



INSIGHTS INTO HEALTHIER INDOOR ENVIRONMENTS: MARINE

COVID-19 outbreaks and travel restrictions brought the cruise industry to a standstill, and operators are now trying to give confidence to guests and crew to sail again. While the pandemic put a great deal of focus on cruise ships, the industry's history with infectious disease transcends the pandemic, as gathering global passengers in close quarters results in increased risks. Now, the right healthy ship strategies can help restore passenger confidence in the health and safety of cruises.

THE NEED

For decades leading up to the COVID-19 pandemic, the cruise industry was one of the fastest-growing segments of global travel. Now, as the reality and perception of cruise ships as high-risk areas for disease transmission proliferates, promoting the health and safety of passengers and crew is critical to the industry's return and survival, and the livelihood of its more than 1 million employees.



Prior to the COVID-19 pandemic, the cruise ship industry was growing steadily. In 2018, over **28.5 million cruise ship passengers were reported globally**.¹



In the United States, **each day the government suspended cruise operations, more than 600 jobs were lost**. In Europe, each day has been estimated at 800 jobs, and 140 jobs in the United Kingdom.²



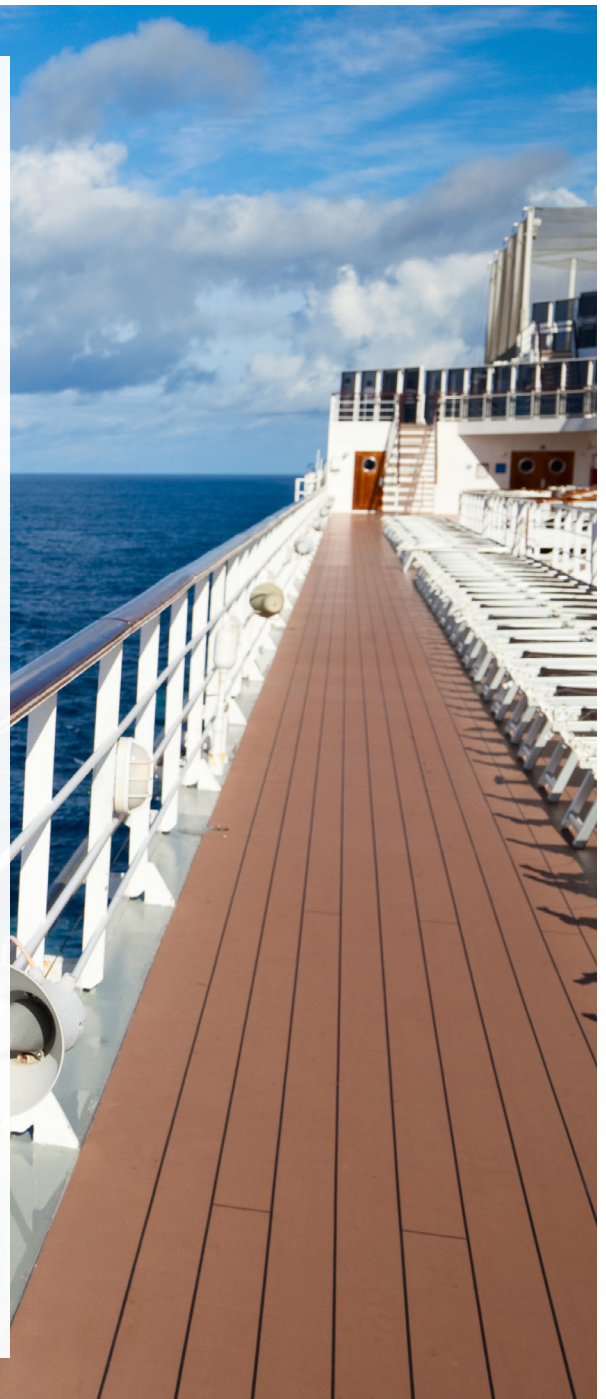
The first major outbreak in the industry occurred on the Diamond Princess cruise ship in February 2020, where **712 passengers and crew members** (19% of the community) **aboard the ship were infected with COVID-19**.³



For international cruise ships porting in the U.S. from 2010 to 2015, **eight to 16 outbreaks of norovirus infections occurred each year**.⁴



Passengers and crew share spaces that are more crowded than most urban settings.⁵ When combined with long voyages where exposure can occur all day, for many consecutive days, **cruising can lead to increased risk of infection for passengers and crew alike**.



THE QUANTIFIABLE IMPACT

One of the greatest losses the cruise industry has incurred as a result of the COVID-19 pandemic is reputational damage, which has the potential for long-term negative impacts on its ability to recover.⁶ Together with vaccination rollout, layered strategies for healthier environments can help combat this negative perception, while impacting overall ship conditions that affect experiences and passenger and crew wellness.



HUMAN HEALTH



A Harvard study of different modes of transmission from the Diamond Princess cruise ship outbreak found that **long-range aerosol and short-range (large droplet and short-range aerosol) transmission each contributed approximately 35% of the infected cases on the cruise ship.**³



Evidence from numerous studies demonstrates that environmental noise is associated with increases in stress hormone levels, which in turn result in adverse health outcomes on the cardiovascular system such as **increased blood pressure and heart rate, heart attack, stroke and increased mortality.**⁹



EMISSIONS AND AIR QUALITY



Studies reported that the range of concentrations of particulate matter on the decks of cruise ships are **comparable to concentrations measured in polluted cities**, including Beijing and Santiago.⁸



Studies have also reported that particulate concentrations in the cabins of several vessels, including on cruise ships, were relatively high compared with homes and offices, and that the **cabins of vessels experienced high CO₂ concentrations and poor air exchange rates.**⁹



LIGHTING AND SLEEP



One of the greatest potential impacts of lighting, both during the day and at night, is its effect on sleep. It is well studied that **providing enough light at the right time of day (e.g., in the morning) may improve sleep quality.**¹⁰



Participants in one study consistently reported large differences in sleep quality in cool and warm sleeping conditions, with most **insufficient sleep reported in the warmer environment.**¹¹

ACTIONABLE STRATEGIES AND SOLUTIONS

Carrier Healthy Buildings capabilities can help inspire confidence in sailing and support ships throughout their lifecycle — from performing health and safety assessments to upgrading building technologies and enhancing operations for optimal performance.

ASSESSMENTS

OPERATIONS

UPGRADES





ASSESSMENTS

There are a variety of indoor air quality (IAQ) and ventilation solutions to choose from — but not every solution fits every ship's needs. To determine which solutions best meet your needs, Carrier provides **IAQ assessments**. Assessments can be customized to each ship or follow a prescriptive assessment approach and include monitoring and testing.



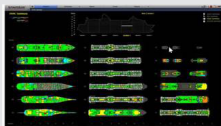
VENTILATION

Strategies

- **Prioritize maximizing fresh air delivery rates to achieve 30 cfm/person.** Occupancy loads can also be decreased to achieve recommended air delivery rates per person.
- **Eliminate or reduce air recirculation** (thus maximizing fresh outdoor air) to the extent possible.

Solutions

- **Automated Logic WebCTRL® building automation system** is the hub for intelligent integrations of



technologies throughout a ship. From heating, ventilating and air-conditioning systems to security and access control to fire, lighting and more, WebCTRL enhances efficiency through greater visibility and control of all systems.

- **Carrier Agion®-coated 39CC air-handling unit** provides clean, long-lasting anti-microbial protection by resisting the growth of microbes on the equipment's interior panels.



FILTRATION

Strategies

- On ships with mechanical ventilation systems, **existing filters can be upgraded to filters with efficiency ratings of at least MERV** (Minimum Efficiency Reporting Value) **13 or the highest MERV rating the system can handle.**
- **Portable air cleaners with high-efficiency particulate air (HEPA) filters may be useful to reduce exposures** to airborne droplets and aerosols emitted from infectious individuals on the cruise ship.

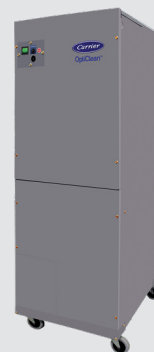


Solutions

- **Carrier filtration technologies** include various MERV filters, HEPA filters for particulate matter and **Infinity™ electrostatic filters** for airborne pathogens. Carrier

also offers devices using UVC light, which are intended to target viruses, and UV photocatalytic oxidation to help remove volatile organic compounds and improve indoor air quality.

- **OptiClean™ Air Scrubber and Negative Air Machine** can be used to help prevent the spread of COVID-19 by keeping potentially contaminated air within a confined space, cleaning it with HEPA-grade filtration* and then ventilating it outside.
- **Electrostatic filters** use static electricity to catch particles as they pass through the filter and help protect ships from harmful microscopic particles.



*HEPA filter is 99.97% effective for particles that are 0.3 microns or larger.





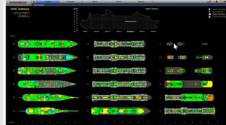
CONTROLS AND SERVICES

Strategies

- **Cruise ships can ensure that there is adequate ventilation and filtration through a process of commissioning and testing.** Commissioning and testing should be performed by trained individuals and should be performed at regular intervals.
- **Testing can be done through the use of low-cost IAQ monitors.** If CO₂ concentrations are measured at levels below 1,000 ppm while facilities are occupied, then the outdoor air ventilation is likely performing according to acceptable minimum standards. Higher CO₂ concentrations may indicate that other strategies for increasing outdoor air ventilation are necessary.
- To promote healthy indoor environments, real-time monitoring for a variety of pollutants and IAQ parameters, including (but not limited to) carbon monoxide, ozone, volatile organic compounds, formaldehyde and other aldehydes, temperature, humidity, noise and light, is recommended.

Solutions

- **Remote Airside Management** provides continuous validation of IAQ parameters, periodic checks of equipment health and continuous airside commissioning, enabled by a command center.
- **Remote Energy Management** connects HVAC and other systems to provide advanced cloud-based analytics that help optimize energy efficiency, equipment uptime, occupant comfort and operational productivity. Carrier's digital services are based on actionable insights by the EcoEnergy Insights CORTIX™ building IoT platform.
- **FireWorks® Incident Management Platform** functions as a remote monitoring and control system and is ready to provide coordinated, timely communications during threats in environments.
- **Carrier's best-in-class BluEdge™ service platform** offers IAQ assessments, wellness services, retro-commissioning and more. As a result, ships can operate at their peak performance, providing lower energy and maintenance costs and a more productive, healthier environment.



- **Abound, a cloud-native platform**, unlocks and unites siloed building data to create smarter and more resilient spaces that improve occupant wellness.

ABOUND

- Cruise ship operators should implement **multi-parameter IAQ monitoring** to baseline performance, identify deficiencies and enable demand control ventilation for specific contaminants of concern. IAQ monitoring can also confirm the effectiveness of filtration and air purification in the cruise ship.
- By integrating with the Automated Logic WebCTRL building automation system, **zone occupancy sensors** can detect occupant presence to help increase ventilation, report alarms and track real-time occupancy. Additionally, **security-based occupancy sensing** provides real-time integration to access control systems to determine occupancy based on access card swipes.
- **AutroMaster** provides a complete Integrated Safety and Emergency Management System (ISEMS) for control and monitoring of alarmed areas, and forms an integrated part of the fire detection system.
- **FLIR Screen-EST™** is efficient, accurate desktop software for performing skin temperature screenings in high-traffic areas.
- **AutroSafe 4** is an advanced fire detection system that can support multiple panels and controllers, specifically designed to support complex environments such as cruise ships.
- **AutroGuard®** is a multi-criteria protector that provides heat, smoke and CO detection in a low-profile, compact, self-verifying device.



TOUCHLESS PRODUCTS

Strategies

- **No-contact infrastructure** is an engineering control method used to **reduce the indirect spread of pathogens** from fomites. This includes technologies such as automatic dispensers of hand soap/hand sanitizer/paper towels, automatic toilet flushers, hands-free garbage cans and **automatic doors**.

Solutions

- **The Carrier MyWay™ building services platform** enables occupants to use a mobile phone to interact with a healthy cruise ship – such as opening doors, controlling room temperature, adjusting lighting, locating available conference rooms and finding someone on a cruise ship.

THE BOTTOM LINE

Healthier indoor environments are critical to restoring passenger confidence in the health and safety of cruise ships, enhancing experiences for both passengers and staff and beginning to bring the industry back to a place of continuous growth.

To learn more about healthy building solutions and strategies for marine, [connect with a Carrier expert today.](#)

¹ CLIA (2019)

² CLIA (2020)

³ Azimi, Keshavarz, Cedeno Laurent, Stephens and Allen (2021)

⁴ Tardivel, White and Duong Kornlyo (2020)

⁵ CDC (2020)

⁶ Nhamo et al. (2020)

⁷ Basner et al. (2014); Hume, Brink and Basner (2012); Munzel, Gori, Babisch and Basner (2014)

⁸ Kennedy (2019)

⁹ Kim and Lee (2010)

¹⁰ Boubekri, Cheung, Reid, Wang and Zee (2014); M. G. Figueiro et al. (2017); M. Figueiro and Rea (2016)

¹¹ Lan, Pan, Lian, Huang and Lin (2014)



HEALTHYBUILDINGS

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