INDOOR AIR QUALITY RELATED STANDARDS IN CHINA

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ABSTRACT
In 2001, the Chinese national standard entitled "Code for Indoor Environmental Pollution Control of Civil Building Engineering" along with another 10 indoor air quality (IAQ) related standards were issued. In addition to this standard, the China Ministry of Health also issued the directive entitled "Hygienic Norm for Indoor Air Quality". This paper reviews the development of IAQ-related standards and regulations in China, specifying the scopes, objectives, administrative authorities, and implementation plan.

INDEX TERMS
Indoor air quality (IAQ), Standards and regulations, China.

INTRODUCTION
Recent high-speed economic growth has improved the living standards of many people in urban areas in China. A great number of airtight buildings with Heating, Ventilating, and Air Conditioning (HVAC) have been built, and refurbishing/remodeling/decorating of building interiors has become very popular. IAQ research began in the late 1970s (Li, 2000), and some comprehensive studies on IAQ were published during the 1980s (Cao, 1985). More and more evidence indicates that indoor air can be more seriously polluted than outdoor air, in even large and industrialized cities (Ma, 1999).

Concentration limits of 111 toxic substances and 9 dust standards relating to different production processes in workplaces and residential area were issued in the directive entitled Hygienic Standards for Industrial Enterprise Designing (TJ36-1979). TJ36-1979 is an important comprehensive hygienic standard that was jointly by the Ministry of Health, the State Basic Construction Commission, the State Plan Commission, the State Economic Commission and the State Labor Administration in 1979. This directive is still in effect at this time, however, the term "indoor environment" used in this paper does not include industrial settings and workshops.

The Air Pollution Prevention Act of the People's Republic of China, which came into effect on September 1, 2000, addresses the prevention of ambient (outdoor) air pollution. In order to control indoor air pollution, the Ministry of Health issued hygienic standards for 12 different categories of public places in 1988 (such as: hotels, entertainment halls, bathhouses, barbershops, beauty salons, indoor swimming pools, gymnasiums, libraries, museums, art galleries, exhibition galleries, emporiums and department stores, bookstores, hospital waiting rooms, public transportation waiting rooms, and restaurants) and issued a revised version of the standards in 1996. However, Chinese authorities did not stipulate any concentration limit standards for the indoor environment of civil buildings until 1995, when the Recommended

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Hygienic Standard for Indoor Formaldehyde was issued. In the following years, recommended hygienic standards for indoor bacterial total, carbon dioxide, inhalable particulate matter, nitrogen oxides, sulfur dioxide (1997) and benzo(a)pyrene (1999) were issued individually (GB/T 16127-1995, GB/T 17903~17907-1997, WS/T 182-1999). In the absence of standards for many indoor pollutants, the directive entitled "The Highest Concentration Limits of Air Pollutants in Residential Area", stipulated in TJ36-79 is referred to for determining the relevant enforceable standards in practice.

In 2000 and 2001, the government and the public began to pay special attention to problems related to indoor air pollution. The idea for issuing comprehensive standards for IAQ and related standards was proposed then. The authors of this paper have participated in drafting three of these standards: the "Code for Indoor Environmental Pollution Control of Civil Building Engineering" (GB 50325-2001), "Indoor Decorating and Refurbishing Materials - Limitations of Harmful Substances Emitted from Carpets, Carpet Cushions and Adhesives" (GB 18587-2001), and the "Indoor Environmental Quality Assessment Standard". This last standard was proposed by the State Environmental Protection Administration (SEPA) in 2001 but has not yet been promulgated.

CODE FOR INDOOR ENVIRONMENTAL POLLUTION CONTROL OF CIVIL BUILDING ENGINEERING (GB 50325-2001)

GB 50325-2001 was promulgated and enacted by the Ministry of Construction and the China State Quality Supervision-Inspection-Quarantine Administration (SQSIQA), and came into effect on January 1, 2002. This code addresses the control of indoor air pollution in newly constructed, enlarged and renovated civil building engineering, but not in industrial building engineering, storage buildings engineering, structures or rooms with special sanitary requirements. The only pollutants addressed in this code are those derived from the building and decorative materials themselves.

Civil building engineering is divided into two categories according to the different requirements involved in the control of indoor air pollution: Group I - residential apartments and houses, hospitals, old age homes, kindergartens, schools and, Group II - office buildings, shops, hotels, entertainment halls, bookstores, libraries, galleries, gymnasiums, public transportation waiting rooms, restaurants, barber shops.

Concentration limits of indoor pollutants for civil building engineering are listed in Table 1.

Table 1. Concentration limits of indoor pollutants for civil building engineering

Pollutant	*Civil Building Engineering Group I*	*Civil Building Engineering Group II*
Radon (Bq/m^3)	≤200	≤400
Released formaldehyde (mg/m^3)	≤0.08	≤0.12
Benzene (mg/m^3)	≤0.09	≤0.09
Ammonia (mg/m^3)	≤0.2	≤0.5
TVOC (mg/m^3)	≤0.5	≤0.6

Note: a. Except for radon, background concentration of the other outdoor air pollutants shall be measured. b. TVOC: total volatile organic compounds

GB 50325-2001 also stipulates limits of harmful substances in building materials and decorative materials including: 1) inorganic nonmetal building materials and decorative

materials such as sand, rock, brick, cement, commercial concrete, prepared structures, and wall bricks of new types; 2) wood-based panels and decorated wood-based panels; 3) water- and solvent-based paints; 4) water- and solvent-based adhesives and, 5) water-soluble treatment agents such as fire retardants, waterproof agents and antiseptics.

HYGIENIC NORM OF INDOOR AIR QUALITY AND RELATED CODES

The directive entitled "Hygienic Norm of Indoor Air Quality" was issued by the Ministry of Health and came into effect on January 1, 2002. This norm set the standards and sanitary requirements for IAQ of residential apartments and office buildings, the sanitary requirements for air ventilation and purification, and standard methods used to measure indoor air pollutants and other parameters. The IAQ standards in this code are listed in Table 2, 3 and 4, respectively.

Table 2. Concentration limits for indoor air pollutants

Name of Pollutant	*Unit*	*Concentration*	*Remark*[a]
Sulfur dioxide (SO_2)	mg/m^3	0.15	
Nitrogen dioxide (NO_2)	mg/m^3	0.10	
Carbon monoxide (CO)	mg/m^3	5.0	
Carbon dioxide (CO_2)	%	0.10	
Ammonia	mg/m^3	0.2	
Ozone	mg/m^3	0.1	Hourly average
Formaldehyde	mg/m^3	0.12[b]	Hourly average
Benzene	ug/m^3	90	Hourly average
Benzo(a) pyrene	$ug/100m^3$	0.1	
Inhalable particulate matter	mg/m^3	0.15	
TVOC	mg/m^3	0.6	
Bacterial total	cfu/m^3	2500	

Note: a. Daily concentrations if not specified otherwise.
b. Concentration limits of indoor formaldehyde is 0.08 mg/m^3.

Table 3. Concentration limits for radon and its products of decay in indoor air
(unit: Bq/m^3 □equilibrium equivalent concentration, yearly average)

Building type	*Concentration*
Apartment and house	200
Underground building	400

Note: Bq (becquerel): One Bq corresponds to one disintegration per second.

Table 4. Parameters for air-conditioned or heated indoor environment

Temperature (℃)	Winter	16-24
	Summer	22-28
Relative humidity (%)*	Winter	30~60
	Summer	40~80
Air velocity (m/s)		<0.3

Note: No limits for the humidity of the sites without air conditioners.

The concentration limits of 7 indoor air pollutants stipulated in this norm are the same as those in the recommended standards issued during the 1990s. The limits of bacterial total are 4000 cfu/m^3 in this norm and 2500 cfu/m^3 in GB/T 17903-1997. In addition, this code added

the concentration limits for 5 other pollutants including carbon monoxide, ammonia, ozone, benzene, TVOC and radon, along with HVAC parameters.

In addition to this norm, the "Hygienic Norm of Formaldehyde in Wood-Based Panels" and the "Hygienic Norm of Indoor Coating Materials" were issued at the same time by the Ministry of Health. These two norms established the sanitary requirements and measurement methods.

COMPULSORY NATIONAL STANDARD FOR LIMITS OF HARMFUL SUBSTANCES IN INDOOR DECORATIVE MATERIALS

SQSIQA established compulsory national standards for limiting harmful substances in ten kinds of indoor decorative materials, including: wood-based panel and finishing products, solvent coatings for woodenware, interior architectural coatings, adhesives, wood based furniture, wallpapers, polyvinyl chloride floor coverings, carpets, carpet cushions and adhesives, concrete admixtures, and radionuclides in building materials (GB18580~18588-2001, GB6566-2001).

Eight standards, not including "Limit of Radionuclides in Building Materials" (GB6566-2001) and "Limit of Ammonia Emitted from the Concrete Admixtures" (GB18588-2001), are classified as relating to indoor decorating and refurbishing materials. GB18580 to GB18588 are all new standards relating to IAQ. Other detailed information can be found in related standards.

DISCUSSION

GB 50325-2001 is the first official IAQ standard for civil building engineering in China. This code will create advantages for the construction of safe and comfortable civil buildings and will play an important role in protecting human health. This code has three features as follows: 1) It focuses on several indoor air pollutants such as radon, formaldehyde, ammonia, benzene and VOCs to limit those indoor air pollutants that are of greatest concern and have the most serious effects on human health. The limitations stipulated in this code are relatively strict, and although it is somewhat hard to meet the requirements, this code will be beneficial to both the country and the public for a long time. 2) Established IAQ objectives and requirement for civil buildings are divided into two categories according to the average length of time they are occupied and the amounts of accumulated indoor air pollutants. This division makes a distinction between various buildings as well as helps to limit the adverse effects of pollutants on human beings. It also promotes the reasonable use of building and decorative materials, thus reducing the costs of engineering. 3) This code is in effect from the design stage through to the final approval of the engineering plan, and addresses indoor pollution caused by furniture, appliances, devices, etc. The functional operations phase and management of a building are not covered by this particular code; its purpose is to manage the construction process as part of the engineering construction quality management system.

The "Hygienic Norm for Indoor Air Quality" hasfollowing features: 1) This norm addresses IAQ issues in residential apartments and office buildings, not other civil buildings such as libraries and hospitals. 2) This norm covers more pollutants than GB 50325-2001. 3) This norm set the hygienic requirements for IAQ during normal functioning conditions of civil buildings. Although it is not a compulsory national standard, it is the only systematical indoor hygienic norm, or indoor environmental quality assessment standard in China.

The ten compulsory national standards establishing limits for harmful substances in indoor decorative materials stipulates the limits of all significant harmful substances emitted/produced by indoor decorative materials, including: ammonia, formaldehyde, benzene, methylbenzene, dimethyl benzene, toluene diisocyanate (TDI), soluble lead, cadmium, chromium, mercury, arsenic. These standards are comparable to similar standards in developed countries. These 10 standards will not only provide technological foundations and goals for manufacturers and markets, but also limit control indoor air pollution sources.

There are several national IAQ standards at present in China that are mentioned above. These standards are valid in different circumstances, which, however, overlap in practice. For instance, the Indoor Environment Assessment Standard proposed by SEPA and the Hygienic Norm for Indoor Air Quality issued by the Ministry of Health are similar in terms of format, pollutants, classifications and various other aspects, but they differ in limitation values for specific indoor air pollutants. This situation creates management problems for planning and enforcement authorities.

Normally, a national standard should take few years to propose, draft, and evaluate before it becomes official. However, just within 2001, more than ten national standards related to IAQ were proposed, drafted and issued; they will be modified in the future when some shortcomings will be found in practice.

REFERENCES

Cao Shouren (Chief Editor). Indoor air pollution and measurement methods, Beijing: Chinese Environmental Press, 1988
GB 6566-2001, Limit of Radionuclides in Building Materials
GB 18580-2001, Indoor Decorating and Refurbishing Materials- Limit of Formaldehyde Emission of Wood-Based Panel and Finishing Products
GB 18581-2001, Indoor Decorating and Refurbishing Materials- Limit of Harmful Substances of Solvent Coatings for Woodenware
GB 18582-2001, Indoor Decorating and Refurbishing Materials – Limit of Harmful Substances of Interior Architectural Coatings
GB 18583-2001, Indoor Decorating and Refurbishing Materials - Limit of Harmful Substances of Adhesives
GB 18584-2001, Indoor Decorating and Refurbishing Materials - Limit of Harmful Substances of Wood Based Furniture
GB 18585-2001, Indoor Decorating and Refurbishing Materials - Limit of Harmful Substances of Wallpapers
GB 18586-2001, Indoor Decorating and Refurbishing Materials – Limit of Harmful Substances of Polyvinyl Chloride Floor Coverings
GB 18587-2001, Indoor Decorating and Refurbishing Materials - Limitations of Harmful Substances Emitted from Carpets, Carpet Cushions and Adhesives
GB 18588-2001, Limit of Ammonia Emitted from the Concrete Admixtures
GB 50325-2001, Code for Indoor Environmental Pollution Control of Civil Building Engineering
GB/T 16127-1995, Hygienic Standard for Formaldehyde in Indoor Air of House
GB/T 17903-1997, Hygienic Standard for Bacterial Total in Indoor Air
GB/T 17904-1997, Hygienic Standard for Carbon Dioxide in Indoor Air
GB/T 17905-1997, Hygienic Standard for Inhalable Particulate Matter in Indoor Air
GB/T 17906-1997, Hygienic Standard for Nitrogen Oxides in Indoor Air
GB/T 17907-1997, Hygienic Standard for Sulfur Dioxide in Indoor Air

Hygienic Norm for Indoor Air Quality (Division of regulation and supervision of Ministry of Health, 2001, No.255)
Li Xianting, et al. Status and development of indoor air quality research, HVACs, 2000, 30 (3): 36~40
Ma Renmin (1999), International development in research of indoor air quality in non-industrial buildings, HV&AC, 29(2): 38-41
TJ 36-1979, Hygienic Standard for Industrial Enterprises Designing
WS/T 182-1999, Hygienic Standard for Benzo(a)Pyrene [B(a)P] in Indoor Air