampler with constant flow rate: during the sampling process, the flow rate shall be stable, and the range of flow rates shall include 0.5L/min. When the flow rate is 0.5L/min, it shall be able to overcome the resistance of 5kPa to 10kPa. Where the sampling system is calibrated with a flow meter calibrator, the relative deviation shall not be larger than ±5%.

2 Thermal desorption apparatus: it shall be able to thermally desorb the sorbent tubes. The desorption temperature and the flow rate of the carrier gas shall be adjustable.

3 Gas chromatographer equipped with hydrogen flame ionization detector.

4 Capillary column: quartz column with a length of 30m to 50m and an inner diameter of 0.32mm, coated with polydimethyl polysiloxane or other non-polar materials.

5 Several micro injectors with capacities of 1μL and 10μL.

D.0.3 Reagents and materials shall meet the following requirements:

1 The activated carbon sorbent tube shall be a glass tube or a stainless steel tube with smooth inner walls, containing 100mg coconut shell activated carbon adsorbent. Before use, it shall be heated with nitrogen flow for activation. The activation temperature shall be 300℃ to 350℃, and the activation shall continue for no less than 10min until there are no impurity peaks. When the flow is 0.5L/min, the resistance shall be 5kPa to 10kPa. The Tenax TA-Carbopack X composite sorbent tube shall be filled with 2 layers of different adsorbents: not less than 175mg of Tenax TA (60 mesh to 80 mesh) and not less than 75mg of Carbopack X (60 mesh to 80 mesh). The sorbent tube shall be marked with the direction of air sampling flow. Before use, it shall be heated with nitrogen flow for activation. The activation temperature shall be 280℃ to 300℃, and the activation shall continue for no less than 10min until there are no impurity peaks. When the flow is 0.5L/min, the resistance shall be 5kPa to 10kPa.

2 The reference materials of benzene, toluene, and xylene.

3 The carrier gas shall be nitrogen, and the purity shall not be less than 99.99%.

D.0.4 Sampling precaution shall meet the following requirements:

1 The sorbent tube shall be opened at the sampling site, and vertically connected with the air inlet of the gas sampler (the air flow direction shall be consistent with the sampling direction marked on the sorbent tube). The flow rate shall be adjusted to be within the range of 0 to 0.5L/min for collecting 10L of air, and the sampling time, sampling flow rate, temperature, relative humidity and atmospheric pressure shall be recorded. The sampling system shall be calibrated with a flow meter calibrator.

2 After sampling, the sorbent tube shall be removed from the gas sampler, sealed at both ends, marked, and put into a sealable metal or glass container. The samples can be stored for 14 days.

3 The collection of blank samples from outdoor air shall be conducted simultaneously with the

collection of samples from indoor air, and the sampling location of outdoor air should be in the upwind direction.

D.0.5 The following recommended conditions can be set for gas chromatography analysis. Alternatively, other optimal analysis conditions can be set according to laboratory conditions:

1 Capillary column temperature: 60℃.

2 Detector compartment temperature: 150℃.

3 Vaporizer temperature: 150℃.

4 Carrier gas: Nitrogen.

D.0.6 For preparing the standard sorbent tube series , known concentrations of benzene , toluene , p (m)-xylene and o-xylene reference gas or reference solution shall be quantitatively injected into the sorbent tubes at room temperature from the air inlet, to prepare standard series of adsorption tubes with benzene content of 0.05μg, 0.1μg, 0.2μg, 0.4μg, 0.8μg, 1.2μg, and toluene and xylene content of 0.1μg, 0.4μg, 0.8μg, 1.2μg, 2μg, respectively, with nitrogen passing through at 100mL/min for 5min. Then, the standard sorbent tubes shall be sealed immediately.

D.0.7 The sample shall be analyzed by a gas chromatographer with thermal desorption apparatus (direct sample injection). The standard sorbent tubes and the sample sorbent tubes shall be placed in the thermal desorption apparatus (direct sample injection) , and the desorption gas flow direction shall be opposite to the sampling gas flow direction. After thoroughly desorbing (the desorption temperature is 350℃ for the activated carbon sorbent tube and 300℃ for the Tenax TA-Carbopack X composite sorbent tube) , the desorption gas directly enters the gas chromatographer through the sample injection valve for chromatographic analysis, using the retention time to determine the compound and using the peak area to determine the mass.

D.0.8 The concentration of benzene , toluene , and xylene in the air samples , and the concentration converted into the standard state shall be calculated according to the following formulas:

$$C = \frac{m - m_0}{V} \tag{D.0.8-1}$$

Where, C—the concentration of benzene, toluene, and xylene in the air samples(mg/m^3);

m—the mass of benzene, toluene, and xylene in the sample tubes(μg);

m_0—the mass of benzene, toluene, and xylene in the blank tubes(μg);

V—the air sampling volume(L).

$$C_c = C \times \frac{101.3}{P} \times \frac{t + 273}{273} \tag{D.0.8-2}$$

Where, C_c—the concentration of benzene, toluene, and xylene in the air samples after conversion to standard volume(mg/m^3).

P—the atmospheric pressure at the check point during sampling(kPa).

t—the temperature at the check point during sampling(℃).

Notes: 1 Where there is a dispute between the test results from an activated carbon sorbent tube and a Tenax TA-Carbopack X composite sorbent tube, the test result of the activated carbon sorbent tube shall prevail.

2 When sampling with an activated carbon sorbent tube, the air humidity shall be less than 90%.

Appendix E Measurement of TVOC in indoor air

E.0.1 TVOC in indoor air shall be tested according to the following steps:

1 A Tenax TA sorbent tube or Tenax TA-Carbopack X composite sorbent tube shall be used to collect a certain volume of air samples.

2 The sorbent tubes shall be heated by thermal desorption apparatus to obtain the desorption gas for TVOC analysis.

3 The desorption gas for TVOC analysis shall be injected into a gas chromatographer for qualitative and quantitative analysis.

E.0.2 Instrumentation of TVOC in indoor air shall meet the following requirements:

1 Gas sampler with constant flow rate: during the sampling process, the flow rate shall be stable, and the range of flow rates shall include 0.5L/min. When the flow rate is 0.5L/min, it shall be able to overcome the resistance of 5kPa to 10kPa. Where the sampling system is calibrated with a flow meter calibrator, the relative deviation shall not be larger than ±5%.

2 Thermal desorption apparatus: it shall be able to thermally desorb the sorbent tubes, and the desorption temperature and the flow rate of the carrier gas shall be adjustable.

3 Gas chromatographer equipped with hydrogen flame ionization detector (FID) or mass spectrometer (MS).

4 Capillary column: quartz column with a length of 50m and an inner diameter of 0.32mm, coated with polydimethylsiloxane (PDMS) or other non-polar materials.

5 Programmed heating process: the initial temperature shall be 50℃, and maintained for 10min. Then, the temperature shall rise to 250℃ at a rate of 5℃/min, and be maintained for 2min.

E.0.3 Reagents and materials shall meet the following requirements:

1 The Tenax TA sorbent tube can be a glass tube or a stainless steel tube with smooth inner walls, containing 200mg of Tenax TA sizing 0.18mm to 0.25mm (60 mesh to 80 mesh) or the Tenax TA-Carbopack X composite sorbent tube marked with the direction of the air sampling flow. Before use, the sorbent tube shall be heated with a nitrogen flow for activation. The activation temperature shall be higher than the desorption temperature, and the activation shall continue for not less than 30min until there are no impurity peaks. When the flow is 0.5L/min, the resistance shall be 5kPa to 10kPa.

2 The certified reference solution or reference gas shall be in accordance with those specified in Table E.0.3.

Table E.0.3 Certified reference solution or reference gas

No.	Chemicals	CAS No.
1	N-hexane	110-54-3
2	Benzene	200-753-7
3	Trichloroethylene	79-01-6
4	Toluene	108-88-3
5	Octene	111-66-0
6	Butyl acetate	123-86-4

Table E.0.3(continued)

No.	Chemicals	CAS No.
7	Ethylbenzene	100-41-4
8	p-Xylene	106-42-3
9	m-Xylene	108-38-3
10	o-Xylene	95-47-6
11	Styrene	100-42-5
12	Nonane	111-84-2
13	Isooctanol	104-76-7
14	Undecane	1120-21-4
15	Tetradecane	629-59-4
16	Cetane	544-76-3

3 The carrier gas shall be nitrogen, and the purity shall not be less than 99.99%. When the carrier gas of the MS is helium, the purity shall not be less than 99.999%.

E.0.4 Sampling shall meet the following requirements:

1 The sorbent tube shall be opened at the sampling site, and vertically connected with the air inlet of the gas sampler (the air flow direction shall be consistent with the sampling direction marked on the sorbent tube). The flow rate shall be adjusted to be within the range of 0.5L/min for collecting around 10L of air and the sampling duration, sampling flow rate, temperature, relative humidity and atmospheric pressure shall be recorded. The sampling system shall be calibrated with a bubble flow meter.

2 After sampling, the sorbent tube shall be removed from the gas sampler, sealed at both ends, marked, and put into a sealable metal or glass container. The samples shall be analyzed as soon as possible and shall not be stored for more than 14 days.

3 The collection of blank samples from outdoor air shall be conducted simultaneously with the collection of samples from indoor air, and the sampling location of outdoor air should be in the upwind direction.

E.0.5 For preparing the standard sorbent tube series, known concentrations of each component of reference gas or reference solution, quantitative injecting into the sorbent tubes, the content of each component shall be 0.05μg, 0.1μg, 0.4μg, 0.8μg, 1.2μg and 2μg, respectively, with nitrogen passing through at 100mL/min for 5min. Then, the series of standard sorbent tubes shall be sealed immediately.

E.0.6 The sample shall be analyzed by a gas chromatographer with thermal desorption apparatus (direct sample injection). The sorbent tubes shall be placed in the thermal desorption apparatus (direct sample injection), and the desorption gas flow direction shall be opposite to the sampling gas flow direction. After thoroughly desorbing with a desorption temperature of 300℃, the desorption gas directly enters the gas chromatographer through the sample injection valve for qualitative and quantitative analysis.

E.0.7 When FID detector is equipped, the retention time shall be used to determine the compound and the peak area shall be used to determine the mass. When MS detector is quipped, the retention time and the characteristic ions of each compound shall be used to determine the compound. After confirming the conditions of compounds, the quantitative ions shall be used to determine the mass of the compounds.

E.0.8 The sample sorbent tubes shall be analyzed using the same thermal desorption-gas chromatography

method as the standard sorbent tube series.

E. 0.9 The concentration of compounds in air samples shall be in accordance with the following requirements:

1 The concentration of each compound in air samples shall be calculated according to the following formula:

$$C_m = \frac{m_i - m_0}{V} \tag{E.0.9-1}$$

Where, C_m—the concentration of compound i in the air sample(mg/m^3).

m_i—the mass of compound i in the sample tube(μg).

m_0—the mass of compound i in the blank tube(μg).

V—the air sampling volume(L).

2 The concentration of each compound in the air sample shall be converted into the concentration in the standard state according to the following formula:

$$C_c = C_m \times \frac{101.3}{P} \times \frac{t + 273}{273} \tag{E.0.9-2}$$

Where, C_c—the concentration of compound i in the air sample after conversion to the standard volume (mg/m^3).

P—the atmospheric pressure at the check point during sampling (kPa).

t—the temperature at the check point during sampling (℃).

3 The concentration of TVOC in the air sample shall be calculated according to the following formula:

$$C_{TVOC} = \sum_{i=1}^{n} C_c \tag{E.0.9-3}$$

Where, C_{TVOC}—the concentration of TVOC in the air sample under the standard condition (mg/m^3).

C_c—the concentration of compound i in the air sample under the standard condition (mg/m^3).

Notes:

1 Using the toluene response factor, convert the area of unrecognized peaks into mass of toluene.

2 When there is a dispute between the test result of the Tenax TA sorbent tube and the Tenax TA-Carbopack X composite sorbent tube, the test result of the Tenax TA sorbent tube shall prevail.

Explanation of wording in this standard

1 Words used for different degrees of strictness are explained as follows in order to mark the differences in implementing the requirements of this standard.

1) Words denoting a very strict or mandatory requirement:

"Must" is used for affirmation;"must not" for negation.

2) Words denoting a strict requirement under normal conditions:

"Shall" is used for affirmation;"shall not" for negation.

3) Words denoting a permission of a slight choice or an indication of the most suitable choice when conditions permit:

"Should" is used for affirmation;"should not" for negation.

4) "May" is used to express the option available, sometimes with the conditional permit.

2 "Shall meet the requirements of..." or "shall comply with..." is used in this standard to indicate that it is necessary to comply with the requirements stipulated in other relative standards and codes.

List of quoted standards

GB 50108 *Technical Code for Waterproofing of Underground Works*

GB 50352 *Uniform Standard for Design of Civil Buildings*

GB 50736 *Design Code for Heating, Ventilation and Air Conditioning of Civil Buildings*

GB 6566 *Limits of Radionuclides in Building Materials*

GB/T 16143 *Charcoal Canister Method for Measuring ^{222}Rn Exhalation Rate from Building Surface*

GB/T 17657 *Test Methods of Evaluating the Properties of Wood-based Panels and Surface Decorated Wood-based Panels*

GB/T 18204.2 *Examination Methods for Public Places Part 2: Chemical Pollutants*

GB 18581 *Indoor Decorating and Refurbishing Materials—Limit of Harmful Substances of Solvent Based Coatings for Woodenware*

GB 18582 *Limit of Harmful Substances of Architectural Wall Coatings*

GB 18585 *Indoor Decorating and Refurbishing Materials—Limit of Harmful Substances of Wallpapers*

GB 18586 *Indoor Decorating and Refurbishing Materials—Limit of Harmful Substances of Polyvinyl Chloride Floor Coverings*

GB 18588 *Limit of Ammonia Emitted from the Concrete Admixtures*

GB/T 23985 *Paints and Varnishes—Determination of Volatile Organic Compound (VOC) Content—Difference Method*

GB/T 23990 *Determination of the Contents of Benzene, Toluene, Ethylbenzene and Xylene in Coatings by Gas Chromatography*

GB/T 23993 *Determination of Formaldehyde Content of Waterborne Coatings—Spectrophtometric Method with Acetylacetone*

GB 30982 *Limit of Hazardous Substances in Construction Adhesive*

GB 31040 *Limit of Residual Formaldehyde from the Concrete Admixtures*

GB/T 33372 *Limit of Volatile Organic Compounds Content in Adhesive*

GB 38468 *Limit of Harmful Substances of Interior Floor Coatings*

JG/T 415 *Limit and Test Method of Harmful Substances in Fire-Retardant Coating*