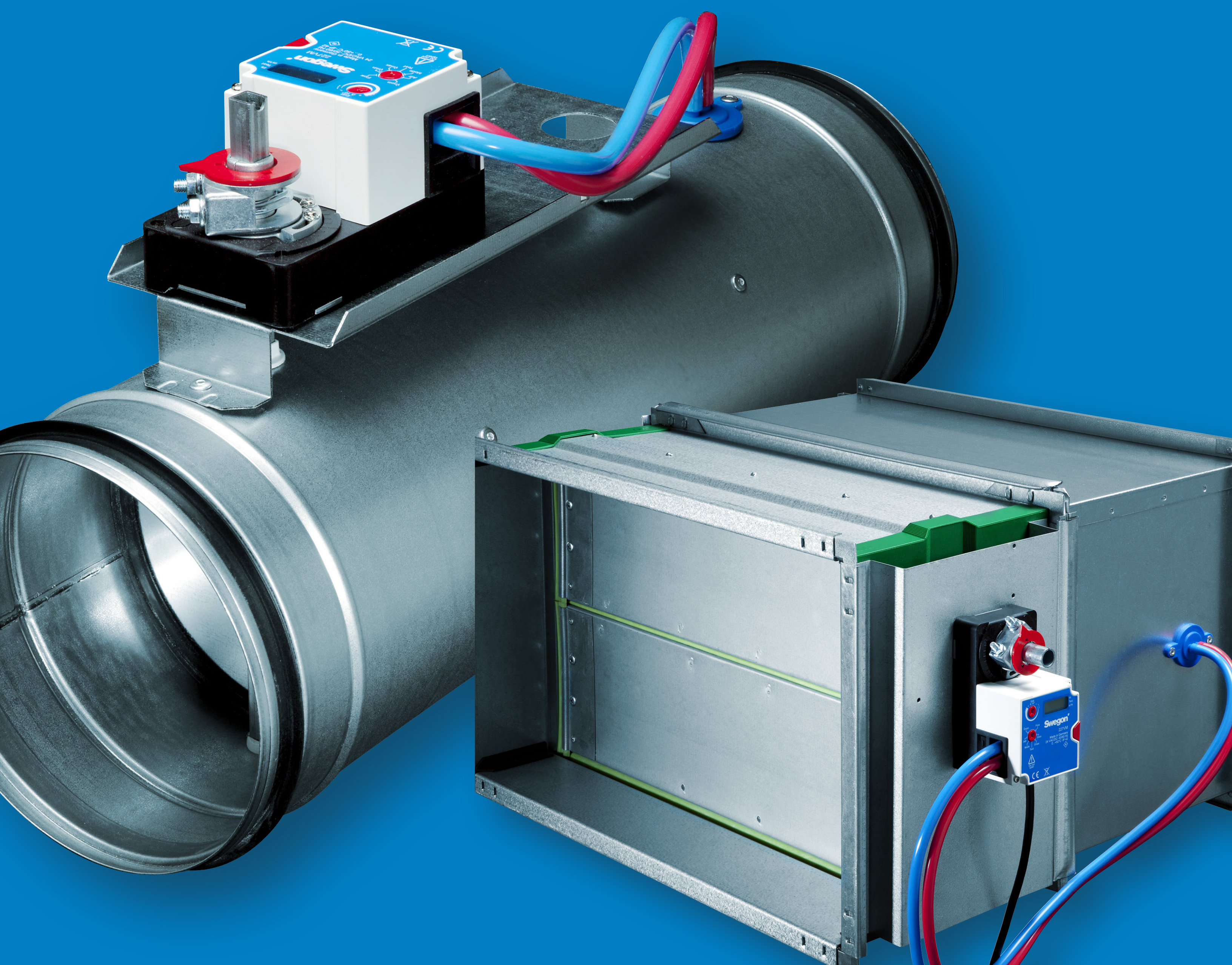
Airflow Control

Application Guide

AIRFLOW CONTROL

Varying the airflow to individual spaces (control zones) provides better control and thus higher occupant satisfaction. This Application Guide provides the HVAC system designer with detailed information on how to use the Swegon React Damper product line in a wide range of comfort and Indoor Air Quality (IAQ) applications. While specific to the React damper, the information herein can be applied to other airflow control products as well.



VARIABLE FLOW (VAV) VS. CONSTANT VOLUME SYSTEMS

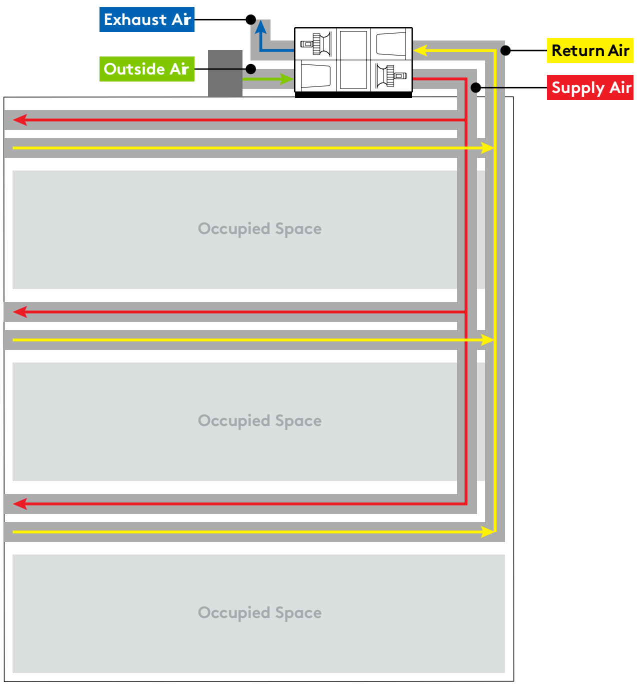


Fig. 1 Constant Volume HVAC Air System

The above image shows a constant volume ventilation air system (Sometimes referred to as a Dedicated Outdoor Air System (DOAS)). When the system is operating, the airflow never changes; it operates at design airflow all the time. Manual balancing dampers are used through the ducting system to balance the airflow amount to each space (control zone) as per the designers' requirements. Since this is an example of a ventilation system, the designer would base the airflow quantities on IAQ requirements such as ASHRAE Std 62.1 (Ventilation for Acceptable Indoor Air Quality) and EN-15251 (Indoor Environmental Input Parameters for Design and Assessment of Energy Performance of Buildings Addressing Indoor Air Quality, Thermal Environment, Lighting and Acoustics). The Test and Air Balance (TAB) contractor will test, adjust and verify the correct airflows to each control zone. Once done, the dampers are fixed and no further adjustment is required unless the space is repurposed.

A constant airflow system is straightforward to design, build and commission however can be very wasteful of energy. In this example (ventilation airflow) the system will deliver design ventilation airflow even if the building is lightly occupied consuming high fan energy and additional energy for any required supplemental heating and cooling. In applications where the airflow is being used to provide space temperature or humidity control, a constant volume system may not provide adequate zone control leading to occupant dissatisfaction.

The image below shows a Variable Airflow (VAV) HVAC air system. As in Figure 2, it is a ventilation system. Airflow control dampers have been added to each control zone which can vary the airflow to the space. A VOC or CO_2 sensor varies the airflow to the space to maintain acceptable indoor air quality based on actual space usage. The type of sensor will change based on the purpose of the airflow (i.e. temperature control, humidity control, airflow control, pressure control etc.)

The air handling unit includes variable airflow fans (i.e. VFDs or inverters) and the fan speed is controlled based on a duct static pressure sensor. If the dampers open to increase the airflow to the control zones, the duct pressure will drop, and the fan will speed up to maintain the duct pressure. The reverse will happen if the dampers start to close.

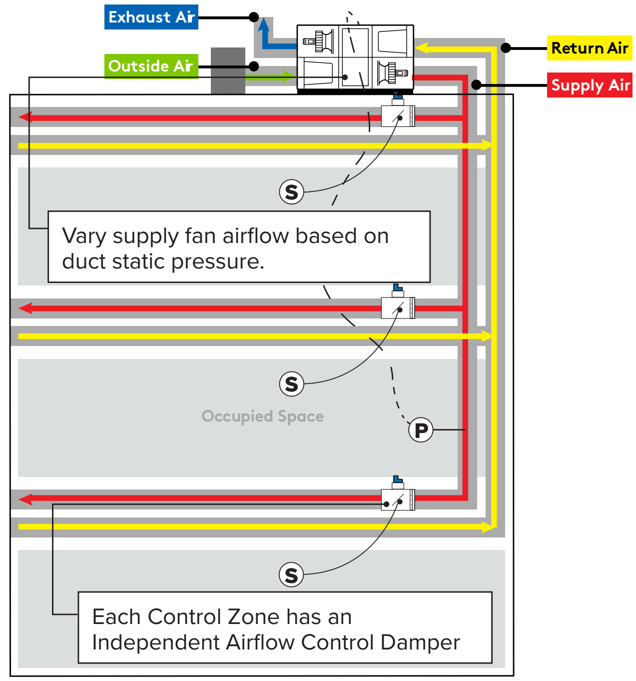


Fig. 2 Variable Airflow HVAC System

Variable airflow systems only deliver the required airflow based on real time space usage requirements. For ventilation systems this is known as **Demand Control Ventilation** (DCV). The energy savings can be significant based on the application. For a ventilation system it can cut the energy usage in half. In North America, ASHRAE Standard 90.1 (Section 6.4.3.8, Energy Standard for Buildings Except Low-rise Residential Buildings) requires demand control ventilation for high occupant density applications. In Europe, ISO 17772-1:2017, Energy Performance of Buildings has similar requirements.

CONTROL DAMPER BASICS

Controller

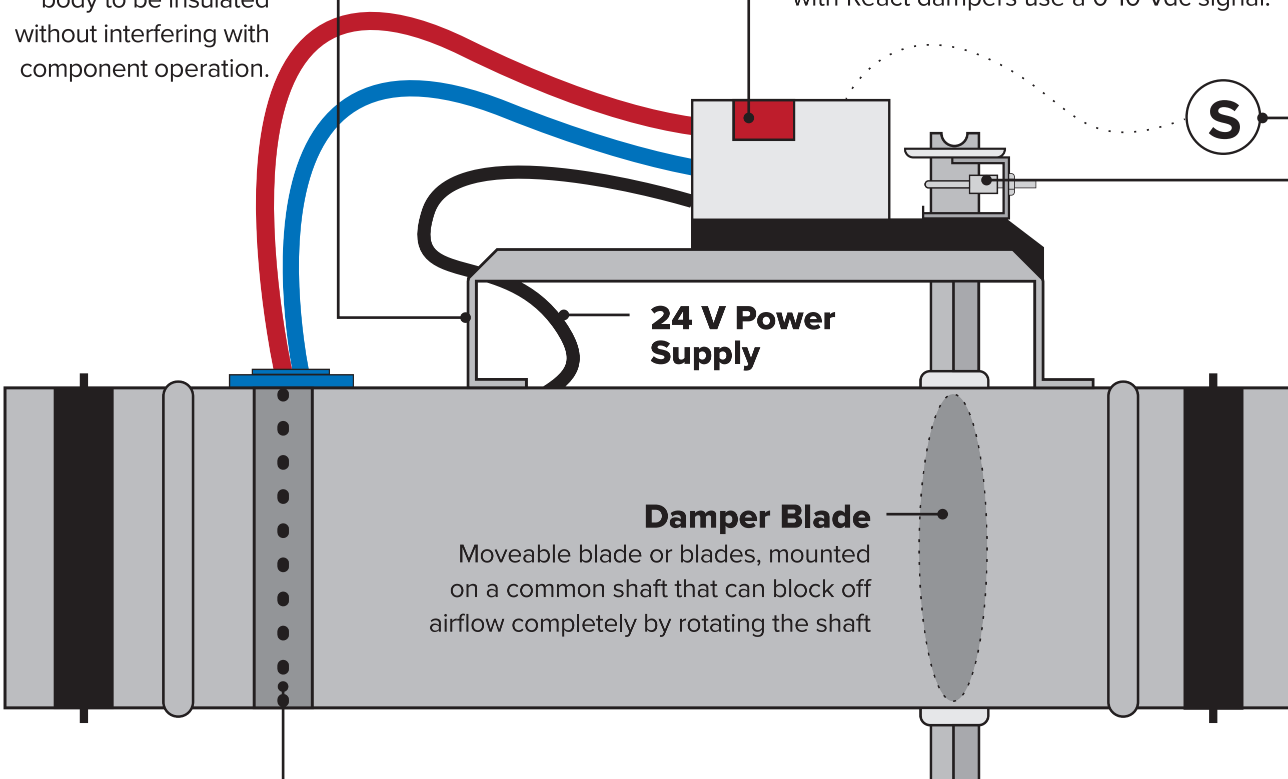
An electronic device that is programmed to command the actuator what to do based on inputs from the sensor(s). It may be stand alone or networkable (Modbus, etc.)

Sensor

A device that will measure a specific parameter (temperature, CO_2, humidity, pressure etc.) and provide that information to the controller. These sensors can be duct or wall mounted. Most sensors will require 24 Vac power source and wiring from the sensor to the damper controller. The signal from the sensor to the controller is hardware dependent. The sensors used with React dampers use a 0-10 Vdc signal.

Bracket

Designed to mount actuator and controller. Allows damper body to be insulated without interfering with component operation.



Damper Blade

Moveable blade or blades, mounted on a common shaft that can block off airflow completely by rotating the shaft

Airflow Sensor

Dampers come in two main types, dependent control and independent control. For independent control dampers some form of air measuring device is required. They are typically pitot tube style so pneumatic tubing is connected to the controller which then calculates airflow.

Actuator

Electric actuator that can rotate the damper blade shaft thus opening and closing the damper. The motor must have enough torque to be able to close the damper against air pressure. The larger the damper, the larger the actuator. Dampers are typically 24 Vac but other voltages are available. In addition to power, the damper will also receive a signal to tell it how much to move. Common signals include 0-10 Vdc, 4-20 mA, 0-135 Ohm and floating setpoint control. React Dampers use 0-10 Vdc signal. As an option, actuators can include a spring which will drive the damper closed if power is interrupted.

Fig. 3 Typical airflow control damper and its components. They can be round (shown) or rectangular in just about any size or shape.

DEPENDENT VS. INDEPENDENT AIRFLOW CONTROL

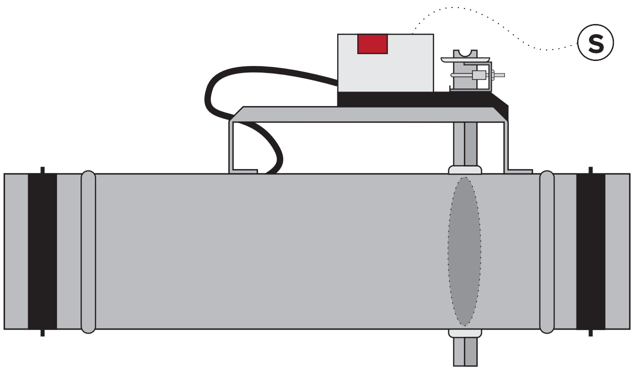


Fig. 4 Dependent Control Damper

A dependent damper is shown above. It is like the React Damper shown on the previous page but does not have an airflow measuring device. This means the controller does not know how much air is flowing through the damper. Consider a damper used to maintain space temperature control. The supply air is 55 °F (12.8 °C). If the space temperature is above setpoint, the damper will open and let more air in to cool the space. The reverse will happen if the space is below setpoint. The control logic adjusts damper position based on the input signal.

The actual amount of air that will flow through the damper into the space will depend on the duct pressure upstream of the damper and the damper blade position. The duct pressure upstream of the damper will change based on what is happening with the whole system throughout the day. The actual airflow through the damper is dependent on the upstream duct pressure. Opening the damper 10% may increase the airflow a little or a lot.

Compare that to the React damper including the airflow sensor. The controller is measuring the airflow and the space temperature. If the space temperature goes above setpoint, the controller will increase the airflow to the space. (e.g. go from 50 cfm (23.6 l/s) to 70 cfm (33 l/s)). The larger the difference from setpoint, the greater the airflow. The damper will be opened until the required airflow is met. If the upstream duct pressure is low, the damper will open a lot. If the pressure is high, the damper will open just a little. If the pressure changes, the damper will adjust to maintain the required airflow. The actual airflow through the damper is **independent** of the upstream duct pressure. Independent control dampers offer far better control and should be used for any control application. To achieve independent control, the damper must have an air flow measuring device, a controller with a pneumatic transducer and the algorithm that calculates the required airflow based on the input signal rather than the required damper position based on the input signal (dependent control). React dampers have independent control.

REACT DAMPERS

Round and rectangular React dampers include the damper assembly, a pitot style airflow measuring device and an integrated damper controller and actuator that operates on 24 Vac. Various sensors are available based on the specific application and will be discussed in future sections.

Below is the interface for the React Controller.

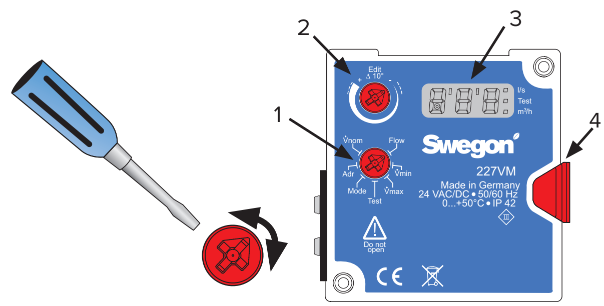


Fig. 5 React Controller
1. Mode wheel, 2. Edit wheel,
3. Display, 4. Gear release button

Each damper can be configured through the controller without external computers or other interfaces. The following parameters are adjustable;

Flow Toggle between l/s amd m3/h

V min Airflow value for 0 Vdc signal (minimum design airflow)

V max Airflow value for 10 Vdc signal (maximum design airflow)

Test Tests damper operation including: oFF, on, oP, cL, Lo, Hi, 123

Mode Toggle between 0-10 Vdc and 2-10 Vdc

ADr Used for Modbus Address (Optional)

Vnom Factory set maximum possible airflow

The display will show the measured airflow through the damper which can be used for field commissioning. For more information refer to React Damper Installation Manual at swegonnorthamerica.com.

Round React Damper Airflow Capacity

SELECTION CHARTS				
REACT	Min.*		Max. (nom.)	
Size	l/s	cfm	l/s	cfm
100	5	11	62	131
125	9	19	102	216
160	16	34	176	373
200	25	53	280	593
250	40	85	456	966
315	63	134	730	1547
400	102	216	1200	2543
500	164	347	1850	3920
630	300	530	2892	6128

*Fig. 6 *The minimum flow varies*

This table shows the maximum and minimum airflows for the Round React Dampers. Complete selection information can be found in the **React Damper Catalog** at swegonnorthamerica.com.

The factory settings are;
0 Vdc = 0 airflow (damper closed)
10 Vdc = Nominal airflow and Maximum airflow

The nominal airflow can only be changed by Swegon. The maximum airflow can be changed via the controller. For example, the React 100 damper has 131 cfm (62 l/s) **Nominal airflow**. The factory setting for **Maximum** airflow is also 131 cfm. A 10 Vdc input control signal will equate to 131 cfm (62 l/s). It is possible to change the **Maximum airflow** to 100 cfm so now a 10 Vdc signal will equate to 100 cfm. The Maximum airflow can be adjusted from 30 to 100% of the damper nominal airflow (e.g. 39 (18.4 l/s) to 131 cfm (62 l/s) for the React 100 damper).

The same can be accomplished for the **Minimum airflow**. The The minimum airflow range can be from 0 to 100% of the damper nominal airflow (e.g. 0 to 131 cfm (62 l/s) for the React 100 damper).

RETURN AIR PATH CONSIDERATIONS

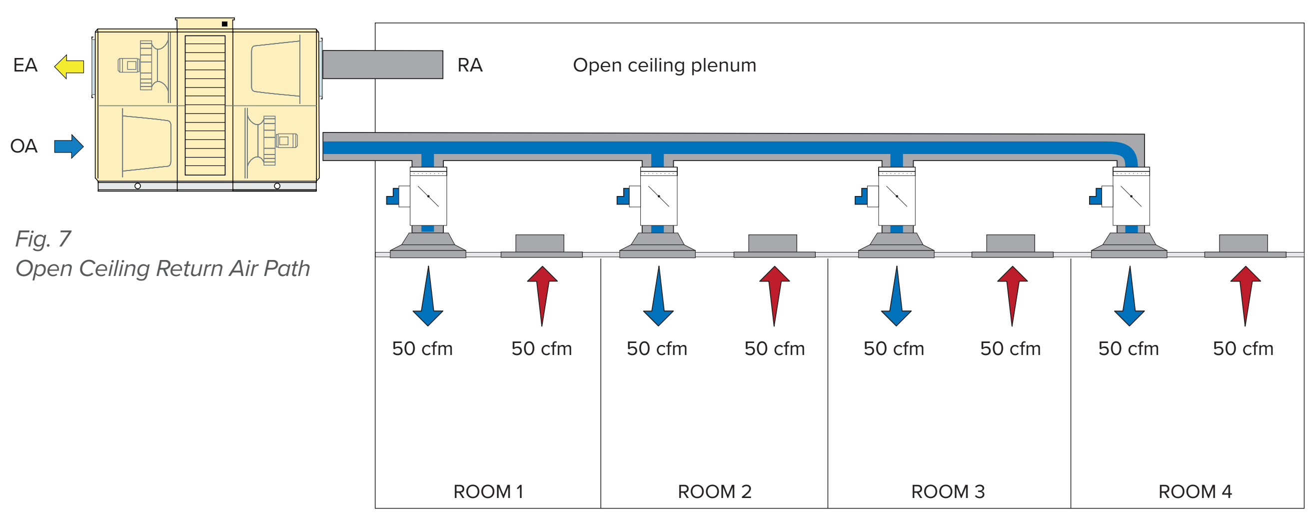
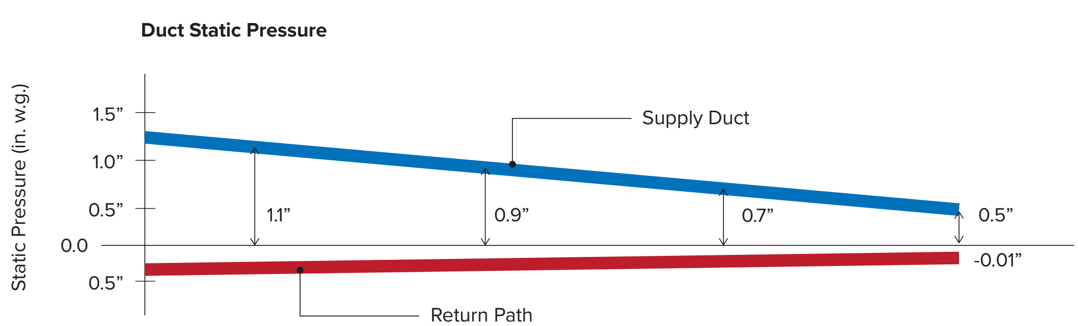


Fig. 7
Open Ceiling Return Air Path



The return air path considerations figure shows a basic system with an open ceiling return air path. The supply air static pressure drops at each control zone take off as the duct pressure loss is overcome. The damper position for Room 1 will be more closed than the damper used in Room 4 even though every room is getting the same airflow. This is key reason to use independent dampers.

The return air path is through an open ceiling plenum so there is very little return air pressure drop and the difference between Room 1 and Room 4 is very small.

DUCTED RETURN

Below shows the same basic system but this time there is ducted return. The ducted return air system will create balance issues. Reviewing Room 1, the supply air damper will deliver 50 cfm (23.6 l/s). The damper will be mostly closed as it must drop the duct pressure by 1.1" wc (274 Pa). **If there are no return air duct dampers,** the return air fan will try and draw the air from Room 1 as it is the closest to the AHU and has the shortest return duct path. The result will be Room 1 will be negatively pressurized and Room 4 will be positively pressurized. The pressure imbalance can lead reduced indoor air quality, poor comfort and possibly envelope damage due to forcing air in and out of the building envelope.

Referring to the image below and now considering the return air dampers, the imbalance is resolved. The return air dampers are integrated with the supply air dampers. In this example, the return air damper airflow matches the supply air damper airflow. If the supply flow is reduced, the return airflow will match it maintaining zone pressure balance.

Whether return air dampers are required is an engineering judgment call based on the pressure drop in the return air path. Generally, an open ceiling return air path should not be an issue while ducted return paths require close consideration.

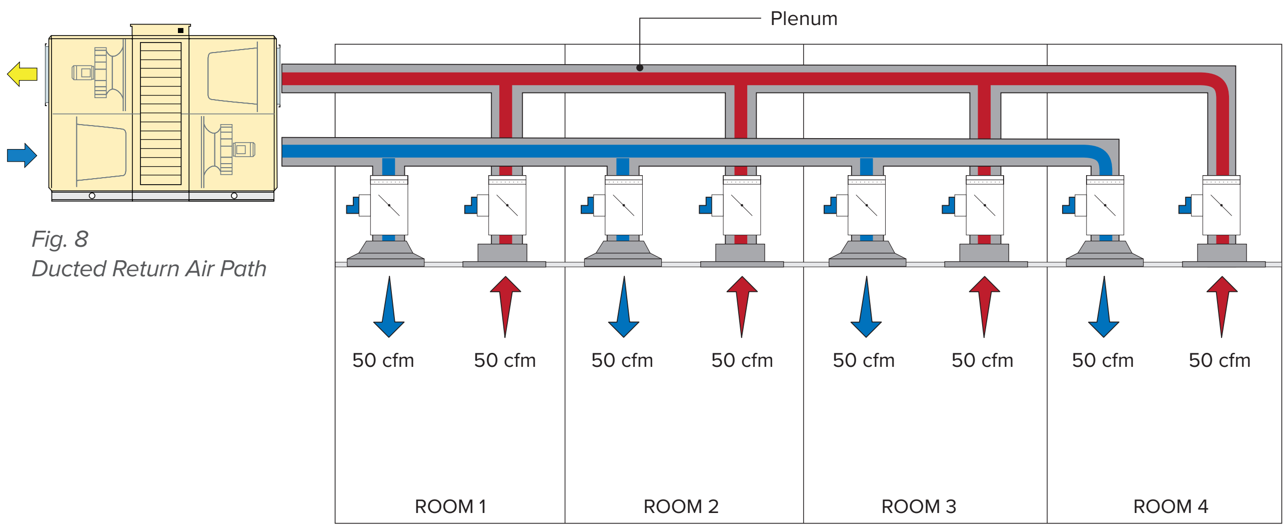
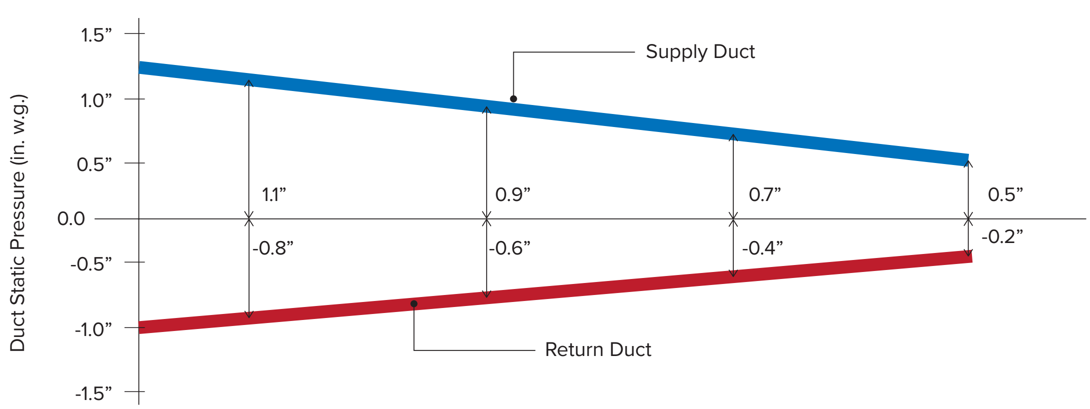


Fig. 8
Ducted Return Air Path

Supply Air Static Pressure



RETURN DUCT OPTIONS WITH REACT DAMPERS

React dampers offer several options to manage pressure imbalance due to return air path pressure issues.

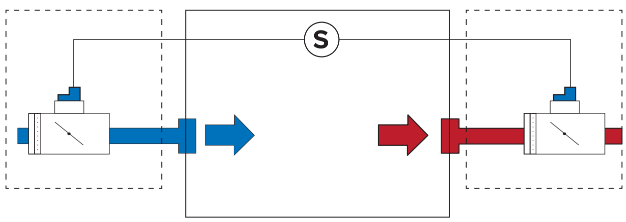


Fig. 9 Single Zone Return Airflow Control

The image above shows a typical zone. A second React damper is used in the return air duct. The supply and return airflows can be balanced or offset as required. To offset the airflows, the Max. and Min. airflows can be changed to offset the two airflows. For example, using two size 100 React dampers. The Max. airflow for the supply air damper can be set a 100 cfm (47.2 l/s) while the Max. airflow for the return air damper can be set at 90 cfm (42.5 l/s). If the zone sensor sends a full airflow command of 10 Vdc, then the supply damper will deliver 100 cfm (47.2 l/s) and the return damper will extract 90 cfm (42.5 l/s).

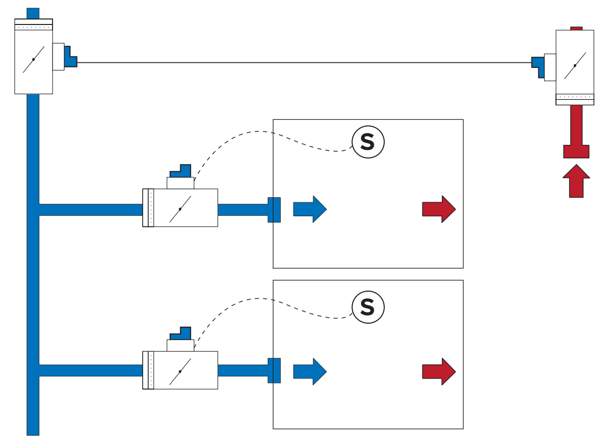


Fig. 10 Return Area Control

This image shows a modified version where the actual supply airflow to a group of zones is measured and the airflow used to control the return airflow amount.

A React CU damper which is only the airflow measuring portion and controller (no damper) is used to sum the combined supply airflows of all the local zones at any given time. The supply airflow amount is then used to control the return damper airflow thus keeping the general area in balance. This can be useful with high rise buildings where the risers are long and stack effect can be an issue.

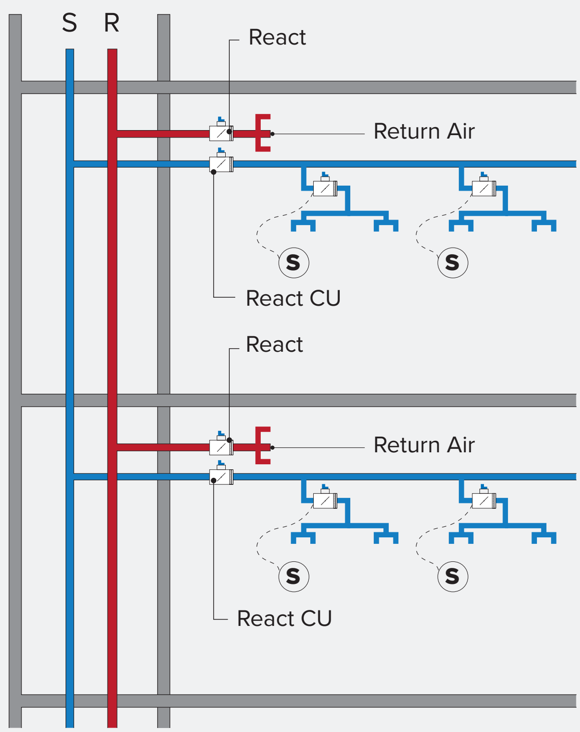


Fig. 11 Multistory Office Example

MULTISTORY OFFICE EXAMPLE

The image to the left (Fig. 11) shows a multi story example where each floor of a multi-story building is considered an area.

On each floor, there are multiple local control zones each with their own damper. Each floor has open ceiling return that is connected to a ducted return air shaft, so the return air pressure drop is fairly even between all the zones on the floor. The React CU damper is installed in the main supply duct riser takeoff to the floor. The React CU damper measures the total airflow to the floor at any given time. A React damper is placed in the connection from the open ceiling plenum to the return air duct shaft. The system will draw a balanced airflow from each floor and avoid any issues from stack effect.

REACT DAMPER

SPACE TEMPERATURE CONTROL

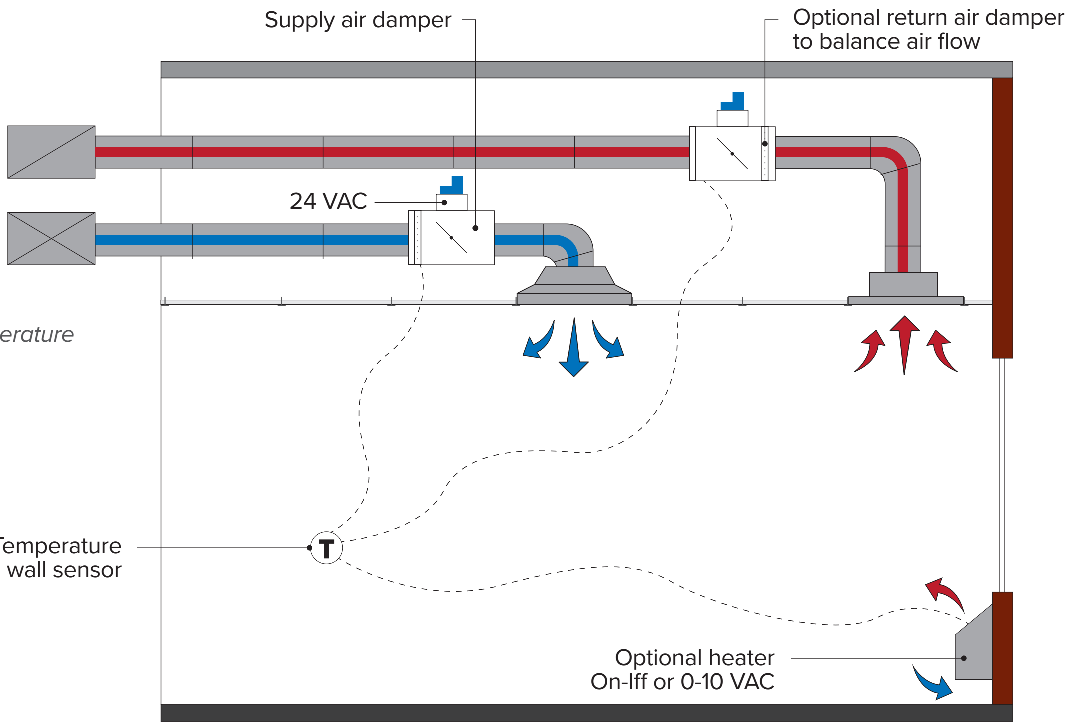


Fig. 12
Space temperature control

PURPOSE

Deliver occupant thermal comfort by maintaining temperature setpoint. Cooling is achieved by increasing airflow, heating can be achieved by operating separate heat source such as a duct or baseboard heater.

SEQUENCE OF OPERATION

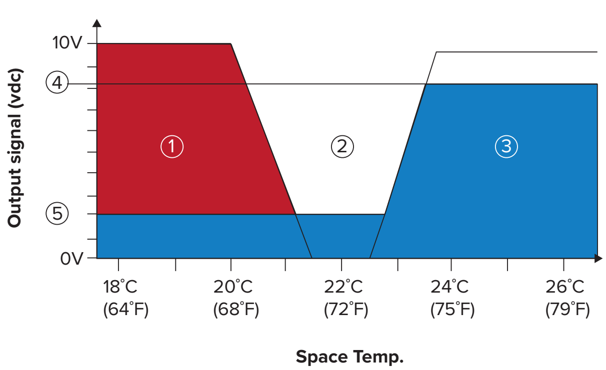


Fig. 13
1. Heating with a radiator.
2. Dead band. 3. Cooling by air.
4. Preset max. output signal, cooling by air.
5. Preset min. output signal, cooling by air.

The damper is controlled by an RTC Temperature sensor where the occupant can adjust the space temperature setpoint. In the deadband (2) the React damper will deliver minimum (adjustable from 0-100% of Nom.) airflow. On a call for cooling (3), the react damper will increase airflow rate from Min. airflow to Max. airflow based on difference between actual zone temperature and space setpoint. On a call for heating (1), the React damper will deliver Min. airflow. Either a 0-10 Vdc or on-off signal at the RTC wall sensor can be used to operate a supplemental heating source such a duct or baseboard heater.

The center setpoint for the RTC wall sensor is 72 °F (22 °C) and can be adjusted by the occupant ± 5 °F (±3 °C). The LED will show green for cooling and red for heating and will be off for deadband.

Fig. 14 RTC Wall Sensor

APPLICATION CONSIDERATIONS

Space Temperature control achieves both the thermal comfort and IAQ requirements using supply air. The entire HVAC system can be "all air" with every control zone getting a React Damper. It is also possible to condition a few specific zones when the supply air is a 100% outdoor air ventilation system. For example, the front entrance area or a meeting room in a chilled beam HVAC system may be better served using just ventilation air and VAV temperature control from the chilled beam primary air system.

The design airflow is based on the amount required to meet the space sensible cooling load.

$Airflow_{design}$ (cfm) = Q_s (Btu/h)/[1.085 x (T_{space} – $T_{supply\ air}$ (°F))]

$Airflow_{design}$ (l/s) = 833 x Q_s (KW)/[T_{space} – $T_{supply\ air}$ (°C)]

In addition, the minimum airflow rate is required, based on the minimum airflow permissible to achieve acceptable indoor air quality. Each control zone has one React damper in the supply air ductwork. The damper will require a 24 Vac power source. Refer to the React Damper NA Catalog (swegonnorthamerica.com) for Damper selections. It should be possible to achieve around 10 to 1 turndown with approximately 0.20 inches w.c. (50 Pa) damper air pressure drop.

RETURN AIR DAMPERS

Return air dampers may be required to maintain balanced space pressurization. When required, the damper can be controlled by the RTC controller as well. It is possible to provide balanced airflow (supply = return airflow) or introduce an offset for space pressurization. This is accomplished by configuring Max. airflow for both the supply and return dampers with different airflow amounts. For example, 100 cfm (47.2 l/s) for the supply damper and 90 cfm (42.5 l/s) for the return damper.

WIRING DETAILS

DAMPER WIRING WITH RTC TEMPERATURE SENSOR & REMOTE HEATER

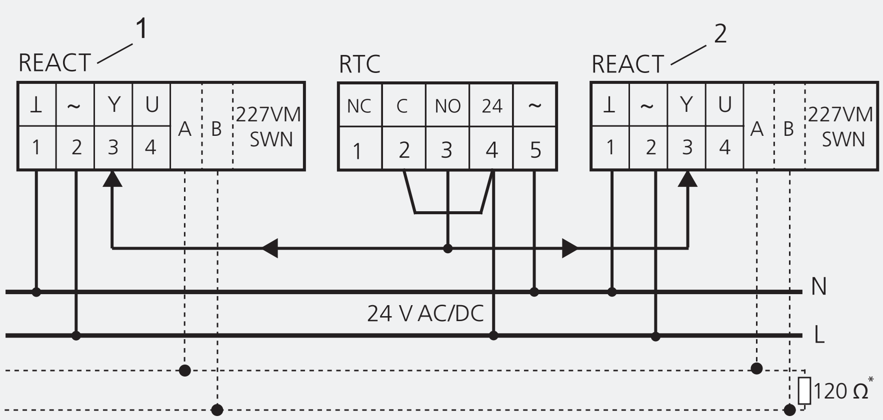


Fig. 15 The diagram shows how to wire and refit jumpers of the RTC room thermostat enabling operation of the on/off 24V VAC thermo-actuator on output YH (4).
**Should only be used on the last REACT in the Modbus loop*

1 – REACT supply air
2 – REACT return air
3 – Thermo-actuator, heat
- - – Modbus

*) The jumper connection in the RTC must be changed when wiring the thermo-actuator (3) to the system. More information is available in the Installation/Commissioning documentation for RTC.

Note: The unit must be de-energized before reconnecting any jumpers!

REACT DAMPER
SPACE HUMIDITY CONTROL

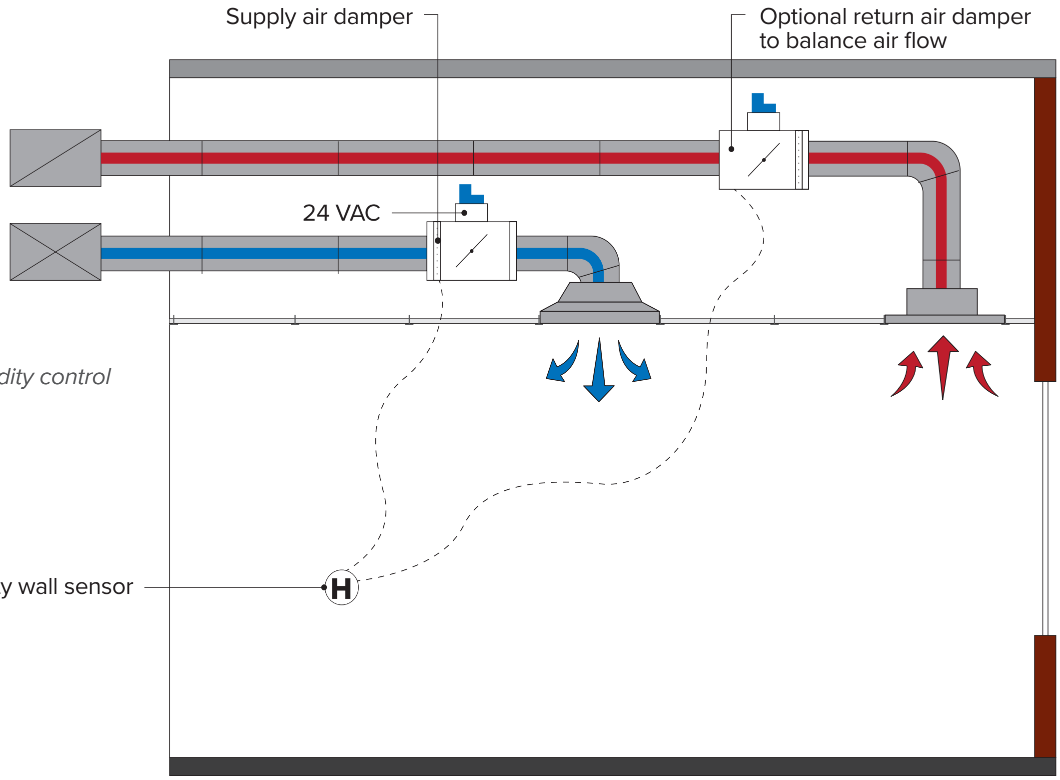


Fig. 17
Space humidity control

PURPOSE

Deliver occupant thermal comfort by maintaining humidity setpoint. Dehumidification is achieved by increasing supply airflow.

SEQUENCE OF OPERATION

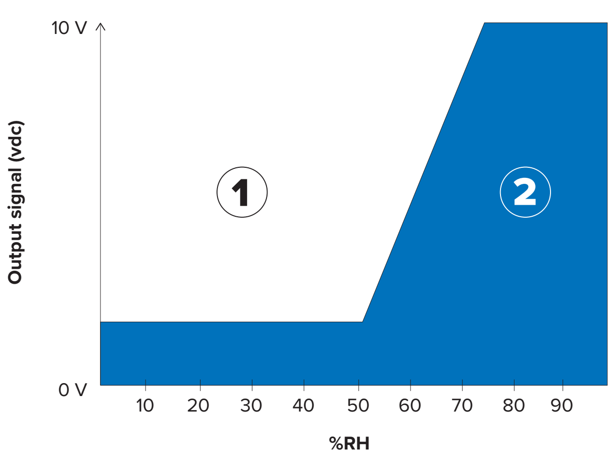


Fig. 18 Sequence of Operation

The damper is controlled by a Detect RH humidity wall sensor. In the low humidity zone (1), the React damper will deliver minimum (adjustable from 0-100% of Nom.) airflow. On a call for dehumidification (2), the react damper will increase airflow rate from Min. airflow to Max. airflow based on difference between actual zone relative humidity level and space setpoint.

The factory setpoint for the Detect RH sensor is 60%. The sensor range is 10-90% RH.

Fig. 19 Detect RH Wall Sensor

APPLICATION CONSIDERATIONS

$Airflow_{design}$ (cfm) = Q_L (Btu/h)/[0.68 x (HR_{space} – $HR_{supply\ air}$ (gr/lb))]

$Airflow_{design}$ (l/s) = Q_L (KW)/[2.95 x (HR_{space} – $HR_{supply\ air}$ (Kg water/$Kg_{Dry\ Air}$))]

Space humidity can build up in areas such as bathrooms and residential kitchens. Increasing ventilation airflow to these zones will reduce the humidity level, improve space comfort and minimize mold formation. The ventilation air must have a lower humidity ratio than the space condition to provide dehumidification. In winter, the outdoor air is very dry (in cold winter climates) so dehumidification is possible with ventilation air. In warm winter climates or summer conditions, the ventilation air may need to be mechanically dehumidified using chilled water or DX cooling.

The design airflow is based on the amount required to meet the space dehumidification load.

In addition, it is possible to have minimum ventilation airflow to maintain acceptable indoor air quality. Each control zone has one React damper in the supply air ductwork. The damper will require a 24 Vac power source.

Refer to the React Damper NA Catalog (swegonnorthamerica.com) for Damper selections. It should be possible to achieve around 10 to 1 turndown with approximately 0.10 inches w.c. (25 Pa) damper air pressure drop.

OPTIONS

Duct mounted Detect RH Sensor.

RETURN AIR DAMPERS

Return air dampers may be required to maintain balanced space pressurization. When required, the damper can be controlled by the RTC controller as well. It is possible to provide balanced airflow (supply = return airflow) or introduce an offset for space pressurization. This is accomplished by configuring Max. airflow for both the supply and return dampers with different airflow amounts. For example, 100 cfm (47.2 l/s) for the supply damper and 90 cfm (42.5 l/s) for the return damper.

WIRING DETAILS

DAMPER WIRING WITH DETECT RH SENSOR

CONSULT FACTORY

REACT DAMPER

DEMAND CONTROL VENTILATION

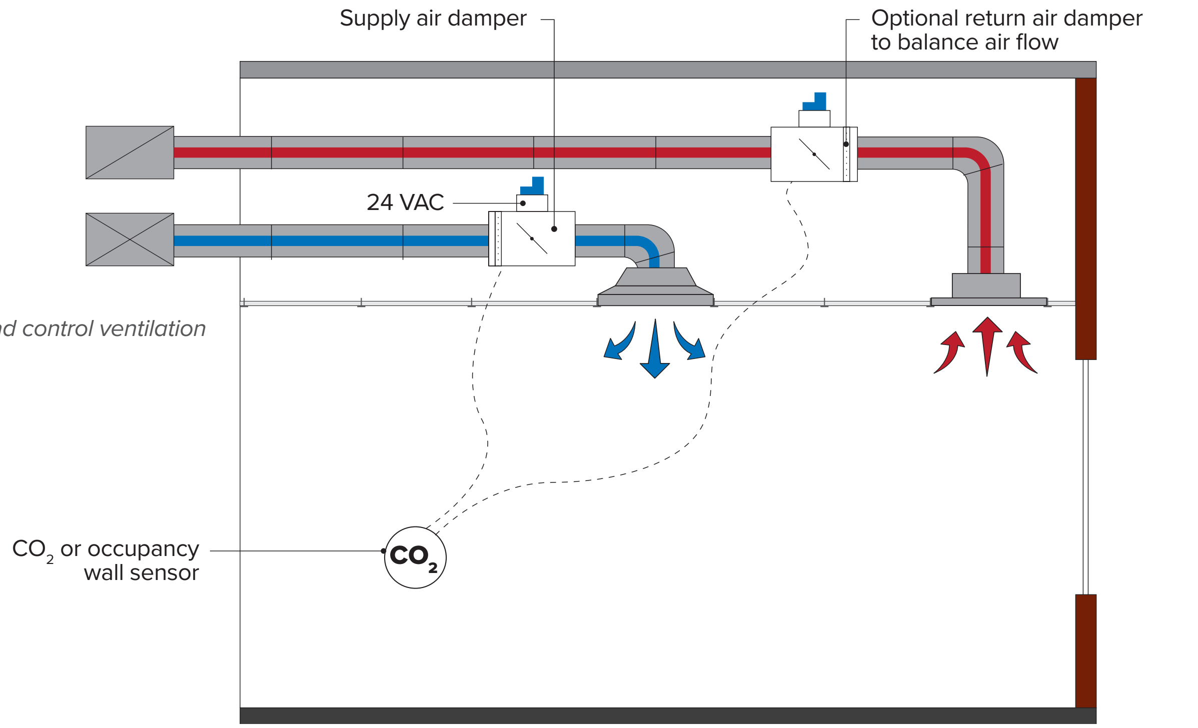


Fig. 20
Demand control ventilation

PURPOSE

Achieve acceptable indoor air quality by delivering ventilation air to the space. Energy savings are achieved by varying the airflow rate based on measuring CO_2 levels in the zone.

SEQUENCE OF OPERATION

The damper is controlled by a Detect Q CO_2 wall sensor. When the CO_2 level is low (1), the React damper will deliver minimum (adjustable from 0-100% of Nom.) airflow. On a call for increased ventilation air (2), the react damper will increase airflow rate from Min. airflow to Max. airflow based on difference between actual zone CO_2 level and space setpoint. Optionally, the space temperature can also be monitored. The Detect Q will use the larger of the two measurements to establish the 0-10Vdc output signal to the damper.

Fig. 21
Detect O
Occupancy
Wall Sensor

Fig. 22
Detect Q
CO_2 Wall
Sensor

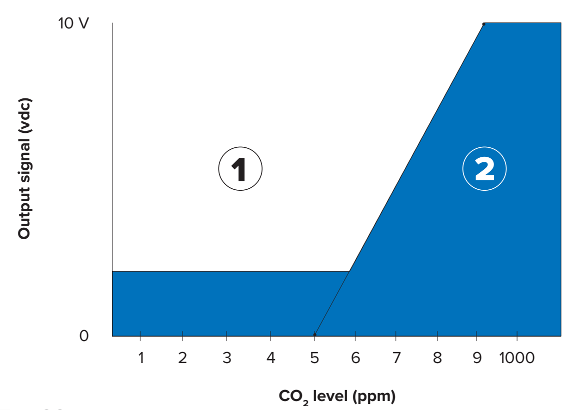


Fig. 23

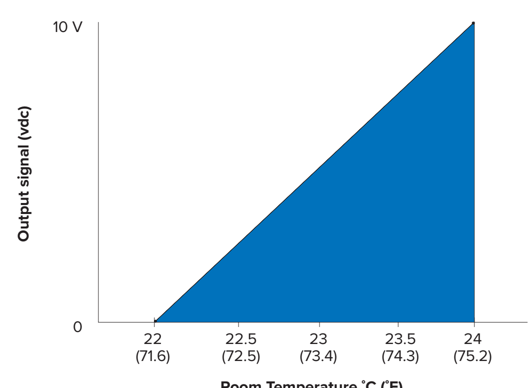


Fig. 24

The Detect Q includes a display showing CO_2 levels between 0-2000 ppm. The Detect O is an occupancy sensor that will close a contact when presence is detected. If the Detect O occupancy sensor is used, the React damper will deliver minimum (adjustable from 0-100% of Nom.) Airflow when there is no occupancy. The React damper will go to maximum airflow when occupancy is detected.

APPLICATION CONSIDERATIONS

Demand Control Ventilation is required by energy standards such as ASHRAE Standard 90.1 (ISO 17772) for high occupant density areas. Being able to vary the ventilation airflow rate when the space is lightly or not occupied can be a significant energy savings. CO_2 is not a pollutant in itself but is used as an indicator of the number of people using the space.

Each ventilation control zone will require a React damper to vary the ventilation air to the space. Calculating the required airflow rate should be based on local ventilation Standards such as ASHRAE Std 62.1 (Ventilation for Acceptable Indoor Air Quality) or EN-15251 (Indoor Environmental Input Parameters for Design and Assessment of Energy Performance of Buildings Addressing Indoor Air Quality, Thermal Environment, Lighting and Acoustics). These standards define a minimum ventilation rate that is required even if the space is unoccupied. This rate should be used to establish the minimum airflow level for the React damper. The design ventilation rate should be used to establish the maximum airflow rate for the React damper. The Detect Q controller will then vary the airflow rate between these two airflow rates based on space CO_2 levels achieving design airflow rate at 1000 ppm.

For small space with one or two occupants like a private office space, the Detect O occupancy sensor can be used. The React damper will operate at either minimum airflow (no occupancy) or maximum airflow (occupancy).

If the ventilation air is also being used to provide cooling, a different output connection on the detect Q can be used to monitor both space temperature and CO_2 levels and use the larger of the two requirements.

Refer to the React Damper NA Catalog (swegonnorthamerica.com) for Damper selections. It should be possible to achieve around 10 to 1 turndown with around 0.20 inches w.c. (50 Pa) damper air pressure drop.

RETURN AIR DAMPERS

Return air dampers may be required to maintain balanced space pressurization. When required, the damper can be controlled by the Detect Q controller as well. It is possible to provide balanced airflow (supply = return airflow) or introduce an offset for space pressurization. This is accomplished by configuring Max. airflow for both the supply and return dampers with different airflow amounts. For example, 100 cfm (47.2 l/s) for the supply damper and 90 cfm (42.5 l/s) for the return damper.

OPTIONS

Duct mounted Detect Q Sensor.

WIRING DETAILS

REACT DAMPER WIRING WITH DETECT Q CO_2 SENSOR

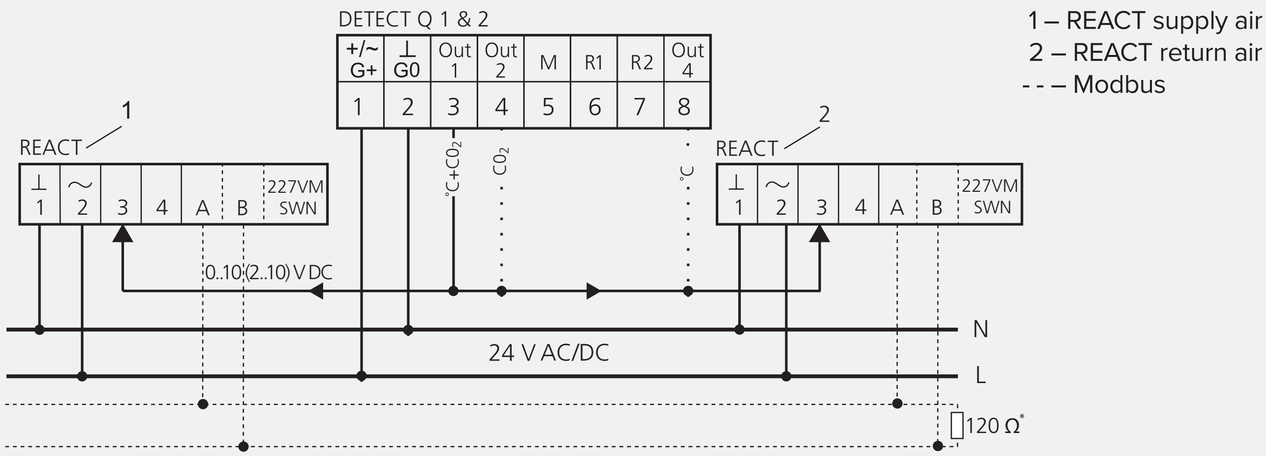


Fig. 25 This diagram shows how to wire the CO_2 sensor with combined Detect Q temperature control and simultaneous control of return air.

WIRING DETAILS

REACT DAMPER WIRING WITH DETECT O OCCUPANCY SENSOR

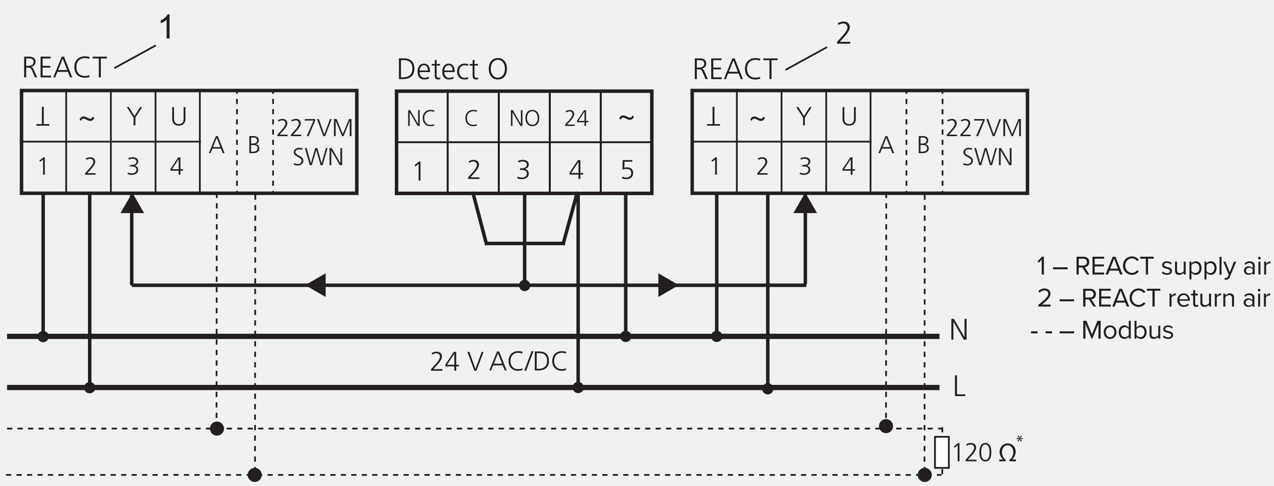


Fig. 26 This diagram shows how to wire the Detect O occupancy sensor with simultaneous control of the return air. Two flow control, min. or max. airflow.

REACT DAMPER

MULTIFAMILY APARTMENT VENTILATION CONTROL

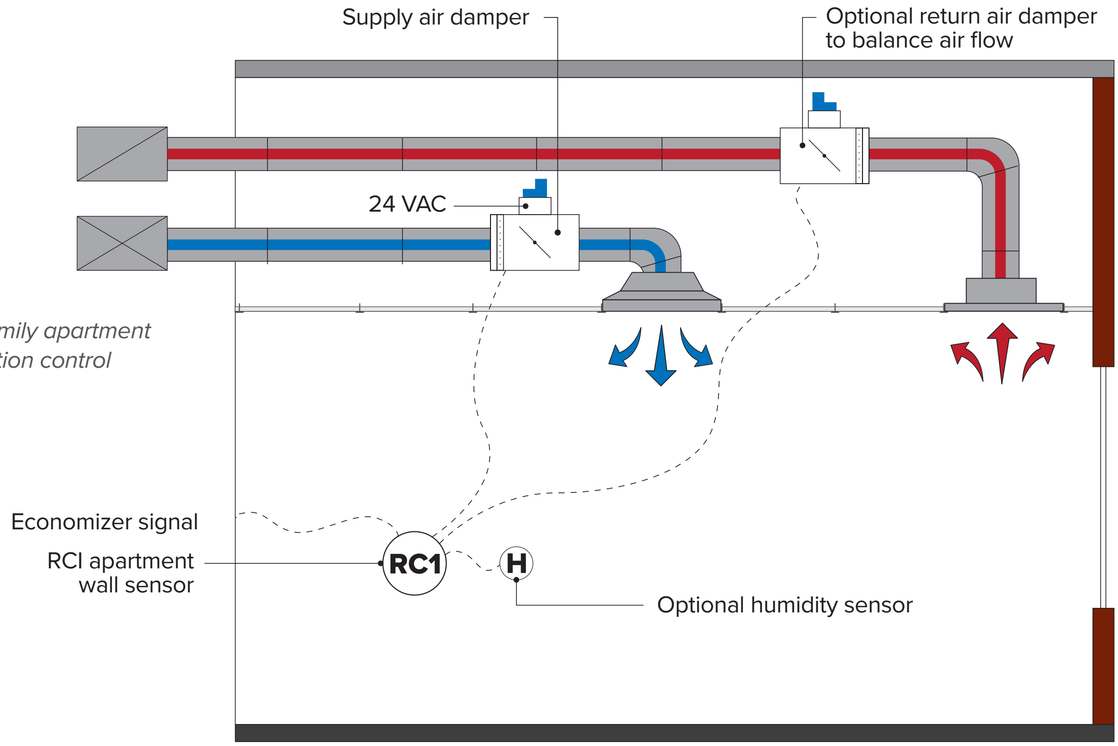


Fig. 27
Multifamily apartment ventilation control

PURPOSE

Allow occupants in multi-family residential (dormintory) buildings with central ventilation units to vary the airflow into their apartment. The controller is designed to meet the requirements of Passive House and supports humidity control and free cooling (economizer) functions for improved occupant comfort and energy savings.

SEQUENCE OF OPERATION

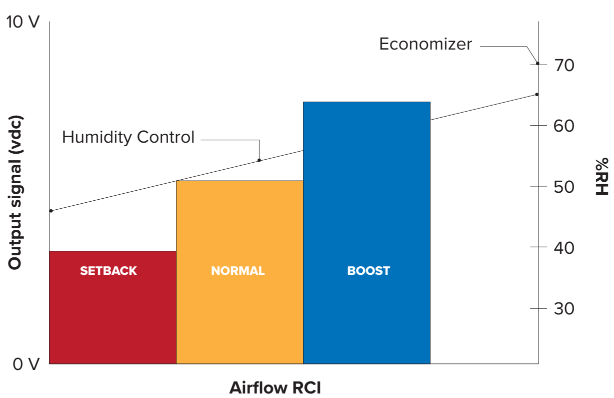


Fig. 28 Sequence of operation

The damper is controlled by an Apartment wall sensor. The basic function allows the occupant to select one of three ventilation rate settings;

Setback Minimum airflow (adj.) when apartment is not in use. Activated by touching the setback button on the RC1. The digital display will show “Setbk”. Unit will stay in this mode until occupant touches the setback button again

Normal Design airflow (adj.) when apartment is in use. The digital display will show “Norml”.

Boost Maximum airflow (adj.) when apartment is in heavy use. Activated by touching the Boost button on the RC1. The digital display will show “Boost”. Unit will stay at Boost airflow for 2 hours (adj).

In addition, the controller offers two optional features;

Humidity An optional Detect RH humidity sensor is located in a high humidity area (e.g. bathroom). As the humidity increases, the apartment controller will ramp up the ventilation air (adj.) to dehumidify the space. The digital display will show “HiHum”. Note, the apartment controller will use the higher of the two readings;

Humidity or Ventilation (setback-Normal-Boost) mode to control the React damper

Economizer An optional dry contact, when closed, will operate the React damper at Economizer (adj.) airflow rate until the contact is opened. The digital display will show “Econo”.

This button is used to switch ventilation between Setback and Normal mode

This button is used to switch ventilation to Boost mode

Fig. 29 RC1 Apartment Ventilation Control Wall Sensor

APPLICATION CONSIDERATIONS

The occupant controlled ventilation rates (Setback-Normal-Boost) are Passive House requirements but can be used for any residential application. The Normal airflow rate is established by local codes, ventilation standards like ASHRAE 61.1 and 61.2 (Ventilation for Acceptable Indoor Air Quality), EN-15251 (Indoor Environmental Input Parameters for Design and Assessment of Energy Performance of Buildings Addressing Inddor Air Quality, Thermal Environment, Lighting and Acoustics) or Passive House requirements. Boost mode is typically 20% more than normal but is the designer choice. Setback is typically 20% less than Normal mode but again is the designer’s choice. How to design and configure the React Damper and Apartment controller is best shown in the following example;

ECONOMIZER MODE

High performance apartments and Passive House projects in particular, have a very low ambient temperature balance point where the space goes from heating to cooling. This is due to very good fenestration, envelope insulation and air tightness. Cooling the spaces with free cooling becomes critical to achieving the building energy performance goals. How to leverage the ventilation system to help achieve free cooling depends on many details of the HVAC system design. Several examples will be shown here but there are many more options.

CONFIGURING RC1 EXAMPLE

Use a React 100 damper with a Nominal airflow rate of 131 cfm. From the factory, the Max. airflow will be 131 cfm and will occur when a 10 Vdc signal is received by the damper.

The designer establishes the airflow rates for the various modes that will be used. In this case, economizer airflow is set at 50% (See Appendix A) more than normal and high humidity is set at the highest airflow which is economizer. The ductwork and ventilation units are sized for 90 cfm x number of apartments served.

The table shown here demonstrates how the output voltages are calculated based on ration of functional airflow to maximum airflow.

The voltage signal outputs are configured into the Apartment controller (See Apartment controller I and M). If Boost mode is selected, the Apartment controller will send a 5.5Vdc signal to the React damper and the damper will deliver 72 cfm. If the economizer contact is closed, the Damper will operate 90 cfm and so on.

Mode	Req. Airflow (cfm)	Req./ Nom Airflow	Voltage Signal Output
Setback	48	48/131 = 37%	3.7 Vdc
Normal	60	60/131 = 46%	4.6 Vdc
Boost	72	72/131 = 55%	5.5 Vdc
Hi Humidity	90	90/131 = 69%	6.9 Vdc
Economizer	90	90/131 = 69%	6.9 Vdc

EXAMPLE 1

VENTILATION UNIT FREE COOLING NO MECHANICAL COOLING

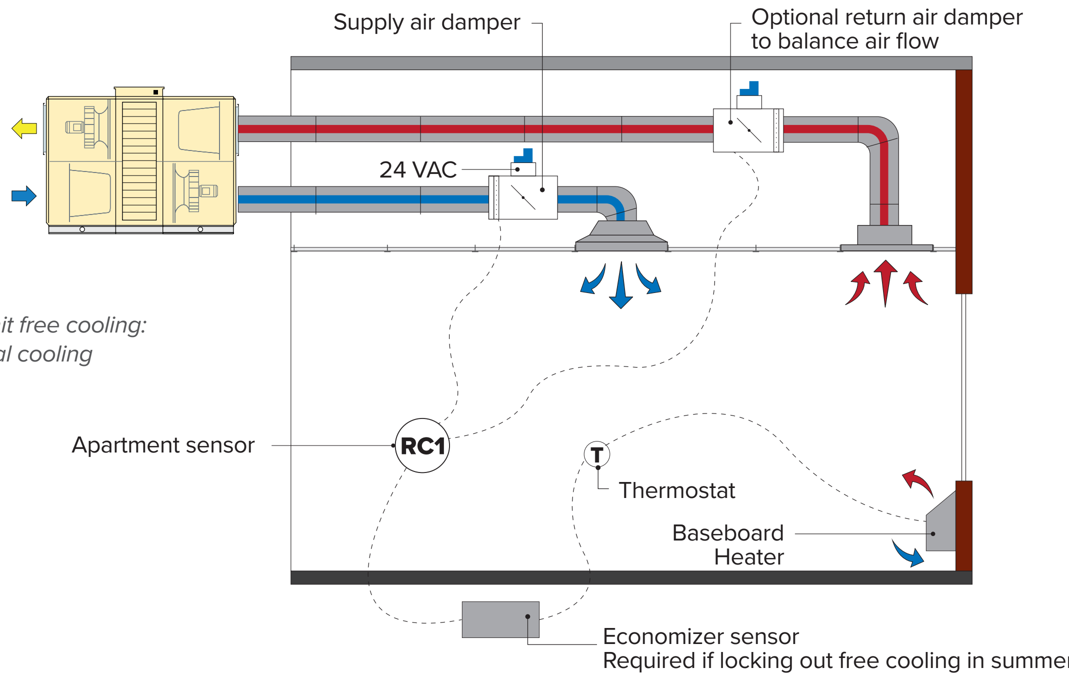


Fig. 30
Ventilation unit free cooling:
no mechanical cooling

SITUATION

The units in the building do not have any mechanical cooling. There are baseboard heaters controlled by a wall thermostat. The ventilation system has been designed to deliver 50% more air than normal mode but does not have any supplemental mechanical cooling.

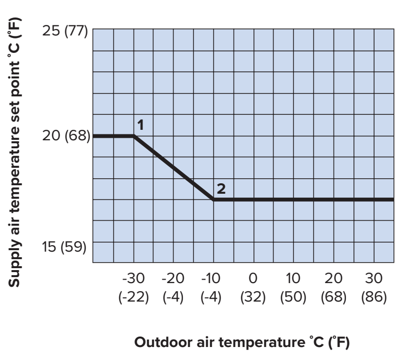


Fig 31. Supply airflow temp reset based on outside air temperature.

SOLUTION

The ventilation unit should be set up to lower the supply air temperature setpoint as the outdoor air temperature rises. In winter, the setpoint should be close to neutral (68-72 °F (20-22 °C)). As the outdoor air temperature rises, the supply air setpoint should be reset down to 55 °F (13 °C). When to start resetting will depend on the building design. If the outdoor air is colder than the setpoint, energy recovery in the ventilation unit can be used to raise the supply air temperature to the setpoint with free energy.

Since there is no mechanical cooling available, the supply air temperature will start to climb as soon as the outdoor air temperature is above supply air setpoint. It will still provide some cooling as long as the outdoor air temperature is below the room setpoint (75°F (24 °C)). Above room setpoint (75°F (24 °C)) the ventilation airflow rate should be lowered back to Normal to avoid unnecessary heating.

The apartment thermostat should have both heating and cooling control. When the apartment temperature rises above cooling set point, the thermostat will close a contact to the RCI Apartment Controller to enable Economizer flow. [Note: A relay may be required.] The damper will allow the economizer airflow to reach the apartment. In locations where summer conditions are very warm and introducing outdoor air to the apartment will add to the heat load, an economizer controller should be used. The economizer controller will only allow the cooling signal to reach the React Damper if the outdoor air temperature is in the right range (approximately 40 to 75°F (4 to 24 °C)).

EXAMPLE 2

VENTILATION UNIT FREE COOLING MECHANICAL COOLING AT VENTILATION UNIT

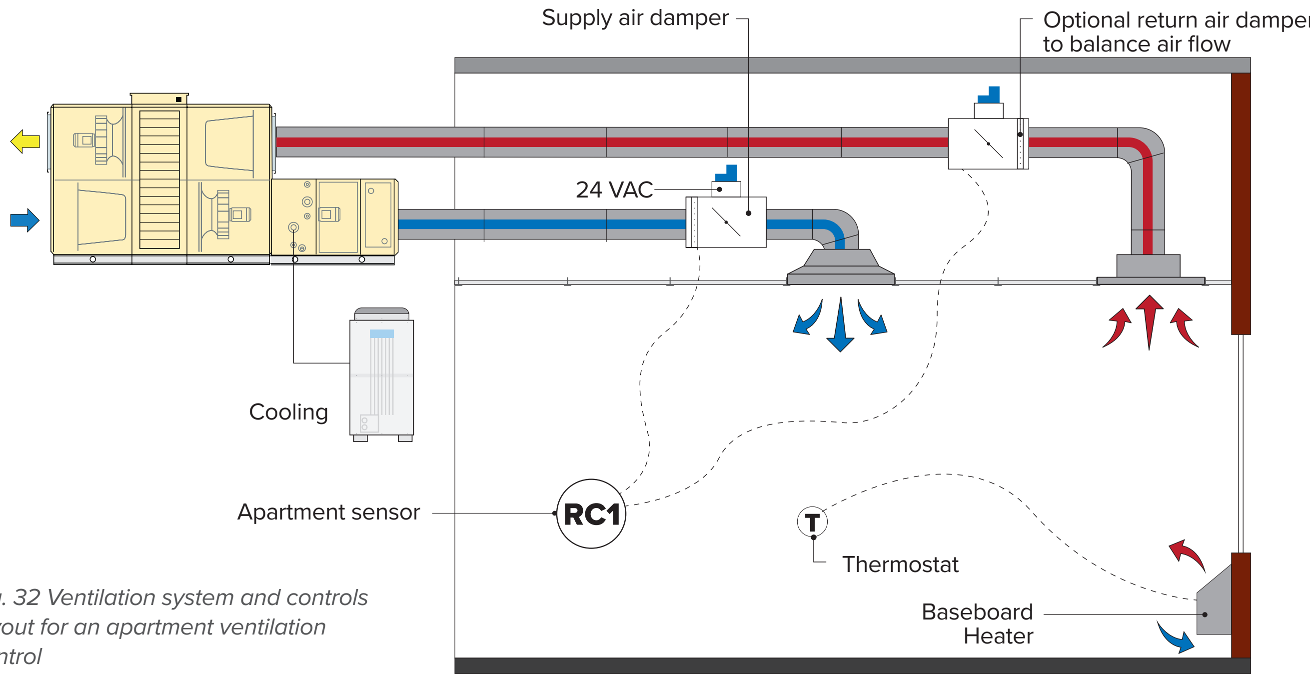


Fig. 32 Ventilation system and controls layout for an apartment ventilation control

SITUATION

The apartments in the building do not have any mechanical cooling. There are baseboard heaters controlled by a wall thermostat. The ventilation system has been designed to deliver 50% more air than normal mode and has supplemental mechanical cooling.

SOLUTION

The ventilation unit should be set up to lower the supply air temperature setpoint as the outdoor air temperature rises. In winter, the setpoint should be close to neutral (68-72 °F (20-22 °C)). As the outdoor air temperature rises, the supply air setpoint should be reset down to 55 °F (13 °C). When to start resetting will depend on the building design. If the outdoor air is colder than the setpoint, energy recovery in the ventilation unit can be used to raise the supply air temperature to the setpoint with free energy.

Since there is mechanical cooling in the ventilation unit, the supply air temperature will always be at setpoint. Mechanical cooling will only occur when free cooling cannot meet the setpoint.

The apartment thermostat should have both heating and cooling control. When the apartment temperature rises above cooling set point, the thermostat will close a contact to the RCI Apartment Controller to enable Economizer flow. [Note: A relay may be required.] The damper will allow the economizer airflow to reach the apartment.

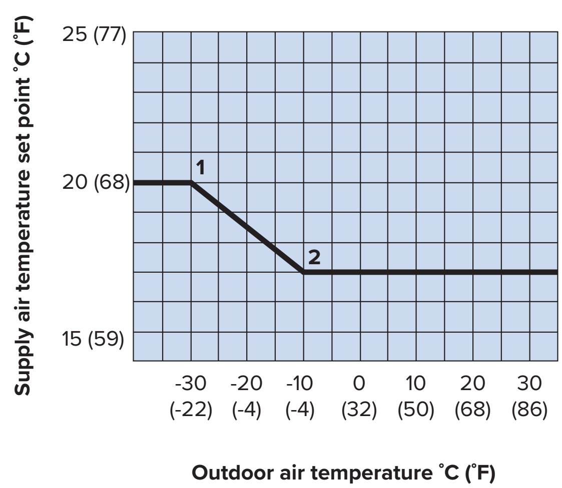


Fig. 33 Supply airflow temp reset based on outside air temperature.

EXAMPLE 3

VENTILATION UNIT FREE COOLING MECHANICAL COOLING AT VENTILATION UNIT & MECHANICAL COOLING IN APARTMENT

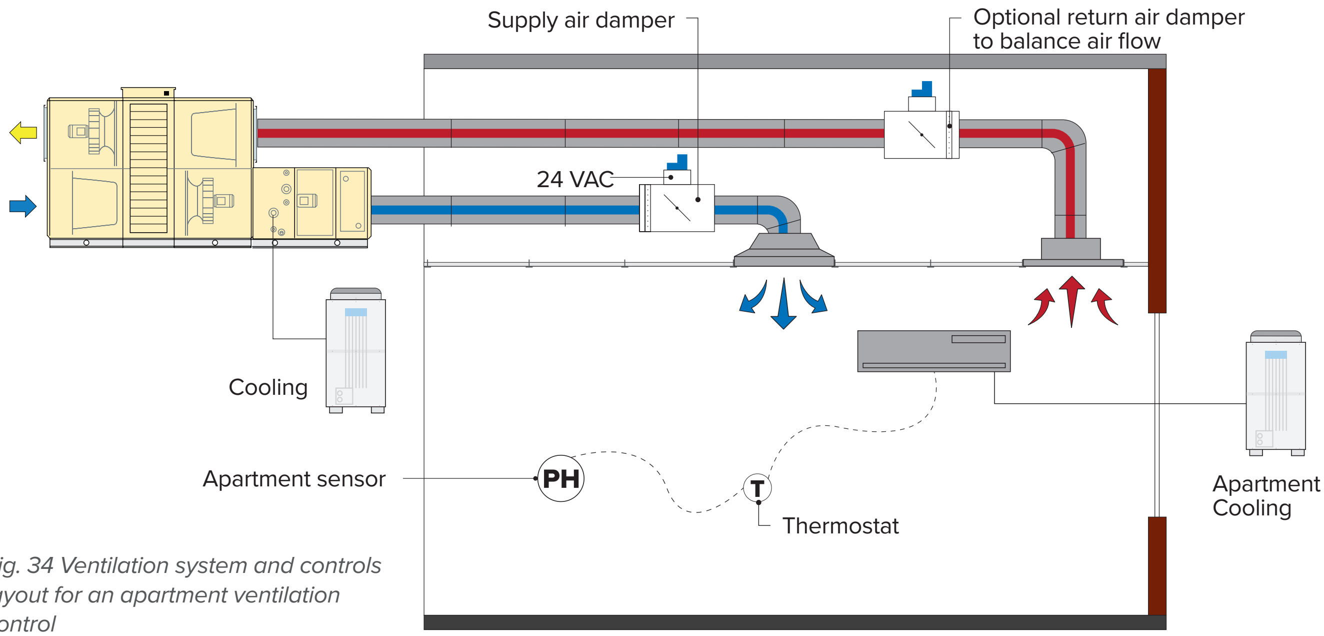


Fig. 34 Ventilation system and controls layout for an apartment ventilation control

SITUATION

The apartments in the building have mechanical cooling controlled by a wall thermostat. The ventilation system has been designed to deliver 50% more air than normal mode and has supplemental mechanical cooling.

SOLUTION

The ventilation unit should be set up to lower the supply air temperature setpoint as the outdoor air temperature rises. In winter, the setpoint should be close to neutral (68-72 °F (20-22 °C)). As the outdoor air temperature rises, the supply air setpoint should be reset down to 55 °F (13 °C). When to start resetting will depend on the building design. If the outdoor air is colder than the setpoint, energy recovery in the ventilation unit can be used to raise the supply air temperature to the setpoint with free energy.

Since there is mechanical cooling in the ventilation unit, the supply air temperature will always be at setpoint. Mechanical cooling will only occur when free cooling cannot meet the setpoint.

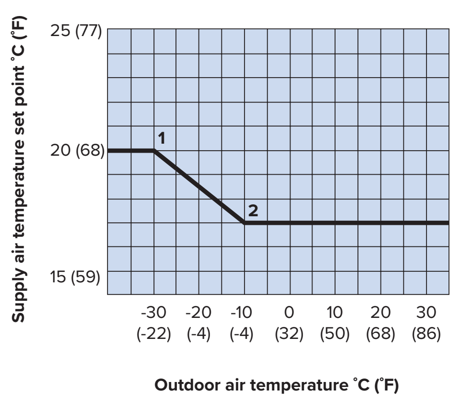


Fig. 35 Supply airflow temp reset based on outside air temperature.

Control of economizer airflow command and the apartment heating cooling must be integrated to avoid the two systems fighting each other. The simplest way is to let the first stage of cooling be the economizer airflow. On a call for cooling, the thermostat will send a signal to the React damper to increase to economizer airflow. In summer, this air will be mechanically cooled at the ventilation unit. If the economizer airflow is not enough to meet the cooling load, then the second stage of cooling starts, and the apartment AC unit is activated.

This approach can lead to bringing more ventilation air into the building than required on a hot summer day thus actually increasing the building load. If there is 80% efficient enthalpy energy recovery in the ventilation unit, then the penalty is only 20% and the extra ventilation will improve the apartment IAQ. It is possible to avoid over ventilating by adding the economizer controller described in Example 1

RETURN AIR DAMPERS

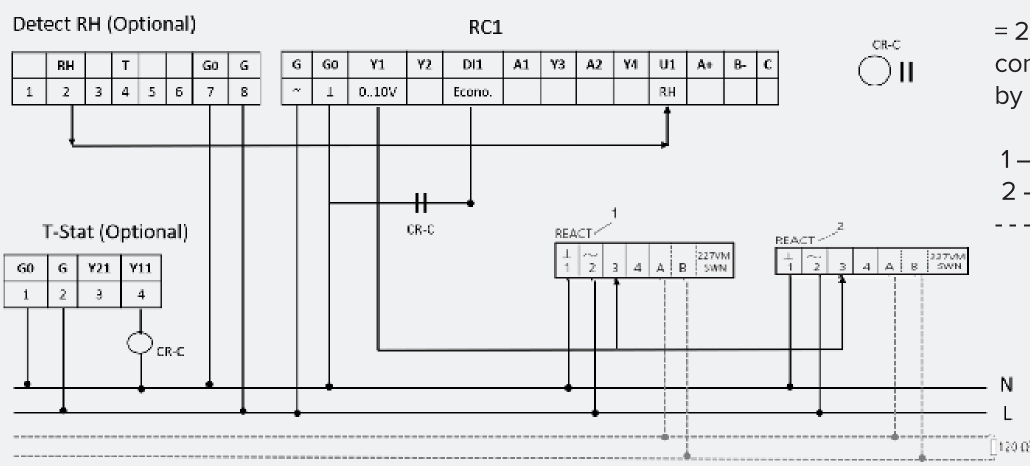
Return air dampers may be required to maintain balanced space pressurization. When required, the damper can be controlled by the RC1 controller as well. It is possible to provide balanced airflow (supply = return airflow) or introduce an offset for space pressurization. This is accomplished by configuring Max. airflow for both the supply and return dampers with different airflow amounts. For example, 100 cfm (47.2 l/s) for the supply damper and 90 cfm (42.5 l/s) for the return damper.

OPTIONS

Humidity Sensor for humidity control.

WIRING DETAILS

REACT DAMPER WIRING WITH APARTMENT CONTROL SENSOR



= 24V Relay with NO contact for cooling by others

1 – REACT supply air
2 – REACT return air
- - – Modbus

Fig. 36 React damper wiring with apartment control sensor

REACT DAMPER
CONSTANT AIRFLOW CONTROL

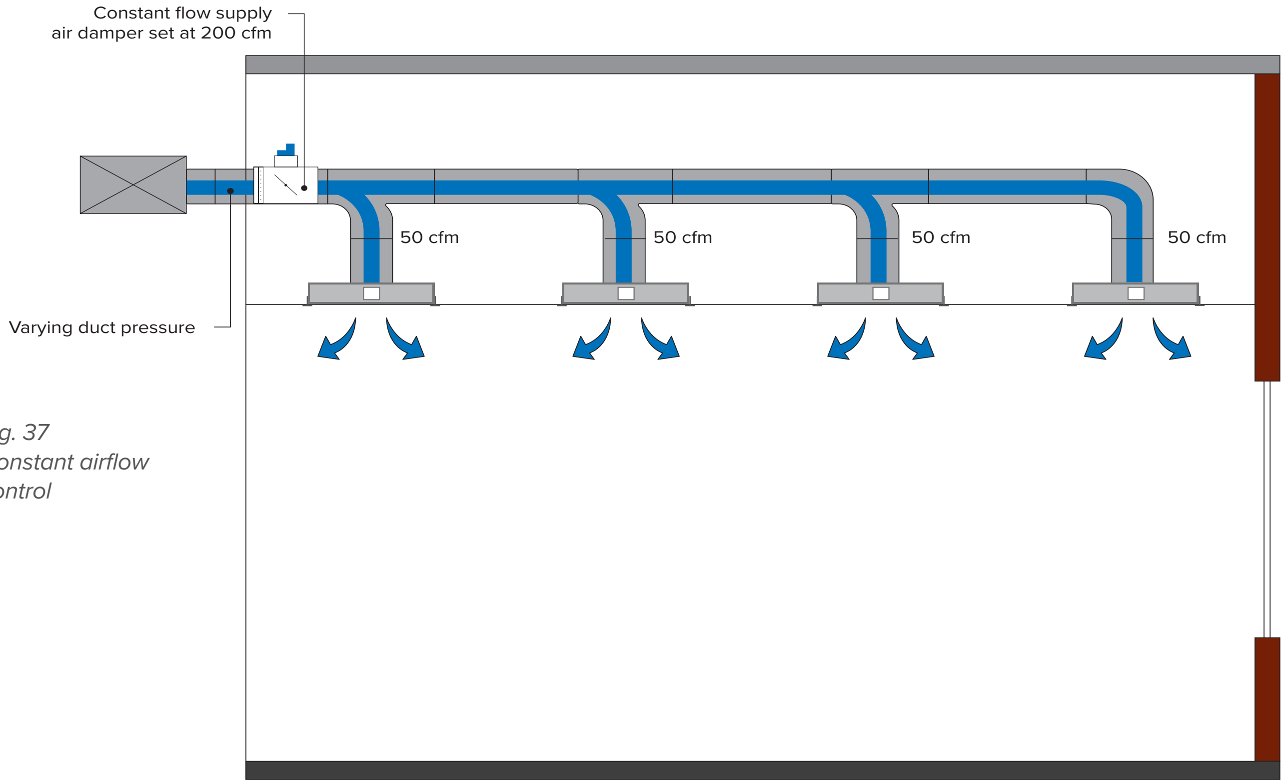


Fig. 37
Constant airflow control

PURPOSE

Deliver a predetermined airflow volume on a branch duct regardless on upstream duct pressure.

SEQUENCE OF OPERATION

The React damper Minimum airflow is set to the required airflow. The Maximum airflow is set to 0. The damper will now deliver the required airflow regardless of upstream duct pressure.

APPLICATION CONSIDERATIONS

Constant airflow dampers are used when a variable air flow system has some zones that require constant airflow. For example, a VAV chilled beam system has some zones serviced by constant volume chilled beams. The branch duct that serves the constant volume chilled beams will have a constant flow React damper configured to deliver the sum of primary airflow of all the beams downstream of the damper.

RETURN AIR DAMPERS

Return air dampers may be required to maintain balanced space pressurization. The airflow for the return air damper is programmed the same way as the supply air damper. An offset can be accomplished by lowering the return air amount.

WIRING DETAILS

REACT DAMPER WIRING

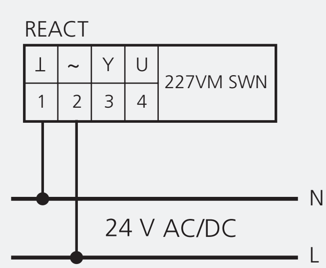


Fig. 38 Wiring details

AIR HANDLING UNIT CONTROL CONSIDERATIONS

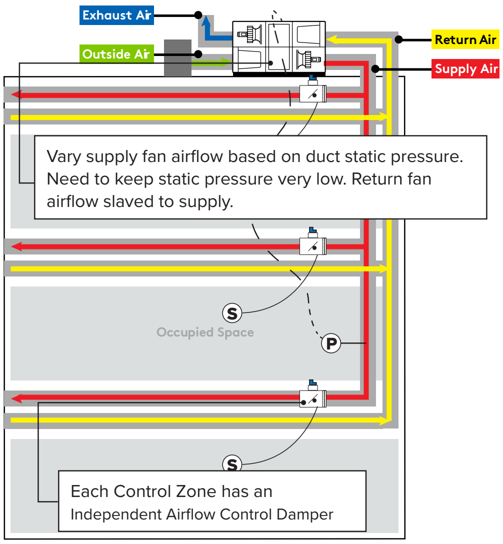


Fig. 39 VAV Ventilation System

SUPPLY AND RETURN AIRFLOW CONTROL

The Ventilation unit must be capable of varying both the supply air and return airflow to the building. This usually entails VFDs or inverters on the fan motors. If the air handling unit is an energy recovery unit, then the supply and return fans are in the same unit. If the air handling unit is a single duct system, then the return fan operation needs to be coordinated with the supply fan.

The supply fan is usually controlled by a duct pressure sensor. The air handling unit controller will use the duct pressure signal to speed up or slow down the fans to maintain duct pressure setpoint. It should be located about 2/3 of the way down the ducting system.

The setpoint should be as low as possible while ensuring no damper goes more than 90% open. The pressure setpoint IS NOT the external static pressure of the supply fan. The pressure sensor should be far away from the ventilation unit discharge and the pressure will have dropped at the sensor location. Unnecessarily high duct static pressure will waste energy and possibly create noise issues. Try to select the dampers at 0.2 in. w.c. (50 Pa) pressure drop or less while maintaining good turndown ratio.

The return fan is usually slaved to the supply fan and works well with return air systems that do not have React dampers in the return side. As the supply airflow changes, the return airflow matches the change. It is possible to include an offset to maintain positive building pressure and account for local exhaust.

When the return air path includes React dampers the return air fan should be operated as a VAV fan based on a return duct static pressure (negative pressure). If slave mode is used the return fan will attempt to draw a specific airflow amount which may not match what the return air React Dampers are set for. This will put the return fan control at odds with the return React Damper control. A duct pressure sensor should be placed 2/3 of the way down the return ducting.

SUPPLY AIR TEMPERATURE CONTROL

Most ventilation systems use discharge air temperature control. A temperature sensor in the supply duct is used to control heat recovery (if included) and any supplemental heating and cooling systems. There are many options for the supply air setpoint; all will depend on the HVAC system design. Here are a couple of options;

Fixed Supply Air Setpoint A single setpoint such as 70°F (21°C) is used at all times. The energy recovery device and then supplemental heating and cooling are used to achieve the supply air temperature setpoint. This is the most common control method.

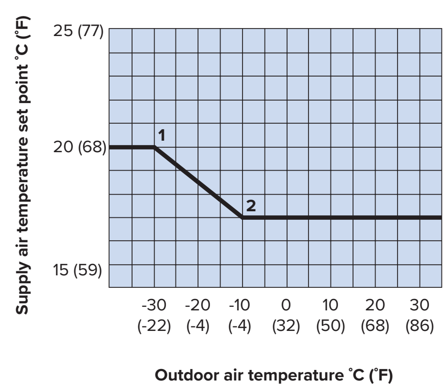


Fig .40 Outdoor air reset control

Outdoor Air Reset The supply air temperature setpoint is changed based on the outdoor air temperature. For example, use 70 °F (21 °C) in winter and 55 °F (13 °C) in summer.

APPENDIX A

AIRFLOW CONSIDERATIONS FOR ECONOMIZER MODE

Using outdoor air when the conditions (outdoor temperature and humidity) are right to assist or meet the building cooling load is a well-known process. It requires an HVAC system that can deliver outdoor air and remove room air for any zone that requires cooling. An all air VAV system, common in office applications, can provide outdoor air free cooling. When the conditions are right (outdoor air temperature at or below the supply air setpoint), the VAV system can meet the entire cooling load with outdoor air. This process is known as air side free cooling or more commonly “economizing”.

Decentralized HVAC systems (water source heat pumps, fan coils, VRF and chilled beams) require a separate ventilation system to meet indoor air quality requirements. It is possible to use this ventilation air to assist with the building cooling when the conditions are right. Ventilation airflow rates are too low to meet the entire design cooling load however locations where there are a lot of “economizer hours” (weather that supports free cooling) benefit significantly from ventilation air free cooling.

Multi family residential buildings, especially high performance, (i.e. Passive House) benefit greatly from ventilation free cooling to the point where designing the ventilation system to deliver more than minimum ventilation rates should be considered to improve overall building energy performance. For Passive House projects with ultra high performance building envelopes, the outdoor air temperature where the building switches from heating can be very low (perhaps 45°F (7°C)). Above this temperature, the HVAC system will start mechanically cooling the building making it very difficult to achieve low annual energy use goals. Free cooling becomes a necessity.

The table to the right shows the amount of sensible cooling that ventilation air can deliver to the space based on varying the supply air temperature, the space temperature setpoint and the airflow rate. The yellow highlighted condition is space temperature setpoint = 78 °F (25 °C), supply air temperature setpoint = 50 °F (10 °C) and 50% increase in ventilation airflow rate delivers twice the cooling vs. the typical design conditions. For a residential application, this can meet a significant amount of the cooling load in midseason weather.

Low supply air temperatures should be carefully considered. Delivering 50°F (10 °C) supply air to a space can lead to uncomfortable drafts and it will reduce the number of free cooling hours available. Increasing the ventilation airflow has capital cost implications as the ventilation unit and ducting system size must be increased. The actual payback will depend on the building design and use, and the climate at the location.

Space Temp.	**Supply Air Temp.**	**Airflow Rate**	**Sensible Cooling**
F (C)	**F (C)**	**cfm/ft2 (l/s.m2)**	**Btu/h-ft2 (l/s.m2)**
75 (24)	55 (13)	0.11 (0.56)	2.4 (7.6)
75 (24)	55 (13)	0.165 (0.84)	3.6 (11.5)
75 (24)	50 (10)	0.11 (0.56)	3.0 (9.6)
75 (24)	50 (10)	0.165 (0.84)	4.5 (14.4)
75 (24)	45 (7)	0.11 (0.56)	3.6 (11.5)
75 (24)	45 (7)	0.165 (0.84)	5.4 (17.2)
78 (25.5)	55 (13)	0.11 (0.56)	2.7 (8.6)
78 (25.5)	55 (13)	0.165 (0.84)	4.1 (13.1)
78 (25.5)	50 (10)	0.11 (0.56)	3.3 (10.5)
78 (25.5)	50 (10)	0.165 (0.84)	5.0 (16)
78 (25.5)	45 (7)	0.11 (0.56)	3.9 (12.4)
78 (25.5)	45 (7)	0.165 (0.84)	5.9 (18.8)