

# The Effect of UV-C Irradiation inside AHU (Air Handling Unit) against Mold Development: A case of the Tokyo Metropolitan Central Library

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## 1. Introduction

The Tokyo Metropolitan Central Library located in Arisugawa-no-miya Memorial Park, which is in the middle of deep forest, central Tokyo, was established in 1973, and greets 42 years old this year. In summer 2005, outbreak of mold development confirmed over large quantities in B2 underground confluence book storage room (approx. 400,000 books stored), and fumigated approx. 60,000 books. But mold occurred to develop again in the next year, and those sterilized approx. 20,000 books. Two consecutive years of mold outbreak led this organization to recognize that coping therapy cannot exterminate damage by mold and, took various measures in order to make "the environment where mold did not grow" from the point of view, such as water (temperature-humidity), nourishment and, mold spore. For example, redecorated three folds of walls in the storage room into the existing wall and, set industrial dehumidifiers and circulators, periodical routine cleaning, change air pressure in the storage room to positive, and temperature-humidity management by data loggers, prepare adhesion mat to library doorway to capture earthy articles and, visual mold inspection by supplier. However damage by mold did not completely exterminate, it decreased year by year and became minimal though. Hence, mold spore was further paid attention as entering from outlet of air conditioning system, and introduced UV-C emitter integrated inside AHU (Air Handling Unit) in March, 2013.

## 2. Adoption of UV-C emitter (exclusive use for AHU)

The UV-C emitter (exclusive use for AHU) set it down stream of cooling coil in AHU and, sterilizes microorganism such as bacteria and fungi on the coil surface and flowing air through AHU, with irradiating very strong ultraviolet rays (UV-C). We have 2 AHU's for archives: one is for underground book storage rooms, the other AHU is for upper floor book storage rooms. Both made back in 1996 which always take outside fresh air in.

UV-C emitter: **Steril-Aire, Inc.**

Configuration (& when emitter adopted):

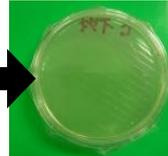
- AHU for underground book storage rooms (3/11/ 2013) : SE 61" x 4, SE 42" x 4 (4 rows)
- AHU for upper floor book storage rooms (1/17/ 2014) : SE 61" x 2, SE 42" x 2 (2 rows)

## 3. Verification - Before & After UV-C -

Microbial test (contact plate & air bio test) was done, "Prior to" and "Post" UV-C irradiation in the AHU's.

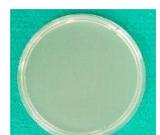
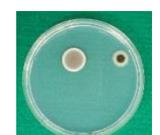
### (1) Contact Plate Test

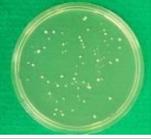
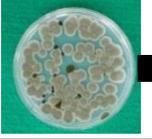
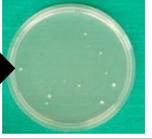
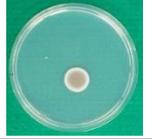
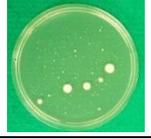
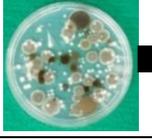
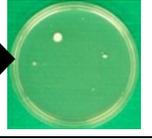
- Target : Coil surface of the AHU for underground book storage room
- Date : Before UV-C : September 4<sup>th</sup>, 2012  
: After UV-C : July 11<sup>th</sup>, 2013
- Method : Contact plate for Bacteria and Fungi
- Culture Condition : 5 days kept at approx. 27 DegC

	Before UV-C (9/4/2012)		After UV-C (7/11/2013)	
	Bacteria	Fungi	Bacteria	Fungi
<Adherent Microorganism> Coil surface of the AHU for underground book storage room				

### (2) Air Bio Test

- Target : ① Flowing air inside the AHU for underground book storage rooms  
: ② Air outlet from the AHU for ”  
: ③ Flowing air inside the AHU for upper floor book storage rooms  
: ④ Air outlet from the AHU for ”
- Date : ①, ② : Before UV-C : N/A  
: After UV-C : August 19<sup>th</sup>, 2013  
: ③, ④ : Before UV-C : ”  
: After UV-C : August 19<sup>th</sup>, 2014
- Method : Collision method (suction volume: 250Liter)  
by the airborne microbe sampler (MIDORI ANZEN Co., Ltd.)  
\* SA from air outlet from the duct was sealed to eliminate the influence of other air
- Culture Condition : Bacteria : 3 days kept at 30±1.0DegC  
: Fungi : 5 days kept at 25±1.0DegC

	Before UV-C		After UV-C (8/19/2013)	
	Bacteria	Fungi	Bacteria	Fungi
<Airborne Microorganism> ① Inside AHU for underground book storage rooms	---	---	4 cfu/m <sup>3</sup> 	8 cfu/m <sup>3</sup> 
<Airborne Microorganism> ② Air outlet from AHU for underground book storage rooms	---	---	0 cfu/m <sup>3</sup> 	8 cfu/m <sup>3</sup> 

	Before UV-C (8/19/2013)		After UV-C (8/19/2014)	
	Bacteria	Fungi	Bacteria	Fungi
<Airborne Microorganism> ③ Inside the AHU for upper floor book storage rooms	316 cfu/m <sup>3</sup> 	460 cfu/m <sup>3</sup> 	48 cfu/m <sup>3</sup> 	8 cfu/m <sup>3</sup> 
<Airborne Microorganism> ④ Air outlet from AHU for upper floor book storage rooms	632 cfu/m <sup>3</sup> 	576 cfu/m <sup>3</sup> 	32 cfu/m <sup>3</sup> 	12 cfu/m <sup>3</sup> 

#### 4. Conclusion

It has been found, by contact plate test prior to the emitter's installation, that the AHU's internal environment was contaminated. That means, adhering microorganisms constitutes "bio-film" on the surface of heat exchange coil (cooling coil) of AHU, as well as airborne microorganism with the air passing through, are said to be diffused and spread into the archive. Visual mold inspection has been done annually since the outbreak in 2005, discovered the number become zero (0) eventually after adopting UV-C emitter in 2014. This may well be considered that by this UV-C emitter, contamination inside AHU is dramatically reduced, consequently airborne mold spores in the archive has been reduced. It is essential to control daily environment for fungi measures, we are convinced to put this new idea (applying UV-C emitter in AHU), are able to reduce the risk of mold outbreak. It is greatly appreciated if our library's case can be help as a good reference to the people, the organizations suffering from mold development.