SINGAPORE STANDARDS COUNCIL

Overview of SS 554 on Air Indoor Air Quality for Air-Conditioned Buildings

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THINK GLOBAL, THINK STANDARDS

50 YEARS OF STANDARDISATION

Summary of key changes

- Aligning acceptable limits of indoor air quality parameters to international standards
- Specifying the reference methods and indicative methods for relevant parameters
- Enhancing the recommended filter ratings (from MERV13 to MERV 14) and providing information on filter use
- Specifying the number of sampling points according to floor sizes and ventilation types, in addition to number of floors

1. Aligning acceptable limits of indoor air quality parameters to international standards

Parameter	Operative temperature	Air movement
SS554:2009	24-26 °C	0.1-0.3 m/s
Revised	**23 – 25 °C (change to air temperature)**	**<0.3 m/s**
Standard adopted	SS553: 2009	SS553: 2009
Rationale	• Industry feedback on the difficulties of using operative temperature recommendations to control thermal comfort. • Air temperature is widely used to monitor and control ACMV system. • Air temperature can be used as a proxy for operative temperature, on the condition that radiant heat is minimised by meeting the minimum Envelope Thermal Transfer Values stipulated in the Singapore Building Code.	• Many buildings have air movement lower than 0.1 m/s but no complaints on thermal discomfort were noted in the air temperature range of 23-25ºC. • Air movement and air temperature can be controlled to improve thermal comfort. Low air speed can be compensated by reducing air temperature; High air temperature can be compensated by increasing air speed.
Measurement method	• ISO 7730	• ISO 7730

1. Aligning acceptable limits of indoor air quality parameters to international standards

Parameter	RH	Carbon dioxide (CO_2)	Carbon monoxide (CO)
SS554:2009	<65% (for buildings designed to SS 553/554: 2009 version) <70% (for other buildings)	700 ppm above ambient (8-hr)	9 ppm (8-hr)
Revised	**Unchanged**	**Unchanged**	**9 ppm (8 hr)** **31 ppm (1 hr)**
Standard adopted	ASHRAE 62.1-2013	ASHRAE 62.1-2013	WHO Guidelines for IAQ: 2010 Selected pollutants
Rationale	• For buildings built before 2009, there was no requirement on RH in the Building Code • SS553 and SS554 recommended RH to be < 65%, in 2009.	• Majority of visitors entering a space with CO_2 levels lower than the stated limit will be satisfied (with respect to human bio-effluent). • CO_2 is commonly used as a proxy for indoor pollutants.	• The inclusion of an additional short-term exposure limit is aimed to limit acute exposure to high levels of CO
Measurement method	• ISO 7730	• ISO 12039 • EPA IP-3A	• EPA IP-3C

Parameter	TBC	TFC
SS554:2009	500 CFU/m^3	500 CFU/m^3
Revised	**500 CFU/m^3 (good)** **1000 CFU/m^3 (acceptable)**	**Removed**
Standard adopted	HK's IAQ Certification Scheme (2003)	WHO, ASHRAE, AIHA, OSHA, ACGIH, NIOSH; Hong Kong, Korea did not recommend any limit on TFC.
Rationale	• TBC indicates sanitary condition of an indoor space and is necessary for tropical conditions where the amplification of microbes can occur rapidly. • Airborne bacteria count exceeding the limit does not necessarily imply health risk, but only serves as an indicator for thorough sanitation or further investigation. • 500 CFU/m^3 represents very good IAQ that a high-class and comfortable building should have; 1000 CFU/m^3 represents a good IAQ level that provides due protection to the public at large including sensitive groups.	• Mould allergens are not contributed by spores only, but also hyphae, fungal fragments, metabolites. • TFC also varies as more spores are released during germination and mycelial growth. • Non-biological particles may serve as carriers of fungal allergen molecules into the lung independently of the whole fungal spore • International cognizant org such as WHO, ASHRAE, AIHA, OSHA, ACGIH and NIOSH does not recommend max concn of bioaerosol levels. (WHO:2009 - dampness/ RH could be used as a risk indicator; ASHRAE:2013 - The presence of visible water damage or stains, visible mould, and/or odours from microbial growth —alone or in combination— is a warning for mould problems. • Although the meas of total fungal count has been removed, SS554 continues to recommend good practices to prevent mould growth and provides guidance on mould remediation in its annex C (Information on indoor air contaminants and micro-biological agents including guidelines on mould remediation)
Measurement method	• NIOSH 0800	• Not applicable

Parameter	Formaldehyde (HCHO)
SS554:2009	0.1 ppm or 120 µg/m^3 (8 hr)
Revised	**80 ppb or 100 µg/m^3** **(For any 30 mins slot in 8 hr)**
Standard adopted	WHO Guidelines for IAQ: 2010
Rationale	• Align with WHO standards • Formaldehyde is a known human carcinogen by International Agency for Research on Cancer (IARC) • The short-term guidelines will prevent effects on lung function as well as other long-term effect, e.g. nasapharyngeal cancer and myeloid leukaemia
Measurement method	• **Reference methods**: ISO 16000-3, NIOSH 2016, EPA IP-6A/B/C, EPA method 0100 • **Indicative method:** ISO 16000-2

Indicative method may not be as accurate as reference method, but can be deployed as a method for screening.

Parameter	Total Volatile Organic Compounds (TVOC)
SS554:2009	3,000 ppb
Revised	**1000 ppb (calibrated to isobutylene equivalent)**
Standard adopted	None
Rationale	• The limit is reduced to improve IAQ. • The old limit is the most lax among intnl standards. A survey of accredited laboratories suggests that the industry could easily meet the old limit with nearly 100% compliance • Improvement is sought within practical means. • Industry feedback that the 3000ppb limit is too relaxed; while the 261ppb limit (highest available international limit recommended by HK 2003, Finnish Society of IAQ & Climate 2001) would be a drastic change. • A limit of 1000 ppb would be appropriate based on data shared by IAQ consultants and instrument capabilities • High TVOC could indicate the exposure to specific hazardous compounds, such as benzene and its derivatives (which are quantifiable using reference method). • TVOC is an indicative/screening tool to provide quick information on the level of VOCs present in the indoor environment. If the TVOC level of a premise exceeds the rec limit, remediation work should be carried out. The tightening of the limit 3000ppm to 1000pm is a step towards adopting international standard in the future revisions.
Measurement method	• **Reference method:** EPA compendium method IP-1B • **Indicative method:** By real-time photoionisation detector

1. Aligning acceptable limits of indoor air quality parameters to international standards
2. Specifying the reference methods and indicative methods for relevant parameters

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Parameter	Respirable Suspended Particles (RSP)	PM 2.5
SS554:2009	50 μg/m^3 (8-hr)	35 μg/m^3 in Table 2 – Target contaminants triggered by specific sources
Revised	**50 μg/m^3 (24-hr)**	**37.5 μg/m^3 (24-hr)**
Standard adopted	"Singapore Ambient Air Quality Target by 2020" based on WHO interim target	"Singapore Ambient Air Quality Target by 2020" based on WHO interim target
Rationale	• Align with WHO recommendations. • Health effects of particles are based on 24-hour exposure period.	• Fine particles have more health implications. • NEA has included PM2.5 into the PSI reporting system.
Measurement method	• **Reference methods**: Gravitational analysis, beta-attenuation or indicative method s that are calibrated to the gravitational method. • **Indicative method:** EPA IP-10A/B (By real-time optical scattering or piezoelectric monitors)	

TABLE 2 – TARGET CONTAMINANTS TRIGGERED BY SPECIFIC SOURCES

Aligning acceptable limits of indoor air quality parameters to international standards – Table 2 (Target contaminants) parameters

Parameter	Semi volatile and volatile organic compounds (VOC)	Nitrogen dioxide (NO_2)	Ozone
SS554:2009	Follow Permissible Exposure Level (PEL) of WSH (General Provision) Regulations	100 μg/m^3	0.1 ppm
Revised	**Unchanged**	**40 μg/m^3**	**0.05 ppm**
Standard adopted	NIOSH	WHO Guidelines for IAQ: 2010	WHO Ambient air quality: 2005
Rationale		• The revised limit is aligned with WHO standards, where at this level, the risk of respiratory illness in children can be reduced	• The revised limit is aligned with WHO standards, where at this level, though some health effects may still occur, adequate protection of public health is provided.
Measurement method	• ISO 16000-6 • EPA IP-1B • NIOSH Manual of Analytical Methods 2549	• ISO 16000-15 • NIOSH Methods 6014 • EPA IP-5A/5B/5C	• ISO 10313

Aligning acceptable limits of indoor air quality parameters to international standards – Table 2 (Targeted contaminants) parameters

Parameter	Radon (Rn)	Absestos	Nicotine
SS554:2009	150 Bq/m^3	0.01 fibre/cc	Not detected
Revised	**100 Bq/m^3**	**Unchanged**	**0.01 µg/m^3**
Standard adopted	WHO Guidelines for IAQ: 2010	UK HSE Analysis Guide for Sampling of Asbestos	Detection limit of ASTM D5075 test method for nicotine & 2-ethenylpryridine in indoor air
Rationale	• Align with WHO • A level of 100 Bq/m^3 is justified from a public health perspective because an effective reduction of radon-associated health hazards for a population is herewith expected. (WHO,2009)		• Nicotine should not be detected in the non-smoking indoor environment. • Conditions for “not detected” depends on the detection limit of the measurement method
Measurement method	• EPA 402-R-95-013 • ISO 11665	• ISO 8672 or NIOSH 7400, followed by ISO 14966 or ISO 10312	• ASTM D5075 • NIOSH 2551

FILTRATION RECOMMENDATIONS

3. Enhancing the recommended filter ratings (from MERV13 to MERV 14) and providing information on filter use

<table>
<tr><th>Details</th><th>SS554:2009</th><th>Proposed revision</th></tr>
<tr><td>Filter rating</td><td>Primary filter: MERV 6
Secondary filter: MERV 13</td><td>MERV 14 (better protection than MERV 13)</td></tr>
<tr><td colspan="3">
<table>
<tr><th rowspan="2">ASHRAE 52.2 Minimum Efficiency Reporting Value (MERV)</th><th colspan="3">Composite average particle size efficiency, % in size range, µm</th></tr>
<tr><th>0.3 to 1.0</th><th>1.0 to 3.0</th><th>3.0 to 10.0</th></tr>
<tr><td>6</td><td>NA</td><td>NA</td><td>$35 \le E_3 < 50$</td></tr>
<tr><td>13</td><td>$E_1 < 75$</td><td>$90 \le E_2$</td><td>$90 \le E_3$</td></tr>
<tr><td>14</td><td>$75 \le E_1 < 85$</td><td>$90 \le E_2$</td><td>$90 \le E_3$</td></tr>
</table>
</td></tr>
<tr><td>Gas-phase filtration</td><td>Not mentioned</td><td>“Gas-phase filters could be used in conjunction with the particulate filter to control gaseous pollutant. For such purposes the fan motor needs to be sized accordingly such that the required air flow rate can be maintained.”</td></tr>
<tr><td>Information in Annex</td><td>Only filter efficiency</td><td>1. Needs for air filtration for better IAQ
2. Types of filters – selection and energy considerations, efficiency, best practices
3. Types of gas-phase filters</td></tr>
</table>

Alignment for air filtration clauses with SS553

	Nature of the Standard	Filter ratings
SS554	Specifies performance	"SS553 specifies the minimum filter requirement. In preparation for unforeseeable haze events, the use of fine dust filters, especially those having at least a rating of Minimum Efficiency Reporting Value (MERV) 14 (ASHRAE 52.2:2012) or F8 (EN779:2012), is recommended. Such filters can remove particulates more effectively than coarse dust filters and can keep the building and the ACMV system clean at all times."
SS553	Specifies design specifications	"The Minimum Efficiency Reporting Value (MERV) for cleaning the air in all air-handling units shall be equivalent to MERV 6 or better, and MERV 14 when the outdoor pollution level is in the unhealthy range in accordance with MOH's guidelines. The MERV for cleaning outdoor air supplied to fan coil units shall be equivalent to MERV 6 or better, and MERV 14 when the outdoor pollution level is in the unhealthy range in accordance with MOH's guidelines. Fan motors shall be sized such that the required air flow rate can be maintained."

RECOMMENDATION ON THE NUMBER OF SAMPLING POINTS

4. Specifying the number of sampling points according to floor sizes and ventilation types, in addition to number of floors

- SS554:2009 – “at least one sample should be taken from each separated area serviced by a separate air handling unit, fan coil unit or any air-conditioning or air distribution system.”
- Industry feedback that it is impractical to follow this recommendation due to cost and time consideration.
- Proposed revision specifies the minimum number of sampling points according to ventilation types (similar as in Hong Kong Guidance Notes for the Management of Indoor Air Quality in Offices and Public Places)

Ventilation type	Area of floor (m^2)	Minimum number of sampling points
Centralised ventilation	-	1 sampling point per system
Non-centralised ventilation	Below 3000	1 per 500 m^2 (minimum 2 points) - new
	3000 - 5,000	6 + 1 per 1000 m^2
	5,000 - 10,000	8 + 1 per 1250 m^2
	10,000 - <15,000	12 + 1 per 1500 m^2
	Above 15,000	15 + 1 per 2000 m^2

Representative organizations in SS554 Working Group



Special thanks to Camfil, Honeywell, for resources shared

THANK YOU