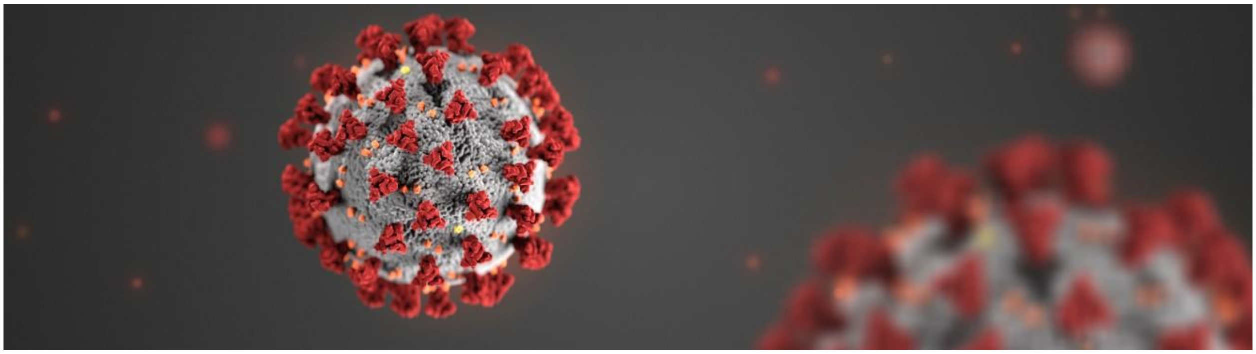

White Paper on

Ventilation for Industrial Settings during the COVID-19 Pandemic

by

American Conference of Governmental Industrial Hygienists (ACGIH®)

Industrial Ventilation Committee

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Preamble

This White Paper, developed by the Industrial Ventilation Committee of the American Conference of Governmental Industrial Hygienists (ACGIH®), originates from concern about the proper use of ventilation controls in industrial workplaces where SARS-CoV-2 (the Coronavirus responsible for COVID-19) is potentially present. This volunteer committee, with expertise in industrial ventilation, offers guidance on the topic of industrial ventilation to industrial/commercial facilities that are planning operational controls to reduce the impact of the COVID-19 pandemic for employees returning to work around the world. These *recommended practices* are intended as guidance for Occupational and Environmental Health and Safety professionals and others including plant managers as they seek to mitigate exposures for their workforce during the COVID-19 pandemic.

Included within this paper are COVID-19 exposure control strategies that consider all of the traditional industrial hygiene Hierarchy of Controls. It will provide some practical suggestions about the use of ventilation principles and concepts that can help reduce worker exposure to droplets and aerosols that may contain Coronavirus-19. It will also communicate some simple guidelines and principles that can be used to select and design ventilation controls to limit the spread of Coronavirus disease. This White Paper will NOT opine on heating, ventilation and air-conditioning (HVAC) systems and other ventilation systems that are used in office situations, as they have been addressed by ASHRAE in recent documents (ASHRAE, 2020).

The design of an overall exposure control strategy in a facility within the context of Coronavirus-19 will likely require a combination of control strategies. Currently available information characterizes this biological hazard as:

- potentially severe in its effects,
- highly contagious,
- associated with a significant percentage of infectious, although asymptomatic, individuals,
- transmitted person-to-person,
- initiating respiratory infection through inhalation and contact with the eyes, nose, and mouth, and
- having an unknown infectious dose range at the time of this writing.

Therefore, these guidelines address possible courses of action regarding the use of industrial ventilation systems for local exhaust, dilution, and convective cooling purposes within the context of prevention of transmission of Coronavirus-19. The type of industry, worker occupation, exposure profile, climate, facility layout, and indoor environmental conditions will affect how these guidelines should be implemented.

Introduction and Background

Coronavirus Disease 2019 (COVID-19) is associated with a pathogenic novel coronavirus (SARS-CoV-2 or Coronavirus-19 for the purpose of this document) from the same family of viruses responsible for the Severe Acute Respiratory Syndrome (SARS) outbreak experienced between 2002 and 2004. COVID-19 is caused by a single-stranded RNA virus with a lipid envelope that has a diameter of approximately 120 nm (wetted particle size larger) (Zhu, 2020; CDC, 2020).

Symptoms associated with COVID-19 vary by age and health status from mild flu-like symptoms to severe respiratory distress and death. According to the Centers for Disease Control and Prevention (CDC), individuals with increased susceptibility to more severe COVID-19 illness include those over 60 years of age and those with underlying health issues, such as serious cardiovascular conditions, moderate to severe lung disease or asthma, immune system deficiencies, obesity, and underlying medical conditions (such as diabetes, or renal or liver disease) (CDCa, 2020). In addition, a proportion (5%–80%) of infected individuals may not show symptoms (asymptomatic) (Oxford University, 2020; Oran and Topol, 2020).

Disease transmission has been demonstrated to occur person-to-person and is thought to occur through:

- propulsion of large droplets generated from coughing and sneezing directly into the face, nose, eyes, and mouth of someone nearby (droplet transmission),
- inhalation of infectious particles generated by breathing, talking, singing, coughing, and sneezing that remain suspended for lengthy periods or are distributed by indoor air currents (aerosol transmission) (Jones, 2015), and
- contaminated hand-to-mucus membrane contact (contact transmission) (CDCb, 2020).

Airborne transmission (inhalation of infectious particles at a long distance from the source, e.g., through a ventilation system) cannot be ruled out given the potential extended viability of Coronavirus-19 in air (van Doremalen et al., 2020) as shown in laboratory experiments (CDCd, 2019).

Currently, there is uncertainty as to how many virions (viruses) are required to achieve an infectious dose (i.e., how much virus is necessary to infect someone) and about the nature of droplet, aerosol and airborne transmissions including relevant particle sizes, particle behavior over time, and the amount of viable virus present in a given aerosol particle. Since aerosols are a potentially important route of exposure, their control must be considered in a larger, overarching strategy for minimizing Coronavirus-19 transmission in industrial settings. Ventilation, as a type of engineering control, can play an important role in controlling exposure to an infectious aerosol in an indoor industrial workplace.

Hierarchy of Controls

As part of the normal hazard assessment, experts such as Certified Industrial Hygienists (CIHs) should inspect and evaluate each area of the workplace through the Hierarchy of Controls lens to determine how best to protect workers. This assessment involves noting all processes and conditions that have the potential to harm employees through chemical/dust exposures, hazardous energy, dangerous machinery, etc. During the current pandemic, it is necessary to look for instances that may increase the risk of worker exposure to the virus.

This worker exposure will primarily be through prolonged close proximity to other workers who are infected, but exposure could also include the use of shared tools, inadequate or poorly directed ventilation, and close contact associated with an excessive number of employees in common areas (such as cafeterias) at one time.

As shown in Figure 1, the methods of controlling a hazard generally become less effective moving down the hierarchy. **Elimination** requires source removal, which could involve removing infected individuals from the workplace through screening or testing, assigning remote work (where possible) or limiting the number of individuals in a space at one time (and enforcing social distancing) to lower airborne concentration. **Substitution**, replacing the source with something less hazardous, may not be relevant although automation (e.g., robots) may be useful in some instances. **Engineering controls, administrative controls and personal protective equipment (PPE)** all have a place in protecting workers during the pandemic. While engineering controls are generally most protective for workers, due to the nature of the virus and the limitations of most industrial ventilation systems, administrative controls or some form of personal protection may also be essential in combination with engineering controls, such as ventilation.

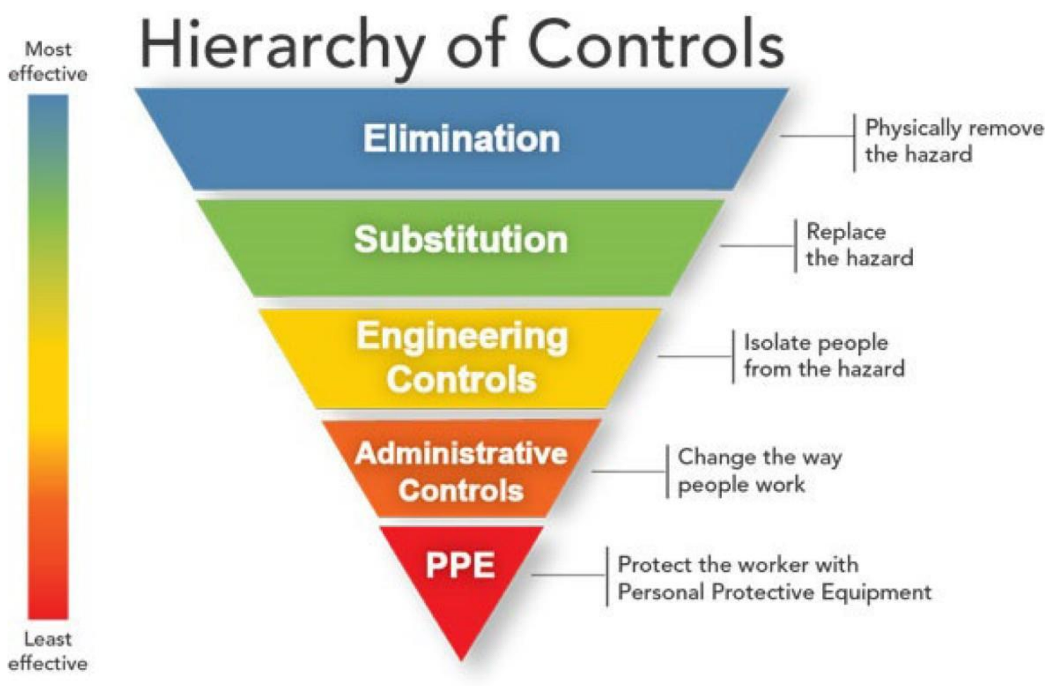

FIGURE 1. Hierarchy of Controls (NIOSH, 2020)

Engineering Controls

Basic Principles for COVID-19 Ventilation in an Industrial Setting

Ventilation, if designed and implemented properly plays a critical role in mitigating disease by reducing droplets and aerosols in air, and subsequent airborne transmission. The two types of ventilation that can impact concentration include general exhaust ventilation (GEV) in the form of dilution ventilation, and local exhaust ventilation (LEV). Dilution ventilation occurs when contaminants of concern within a space are reduced by removing contaminated air and replacing it with clean air. This may be accomplished either by 1) replacing room air parcels with clean ones (plug or laminar flow, 50–150 feet per minute) (see Figures 2 and 3), or 2) diluting existing contaminated air with cleaned, outside air using mixing (see Figure 4). Alternatively, LEV occurs when contaminants generated within a space are captured using exhaust capture devices (e.g., hoods) at or close to the source.

In order to fully understand how a ventilation system is working, an audit should be conducted to determine where and how air enters and exits from the space. Then a general idea about the overall airflow pattern can be estimated. For any air that is being recirculated, such as from LEV or from office spaces, the ability to remove as much of the virus load as possible before reintroducing the air is critical. (See section titled Filtration in this document and ASHRAE 2020 document.)

1. General Exhaust Ventilation

For typical industrial applications, the intent of dilution ventilation is to either replace parcels of contaminated air or dilute those parcels with clean, outside air (or filtered recirculated air) to reduce the contaminant level below some recommended level to avoid worker overexposures and adverse health effects. In the case of Coronavirus-19, where each worker is a potential contaminant source, the airflow pattern is the most critical issue to determine, modify, and control.

Dilution ventilation consists of exhaust fans that pull air through exhaust openings in the workspace and the makeup air and supply fans that replace the air that was removed. The makeup air may come from supply fans or openings in the building envelope such as windows, doors, or vents.

If open doors, windows, or vents are currently the only source of available replacement air, consideration should be given to installation of a ducted, powered air system, with airflow introduced at or near the floor level so the replacement air can move past a worker and up to the exhaust without passing other workers (combined with social distancing practice). If there is an existing supply air system, consider modifying the system to duct and deliver the air at or near floor level. Figure 2 illustrates an example of an appropriate supply/exhaust airflow arrangement.

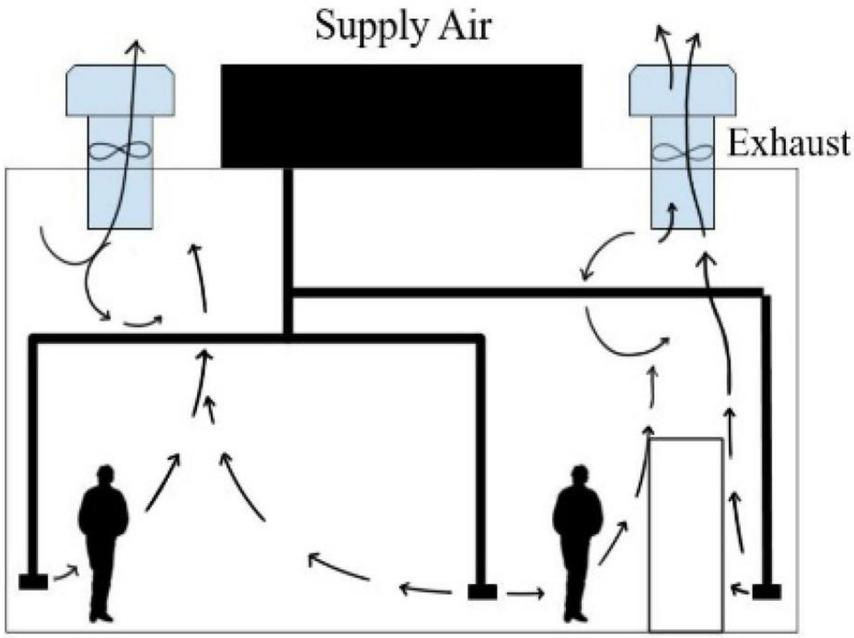

FIGURE 2. Displacement Ventilation

Vertically directed dilution ventilation, taking advantage of thermal displacement (warmer air at the breathing zone rising up toward the exhaust source) should effectively reduce risk of worker exposure to potentially infectious aerosols exhaled or generated by other workers. To understand thermal rise for a human being, consider the fact that the air expelled from human lungs is significantly lighter and more buoyant than most air because of its inherent relative humidity and human body warmth (see Figure 3). In general, replacing air at low velocities is preferable to mixing air with high velocities when a high toxicity contaminant is present. In certain applications, turbulent mixing may increase the potential for employee exposure.

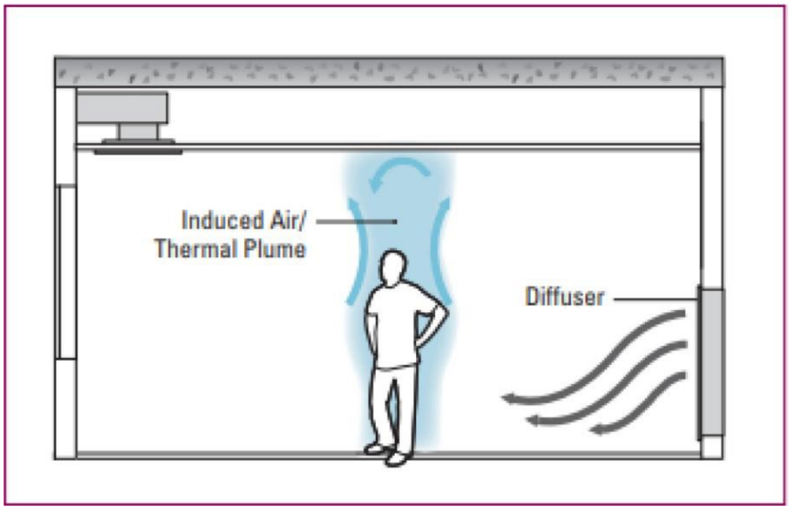

FIGURE 3. Thermal Plume in Displacement Ventilation (Courtesy of Price Industries)

2. Local Exhaust Ventilation

LEV utilizes dedicated exhaust fans and ducts to capture contaminants at their source, keeping them from creating potential exposures. See Chapters 5, 6, and 7 in *Industrial Ventilation: A Manual of Recommended Practice for Design,* 30th Edition (the “Design Manual”) (American Conference of Governmental Industrial Hygienists, 2019). Examples of LEV in industrial settings include fixed or portable snorkels for capturing welding fumes or downdraft tables for capturing grinding particles in metal working applications. See VS-80-01 and VS-90-02 in the Design Manual (American Conference of Governmental Industrial Hygienists, 2019). LEV offers the advantage of much lower airflows and lower volume of make-up air. The major disadvantage of LEV is that the capture point is fixed and not always located at the point of contaminant generation (in the case of Coronavirus-19, the worker’s face). To protect the worker from workplace contaminants, the worker should be located upstream of the contaminant when possible, not positioned downstream of another potentially infectious worker.

3. Fans

Large ceiling fans will cause downflow of air around workers and potentially return buoyant viral particles back towards worker breathing zones. Taking the large ceiling fans offline during a pandemic should be considered. Ideally, air replacement at or near the floor in the building with roof exhaust is preferred to promote displacement ventilation and establish the optimal direction of airflow. However, where displacement ventilation cannot be established, mixing air using ceiling fans with dilution ventilation may be the only practical alternative (Figure 4).

Personal cooling fans are another source of air movement. Without the benefit of perspiration/evaporative cooling, many industrial workers could suffer harm from heat-stress related illnesses. Therefore, personal cooling fans should **NOT** be removed in industrial settings without regard for worker health. By ensuring that the air source moved by the cooling fan is originating from a cleaner area and not near another worker, these fans can provide safe cooling airflow. It is important to make sure that a fan does not blow air from one worker to another. The preferred airflow arrangement is vertical displacement with supply coming in above the floor baseboard level and being exhausted at or near the ceiling.

A study from a recent COVID-19 outbreak in a restaurant (Jianyun Lu, 2020) indicates that a high-velocity HVAC air current induced a countercurrent flow vector that appears to have effectively spread the virus to a number of other patrons who were in or very near the airflow pattern but still proximate to the primary infectious individual. Ventilation practitioners should keep in mind the potential for eddy currents and other airflow disturbances to avoid virus transmission.

4. Filtration

Filtration at the appropriate level may be capable of conditioning air to a contaminant level that is equal to or reasonably as clean as outside or "fresh" air. Replacing air is important, measured as air changes per hour (ACH) or the total air delivered to a space per hour divided by the volume of the space. Both mixing ventilation (turbulent flow) and displacement ventilation (streamline or plug flow) have application in dilution ventilation schemes as the application demands. See Figure 4 for both of these concepts. [The white box shown in the corner is a low-velocity non-turbulent supply diffuser.]

ACH = CADR (ACFM) × 60 (min/hr)/room volume (cu ft)

CADR = airflow rate (ACFM) × removal efficiency

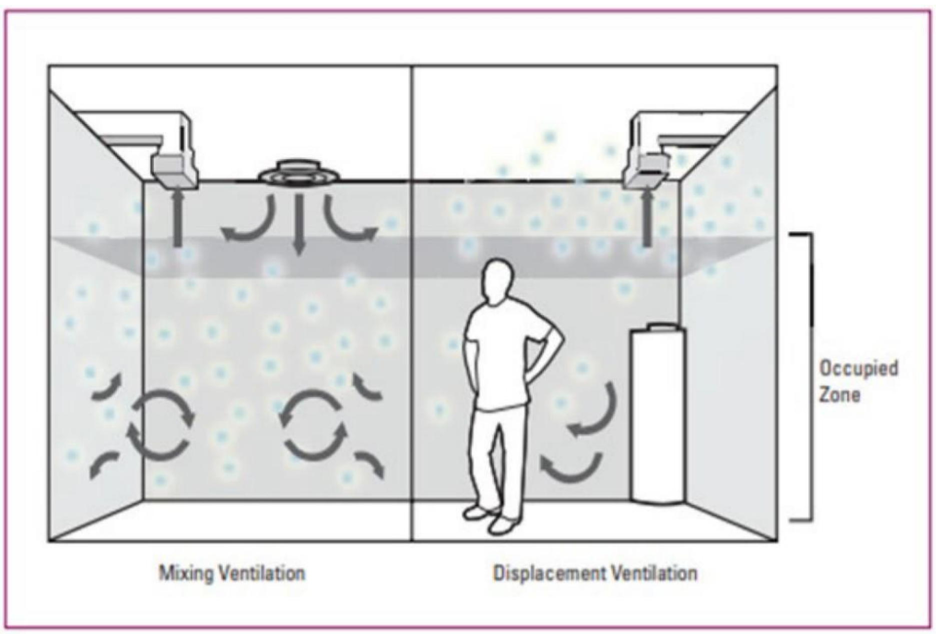

FIGURE 4. Mixing vs. Displacement Ventilation

Filtration of 99+% of particles requires high efficiency particulate air (filtration, HEPA) (ASHRAE MERV 17; MERV—Minimum Efficiency Reporting Value) or greater efficiencies, and existing make-up air and recirculating systems are not typically capable of handling true HEPA filtration due to the high pressure drop and size constraints of this type of filter. However, a recent ASHRAE study shows that *electret (electrostatic charged)* MERV 13 or 14 filters are capable of high filtration efficiencies on viral particles (89%–97%) with filter sizes similar to existing MERV 5–8 “throwaway” filters commonly used in HVAC applications (Zhang et al., 2020). Figure 5 shows the efficiencies of various MERV rated filters. The blue shaded areas indicate the size of particles created by humans while breathing normally (light blue), and with other respiratory activities (dark blue) (Parienta et al., 2011).

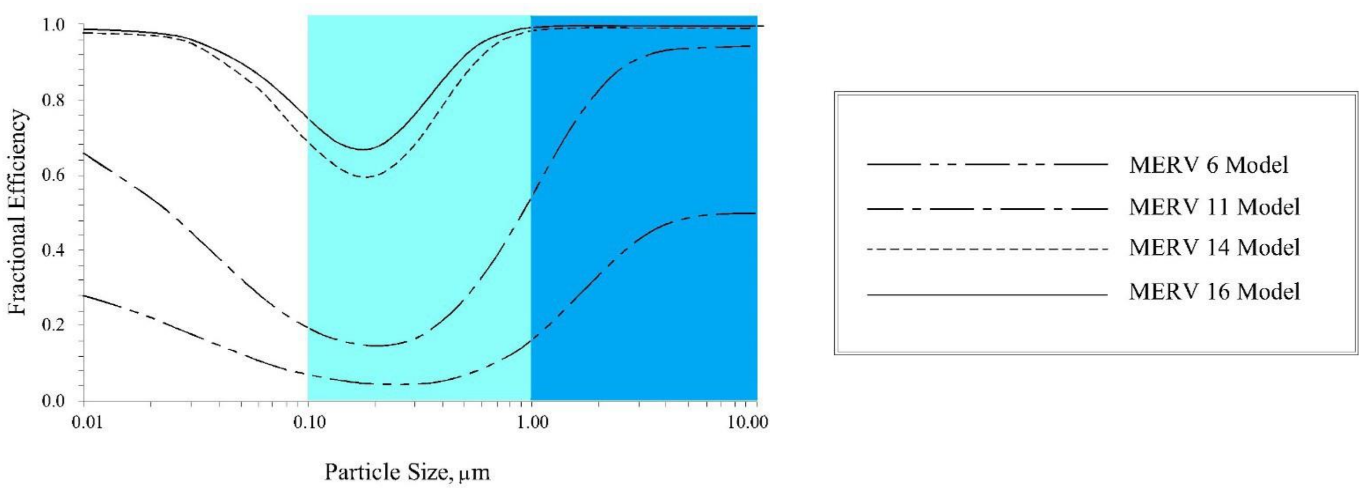

FIGURE 5. Filtration Efficiency at Different Particle Sizes for Different MERV Efficiencies (Figure adapted from ACGIH® 2019)

In addition, it should be known that air filtered through conventional fabric filter (baghouses, etc.) and electrostatic precipitators are capable of similar efficiencies and specifically that a “seasoned” fabric filter typically exhibits a similar efficiency to HEPA filtration. These dust collector style filters will also reduce the risk of Coronavirus-19 distribution and transmission as long as the air is reintroduced to the plant in a non-turbulent fashion and in a manner that establishes the preferred airflow direction (see Chapter 8 of the Design Manual)

Portable HEPA filtration units could be useful if placed in close proximity to workers who remain in place during their working day. These units have a limited area of influence and many units do not meet their stated efficiency, particularly the electrostatic units. These portable units should be considered carefully before purchase and use. Existing portable HEPA filtration should not be turned off, but one should consider the potential for exposure of downstream individuals if an infected worker is located between the unit and other individuals in the same room.

Employers should investigate the use of improved filtering systems that may be available and either compatible or potentially fitted to their existing air handling systems. Good examples of this are ‘electret’ filters and electrostatic precipitators (ESPs). Both of these filtration technologies are robust, have been used effectively for many years, and remove fine and ultrafine particles with predictable success. Placed in series within an air handling system, they could be effective in the capture and reduction of Coronavirus-19 in air. Seek professional design help before modifying any air handling system.

Paint-spray and other large exhaust booths are useful in reducing Coronavirus-19 exposure risks because they require the facility ventilation system to supply large amounts of outdoor (replacement) air. In addition, workers stationed in the booth have a low risk of Coronavirus-19 exposure due to the high air volume turnover rates.

Local exhaust hoods are typically not effective in capturing particles at more than one hood diameter away from the hood inlet. At three times the hood diameter, aerosols are significantly more influenced by room currents than by the LEV (see Chapter 6, Hood Design, of the Design Manual). This does **NOT** mean that LEV systems should be turned off during a viral pandemic. In fact, they are an important source of reducing local airborne virus concentrations. LEV systems evacuate air from the space creating a negative pressure gradient therefore encouraging air at higher pressure (outside the building) to infiltrate in an attempt to balance the pressure difference between inside and outside. Permit LEV systems to operate continuously while workers are present. In a general sense, LEV systems are designed to replace exhausted air with makeup air unless it is a recirculated system. As usual, maintain makeup air systems to reduce air sweeping into the workspace through open doorways and windows.

All established LEV systems should continue to be used for existing workplace hazards. The presence of a new hazard – infectious aerosols – does not negate or change the ongoing need for continued protection of workers from all other hazards. As with any new hazard, assessment of exposures and selection of controls must be done in the context of all hazards. Allow the GEV and LEV systems to operate continuously or long enough to allow for several complete air changes following the departure of all building occupants. If the system is shut down or set back overnight (i.e., between work shifts), return to full operating conditions prior to occupant return. Permit LEV systems to operate continuously. If variable air volume laboratory hoods are present, leave the hood sash in the up position to allow for maximum airflow and maximum air volume to be exhausted when not in use by workers.

If an industrial site has an HVAC system for the purposes of general dilution and comfort control, it may be appropriate to:

- Increase the amount of outdoor air supplied by the system to the maximum capacity permitted by the system. Additional considerations include climate and local air quality (e.g., humidity).
- If air is recirculated, a MERV 13 or better filter is recommended to improve the capture of infectious aerosols.

- Consult with a ventilation system engineer to ensure that the system is operating correctly, is well-maintained and can accommodate the added pressure drop caused by a MERV 13 or better filter.
- Depending on the actual air exchange rate and number of occupants, it may be appropriate to operate the HVAC system for an extended period of time after all occupants have departed, to ensure adequate clearance of infectious particles.

In restrooms, the following practices are recommended:

- Restroom fans should be operated continuously and should exhaust directly outdoors.
- To minimize aerosolization of infectious particles not removed by handwashing, disposable paper towels should be used for hand drying, rather than air dryers.

3. Room/Building Pressurization

An additional ventilation control technique is room pressurization. By adjusting the volumes of air entering and leaving a particular space, that space can be balanced to become positively, negatively, or neutrally pressurized. Slightly positively pressurized spaces tend to keep air from coming in from outside to control contaminants from the adjoining space. Negatively pressurized spaces tend to limit the escape of contaminants generated within the space such as with airborne infection isolation rooms and autopsy rooms. These required conditions may have application to the ventilation schemes addressed above and should be considered. It is recommended that the ventilation professional at industrial facilities consider positive or negative room pressurization to potentially control the spread of COVID-19 in their facilities.

Additionally, an entire facility or large workspace can be positively pressurized, thereby eliminating indraft currents that may cause unpredicted airflow from one employee towards another. Bringing a facility under positive pressure (vs. atmospheric pressure) causes the area to have a mixing factor (m_i or K factor) of 1. This technique is discussed in Chapter 11, Supply Air Systems, of the Design Manual. Consult local codes for compliance.

4. Ultraviolet Germicidal Irradiation

Ultraviolet germicidal irradiation (UVGI) has been used for supplemental engineering control (ventilation being the primary control technique) of airborne microbial contamination in indoor spaces. It has been most commonly used in homeless shelters and hospitals. UVGI systems have been applied for disinfection and inactivation of fungal and bacterial microorganisms for sixty (60) years or more; they have been examined in remote applications including in ducts, inside filter banks, and also in point-of-use and upper room (ceiling return) applications. UVGI has been determined to provide a viable, supplemental control technology for Coronavirus-19 applications. However, a thorough treatment of this topic is beyond the scope of this paper; additional information can be found in ASHRAE, 2019. Note: The use of UVGI at typical wavelengths (i.e., ~254 nm, UVC) requires protection from the light emitted from the UV source for employees, maintenance personnel, and other room occupants, as UV exposure is harmful to human skin and eyes at relatively low source power.

Before World War II, much research was conducted on the germ-destroying ability of UV light, which later diminished with the advent of antibiotics. Recently, however, due to the pandemic a resurgence of interest in the use of UVGI has brought this technology back as a valid viral inactivation treatment for large amounts of air that may be readily applied to the manufacturing workplace. One must do the research to determine whether the UVGI vendor truly understands the application and requirements for effective virus inactivation. UVGI effectiveness requires addressing the ability of the system design to meet the specific conditions while considering the light wavelength, the contact time and the distance from the source (intensity), which are the primary criteria for effective disinfection by UVGI.

Administrative Controls

Administrative controls are ways of changing how employees conduct their job that will tend to limit their risk of exposure to hazards. Some administrative controls may reduce the potential for worker exposure to infectious aerosols. A number of these are mentioned below.

- Inform all employees about the hazards and symptoms of COVID-19. Tell them to stay home or to leave work if they feel sick.
- Provide a station to screen employees entering the building using a standard questionnaire and non-contact temperature measurement device.
- Provide training for all employees about rules for social distancing, sanitation, handwashing, and sick leave policies. Have a plan to separate sick employees if someone fails the health check or becomes ill during the workday.
- Develop enhanced cleaning and sanitation plans for the entire facility. Use EPA-registered disinfectants that are effective against Coronavirus-19. A link to this list may be found here (EPA, 2020).
- Remind employees to stay six (6) feet apart with signage and by placing marks on the floor or using stanchions. Workers should be reminded about maintaining social distancing during breaks, in restrooms, and when entering and leaving the facility.
- Supply additional handwashing stations to facilitate regular handwashing. No touch hand sanitizer dispensers should also be supplied for times when workers cannot wash their hands with soap and water.
- Remind employees to cover their coughs and sneezes with their elbow or a tissue. Dispose of the tissue and wash hands afterward. This can be accomplished with signage.
- Arrange workstations to allow for adequate physical distancing – at least six (6) feet – between workers. This may require rerouting aisles to keep workers from passing too close to one another. One-way (i.e., unidirectional) aisles are another way to avoid workers coming into close contact with one another (Figure 6).
- Supply paper towels, tissues, and no touch waste receptacles.

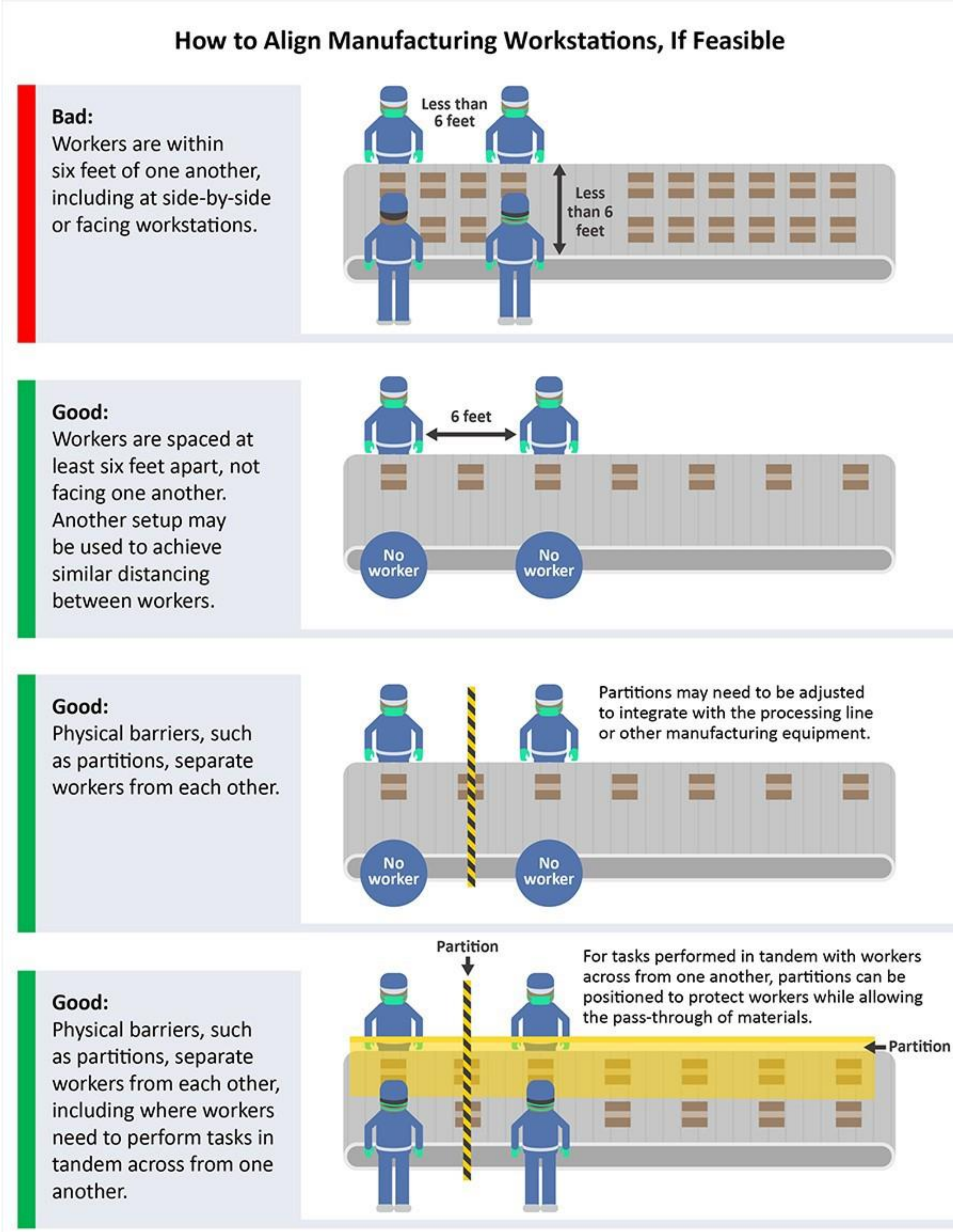

FIGURE 6. How to Align Manufacturing Workers (CDCc, 2020)

Personal Protective Equipment

PPE, particularly respiratory protective equipment (RPE), is usually the least favorable choice in the Hierarchy of Controls strategy. However, due to the uncertainties associated with COVID-19 transmission and the unknown infectious dose, most localities are requiring that individuals wear cloth face coverings or a form of respiratory protection. A cloth face covering helps protect others from respiratory droplets, but it does NOT protect the person wearing it or others from smaller particles. If everyone in the workplace wears a cloth face covering, it is expected that the risk of exposure to Coronavirus-19 will be decreased by limiting droplet exposure. It is important to recognize that only NIOSH-certified respirators are true RPE that provide reliable protection for the wearer. Surgical and similar procedural masks (including cloth face coverings) are primarily for protecting others from contaminants exhaled or generated by the wearer. To protect the wearer from Coronavirus-19 exposure, current guidelines indicate that a NIOSH-certified N95 filtering facepiece respirator affords the minimum recommended protection. Such a respirator must be properly fitted and used on a clean shaven face. In locations such as meat packing facilities, where employees actively work within 6 feet of each other, engineering controls (such as ventilation and barriers, see Figure 6) alone should NOT be relied upon to provide the protection needed for continued worker health. PPE such as respirators may be required for control of potential exposure to Coronavirus-19 during this type of work.

CDC recommends wearing cloth face coverings as a protective measure in addition to social distancing (i.e., staying at least 6 feet away from others). Cloth face coverings may be especially important when social distancing is not possible or feasible based on working conditions. Cloth face coverings are not PPE or RPE. They are not appropriate substitutes for PPE such as respirators (like N95 respirators) or medical facemasks (like surgical masks) in workplaces where respirators or facemasks are recommended or required to protect the wearer (OSHA, 2011).

A cloth face covering may reduce the amount of large respiratory droplets that a person spreads when talking, sneezing, or coughing. Cloth face coverings may prevent people who do not know they have been infected with the Coronavirus-19 virus from spreading it to others. Cloth face coverings are intended to protect other people—not the wearer (CDCc, 2020). Employers who determine that cloth face coverings should be worn in the workplace, including to comply with state or local requirements for their use, should ensure the cloth face coverings are worn appropriately (CDCe, 2020)

Important Suggested Measures

- Increase the outdoor air supply to 100%, if possible, or to the maximum allowed by the capabilities of the ventilation system. Some additional considerations include the climate, air pollution, and system capacity, and making sure the outdoor air intakes are clear and not drawing air from a parking lot, traffic side of building, or near smoking areas or loading docks. Make sure the ventilation system is performing as designed and has been properly maintained per ASHRAE 62.1.
- Maintain between 6 and 12 ACH, which will provide greater than 99% purge in 30–60 minutes (CDCd, 2019).
- Increase the filtration efficiency of the system to MERV 13 or as high as the filter racks and fan pressure drop will allow. System designers should attempt to accommodate Tier 1 MERV filters (MERV 13 and 14) in their current and future designs, as applicable, to ensure best airflow through the system with equipment that can withstand the added pressure drop.
- Provide additional dilution ventilation to disperse small airborne particles. Dilution ventilation should be introduced into the facility at low velocities at floor level whenever possible, with directed flow toward exhaust fans above, and spread over large areas.
- Allow the ventilation system to operate continuously if the building is occupied or long enough to allow for several complete air changes following the departure of all building occupants. If the system is shut down or set back overnight, return to full operating conditions prior to occupant return.
- Make sure restroom fans operate continuously and are exhausted directly outdoors with exhausts away from facility ventilation supply intakes. Temporarily disable or discontinue use of hand dryers in restrooms and replace with disposable paper towels.
- Allow LEV systems to operate continuously while attended. If variable air volume laboratory hoods are present, leave the hood sash in the up position to allow maximum airflow and maximum air volume to be exhausted when not in use.
- General airflow direction should be from cleaner air to less clean air, and processes and workers should be placed on the cleaner side of the airflow pattern within this general airflow pattern to reduce their exposures. Avoid having personal or pedestal fans blow from one person to another. Remember they will blow 30–40 times the fan diameter very effectively.
- Typically, more outdoor air is better. However, high velocity currents passing through open doorways or from a pedestal fan can project viruses hundreds of feet in rapid fashion (although some dilution will also occur). Where inflow occurs at high velocity near workers, attempt to diffuse large air currents by directing or blocking the flow stream to avoid moving the air from person to person. Expanded metal and perforated or unperforated screens are very effective to diffuse large air masses at high velocity.

Useful Resources for COVID-19 Related Information

CDC (Centers for Disease Control and Prevention). Coronavirus (COVID-19) (cdc.gov/coronavirus/2019-nCoV)

Businesses and Workplaces (https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/businesses-employers.html)

Cleaning and Disinfecting (https://www.cdc.gov/coronavirus/2019-ncov/community/clean-disinfect/index.html)

Guidance for Reopening Buildings after Prolonged Shutdown or Reduced Operation (https://www.cdc.gov/coronavirus/2019-ncov/php/building-water-system.html)

Worker Safety and Support (https://www.cdc.gov/coronavirus/2019-ncov/community/worker-safety-support/index.html)

OSHA (Occupational Safety and Health Administration). COVID-19. (osha.gov/SLTC/covid-19)

National Safety Council. Guidance for Employers: COVID-19 and the Workplace. (https://www.nsc.org/work-safety/safety-topics/coronavirus)

EPA (Environmental Protection Agency). Coronavirus (COVID-19). (epa.gov/coronavirus)

AIHA (American Industrial Hygiene Association). Coronavirus Outbreak Resource Center. (aiha.org/public-resources/consumer-resources/coronavirus_outbreak_resources)

National Association of Manufacturers. Covid-19 Resources (nam.org/coronavirus)

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