ANATOMY OF A HEALTHY BUILDING

An analysis of safety & security elements
to help create healthier spaces

TECHNICAL REFERENCE GUIDE

August 2020

Honeywell

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EXECUTIVE SUMMARY

> Change has been a constant theme for the world in recent months. It's been business as unusual. Many of us have changed where we work, how we socialize, how our children learn, and how we shop, and more. The full extent of our new normal is still unknown.

Change is also required to the way that we interact with, use and think of buildings in the future. Now more than ever, there is a need to create healthier built environments. From public health experts to building industry organizations, the call for change and investment in healthy buildings has been consistent.[i] Business owners, building owners and organizations worldwide – from schools to sports teams – are trying to answer one key question, "how do I get people safely back to buildings?"

Traditionally, building system design emphasizes efficiency to minimize construction and operating costs. Given challenges presented due to the COVID-19 pandemic, efficiency is now just one factor in building design. Creating safer, healthier environments that help to redefine how occupants experience and perceive a building will be critical. Leveraging existing building systems including Heating, Ventilation and Air Conditioning (HVAC) which provide and manage air quality and integrated security systems which govern the facility usage patterns, can play a vital role in reducing the risk of disease transmission and the spread of other pathogens. Importantly, there isn't one single solution to creating a healthy environment. A "Swiss Cheese Model" needs to be taken to improve the safety and health of buildings. As James Reason, PhD, noted in 1990 when he introduced the model,[ii] many risks are aren't realized because there are safeguards in place to prevent them. These safeguards are represented in his mode as multiple layers of Swiss cheese. A layering effect of safeguards within a building – from deploying integrated security systems in new ways to improving air quality and measuring success – is what can help to create a healthier environment.

Minimizing Risk in the Workplace

Using a hierarchy of controls as a response framework, companies can take a range of actions, weighing the effectiveness and financial impact of each, to combat Covid-19 in their buildings.
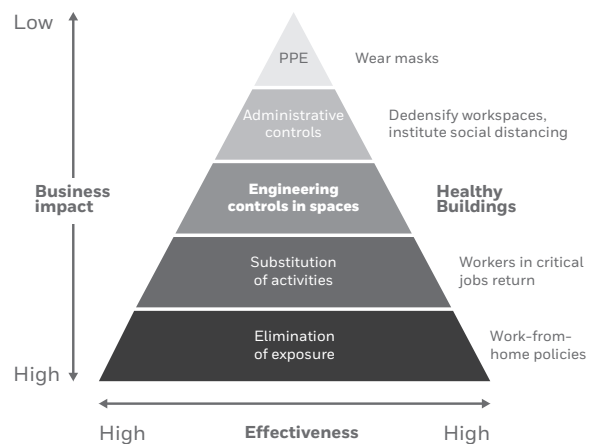
Note: "PPE" stands for personal protective equipment.
Source: Joseph Allen and John Macomber.
Originally published in the Harvard Business Review[i]

Through this series of technical reference guides, Anatomy of a Healthy Building, we will examine the key factors related to creating a healthy building as well as evaluate the several available technologies in areas related to Safety & Security, Air Quality and Key Performance Indicators to help building owners to identify the layers that best suit their buildings.

MAKING SENSE OF
REGULATORY GUIDELINES

Organizations worldwide – from government agencies, non-government organizations (NGOs), industry organizations, professional organizations and individual experts – have issued information on mitigating the risk of COVID-19 and pathogens transmission in a built environment, including those at right.

- Center for Disease Control and Prevention (CDC)
- World Health Organization (WHO)
- American Industrial Hygiene Association (AIHA)
- Building Owners & Managers Association International (BOMA)
- Environmental Protection Agency (EPA)
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
- Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA)

The regulatory guidelines issued to date are broad in nature, primarily covering intent. This technical guide series attempts to delve deeper into the guidelines, intent and industry best practices, keeping in mind the present and future, long-term needs of a healthier facility. It aims to introduce facility owners, managers, operators and occupants to various concepts and best practices to potentially mitigate pathogen transmission risks through assessment, maintenance and modifications, to existing building systems, primarily integrated security and HVAC. It also explores future design needs of building systems to better manage contagious events with minimal business disruptions.

Although the principles apply primarily to buildings, they may also be applicable to other enclosed areas, such as mass transit systems or planes.

HOW TO CREATE
HEALTHIER
BUILDINGS

A healthy building environment starts with a baseline of understanding – what is the health of your building environment and where are opportunities for improvement. Conducting an audit of your building systems – from air quality, space management and integrated security – will identify potential upgrades and changes. The two primary systems for a healthy building are in air quality and safety and security.

Below we review considerations and processes that help to create and manage a healthy building as well as specific areas for Safety & Security and Air Quality.

AUDIT

Conduct an audit of your building's current strengths, weaknesses and optimal next steps.

IDENTIFY AND ISOLATE

Use tools such as thermal imaging stations, contact tracing, mask detection, crowd counting to identify and isolate potential exposure.

PREVENT

Maintain operational parameters like temperature, humidity, pressurization, air changes and particle count at optimal ranges.

Enhance procedures and capabilities for surface cleaning and consider disinfection using UV light or similar techniques.

Minimize contact with frequently touched surfaces through frictionless access and monitor and manage occupancy of a specific building, area or zone.

REPORT

Make the right data readily available to the right people, in the right time, through advanced, operational dashboards.

ANALYZE

Use a combination of on-premise database and advanced cloud analytics.

SAFETY & SECURITY
RISK MANAGEMENT

Thermal Screening

Employ thermal Screening, a method to detect a person's initial body temperature, by various devices like thermal cameras, infrared thermometer, etc.

Density/Occupancy Management

1. Identify ways to manage social distancing adherence and mask compliance.
2. Create awareness for facility managers regarding trends within a space on social distancing and mask compliance as well as deploy contact tracing to identify potential exposure.
3. Manage crowds using access control system and video analytics detection systems.
4. Use frictionless access control to limit interactions with frequently touched surfaces.
5. Explore the best frictionless access control strategies for your building such as touchless access readers and PIR sensors.

AIR QUALITY & SPACE
HEALTH MANAGEMENT

Indoor Air Quality (IAQ) depends on the presence and management of pollutants in the indoor environment that may cause harm. Indoor air quality is impacted by chemical and biological pollutants in gas, liquid or solid states in the indoor environment. When IAQ is poor, occupants can experience illnesses such as asthma, fatigue, irritation and headache.[iii] Creating strategies to measure and improve indoor air quality is a key factor to a healthy building.

Temperature and Relative Humidity

Maintain proper temperature to improve health as well as productivity. The right humidity range, typically between 40-60%,[iv] is known to decrease occupant exposure and reduce viral transmission risks.

Air Filtration, Cleaning and Disinfection

Use filtration as an effective defense against some airborne pathogens through its high capture efficacy.

Ventilation

Increase ventilation in buildings to bring fresh air into a space from the outdoors to increase oxygen levels and dilute occupant-generated pollutants (e.g., carbon dioxide) and product-generated pollutants (e.g., volatile organic compounds).

Pressurization

Control air flow direction between clean zone and contaminated zone using pressure by maintaining pressure gradient and pressure difference between different zones.

Surface Cleaning and Disinfection

Consider the efficacy of surface disinfectants, including the mechanisms, action of the active substance and its interaction with the target organism. The purpose of routine or targeted disinfection of inanimate surfaces is the killing or inactivation of pathogens to an extent which mitigates the risk subsequent infection transmission.

We will review Air Quality in depth in a subsequent technical guide in the Anatomy of a Healthy Building series.

SAFETY & SECURITY
RISK MANAGEMENT

Building owners need to safely bring people back to work while addressing new challenges. Occupants want to know that a space is not just safer but also healthier. Implementing new policies and practices is the first challenge. The second is sustaining compliance. Using integrated security systems in new ways to create a safer and healthier environment can help prevent, identify, analyze and report non-compliances and incidents alike.

We are going to explore different ways this can be achieved to understand why specific methods matter, potential deployments for each and recommendations for consideration.
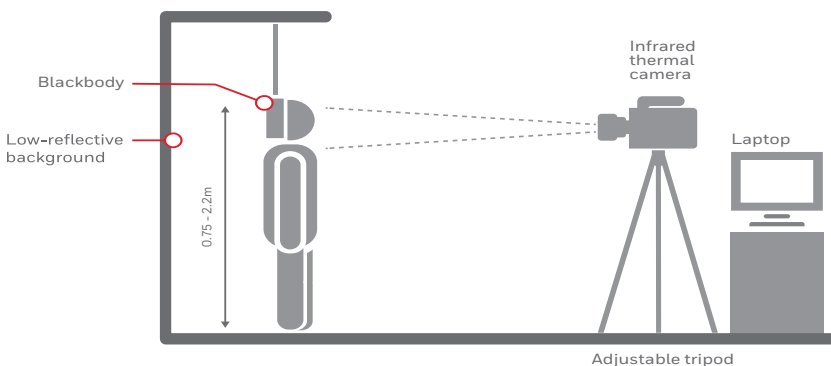
THERMAL SCREENING

Why it matters

According to the World Health Organization, a key symptom of COVID-19 is an elevated body temperature or fever. CDC guidelines recommends that businesses conduct daily health screenings[v] including potential screenings for elevated body temperatures prior to entering a facility. Normal average body temperature is assumed to be 97.5°F and 97.9°F. Studies also show that average body temperature varies throughout the day – lowest in the morning, peaking in the afternoon,[vi] to which some businesses may look to identify ways to screen employees' body temperatures multiple times a day.

Businesses face the challenge of preventing someone who be potentially infected from entering the building which could increase the risk for other occupants. Limiting potential exposure will be a key goal of most organizations to ensure business continuity.

Certain thermal imaging systems like thermal cameras can be used to measure surface skin temperature. To be clear, though, thermal cameras are not diagnostic tools for detecting viral infection; rather, they are for initial body temperature assessment for triage use and results should be evaluated by health care professionals.

As per the FDA,[vii] "Temperature-based screening, such as thermal imaging, is not effective at determining if someone definitively has COVID-19 because, among other things, a person with COVID-19 may not have a fever."

Thermal cameras which detect elevated body temperature can be a way of proactively screening people with a higher elevated body temperature. There are different ways of measuring elevated body temperatures.

Blackbody

Low-reflective background

0.75 – 2.2m

Infrared thermal camera

Laptop

Adjustable tripod

THERMAL SCREENING

Solutions and outcomes

There are different ways of measuring for elevated body temperatures.

Handheld forehead or ear thermometer (NCITs – Non-Contact Infrared Thermometers)

Although this is an accurate way of measuring temperature, it is a more intrusive method and may expose the operator to risk of infection due to proximity and manual intervention required.

Thermal cameras

This method can either measure elevated body temperature by scanning the surface skin temp (mainly forehead) or the core body temperature using tear ducts, which are more accurate but require extra time for measurement and may stem the flow of people. The thermal cameras which use tear ducts to measure core body temperature also require the subject to remove any hats and glasses for the temperature measurement to be properly recorded.

Typically, thermal cameras should be placed at least one to three meters from the person whose body temperature is being detected. to increase the accuracy of some thermal cameras, a blackbody must be employed. A blackbody is typically used as a calibration tool for the IR temperature sensor.

Minimize infection exposure to occupants by initial screening for symptoms such as elevated body temperature at entrances.

- Simple setup and easy to use, some only take 45 mins to install, calibrate and start capturing.

- Conduct high volume capture rates to satisfy mass screening requirements.

- Integrate with other access and video management systems to drive reporting and compliance needs.

It is key to note that thermal cameras are not diagnosis tools for detecting viral infection. They are only used to detect elevated temperature levels.

Recommendations

For the purposes of screening employees and visitors for elevated body temperature, it is important to consider the following[vii] when using thermal cameras:

- Look to use a thermal camera that can measure temperature with at least an accuracy of +/- 0.5°F or 0.3°C to meet initial screening goals.[viii, ix]

- Identify the least intrusive experience as possible that also helps maintain a steady flow of people.

- Use thermal cameras as a device for screening a continuous flow of people to prevent choke points, but if someone is identified with an elevated body temperature, a second level of temp measurement using a NTIC device should also be used.

- Employ a queuing mechanism (as seen at airport check-in counters – see below) to manage the flow of people and negate the impact of outside weather on the surface skin temperature as it helps in acclimatizing the person's body to the ambient temp and thus may result in lower false positives.

SOCIAL DISTANCING ADHERENCE
MASK COMPLIANCE AND CONTACT TRACING

Why it matters

CDC guidelines recommend wearing mask or cloth face coverings in public places and especially at places where social distancing guidelines are difficult to follow – for e.g. elevators or other enclosed spaces.[x] Breathing, talking, singing, coughing and sneezing produce aerosols that may contain pathogens with a wide spectrum of sizes. Although viruses like SARS-CoV-2 are very small (0-100nm), they typically exist in droplets and droplet residues. Recent studies find that more than 50% of shed viruses are in particles smaller than 5 micrometers.[xi] Many respiratory particles can remain airborne for hours, SARS-CoV-2 can survive for hours in the air.[xii] This reinforces the need to wear masks and adhere to social distancing guidelines.
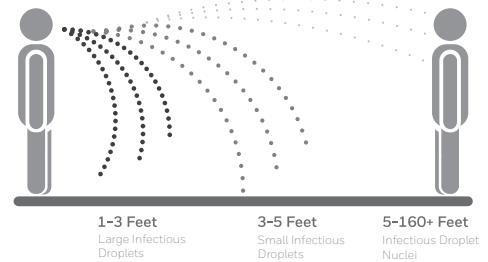
Recent studies have shown the impact of wearing masks and social distancing guidelines are significant in fighting the spread of virus.[xiii]


| 1–3 Feet | 3–5 Feet | 5–160+ Feet |
| Large Infectious Droplets | Small Infectious Droplets | Infectious Droplet Nuclei |

ASHRAE Position Document on Infectious Aerosols [xvii]

PARTICLE SETTLING IN STILL AIR

Time to settle five feet by unit density spheres

0.5 μm	1 μm	3 μm	10 μm	100 μm
41 hours	12 hours	1.5 hours	8.2 minutes	5.8 seconds
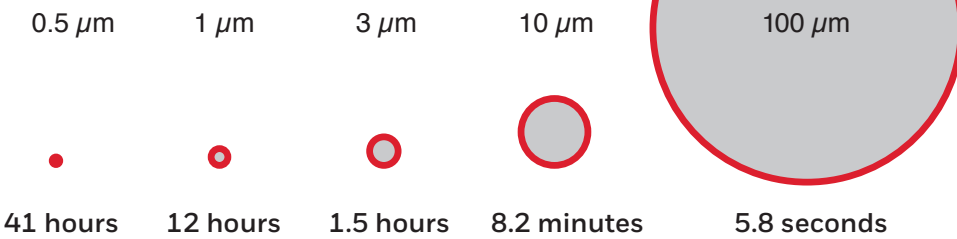
Aerodynamic diameter definition is the diameter of a unit density sphere that settles at the same velocity as the particle in question.   ASHRAE Position Document on Infectious Aerosols[xvii]

Virus Spread Model
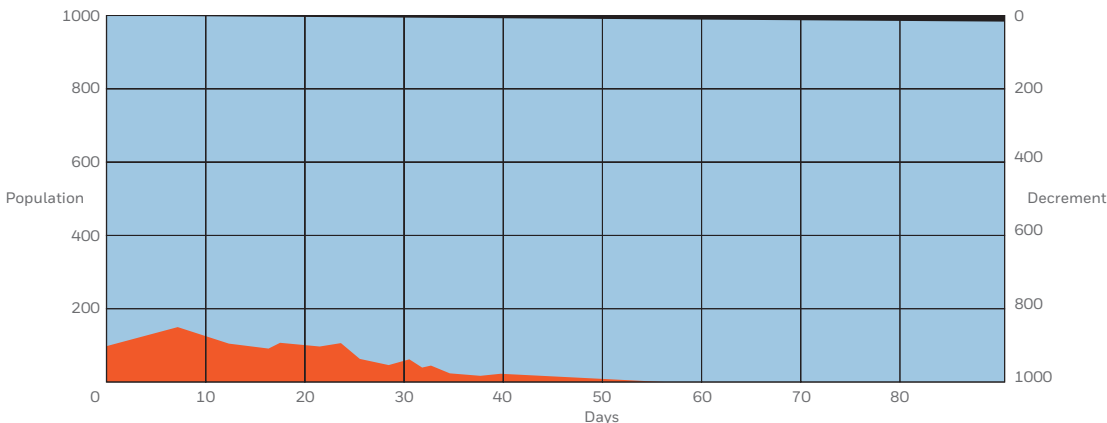
This simulation shows the effect on the same hypothetical group of 100 infected people out of a group of 1000 where 80% of people wear masks and practice social distancing, which slows the infection rate to almost zero after two months.

Dead
Healthy
Infected

Image: Goldenson Center for Actuarial Research, CC BY-NC-ND

Solutions and outcomes

Following CDC guidelines, many businesses trying to sustain or re-open have made it mandatory to wear masks on premises. Floor markers indicating and prompting occupants of a space to follow social distancing guidelines (typically six feet) are also a common sight now. Enforcing compliance to wear masks within the facility to create a safer environment is currently a manual process and with no workflow processes for many organizations.

Advancement in deep learning video analytics can determine if a person is wearing a mask or even maintaining proper social distancing using video analytics or BLE technology.

Using technology to monitor and identify occupants in a space can help in minimizing occupants' potential virus exposure. You can drive compliance based on health, government or corporate guidelines by creating compliance reports using video analytics-based mask detection technologies.

It might be difficult to manually enforce social distancing by using either floor markers or even other monitoring solutions as this is mostly driven by personal behavior. Analyzing violations of social distancing using video analytics can help you adjust the space being monitored to create the infrastructure to automatically avoid close contact of people. Video analytics can identify potential hot zones where social distancing violations occur most frequently and provide analytics to help building operators to organize the space to enforce people to be 4 to 6 feet apart as recommended by several studies.[xiv]

Similarly, using visual techniques like Smart Badges (with amber or green lights) which measure distance between two people who are in conversation or have potential to inculcate the habit of adhering to social distancing guidelines without being rude.

One of the most important outcomes that can be achieved using Access, Video Analytics or BLE technology is to identify, over a period, the number of people who might have come in contact with a potentially suspected carrier. This is known as Contact Tracing. This can help you reduce your forensic efforts and cost by automating the ability to trace individuals at potential risk of exposure. Access control systems can also be used to create compliance reports to investigate a card of an individual and show any other card reads at that location and time if a known or suspected case is identified.
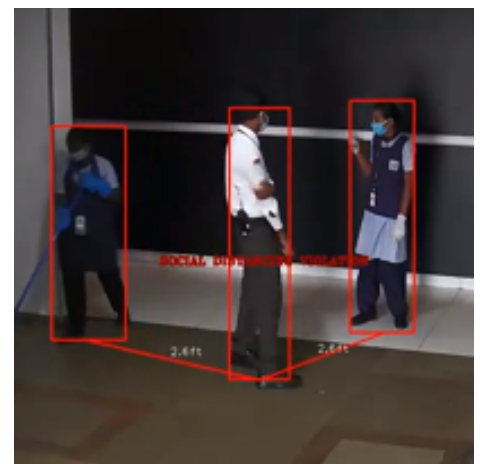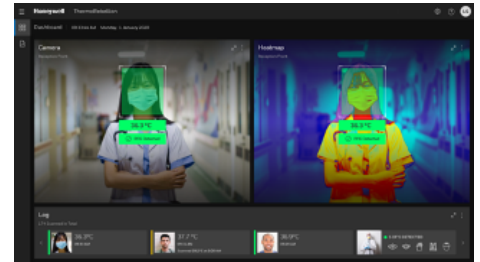
Recommendations

There is no one way to enforce compliance adherence which can help businesses re-opening and sustain business continuity in order to minimize the risk of exposure to their employees, vendors or visitors. Honeywell recommends deploying a suite of solutions that can help you achieve the following outcomes.

Using video analytics and deep learning AI to identify occupant mask compliance. It is recommended to use this in critical areas where you can take corrective actions, for e.g., monitoring at entrances, in common areas within a commercial building like the cafeteria, and before entering an elevator. Creating real-time notifications and reporting capabilities to can help adequately inform and protect building occupants.

Using video analytics can allow building owners and operators to monitor large spaces for social distancing adherence. Analyzing data can create trends, track compliance and identify hotspots where chances of exposure due to close contact might be high.

Finally, using access based solutions or video analytics to trace people who might have come in contact with a potentially infected person can trigger an incident and standard operating procedure (SOP) which can automate rapid tracking of suspected carriers and potential exposures to protect staff, visitors and the community.

DENSITY AND OCCUPANCY MANAGEMENT

Why it matters

Managing occupancy density is critical in this new normal. Keeping a safe distance is recommended by organizations like the CDC.[xiv] The need to social distance is required in buildings – from commercial offices to stadiums. This means building owners will need to monitor high traffic areas and potentially stagger arrivals or footfalls to specific areas. to allow for social distancing. Washroom facilities will require more frequent sanitization while also managing the number of entrants at a given time.

An Occupancy Management System can help optimize workspace usage patterns. An Occupancy Management System can help monitor the overall building occupancy as well as specific space usage, such as setting the capacity of and monitoring the usage of meeting rooms. Many companies may prioritize in-person meetings for the only most business-critical situations so these systems can help to manage occupancy in a space. A minimalist approach to furniture and creating necessary space between occupants will be critical in preventing the spread of germs. The new focus will be on creating valuable interactions between employees and clients in safer, well-ventilated space.

Solutions and outcomes

Occupancy management can be deployed using a variety of systems. Following, we'll explore several ways to monitor and manage occupancy.

Access control system

Most modern facilities use some type of networked video system and access control system. An access control system can support occupancy management with both software and hardware tools.

- Muster Reader: Understand occupancy of a specific zone or room with a Muster Reader.

- Configure Limits: Determine and manage occupancy limits for a specific zone or room, even customized to a given time, to allow access to a space.

- Access Door Lock and Unlock Authority to Security Personal: Allow security personnel to restrict certain areas if they are found to be frequently too crowded. This can be done through a dedicated access card that can be programmed in such a way that once badged on the door, it will lock the door until a stipulated time period as defined in system and then it will be normalized (i.e., normal operation) or door will remain locked until the same card is badged again on the same reader.

Occupancy Sensor

Occupancy management can also be achieved by strategically installing the occupancy sensors in the facility. Occupancy sensors can provide immediate overview of how a building is being used at any given time and integrate with other smart building technologies.

The data provided by occupancy sensors can improve the efficiency of buildings and help make them safer and more welcoming places for occupants.

Video Analytics Solutions

Video analytics can provide a highly accurate counting solution. These analytics can be deployed to count people entering or exiting a space, vehicles, and exiting, people counting in a crowd or even in a queue.

With the help of bi-directional people counting feature, supported with overhead cameras that are installed at all transit points, it can provide occupancy at any instant for a specific location. For outdoor or open indoor spaces that are not bound by specific transit points, and approximate crowd count is provided by analyzing video of angular camera and focusing on any region of interest marked by a virtual polygon.

In a parking area lot or structure, video analytics can count vehicles, going in or coming out, to provide real-time parking slot occupancy and availability statistics section-wise, floor-level-wise or even for the complete parking lot.

In addition to occupancy management, with the right analytics layered with tools such as heat maps, or a movement density map, and flow maps, or movement direction trends, over a region or floor area to identify uniform movement or bottle necks.

Recommendations

Deploy an occupancy management solution supported by good quality IP cameras to leverage the abilities of video analytics.

Analytics Server

Open Platform VMS

Operator
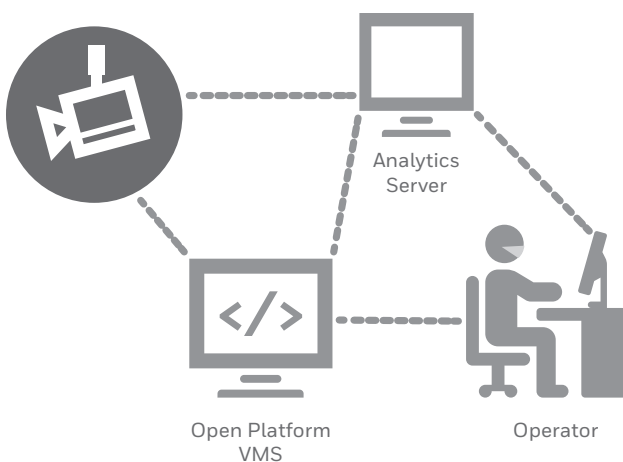
FRICTIONLESS ACCESS CONTROL SYSTEM

Why it matters

Outside research shows that virus can be transmitted directly or indirectly through contaminated objects or surfaces, or close contact with infected people via mouth or nose secretions.[xv] There is also growing evidence that transmission is possible through airborne microdroplets.[xii, xvi] Droplets and small particles of a broad spectrum of diameters may be generated during coughing and sneezing and, to a lesser extent, even by talking and breathing.[xi]

Larger emitted droplets are drawn by gravity to land on surfaces within about three to seven feet from the source. Small aerosols (<5 micrometers), may stay airborne and infectious for extended periods and may can travel longer distances and infect secondary hosts who had no contact with the primary host.[xvii] As the droplets fall, they will land on nearby surfaces and objects such as desks, tables, doorknobs, handrails or telephones. While viral spread through surfaces may be limited, there is still a need to keep frequently touched surfaces clean or even identify ways to reduce contact with them.[xvii]

Many workplaces and buildings use access control systems to allow only authorized entry. This often involves equipment which needs to be used by physical interaction – like the need to touch access card on the card readers, push the door to open by holding the door handle or pushing a button to exit, for example.

Similarly, parking management systems often need authentication by either touching the card to reader, push buttons or kiosk receipts.

Elevators are also high touch that involve calling the lift car by pressing button.

Electrical switches for lighting control coffee areas and vending machines also often require physical interaction.

Solutions and outcomes

Through the integration of technologies like Artificial Intelligence (AI), Bluetooth and passive infrared sensor (PIR), among others, it is possible to create frictionless access control systems to help eliminate contact with frequently touched surfaces.

Additionally, many buildings deploy motion sensors to trigger the lighting control and the electrical system.

**These systems can be deployed to achieve frictionless access to a facility.**

- Automatic Number Plate Recognition (ANPR) for parking
- Touchless Lift Control using tools such as:
- Foot-operated buttons
- QR code scanning
- Mobile applications

Touchless access control with

- Face recognition readers
- Bluetooth readers
- Touchless rex
- PIR motion sensors

Automatic Number Plate Recognition (ANPR) System

With an ANPR System, buildings can deploy a frictionless access to a parking slot or area. ANPR uses optical character recognition on images to read license plates on vehicles. ANPR can be used with either existing CCTV systems or using cameras specifically designed for the task.
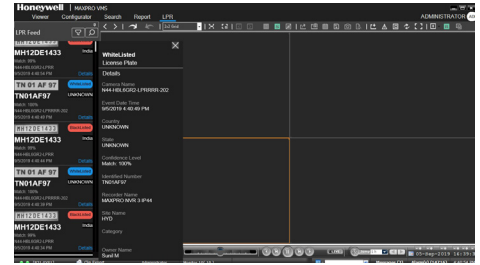
Touchless Lift Control

Touchless lift control can be achieved via several different modes.

- Foot operated call or floor selection buttons: These foot operated pedals are added in the elevator lobby on each floor and inside the elevators.

- QR Code Lift Control: Deployment of QR codes and mobile applications can also help to manage lift operation. To call the lift, an individual would scan the QR code in the respective elevator lobby and use the mobile application to select destination floor.

- Mobile application for Lift Access: Mobile applications to manage lift access can be used to authorize entry. It allows users to quickly and conveniently make personalized elevator calls from anywhere in the building. It offers the following benefits:

- Place a call from anywhere in the building – not just when directly at the elevator

- Reduce waiting time and lobby congestion

- Program different call types in advance, i.e., priority or normal calls

Touchless Visitor Management

Creating a frictionless visitor experience is also important. Visitors can communicate on a video intercom placed on the entry door and similarly, touchless rex can be used to unlock doors installed near the reception area. Once the visitor approaches the reception area, on valid verification, access can be granted by issuing either card or visitor management application access, which supported by a mobile phone.

Smartphones can be used to unlock access-controlled doors, to raise requests and to provide a digital photo identification. Apps are supported by a cloud-based infrastructure and use smartphones to unlock doors from a distance. A digital photo ID with a clear and current photo on a user's phone can be created in seconds with no printing or long lines.

Touchless Intercom System

Touchless intercom system can also be used by visitors. Visitors can avoid face-to-face interaction with guards or persons sitting in the reception. Once authenticated, guard or person managing the reception area can allow the visitor to enter the premises.

Touchless operation can be initiated by:

1. Voice-activated call initiation

2. Gesture-activated call initiation like waving a hand in front of the intercom.

Touchless intercom can be installed on the main entrance door or near the guard house.
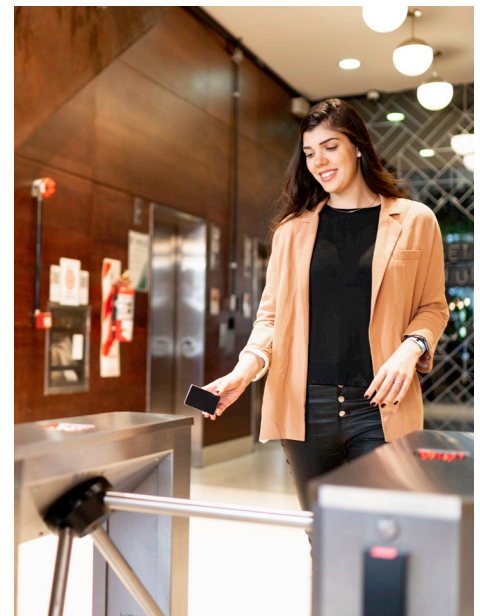
Touchless Access Control System

Biometric reader

Biometrics is a growing field when it comes to access control. While many people just consider facial recognition, there are also readers that use fingerprint or finger vein authentication.

Facial recognition readers can also support frictionless access into a facility Facial recognition reader typically use a 2D or 3D scanner to scan the image. The scanning is achieved with the help of cameras built into the facial recognition reader. It uses advanced algorithms to map and detect the face. The recognition system then translates them into hundreds of data points representing the unique geometry of face. The facial recognition algorithm can detect unusual angles or poor image quality and make the adjustments necessary to the faceprint.

Some biometric readers available in the market also support RFID card technologies like Proximity, iClass, MIFARE and DESFire.

Bluetooth card reader

With the help of a Bluetooth reader, frictionless access in the facility can be achieved. With Bluetooth operation, building access credentials are sent from a partner app on the authorized user's Bluetooth smartphone to the reader, enabling the user to gain access simply by holding their mobile device to the reader. It supports RFID card technologies like Proximity, iClass, MIFARE and DESFire.
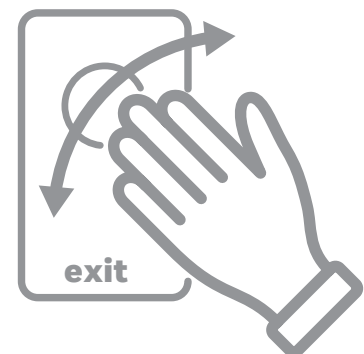
Touchless Rex

Touchless Request to Exit button with IR sensor is the best suitable option to replace the manual touch Rex button. A simple wave of the hand in front of Touchless REX button will open the door. It typically features an LED illuminator which changes color upon movement detection.

PIR sensor

Touchless PIR Sensor is also suitable for frictionless access. It identifies the movement within the detection range and releases the access control door. They are often installed above the door.

NO TOUCH
JUST WAVE YOUR HAND

exit

FRICTIONLESS ACCESS CONTROL SYSTEM

Recommendations

Working to identify ways to create a frictionless experience in a building can help to reduce contact with frequently touched surfaces. While a building may not be fully touchless, there are ways to limit contact and improve footfall in specific areas by employing frictionless access solutions. A building may require a suite of solutions to achieve desired outcomes.

- Consider an ANPR system in the parking lot to create frictionless access and ease for the occupant in the parking area.

- Add facial recognition, biometric and Bluetooth readers in main transit areas to help overcome the limitations of traditional swipe and touch card readers. It is important to use technology that meets your company's privacy and regulatory guidelines. .

- Use touchless rex button and motion sensors to avoid manual touch rex buttons.

- Employ touchless electrical switches for lighting and other equipment; often, these automated switches and controls can also help save energy by adjusting usage based on occupancy providing an additional benefit.

- Identify ways to further limit contact by deploying touchless vending machines or cashless canteen services supported by a mobile app.

FRICTIONLESS ACCESS CONTROL SYSTEM

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