

## I.2: Integration of ultraviolet – C fixtures in HVAC system for improved air quality

Heating, ventilation and air conditioning (HVAC) system comprising of dedicated air handling units (AHUs) and air duct networks are commissioned in various labs, offices and other facilities at RRCAT. The AHUs are designed to operate in recirculation mode with continuous fresh air intake of 10-15%. Good quality of air for occupants is ensured by regular maintenance of the HVAC systems. Under prevailing COVID-19 conditions, additional measures were put in place to further improve the air quality of closed office spaces. One such measure was to operate the AHUs in once through mode, where in the return air is blocked and 100% fresh air is fed. However, it is difficult to achieve the comfort temperature in summer season in this arrangement. Thus other option based on ultraviolet – C (UV-C) radiation was also explored.

UV-C radiation is known for its beneficial use in inactivating bacteria, virus, and fungus population. Also, as per the recommendations of 2019 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) handbook on HVAC applications, 'an UV-C installation that produces a maintained, uniform distribution of ultraviolet irradiance averaging between 30-50  $\mu\text{W}/\text{cm}^2$  is effective in inactivating the most air borne droplets nuclei containing mycobacteria and is presumably effective against virus as well. The required average irradiance for a typical in-duct system is of the order of 1000 to 10,000  $\mu\text{W}/\text{cm}^2$ , but it could be higher or lower depending on application requirements'. The higher side irradiance is recommended for public installations like hospitals, conference halls, air ports, etc., wherein population density and probability of spread of infection is high. In a recycled HVAC system, wherein substantial volume of air is recirculated in closed loop through AHU for purification and control of temperature and humidity, the installation of UV-C fixtures is effective in improving the air quality. This enables high retention time and repeated UV-C exposure from different angles to bacteria, virus, and fungus blown with air, which leads to effective inactivation of germs. The continuous UV-C irradiation of air in recirculation mode is more effective in inactivating the harmful virus. As per ASHRAE, the minimum UV-C dose of 611  $\mu\text{J}/\text{cm}^2$  should be applied for 90% inactivation of SARS-CoV-2, i.e. COVID-19. A typical recommended scheme by ASHRAE for the AHUs with UV-C fixtures is shown in Figure I.2.1.

Under prevailing COVID-19 conditions, it was planned to integrate the UV-C fixtures in various existing AHUs in a phased manner. In the first phase, it was planned to integrate UV-C fixtures in 40 AHUs in large buildings, namely library, Auditorium, ADL, Indus-1, Indus-2 and RF. Necessary arrangements are made to have sufficient UV-C irradiance at downstream of cooling coil in each AHU, along with safety interlocks to ensure no exposure of UV to maintenance staff. The work involved mounting of Philips make, model TUV 36 W SLV/6 germicidal UV-C lamps, door safety interlock and associated electrical control wiring. 160 numbers of UV-C germicidal lamps are commissioned in 40 AHUs and are in service presently.

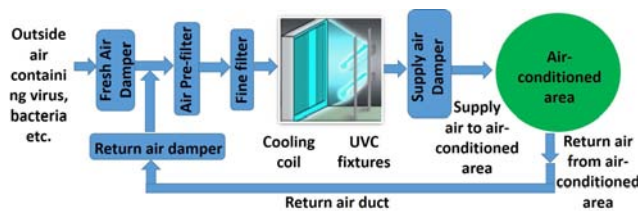


Fig. I.2.1: Recommended scheme by ASHRAE for the AHUs with UV-C fixtures.

Figure I.2.2 shows operational AHU-36 commissioned with germicidal UV-C lamps at Indus-2 complex.



Fig. I.2.2: Photograph showing germicidal UV-C lamps integrated in AHU at Indus-2 complex.

Typical size (area) of cooling coil in AHUs is 250 cm x 150 cm (i.e. 37,500  $\text{cm}^2$ ). Each germicidal lamp produces 15 W UV-C radiation and has effective life span (L70) of approximately 9000 hours. Thus the mounting arrangement of four lamps provides UV-C irradiance of 1600  $\mu\text{W}/\text{cm}^2$ . The air velocity at cooling coil of AHUs is of order of 2.5 m/s and exposed air path length is more than one metre. Thus, the arrangement provides UV-C dose around 640  $\mu\text{J}/\text{cm}^2$ , which is more than the ASHRAE recommendations for inactivating 90% of SARS-CoV-2.

Thus, by following the ASHRAE recommended guidelines, the integration of UV-C fixtures in HVAC systems improves the air quality and cleanliness of cooling coil as well by inactivating bacteria, virus and fungus population in the air. This will minimize the possibility of spread of air borne diseases like COVID-19 by respiration among the occupants who are sharing common air space. The cleanliness of cooling coil will also contribute to effective heat transfer and enhance the cooling efficiency of AHUs.

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