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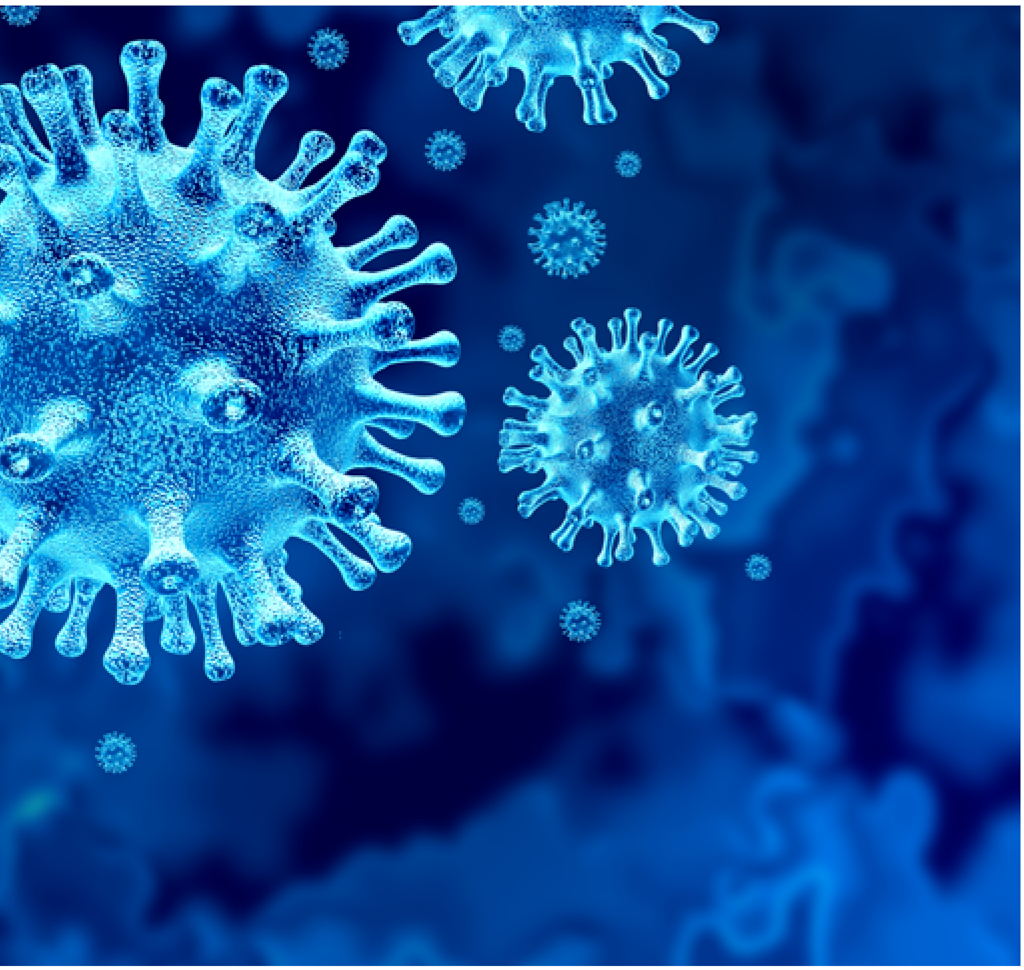
FAQ: operation, upgrade and air cleaning of HVAC systems



Johnson Controls Powering the COVID-19 Crisis Response

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Purpose of document

To provide general guidance and a list of considerations for those who design, operate and maintain commercial HVAC systems. Information is not intended to specify solutions as these would be application-specific and would require the design guidance of a qualified professional.

FAQs relevant to COVID-19

Converting mixed-air HVAC systems to use 100 percent outside air (OA).

Q: What are the factors that should be considered?

A: Factors include:

1. Unit economizer changes:
    - Close the Return Air (RA) damper.
    - Open the OA damper.
    - Close the Exhaust/Relief damper.

2. Exhaust air from the space served by the unit. Then create a new path for the air to exit the space since the return air path cannot be used (return damper is closed) to bring room air back to the economizer exhaust/relief damper.

3. What if there is no economizer (min. OA only – not capable of 100 percent)?
    - Systems without economizers may not have the capability to provide 100 percent OA. In this case, additional OA capacity must be added.

4. Conditioning 100 percent OA:
    - Capacity of existing air handling unit (AHU) coils – determine if the existing coils (cooling or heating) can meet the revised design conditions.
    - Adding cooling and/or heating capacity to the AHU:
        - Evaluate if existing coils can be replaced to deliver the additional capacity.
        - Evaluate if existing cooling and/or heating sources can meet the additional capacity demands.
        - Additional coils may be required to handle the additional loads of the OA – particularly if a replacement of existing coils is not feasible.

    - Humidity control
        - Ensure the system can maintain the Relative Humidity (RH) nominally at 50 percent. Studies have shown that low RH results in microbes staying airborne longer and being more easily drawn into the lungs. [21] [22]
            - Dry areas may require additional humidification (example: ASHRAE Dry "B" climate zones).
            - Moderate and marine areas may require adjustment of chilled water temperatures (Example: ASHRAE "A" and "C" climate zones).

HVAC and Infectious Disease.
The common cold (rhinoviruses) and influenza (e.g. H1N1) can be transmitted by airborne aerosol, droplets, or direct contact. HVAC systems can have a positive effect on limiting airborne and droplet transmissions. According to the CDC, Coronavirus (e.g. COVID-19) similarly is transmitted via droplets and direct contact. HVAC systems may be operated, maintained and serviced in an attempt to mitigate the transmission of infectious disease.

  - Steam humidification methods are preferred to cool mist humidification methods. [24]
- Air cleaning/treatment
  - Evaluate location to determine if additional treatment or filtration is needed.
    - Urban and suburban areas may require additional treatment for Volatile Organic Compounds (VOC) and other pollutants. Bipolar ionization and UV systems may be helpful. See section on air cleaning for more information on these technologies.
    - Rural areas may require additional pre-filtering or more frequent filter changes.
- Regional factors based on OA quality
  - Some areas will require special air treatment, including the removal of outdoor contaminants such as dust, dirt, pollen, odors, smog, etc.
- Airside energy recovery devices that have leakage between the airstreams by design should be bypassed.

Q: What are suggested strategies for converting existing areas to negative pressure spaces for isolation patients?

A: Conversion strategies will vary based on building type and original design use. The U.S. Army Corps of Engineers offers design guidance resulting in at least 12 Air Changes per Hour (ACH) and a minimum of 200 cubic feet per minute (cfm) for each dedicated patient pod. For a complete list of the guidelines, refer to www.usace.army.mil/Coronavirus/Alternate-Care-Sites/. [26]

Filtration and air treatment

Q: Existing systems serving health care spaces have 95 percent (MERV15) final filters. Can these be replaced with 99+ percent (HEPA) filters?

A: This is a site-specific situation that depends on the available fan power, filter rack construction, and ventilation needs. An option is to consider adding a bipolar ionization unit upstream of the filter bank to coalesce the small aerosol particles into larger particles that are more easily captured by the filters. [3] [7]

Q: Should I upgrade my existing filters? If so, what do you suggest?

A: Filter efficiencies vary by system type and application. Filters located upstream of your coils (pre-filters) typically do not have more than a MERV 13 rating. Filters below MERV 15 have a minimal ability to trap virus microbes. [25] Keep in mind that new filters perform better as they begin to load up so a replacement of the same MERV rating make actually be less effective at trapping virus microbes. Any filters that are removed should be immediately bagged and sealed. [24]

Q: What air cleaning technologies are effective for inactivating the virus?

A: No single technology can guarantee 100 percent effectiveness for inactivation of this coronavirus. As it is so new, information on the virus's survivability in air and on surfaces is being updated regularly. A balanced approach that utilizes multiple techniques may be the best option.

1. OA Ventilation
   - Maximizing use of outside air to displace contaminated air is typically the first technique utilized and many times is coupled with one or more of the other listed technologies. See section on converting to 100 percent OA for items to consider when increasing use of ventilation air.

2. Ultraviolet Germicidal Irradiation (UVGI)
   - UVGI is a popular, active line-of-sight technology, meaning that it only affects areas directly exposed to the light source (i.e. the bulbs). This includes the direct airstream and surfaces. [16] [17] [18] [19] [20]
   - UVGI inactivates viruses by disrupting their genetic matter, the RNA.
   - Can be deployed in air handlers, ducts, and in rooms. [21] [24]
     - Cannot be operated in occupied spaces nor in locations very near occupied spaces where people could potentially become exposed. [21]
     - Can be used in normally occupied spaces when they are not occupied (example: operating rooms). [21]
   - Effectiveness depends on the UVGI dosage, exposure time, and humidity level. [17] [18]
     - Higher UVGI dosage (i.e. power) increases effectiveness.
     - Longer exposure time increases effectiveness. [19] Most effective at low RH (<30 percent) but slightly less effective at higher RH. The lower performance with high RH is more pronounced in bacteria.

3. Air ionization
   - Air ionization is gaining popularity as a viable active air treatment option that not only affects contaminants and microbes in the air, but also on surfaces, even hidden surfaces. [2] [6] [10] [11] [12] [13] [15]
   - Monopolar (unipolar) ionization works by flooding the air with millions of either negatively or positively charged particles to react with both microbes and VOC contaminants. This system is typically used in small, room-size systems that precipitate the particles from the air and collect them on an oppositely charged plate. [3] [4] [5] [6] [9] [10]
   - Bipolar ionization works by flooding the air with millions of both negatively and positively charged ions that react with both microbes as well as VOC contaminants. [8] [13] These are typically deployed in Central Station AHU or ducts.
   - Bipolar ionization has been shown to be more effective at inactivating microbes than monopolar systems. [1]
   - The reported mechanism for inactivation of microbes is that ionization "causes production of clusters of hydroxyl radicals which are formed on the surface of microbes, removing hydrogen from the microbial cell walls, thereby killing them". [14]
   - The ionization has been shown to cause smaller particles to coalesce into larger particles (because of opposite charges), which enhances the effectiveness of static filters. [3] [7]
   - It can be deployed anywhere inside the building. Review the location that is best for your application with a qualified professional. [6]
   - Safe for continuous operation, even in occupied spaces. [6]
   - It not shown a performance dependence on humidity levels. [1]

4. Filters
   - Unlike UVGI and bipolar ionizations technologies, media filters are static devices that do not inactivate viruses. Media filters can be effective for trapping particles containing the virus depending on the particle size and filter MERV rating. [25]
   - According to the study, *Measurements of Airborne Influenza Virus in Aerosol Particles from Human Coughs*: "35 percent of the influenza RNA is contained with particles > 4 μm in aerodynamic diameter, while 23 percent was in particles from 1 to 4 μm, and 42 percent in particles < 1 μm." [22]

Q: How should the various effective air cleaning technologies be applied?

A: Project requirements for air cleaning are application-specific and require the design guidance of a qualified professional.

Q: How does the humidity level inside the building impact the virus?

A: Humidity levels are very important to consider when dealing with extremely small microbes, such as viruses.

1. While the diameter of the virus is approximately 120 nanometers (0.120 microns), it must be attached to an aerosol particle to be transported through the air. [22]

2. Technical studies have shown that more than 50 percent of virus-carrying aerosol particles have sizes of <4 microns. [22] Small particle sizes more readily exist in low-RH conditions.
   - These small particles are more easily drawn into the lungs and therefore are more likely to cause infection.
   - These small particles are more likely to exist in low RH conditions (<30 percent). Thus, increasing the RH from this condition to 50 percent can help reduce the amount that can be pulled directly into the lungs.

3. Studies also report that larger particles tend to fall out of the air faster and deposit the virus on surfaces.
   - These particles are more likely to result in direct transmission from surfaces through touching rather than by airborne transmission.

HVAC system operation

Q: Should HVAC systems be operated differently now? If so, how?

A: Mixed-air HVAC systems serving occupied spaces should be operated with a focus on increased OA ventilation rather than energy conservation. The amount of increased OA required will be application-specific and requires the design guidance of a qualified professional to ascertain. Unoccupied spaces should be operated as they normally would. As plans for transitioning building HVAC operation from long periods of unoccupied to occupied are formulated, an Indoor Air Quality (IAQ) analysis should be performed prior to the transition.

Many systems use Variable Air Volume (VAV) boxes to control the flow of air into the building space zones. VAV boxes without reheat capabilities have limited controllability of zone temperature with increased ventilation air. Reheat capacity may need to be added through methods such as HW duct booster coils or electric heat.

Q: What are suggestions for economizer settings (max outdoor air) and shutting or minimizing the return air damper?

A: General best practice guidance is that more is better with increased outdoor air ventilation. It is important to understand the locations of exhaust outlets relative to the intakes to ensure that contaminated air is not reintroduced to the building. Refer to questions related to 100 percent OA applications.

Q: Any difference in this recommendation based on ducted return and plenum return systems?

A: There is no difference.

Q: What are suggestions for shutting down units if an impacted individual has been working in the area?

A: This is not necessarily needed. The primary mechanisms for spread of the infection are surface and airborne (aerosols). The HVAC system has no effect on viruses on surfaces - they must be decontaminated through methods such as mechanical cleaning and UV sterilization. If the HVAC system has adequate filtration for removal of small particles – MERV 14 minimum, MERV 15+ preferred - then a considerable percentage of aerosol particles would be removed there. Unless there is a high velocity with moisture carryover or high humidity, viruses typically would not be re-entrained from the HVAC equipment because there would not be a mechanism for the creation of aerosols to carry them.

Q: What are suggestions for changing filters and sanitizing the units if an impacted individual has been working in the area?

A: As noted above, adequate filtration is important and maintaining clean filters is paramount. Sanitization of AHUs with UV retrofit may be a viable option. Aqueous cleaning may create aerosols that re-entrain the virus. Any filters that are removed should be immediately bagged and sealed. [24]
Special handling may be required by persons trained to perform this work.
NOTE: The survivability of the virus on different surfaces is still being studied. Early indications of hours to maybe three days on some surfaces are now in doubt as information released this week from studies of two affected Princess cruise ships – one in Japan and one in California – indicate the virus may survive up to 17 days on some surfaces.

Q: Any different operational suggestions for VAV vs constant volume systems?

A: From the air handler viewpoint, there is no difference. However, changing air velocities may affect air patterns in occupied spaces - individuals may be exposed to the virus more due to low velocity zones. Additionally, this may reduce the amount of ventilation air reaching those room areas. This is a site-specific issue. Preferable design would have the returns pulling/directing (contaminated) air away from occupants.

Q: What are suggestions for closing or minimizing return air on large volume air houses?

A: As noted above, maximizing ventilation air is preferable and exhaust and intake locations should be studied to prevent re-entraining contaminated air.

Q: What are suggestions for changing filters and/or sanitizing units serving an area where an impacted individual has worked?

A: Same as above. Any filters that are removed should be immediately bagged and sealed. [24]

Q: What are some main recommendations for operational changes?

A: In general, operational changes should be focused on performance confirmation and increased maintenance of existing systems:

1. Change filters more often and consider if an upgrade of the MERV rating is applicable without an adverse effect on the fan system. Any filters that are removed should be immediately bagged and sealed. [24]
2. Inspect existing UV light systems to confirm they are functioning at peak performance. This may require lamp replacement.
3. Confirm effectiveness of existing HEPA filters – particularly how well filters are sealed within the frames that hold them.
4. Increase inspection schedule of HVAC system cleanliness for the entire air path.

The information above is general guidance only and may or may not apply to a particular circumstance. Use of the guidance without consulting a Johnson Controls representative shall be at your own risk and you assume all responsibility arising from its use, including but not limited to loss, interruption or malfunctions of your facilities, systems and any resulting fines. All information is provided "as is", with no guarantee of completeness, accuracy timeliness or results, and without warranty of any kind, express or implied, including but not limited to warranties of performance, merchantability and fitness for a particular purpose. For more detailed information relating to a specific project or installation, please contact your Johnson Controls representative.

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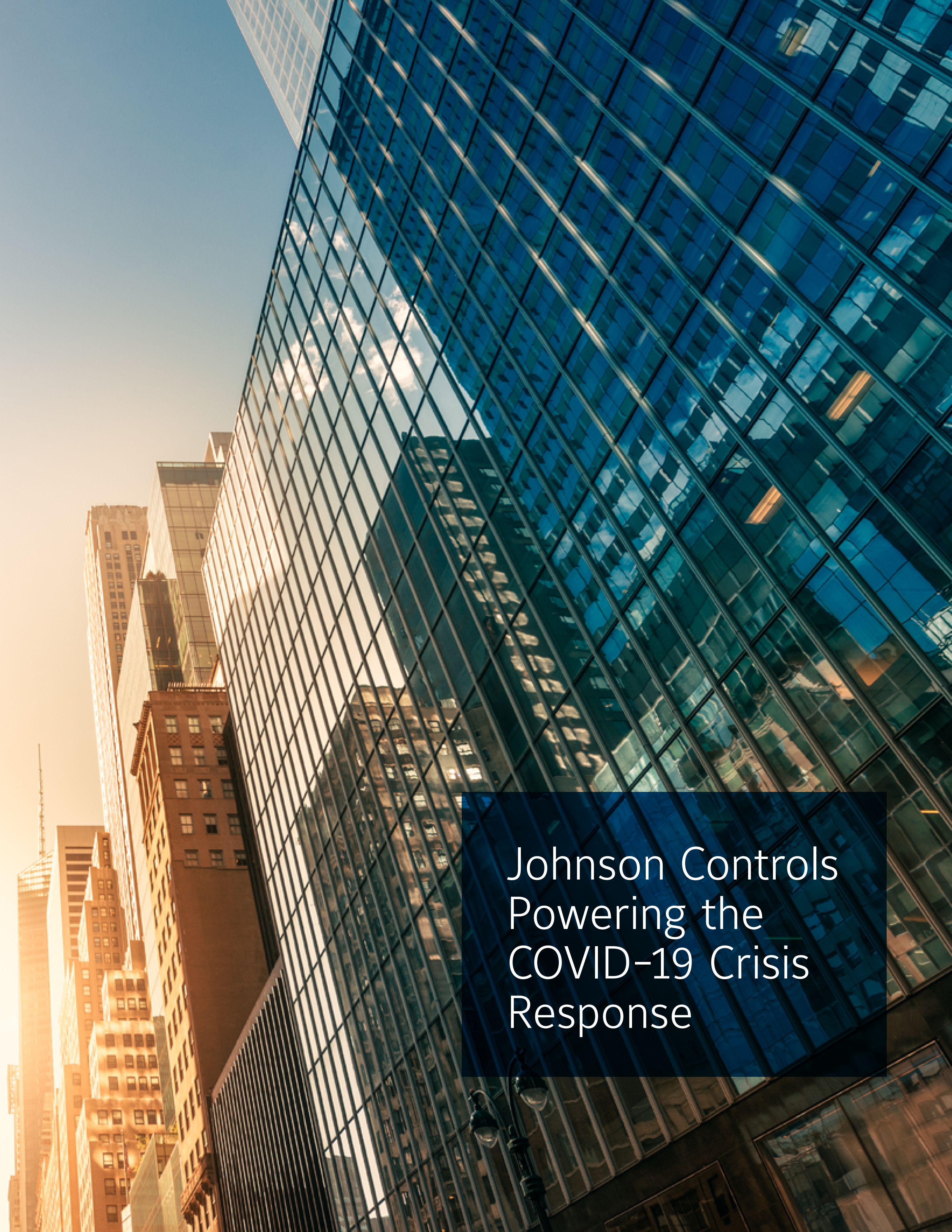

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