UV Disinfection in Public Transportation

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(Part 1)

Introduction

Cost-efficient, personal safety, reduced pollution, fewer number of accidents and less traffic congestion are the typical benefits of public transport leading people to use transits. It is crucial to have comfortable, reliable and affordable public transportation system. One of the things passengers care deeply about is cleanliness especially with the spread of coronavirus in these days. Disinfection and sterilization are essential for ensuring that transit vehicles do not transmit infectious pathogens to passengers. Growing concerns over possible cross infections via airborne micro-organisms, floors, cloth seats, most commonly touched - buttons, handrails, handles, ticket validators and ticket vending machines induced people around the world to introduce UV[1] disinfection. The germ-killing power of ultraviolet light can protect people from harmful germs resisting to traditional forms of disinfecting. UV light provides rapid, effective inactivation of microorganisms through a physical process. It has been employed in the disinfection of transit vehicles and facilities. Disinfection procedures should be designed to remove all infectious pathogens. The paper addresses UV disinfection mostly in Moscow Metro Public Transport Systems [1]. Russia is not the only place to use UV light. Due to the widespread outbreak of the coronavirus (COVID-19), New York MTA[2] worked with Columbia University to test UV technology on its transits as shown in Figure 1 [2, 3]. TriMet[3], NCTD[4] and GCRTA[5] have recently begun testing UV lights for interior surface disinfection [4]. UV disinfecting has also being tested in India and Spain to disinfect transit vehicles and facilities to fight COVID-19 spread [5][6].

1 Ultraviolet

2 Metropolitan Transportation Authority

3 known as the Tri-County Metropolitan Transportation District of Oregon in the U.S.

4 The North County Transit District in North San Diego County, California, United States

5 Greater Cleveland Regional Transit Authority in Cleveland, Ohio

Figure 2. New York MTA UV disinfecting technology [3].

Metro Public Transport Systems

Much of the current debate revolves around whether it is wise to use metro in corona time. It is a very controversial question rendering discussions. The UV disinfection assert that it can be safe. Since metro is an underground railway system, it is necessary to disinfect the air in addition to surfaces. A salient example would be heavily populated Moscow Metro. The adequate UV doses to inactivate micro-organisms and pathogens were determined for three areas by LIT Technologies and the Russian Research Institute of Railway Hygiene: internal surfaces of train carriages, escalator hand rails, air in passage ways and platforms in railway stations. Low pressure mercury UV lamps have low energy efficiency so LIT Technology developed a series of straight and U-shaped LPHO[6] "Amalgam" UV lamps for Metro disinfection applications [1]. Amalgam lamps offer significantly greater power than low pressure mercury UV lamps. Mercury low pressure lamps typically have an electrical power of 0.3 to 0.5 W/cm^2 of illuminated length but Amalgam lamps approach 6 W/cm^2. Figure 2 shows 254 nm spectrum of a UV amalgam lamp and an effective spectrum for killing bacteria [7].

6 Low Pressure High Output

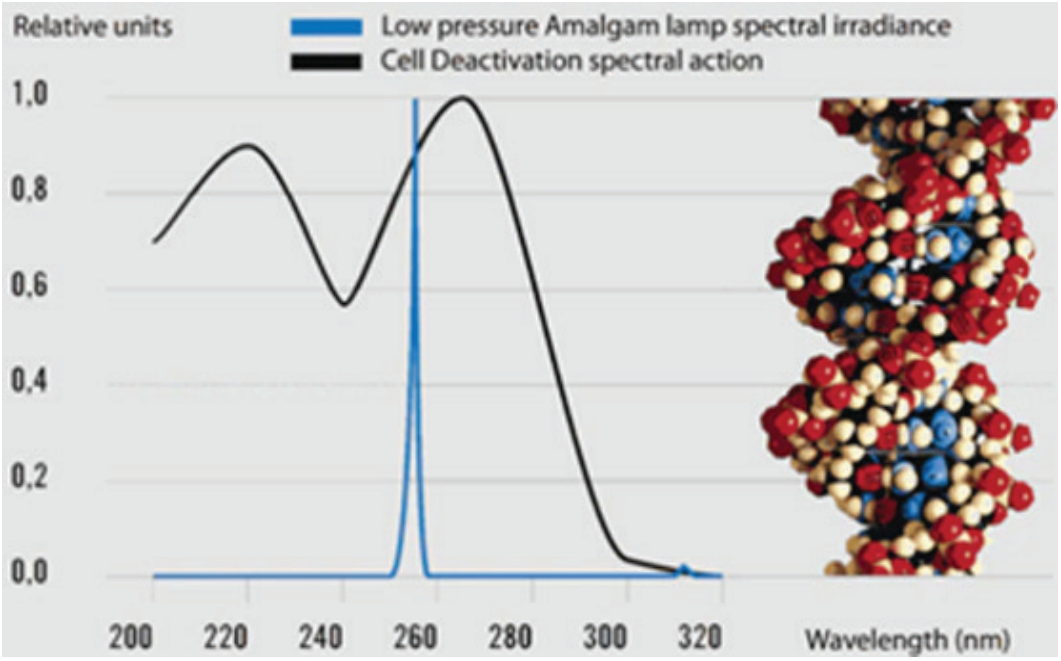

Figure 3. UV amalgam lamp for cell deactivation [7].

The optimum UVGI[7] efficiency wavelength is about 254 nm. Aromatic amino acids are the main agents causing UV absorption between 220 and 280 nm simply because micro-organisms on surfaces are always embedded in and shielded by protective layers of proteins. Furthermore, the type and structure of surfaces like imitation-leather seats, linoleum, rubber escalator hand rails, as well as glass and metal surfaces have a strong influence in dropping the overall UVGI efficiency, mainly because the different structures create shadows for the UV radiation. The various UV doses at 253.7 nm to disinfect 90% for different types of surfaces can be seen in Figure 3.

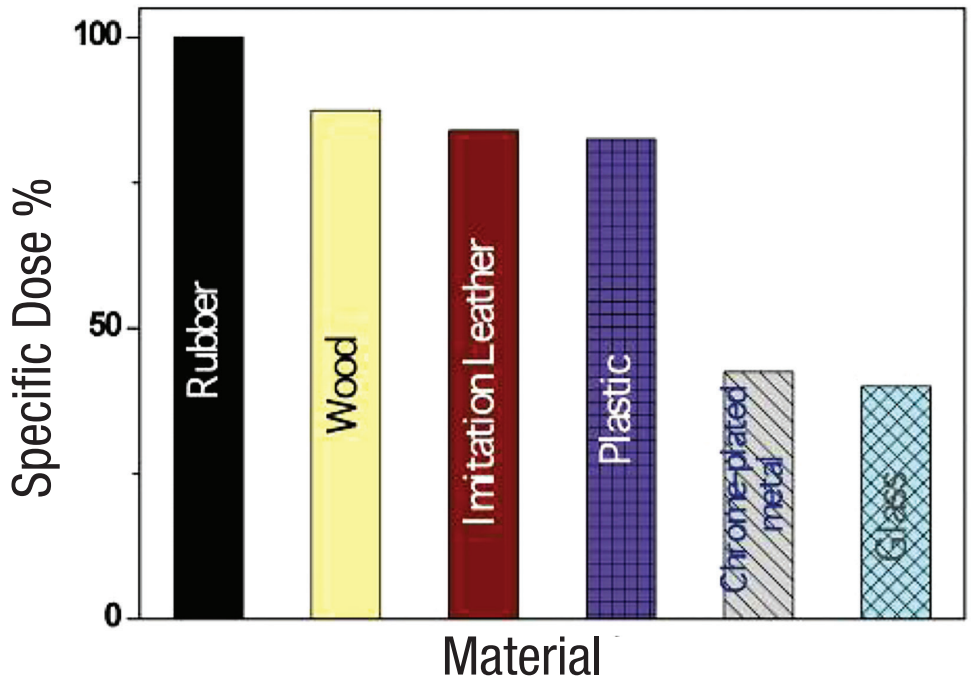

Figure 4. UV doses at 253.7 nm for different surfaces [1].

7 Ultraviolet Germicidal Irradiance

Internal surfaces of train carriages

Internal surfaces and the air of train carriages was disinfected by a trolley equipped with two 170 W U-shaped amalgam lamps and a timer (Figure 4). The effect of different UV doses and irradiation cycle of the carriage has been shown in Table 1. Also the average percentage of disinfection left end, middle and right end of the seats and backs can be seen [1].

Figure 5. UV system for interior disinfection [1].

Table 1. The effect of UV irradiation on disinfection[1].

Irradiation cycle - 21 min, UV dose -4025-4600 J/m^2 for seats; -5750-7475 J/m^2 for the backs of the seats	seat: average reduction 96.47% back: average reduction 96.20%
Irradiation cycle - 15 min UV dose -2625-3000 J/m^2 for seats; -5750-7475 J/m^2 for the backs of the seats	seat: average reduction 96.53% back: average reduction 96.67%
Irradiation cycle –6 min UV dose - 1155-1320 J/m^2 for seats; - 1650-2145 J/m^2 for the backs of the seats	seat: non disinfected back: non disinfected
Irradiation cycle - 3 min UV dose - 190-216 J/m^2 for seats; 270-350 J/m^2 for the backs of the seats	seat: non disinfected back: non disinfected

At present internal surfaces of train carriages and train interiors are exposed to 25 minute doses of UV-C.

UV radiation not only doesn't add toxic substances but also reduces harmful chemicals. Chemical analysis results of air in metro carriages prior to and after 25 minute UV irradiation is shown in Table 2 [1].

Table 2. Chemical analysis results [1].

Chemical	Chemical concentrations before UV	Chemical concentrations after UV
Benzol	Carriage No.1: 0,057 Carriage No.2: 0,035	No No
Acrolein	Carriage No.1: 0,054 Carriage No.2: 0,015	0,017 0,011
Acetone	Carriage No.1: 3,63 Carriage No.2: 1,99	1,21 No
Ammonia	Carriage No.1: 0,045 Carriage No.2: 0,120	0,052 0,122
Ozone	Carriage No.1: No Carriage No.2: No	0,15 0,14
Phenol	Carriage No.1: No Carriage No.2: No	No No

Escalator hand rails

Under UV system with two LIT U-shaped amalgam 170 W lamps about 10 seconds will be achieved 99 % disinfection escalator handrails (Figure 5) [1].

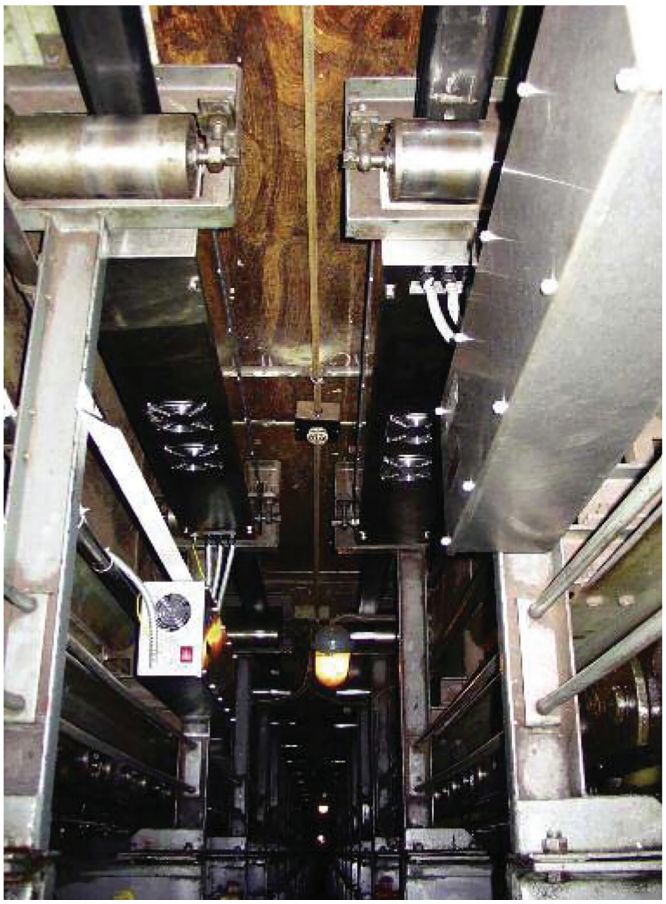

Figure 6. UV system on escalator handrails [1].

Air in passage ways and platforms in railway stations

UV disinfection air re-circulators of type AR-UF-170P-2 (with two 170 W lamps inside) with a capacity of 400 m^3/h disinfect with people inside the facility, for a continuously operation (Figure 6) [1].

Figure 7. UV disinfection air re-circulators [1].

References

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