



Aerosol and Surface Contamination from Controlled Aerosol Releases in the Cruise Ship Environment to Simulate the Spread of Infectious Disease

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ABSTRACT:

During July of 2020, researchers from the University of Nebraska Medical Center and the National Strategic Research Institute studied the transport of inert aerosol particles in the public spaces and cabins on *Oasis of the Seas*, while the cruise ship was berthed in Miami. These nine experiments were designed to understand the role of ship ventilation systems in the spread of airborne diseases, like COVID-19, and to provide a scientific basis for changes to shipboard operation to minimize the spread of disease.

In this study, no exchange of aerosol particles was observed between spaces only connected by the ventilation system (such as adjacent staterooms, both crew and guest), indicating that the likelihood of aerosol exchange between adjacent rooms is very unlikely. Improved filtration (i.e., MERV13) in the air ventilation path will further reduce the likelihood of cross-contamination of the incoming fresh air.

In the public areas, test aerosol appeared to move directly between the connected spaces (outside of the ventilation systems), as expected, but smoke control systems in the public areas appear to impact the transport. Aerosol released in areas equipped to manage tobacco smoke (casino and comedy club) were largely contained within those areas. Aerosol released in the ice rink venue, which does not allow smoking, migrated to the comedy club, likely due to the smoke control system in that space. The lounge, a “no smoking” area adjacent to releases in both the comedy club and ice rink, where no release was performed, showed no evidence of aerosol or surface contamination. In general, particles released in the public areas were not observable after 15 minutes, likely due to dilution in the large spaces.

Particles released in guest rooms decayed differently, depending on whether balcony and hallway doors were open. The local fan coil unit, which in these spaces was equipped with a MERV 13 filter, likely contributed to the removal of test aerosol from the room, beyond what we expected by fresh air exchange alone. The fastest particle removal occurred when the balcony door was open, likely due to the introduction of outside air. The slowest decay occurred when the hallway door was open. When the hallway door was opened and ajar for more than one hour, transport of aerosol into the hallway was observed.

TABLE 1: AEROSOL AND SURFACE CONTAMINATION DATA ANALYSIS

Test No.	Area	Deposited contamination in Air Handling Unit	Airborne Contamination in Adjacent Rooms	Airborne Contamination in Connected Spaces	Surface Contamination Observed in Adjacent Rooms	Surface Contamination Observed in Connected Spaces	Aerosol Decay from Release
1	Crew stateroom	Not Detected	Not Detected	NA	Not Detected	NA	NA
2	Crew stateroom	Trace (~99.7% reduced)	Not Detected	NA	Not Detected	NA	NA
3	Crew stateroom	Trace (~99.9% reduced)	Not Detected	NA	Not Detected	NA	NA
4	Guest stateroom (doors closed)	Detected*	Not Detected	NA	Not Detected	NA	~23 min
5	Guest stateroom (hallway door open)	Detected*	Not Detected	Detected (hallway)	Not Detected	Not Detected	~41min
6	Guest stateroom (balcony doors open)	Detected*	Not Detected	NA	Not Detected	NA	~15mins
7	Casino	Not Detected	NA	Not Detected	NA	Detected (hallway)	<10mins
8	Ice rink	Not Detected	NA	Detected (comedy club, hallway)	NA	Detected (comedy club, hallway)	<10mins
9	Comedy club	Not Detected	NA	Not Detected	NA	Not Detected	~15mins

Note: Casino, ice rink, comedy club are interconnected public spaces and fresh air is supplied individually to each space. The given spaces have multiple local fan coils continually providing both air cooling and filtration.

NA - Not Applicable

* Reduction could not be calculated