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APPENDICE E-I

Valori di concentrazione raccomandati in letteratura per gli inquinanti aerodispersi all'interno di musei, archivi e biblioteche

Inquinante	Archivi (NISO-TR01/95)	Museo (Brimblecombe)	UNI 10586/97
Biossido di zolfo	5–10 ppb (vol)	<0.4 ppb (vol)	≤10 µg/m ³
Biossido di azoto	5–10 ppb (vol)	<2.5 ppb (vol)	≤2 µg/m ³ (NO _x)
Ozono	5–10 ppb (vol)	1 ppb (vol)	≤2 µg/m ³
PS (fine)	rimoz. >95%	rimoz. >95% (>2µm)	≤50 µg/m ³

Tab. 1-E – Da: Ministero per i Beni e le Attività Culturali, Atto di indirizzo sui criteri tecnico-scientifici e sugli standard di funzionamento e sviluppo dei musei (D. Lgs. n.112/98, Art. 150, Comma 6)

Major indoor-generated pollutants found in museums	Suggested Pollutant Limits (ppb)		Action Limits (ppb)		Reference Concentrations (ppb)				
	Sensitive materials	Collections in general	High	Extremely high	Natural background levels	Urban areas	Health: Acute toxicity level for 1-hr exposure	U.S. EPA Clean Air Act limits	World Health Organization TWA limits
Hydrogen sulfide, H ₂ S	< 0.010	< 0.100	0.4–1.4	2.0–20	0.005–10 ³	0.1–5 ⁶ 0.080–0.150	OEHHA: 30 OSHA: 10 ppm		107 ppb
Organic Carbonyl Pollutants									
Organic acids	Acetic acid CH ₃ COOH	< 5	224 ^{7, 8} 40–280	200–480 ⁹	600–1000 ⁹	0.1–4 ⁴	0.1–16 ^{4, 10}	OSHA: 10 ppm	
	Formic acid ^k HCOOH	< 5	5–20	20–120	150–450	0.05–4 ¹¹ 0.05–0.2 ⁴	0.05–17 ¹⁰ 0.6–10 ⁴	OSHA: 5 ppm	
Aldehydes	Formaldehyde HCHO	< 0.1–5	10–20	16–120 ⁹	160–480 ⁹	0.4–1.6 ²	1.6–24 ¹² new home: 50–60 ¹³	OEHHA: 75 OSHA: 750	80 [30 min]
	Acetaldehyde ^l , CH ₃ CHO	< 1–20					3–17 ¹²	OEHHA ^m : 5 OSHA: 200 ppm	
Total VOCs (as hexane) ⁿ		< 100 ppb	700 ppb	1700 ppb		New or renovated building 4500–9000 ¹⁴			

1. World Health Organization 2000.
 2. Seinfeld 1986.
 3. Graedel 1984.
 4. Tétéault 2003b.
 5. Grosjean 1988.
 6. Graedel, Kammlott, and Franey 1981.
 7. Sano 1999.
 8. Sano 2000.
 9. Bradley and Thickett 1999.
 10. Kawamura, Steinberg, and Kaplan 1996.
 11. Granby and Christensen 1997.
 12. Grosjean and Williams 1992.
 13. Hodgson et al. 2000.
 14. Rothweiler, Waeger, and Schlatter 1992.
 15. Lavedrine 2002.
 16. NAFA 2004.
^aThese are current standards based on the best available sources and are not meant to be absolute and final concentration recommendations. Concentrations limits for materials and objects continue to be reviewed. Two sources are CCI (www.cci-icc.gc.ca) or the IAQ in Museums and Archives website (IAQ.dk).
^bMaximum levels allowed to ensure minimum risk to sensitive objects; assumes a temperature between 15°C and 25°C, cleanliness of the collection, and RH below 60% and ideally below 50% (Tétéault 2001).
^cTemperature and relative humidity as well as pollutant concentration should always be minimized to reduce risk.
^dMitigation measures should be taken to protect objects in the collection.
^eSensitive materials are those that are at risk from the particular gaseous pollutant; see Appendix 1.
^fAcute Reference Exposure Levels (RELEs) established by the California Office of Environmental Health Hazard Assessment (California OEHHA 2000).
^gU.S. Environmental Protection Agency Office of Air and Radiation Clean Air Act limit (U.S. EPA 1990).
^hWorld Health Organization's maximum exposure recommendations (World Health Organization 2000).
ⁱU.S. Department of Labor: Occupational Safety and Health Agency Maximum Permissible Exposure Limit (PEL) for an 8-hour workday.
^jNO is unstable and will break down. However, it reacts with ozone to form HNO₂, nitrous acid, which is damaging. To reduce the risk from NO, eliminate O₃.
^kVery little is known about the effects of formic acid at various concentrations.
^lLittle damage has been directly attributed to acetaldehyde.
^mChronic RELs established by California OEHHA (2005).
ⁿTotal VOCs are reported referenced to a calibrated gas such as hexane or toluene.

Major outdoor pollutants found inside museums	Suggested Pollutant Limits for Collections (ppb) ^{b, c}		Action Limits ^d (ppb)		Air Quality Recommendations (ppb)		Reference Concentrations (ppb)				
	Sensitive materials ^e	Other materials in collections	High	Extremely high	Archival document storage ¹⁵	Libraries, archives and museums ¹⁶	Natural background levels	Urban areas	Health: Acute toxicity level for 1-hr exposure	U.S. EPA Clean Air Act limits ⁸	World Health Organization ^h TWA limits
Nitrogen dioxide, NO ₂	< 0.05–2.6	2–10	26–104 ¹	> 260 ¹	Canada: 2.6 USA: 2.6	2.6	0.2–4.9 ¹ 0.05–0.3 ^{2, 3}	1.6–68 ⁴ 10–47 ¹ USA: 22–52 ⁴ Canada: 16–22 ⁴ Europe: 2–34 ⁴	OEHHA ⁱ : 246 OSHA ^j : 5 ppm	50 [1 yr]	104 [1 hr] 21 [annual] 62 [8 hr]
Nitrogen monoxide, NO (see ozone)							0.16–1.6 ⁴ 1–21 ⁵	1.6–32 ⁵	OSHA: 25 ppm		
Acidic nitrogen gases, HNO ₂ , HNO ₃	< 0.1	< 1.0					0.02–0.2 ²	1–11 ⁴ 3–49 ²	OEHHA (HNO ₃): 33		
Ozone, O ₃	< 0.05	0.5–5	25–60	75–250	Canada: 1.0 USA: 13	2.0	1–100 ⁴	5–200 ¹ 20–150 ¹ USA: 100–120 ⁴ Canada: 17–21 ⁴ Europe: 65–145 ⁴	OEHHA: 90 OSHA: 100	120 [1 hr] 80	60 [8 hr]
Sulfur dioxide, SO ₂	< 0.04–0.4	0.4–2	8–15	15–57	Canada: 0.4 USA: 0.4	1.0	0.04–11 ⁴ Rural: USA: 6–10 ⁴ Europe: 1–14 ⁴	8–380 ¹ 2–152 ⁴ USA: 4–6 ⁴ Canada: 4–6 ⁴ Europe: 2–94 ⁴	OEHHA: 248 WHO: 19 OSHA: 5 ppm	30 [1 yr] 140 [24 hr]	190 [10 min] 10 [24 hr] 19 [annual]

Tab. 2-E – Da: Cecily M. Grzywacz, *Monitoring for Gaseous Pollutants in Museum Environments*, The Getty Conservation Institute, Los Angeles, 2006.

Key airborne pollutants	Maximum average concentration for indicated preservation targets, $\mu\text{g m}^{-3}$ (ppb) ¹			Reference average concentration range, $\mu\text{g m}^{-3}$	
	1 yr	10 yrs	100 yrs	Clean low troposphere	Urban area
Acetic acid	1000 (400)	100	100	0.3-5	0.5-20 ²
Hydrogen sulfide	1 (0.71)	0.1	0.01	0.01-1	0.02-1
Nitrogen dioxide	10 (5.2)	1	0.1	0.2-20	3-200
Ozone	10 (5.0)	1	0.1	2-200	20-300
Sulfur dioxide	10 (3.8)	1	0.1	0.1-30	6-100
Fine particles (PM _{2.5})	10	1	0.1	1-30	1-100
Water vapour	keep below 60% RH ³			N/A	

Tab. 3-E - Linee guida sulle massime concentrazioni raccomandate di inquinanti aerodispersi per incorrere a rischi minimi per collezioni composte da oggetti di vario tipo per determinati periodi di esposizione (Tetreault, 2003 e ASHRAE Handbook, 2019). Le concentrazioni massime sono state raggruppate in 3 “preservation targets”: 1, 10 e 100 anni. Il “preservation target” è il periodo di tempo (in anni) per il quale gli oggetti possono essere esposti al livello indicato di inquinanti con il minimo rischio di deterioramento. Questi obiettivi si basano sul LOAED (lowest observed adverse effect dose) osservato per la maggior parte degli oggetti che solitamente compongono una collezione (escludendo gli oggetti ad alto rischio) e presuppongono che l'UR media sia mantenuta tra il 50 e il 60%, che la temperatura sia compresa tra 20° e 30°C e che la raccolta sia sottoposta a manutenzione regolare (<https://www.canada.ca/en/conservation-institute/services/conservation-preservation-publications/technical-bulletins/pollutants-museums-archives.html>)