PANDEMIC-READY AIRFLOW CONTROL

USED IN HOSPITALS DURING COVID-19

Azbil Corporation

Pandemic Readiness in Hospitals

COVID-19 has made pandemic countermeasures a necessity in healthcare infrastructure. With heating ventilation and air-conditioning systems (HVAC) playing a crucial role in preventing airborne and aerosol-based transmission, we would like to introduce airflow control methods and Azbil's venturi airflow control valve —both of which are helping hospitals in Tokyo battle the pandemic.

Airborne Infection Isolation Room (AIIR)

The need to accommodate infected patients in airborne infection isolation rooms (AIIR) with negative pressures have come to the attention of healthcare staff and the general public. Nosocomial infection, arising from the transmission between infected patients and other inpatients, outpatients, and staff, has been one of the main causes of spreads. This can be curbed with AIIRs, which ensures appropriate levels of negative pressure and inward airflow.

From the viewpoint of public health, the ideal setting is to set up sufficient AIIRs in as many hospitals as possible; but from the viewpoint of hospital management, this means increasing needs for space and high initial and operational costs, especially if the facilities will become redundant during the normal periods. Since the design requirements for HVAC differ greatly in general patient rooms and AIIRs (as summarized in Table 1), inefficiencies in HVAC energy consumption arise when the latter serves as the former after a pandemic. Furthermore, airflow from the surroundings can affect the cleanliness standards of these hospital rooms, rendering the option even less feasible.

Pandemic Mode HVAC System

An HVAC system with a "pandemic mode" can be an effective solution to solve this issue. As depicted in Fig. 1, the HVAC system is available in two modes. The first is characterized by normal air changes and equal pressure between rooms and surrounding spaces. The second one, which is to be used during a pandemic, features increased air changes with negative pressure and inward airflow from the surroundings.

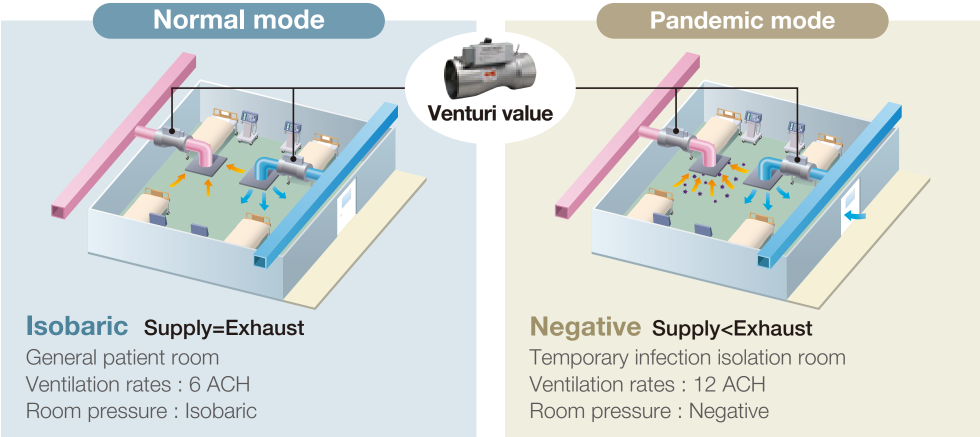
Table 1 Excerpt from ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities

	Pressure relationship to adjacent areas	Minimum outdoor air changes	Minimum total air changes	All room air exhausted directly outdoors
Patient room	–	2 ACH*	6 ACH	–
Airborne infection isolation room	Negative (-2.5 Pa)	2 ACH	12 ACH	Yes

* ACH: Air changes per hour.

Fig. 1

Temporary negative-pressure isolation (TNPI) room using an HVAC system with a pandemic mode



Depending on the severity of community transmission, parameters can be adjusted suitably. In its early stages of a pandemic, the system can be activated in single-bed rooms. As transmission becomes widespread, multiple-bed rooms can operate on this mode as they become temporary isolation rooms for infected patients.

AIIR precautions prevent the transmission of infectious agents that remain in the air for long periods. Patients with airborne infections should be placed in rooms with negative pressure. According to the Joint Commission International (JCI) Accreditation Standards for Hospitals, if an existing building structure prevents the construction of an immediate negative-pressure room, the hospital may construct a temporary negative-pressure isolation (TNPI) facility.

Use Case in Tokyo

During the H1N1 pandemic in 2009, as part of the pandemic countermeasures, an HVAC system with a pandemic mode was installed in two designated hospitals in Tokyo, which have also been treating COVID-19 patients in this current pandemic. This system was able to significantly increase the number of beds to accommodate patients with severe infections.

CONTROLLING THE COMMON AREAS

In the event of widespread community transmission, preventing airborne transmission in public areas such as in the lobbies or entrances is also necessary to prevent nosocomial infection from the patients to visitors and healthcare providers, and vice versa.

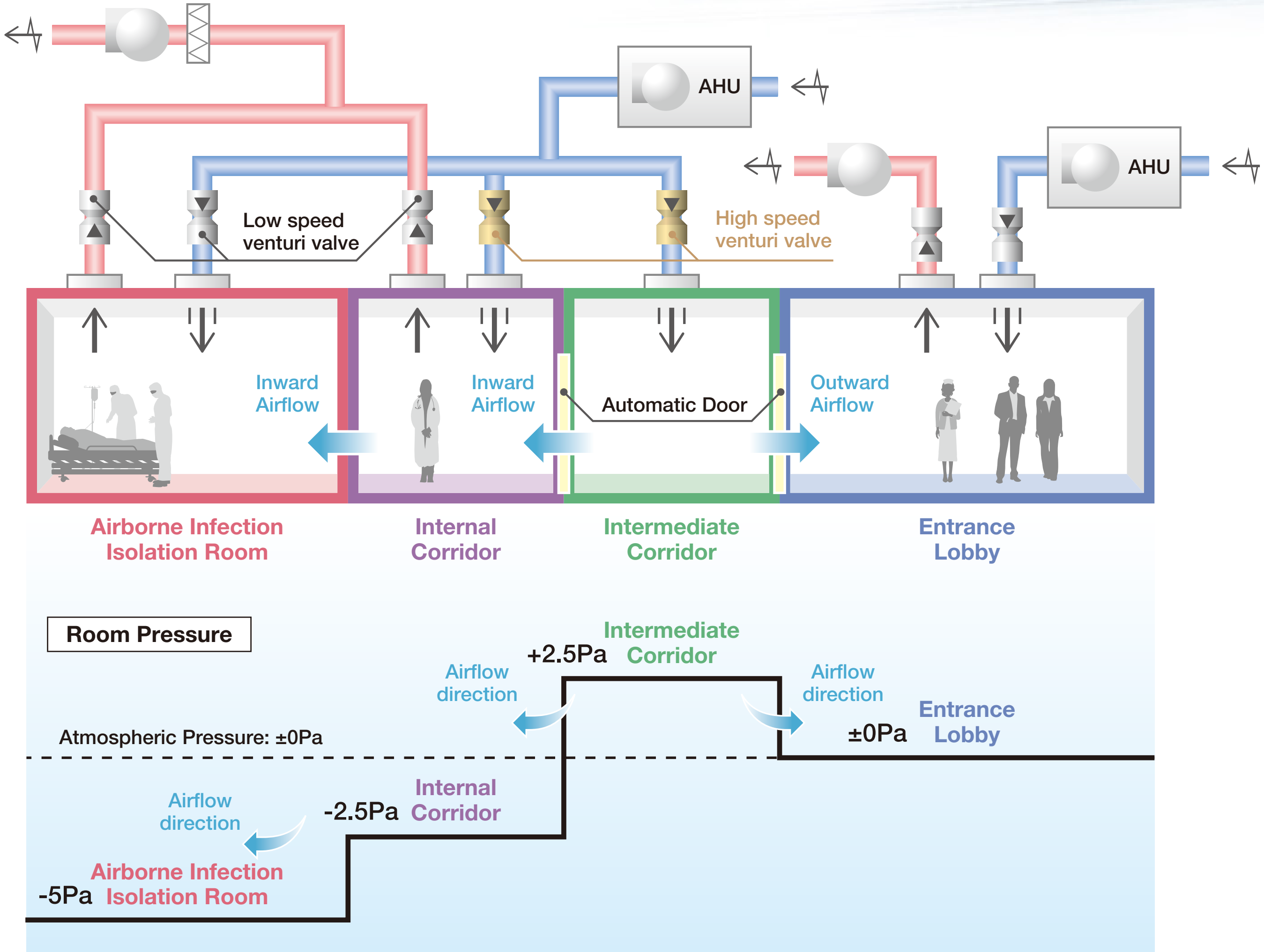
As depicted in Fig. 2, an effective approach would be to build an intermediate corridor halfway between the public areas and the wards' internal corridors—a narrow space with positive pressure serving as an airlock to create an embankment of pressurized air.

The inward airflow from the intermediate corridor to the internal corridor and patient rooms prevents the transmission from the wards to public areas. At the same time, the outward airflow from the intermediate corridor to these public areas prevents the transmission from public areas to rooms.

The doors at both ends of the intermediate corridor should be automatic to allow for a convenient passage for stretchers or large equipment. An interlock should also be activated to prevent both doors from opening at the same time. When an automatic door opens, in order to prevent the dispersion of contaminated air, it is necessary to increase the supply of airflow into the intermediate corridor, which will increase the directional airflow into the adjacent space. Since this airflow control would require a quick response to the opening and closing of the automatic doors, it is necessary to install a high-speed variable air volume (VAV) device with a response time of one second or less.

Fig. 2

Creating a pressure "embankment" to prevent cross contamination in pandemic mode using a high-speed VAV device



In order to prevent airborne and aerosol-based transmission and to protect healthcare providers, airflow control should also be accurate and reliable. There are two common methods of control. The first is known as volumetric offset control, which creates an accurate inward (or outward) directional airflow between corridors and rooms by using VAV or constant air volume (CAV) devices. A volumetric offset is created by maintaining a higher volume of exhaust air than supply air. The second method is direct pressure control, which adjusts the VAV device or the motor damper based on the measured room pressure values.

Although both methods are able to create different room pressure levels, particularly in spaces with high door traffic and low levels of airtightness, volumetric offset control may be more accurate and reliable. When a door is opened, the pressure difference between the spaces will instantly become zero. The VAVs or motor dampers used in direct pressure control tend to respond excessively to the room pressure values, which may result in unstable room pressure or airflow. In spaces where airtightness level is low, this method might fail since the measured room pressure values would only be minute. Also, a very small error occurring in the room pressure sensor would destabilize the system. For example, if the zero-point on the room pressure sensor shifts by as little as 2 to 3 Pa towards the negative, direct pressure control may interpret the present value as the sufficiency of negative pressure and proceed to reduce exhaust air volume. This leads to a reversal in airflow direction from inwards to outwards.

Conversely, if the zero-point shifts by 2 to 3 Pa towards the positive, direct pressure control may not register that there is sufficient negative pressure. Instead, it would respond by increasing exhaust air volume beyond what is required, leading to insufficiency in other rooms belonging to the same HVAC system. This fails to maintain inward airflow to them.

Selecting VAV/CAV carefully

The selection of the VAV/CAV device that controls the airflow has to be done carefully.

The pressure loss of the air in a duct is proportional to the squared value of air velocity. This means that keeping the duct size constant, doubled air volume will result in doubled air velocity and quadrupled loss of air pressure. Any adjustment to the air volume, for example switching the pandemic mode, can affect the distribution of duct pressure greatly in the HVAC system.

A careful selection of the VAV/CAV airflow control device is paramount. If air volume is altered due to switching to the pandemic mode, there will be a great change in the distribution of duct pressure in the HVAC system. Also, when there are strong winds outside of the building—especially onto the exhaust port of the exhaust fan or the outdoor air inlet of the air handling unit— the duct pressure will severely fluctuate. In order to control airflow accurately and reliably, the system needs to be able to control airflow to the set point without being affected by changes in the duct pressure. Such a system is commonly known as a pressure-independent mechanism.

Even when there are great fluctuations in pressure differences across the VAV/CAV devices caused by duct pressure, we need to control supply air and exhaust airflow accurately based on the settings. This helps to maintain appropriate volumetric offset and create stable directional airflow to reduce the risk of airborne infections.

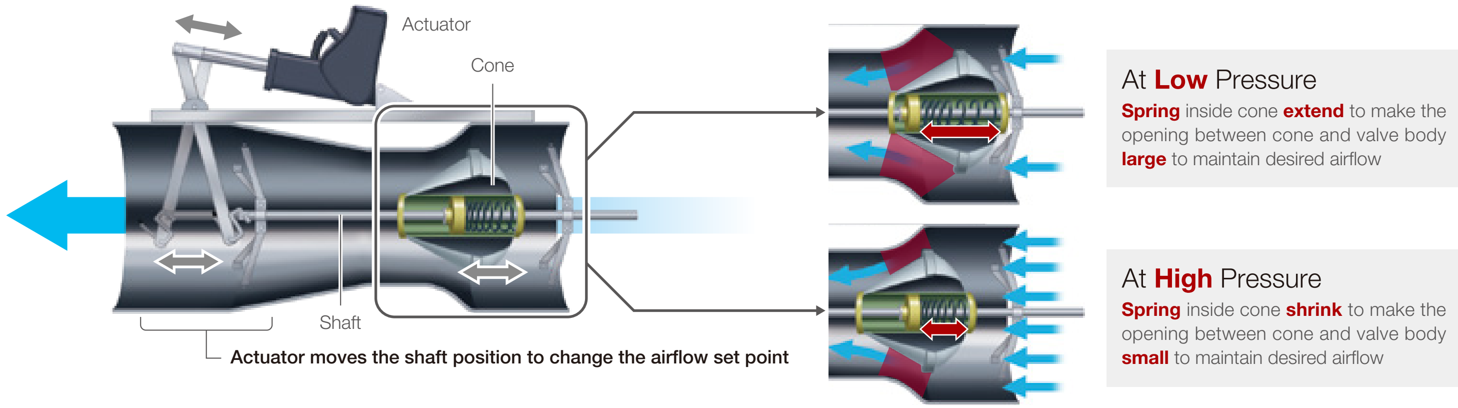
As depicted in Fig. 3, the venturi airflow control valve Infilex VN offered by Azbil is equipped with a superior pressure independent mechanism. This is made possible by the expansion and contraction function of the spring in the inner part of the cone and the curve of the venturi tube. Such a valve suits perfectly with the HVAC systems used for pandemic countermeasures. Indeed, it has been adopted extensively in healthcare and research facilities, with extensive evidence of its capabilities.

Airflow Control Valve Infilex™ VN with Pressure Independent Mechanism

Pressure independent mechanism will assure your desired airflow even when duct static pressure frequently changes

Fig. 3

The accurate and highly reliable airflow control valve Infilex VN with pressure independent mechanism



CONCLUSION

In the current COVID-19 outbreak, the author of this article and the staff of Azbil have been present at the two hospitals in Tokyo mentioned above as support personnel for the airflow control system. The switch to pandemic mode was one of great urgency, with the hospitals expanding their capacity as quickly as possible with rising infections.

We witnessed the situation at healthcare facilities growing tenser by the day, demanding a swift and apt response with no room for failure. If hospitals relied on VAV/CAV devices of poor performance, the consequences of ineffective pressure conditions, readjustment, and displacement of inpatients would have been disastrous and unthinkable.

Healthcare staff fight day and night to save the lives of infected patients, so infrastructure must perform perfectly to protect the safety of the healthcare staff. Provision of quality devices that can perform accurately without causing concern for safety is very important. Technology such as Azbil's venturi airflow control valve Infilex™ VN can deliver accurate and highly reliable airflow control for healthcare facilities, allowing them to treat patients and protect medical staff at the same time. We hope this article has deepened your understanding of pandemic countermeasures involving HVAC systems in healthcare facilities.

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Specifications are subject to change without notice.