HVAC Characteristics

Information on the characteristics of the heating, ventilation, and air conditioning (HVAC) system(s) in the entire BASE building including types of ventilation, equipment configurations, and operation and maintenance issues was acquired by examining the building plans, conducting a building walk-through, and speaking with the building owner, manager, and/or operator. This information was collected using standard forms available in the appendices of the protocol (see protocol) during the building preliminary visit, and verified by the field team during the study week.

Test Space HVAC Characteristics

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2. Central Air Handling and Distribution Systems - Percentage of Total Air Handling Unit (AHU) Capacity Serving Test Space
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BASE Buildings Test Space HVAC Characteristics: Total Number of Air Handlings Units (AHUs) Serving Test Space

Total Number of AHUs Serving Test Space[1]	Number of Buildings Reporting
0 AHUs	3
1 AHU	54
2 AHUs	41
3 AHUs	1
4 AHUs	0
5 AHUs	1
Total Number of Buildings Reporting	100

Notes:
[1]Number of buildings represent summary data for all BASE building test spaces (n=100). Note that three test spaces were naturally ventilated (0 AHUs).

Variable Descriptions:

Total Number of AHUs Serving Test Space describe the total number of air handling units that serve BASE test spaces.

BASE Buildings Test Space HVAC Characteristics: Central Air Handling and Distribution Systems - Percentage of Air Handling Unit (AHU) Capacity Serving Test Space

	Central Air Handling and Distribution Systems - Percentage of AHU Capacity Serving Test Space
Number of Test Space Air Handlers	141
Mean (Arithmetic)	70
Standard Deviation	35
Minimum	4
10th Percentile	16
25th Percentile	34
50th Percentile	100
75th Percentile	100
90th Percentile	100
Maximum	100

Variable Descriptions:

Percentage of AHU Capacity Serving Test Space describes the percentage of the AHU capacity serving the test space, for each AHU. This value was usually determined based on the air handling unit's design air volume delivery rate compared to the air volume delivery rate that the air handling unit delivered to the test space.

BASE Buildings Test Space HVAC Characteristics: Test Space Air Handling Unit (AHU) General Design Specifications

	AHU Supply Airflow Capacity (m^3/min) [1]	AHU Minimum Outdoor Air Intake Rate (m^3/min) [2]	Floor Area Served By AHU (m^2) [3]	Number of Occupants Served By AHU
Number of Test Space Air Handlers	134	77	141	141
Average	965	194	3,037	149
Standard Deviation	1,272	432	4,200	225
Minimum	31	0	112	0
10th Percentile	171	19	542	20
25th Percentile	396	35	989	41
50th Percentile	538	61	1,558	60
75th Percentile	963	170	3,423	133
90th Percentile	2,319	471	7,353	393
Maximum	7,922	3,398	33,783	1,500

Notes:

[1]Data represent statistics for AHU supply airflow rate capacity for 134 study space air handling units. Capacity data were not reported for 7 study space AHUs. Conversion: 1 m^3 equals 35.311 ft^3.

[2]Data represent statistics for AHU minimum outdoor airflow design for 77 study space air handling units. Minimum outdoor air design data were not reported for 64 study space AHUs. Conversion: 1 m^3 equals 35.311 ft^3.

[3]Conversion: 1 m^2 equals 10.764 ft^2.

Variable Descriptions:

AHU Supply Airflow Capacity describes the design supply airflow delivery rate for each BASE test space air handling unit. Statistics are reported in m^3/min. Note that all supply airflow did not go to the test space when an air handling unit also served other areas outside the test space.

AHU Minimum Outdoor Air Intake Rate describes the design minimum outdoor air flow delivery rate for each BASE test space air handling unit. Statistics are reported in m^3/min. Note that all outdoor airflow did not go to the test space when an air handling unit also served other areas outside the test space.

Floor Area Served By AHU describes the floor area served by the BASE test space air handling units. Statistics are reported in m^2. This includes floor area outside the test space when an air handling unit also served other areas.

Number of Occupants Served by AHU describes the total number of occupants who occupy the space served by the BASE test space air handling units. This includes occupants outside the test space when an air handling unit also served other areas.

BASE Buildings Test Space HVAC Characteristics: Overall Types of Central Air Handling and Distribution Systems

Overall Types of Central Air Handling and Distribution Systems	Number of Test Space Air Handlers
Constant Air Volume (CAV)	50
Variable Air Volume (VAV)	91
Total Number of Test Space Air Handlers	141

Notes:
The database describes various system types, where each type is defined based on its operating characteristic. This table was generated by summarizing the various system types based on whether the system operated at a constant air volume, or variable air volume.

Variable Descriptions:

Overall Types of Central Air Handling and Distribution Systems shows a breakdown of the overall BASE test space air handling unit types. These include air handling units that operate as constant air volume (CAV) systems and air handling units that operate as variable air volume (VAV) systems. CAV systems deliver a constant volume of supply air to zones served and control space temperature by varying the temperature of the air delivered to the zone. VAV systems vary the volume of air delivered to the zone based on the thermal requirements of the zone. VAV system delivery temperature is generally constant.

BASE Buildings Test Space HVAC Characteristics: System-Type Breakdown of Central Air Handling and Distribution Systems

Breakdown of Central Air Handling and Distribution System Types	Number of Test Space Air Handlers
SINGLE DUCT	
Single Duct, Constant Volume, Single Zone	13
Single Duct, Constant Volume, Multiple Zone Reheat	8
Single Duct, Constant Volume, Multiple Zone Bypass	0
Single Duct, Variable Air Volume	37
Single Duct, Variable Air Volume, Reheat	17
Single Duct, Variable Air Volume, Induction	7
Single Duct, Variable Air Volume, Fan Powered, Constant Fan	8
Single Duct, Variable Air Volume, Fan Powered, Intermittent Fan	18
Single Duct, Variable Air Volume, Dual Conduit	0
DUAL DUCT	
Dual Duct, Constant Volume	2
Dual Duct, Constant Volume, Reheat	7
Dual Duct, Variable Volume, Single Fan	3
Dual Duct, Variable Volume, Dual Fan	1
OTHER	
Multizone, Constant Volume	17
Constant Volume, Blow Through Bypass	3
Texas Multizone, or Three Deck Multizone	0
Total Number of Test Space Air Handlers	141

Variable Descriptions:

Breakdown of Central Air Handling and Distribution System Types describes the type of air handling unit configuration for air handling units serving the BASE test spaces. The following categories apply:

Single Duct, Constant Volume, Single Zone The air handler supplies a constant volume of supply air to a single zone with minimum heating and cooling load variations. The load within the space is controlled by varying the temperature of the supply air. The supply air temperature is controlled by varying the quantity and/or temperature of the heating or cooling source, by varying the relative proportions of outdoor air intake and recirculation, by modulating the position of face and bypass dampers within the air handler, or a combination of these approaches.

Single Duct, Constant Volume, Multiple Zone Reheat The air handler supplies a constant volume of supply air to multiple zones with unequal loads. The load within each zone is controlled by varying the temperature of the supply air delivered to the zone. The supply air temperature is controlled by varying the amount of heating or cooling at the air handler, the relative proportions of outdoor air intake and recirculation, the position of face and bypass dampers within the air handler, or a combination of these approaches. Further temperature control is provided by reheat coils in the ducts in each individual zone.

Single Duct, Constant Volume, Multiple Zone Bypass The air handler supplies a constant volume of supply air to multiple zones with unequal loads. The load within each zone is controlled by varying the temperature of the supply air delivered to the zone and the amount of supply air that is actually delivered to the zone. The supply air temperature can be controlled by varying the amount of heating or cooling at the air handler, the relative proportions of outdoor air intake and recirculation, the position of face and bypass dampers within the air handler, or a combination of these approaches. Further temperature control in individual zones is provided through the use of a bypass box in the zone which dumps some of the supply air into the return air plenum or duct.

Single Duct, Variable Air Volume The air handler supplies air at a constant temperature of approximately 10°C (50°F) through a duct system to VAV units located in the ceiling plenum. In each zone, the VAV units control the quantity of supply air delivered to each zone to meet the cooling load requirements within the zone. The total quantity of supply air delivered by the air handler therefore varies in response to variations in the space load within the building. A true VAV system provides cooling only, with perimeter zones heated by some other system.

Single Duct, Variable Air Volume, Reheat This system is a modification of a true VAV system capable of providing both heating and cooling. Heat is provided in or near the terminal units after the supply airflow rate has been reduced to a predetermined minimum.

Single Duct, Variable Air Volume, Induction A VAV air handler provides primary air to unpowered terminal units that induce plenum or room air into the supply airstream. The combination of primary and induced air provide a constant airflow. Variations in space load are met by varying the relative proportions of the primary and induced air. Reheat coils or some other form of auxiliary heat are required when heat gain in the room and ceiling can not balance transmission losses and cooling loads associated with the primary supply air.

Single Duct, Variable Air Volume, Fan Powered, Constant Fan A VAV air handler supplies primary air to fan powered induction units that are installed in series with the primary supply airflow. The fan powered units run continuously and operate at a relatively constant volume. In each zone, the unit mixes the required quantity of primary supply air with induced return air from the plenum. Terminal units in exterior zones have heating coils for winter heating requirements. The heating coil is not activated until the primary air volume is reduced to a minimum.

Single Duct, Variable Air Volume, Fan Powered, Intermittent Fan A VAV air handler supplies primary air to fan powered induction units that are installed in parallel with the primary supply airflow. The unit modulates the primary supply air in response to the cooling needs of the zone and operates the fan powered unit when induced air is needed to meet the heating requirements. The primary air and the induced air mix within a common plenum within the fan powered unit.

Single Duct, Variable Air Volume, Dual Conduit This system has two airstreams, a primary system used to offset transmission losses and a secondary system to meet year round cooling loads. The primary system operates at a constant volume and conditions return air from the ceiling plenum. This system cools the air in the summer and heats it in the winter to meet transmission losses and sometimes operates only during peak conditions. The secondary system is a conventional VAV system that provides year round cooling to meet space cooling loads.

Variable Descriptions: (continued)

Dual Duct, Constant Volume The air handler supplies a constant volume of supply air to multiple zones, with the supply fan blowing through cooling and heating coil sections connected to cold and hot ducts respectively. These two ducts run through the building to mixing boxes (unpowered) in the ceiling plenum, which mix the warm and cold air in proper proportions to meet the loads in the zone. The dampers in the mixing boxes are controlled by zone thermostats.

Dual Duct, Constant Volume, Reheat The air handler supplies a constant volume of supply air to multiple zones, with the supply airstream being split into two flows, one blowing through cooling coils and the other blowing through heating coils. The hot and cold air ducts run through the building to mixing boxes (unpowered) in the ceiling plenum, which mix the hot and cold air in proper proportions to meet the loads in the zone. The dampers in the mixing boxes are controlled by zone thermostats. Interior zones mixing boxes may only be connected to the cold deck.

Dual Duct, Variable Air Volume, Single Fan A single VAV air handler supplies air to multiple zones, with the supply fan blowing through cooling and heating coil sections connected to cold and hot ducts respectively. These two ducts run through the building to VAV mixing boxes in the ceiling plenum, which mix the hot and cold air to meet the loads in the zone. The dampers in the mixing boxes are controlled by zone thermostats. Interior zone boxes may be connected to only the cold duct, while exterior zones will be connected to both the hot and cold ducts.

Dual Duct, Variable Air Volume, Dual Fan In this system, separate supply fans serve the cold and hot decks. The two ducts run through the building to VAV mixing boxes in the ceiling plenum, which mix the hot and cold air to meet the loads in the zone. The dampers in the mixing boxes are controlled by zone thermostats. Interior zone boxes may be connected to only the cold duct, while exterior zones will be connected to both the hot and cold ducts.

Multizone, Constant Volume The air handler supplies a constant volume of supply air to multiple zones, with the supply fan blowing through a cooling coil, a heating coil, or both coils. The space load of each zone is met through a mixture of the hot and cold airstreams that is carried by single duct to the zone. The mixing of the hot and cold airstreams for each zone takes place at the unit, employing dampers in the heating and cooling ducts. The total air quantity to each zone is more or less constant depending on the pressure drop through each coil and the position of the mixing dampers.

Constant Volume, Blow Through Bypass The air handler supplies a constant volume of supply air to multiple zones, with the supply fan blowing air through the cooling coil section or through a bypass section around the cooling coil. The two supply air ducts, cold and bypass, each split off such that there is a cold duct and bypass air duct for each zone. These two supply airflows are brought together within the mechanical room, with a damper in the bypass air duct and a heating coil downstream of where the two flows merge. A constant quantity of air is supplied to each zone through this single duct, and the supply air temperature to each zone is varied as required to meet cooling or heating requirements by modulating the bypass damper and the use of the heating coil. The heating coil is activated only when all of the zone's supply air is bypass air.

Texas Multizone, or Three Deck Multizone The air handler supplies a constant volume of supply air to multiple zones, with the supply fan blowing through a cooling coil or a bypass section. The space load of each zone is met through a mixture of the neutral and cold airstreams that is carried by single duct to the zone. An individual heating coil is located in the duct of each perimeter zone. The mixing of the neutral and cold airstreams for each zone takes place at the unit, employing dampers in the two decks. The heating coils are activated only if the bypass air can not meet the loads. The total air quantity to each zone is more or less constant depending on the pressure drop through each coil and the position of the mixing dampers.

BASE Buildings Test Space HVAC Characteristics: HVAC Configurations in Test Space

	Rooftop Units[2]	Air-Water Induction Units	Fan Coil Units	Unit Ventilators	Fin-Tube Radiator	Electric Baseboard (Heat)	Individual Room Packaged AC	Heat Pump Systems	Direct Evaporative Air Cooler	Other
Number of Test Spaces Having HVAC Configuration Shown[1]	12	2	11	2	31	3	29	3	1	80

Notes:
[1] HVAC configurations as reported for all BASE building test spaces (n=100).
[2] For example, data indicate that of the 100 BASE buildings test spaces, 12 test spaces were equipped with rooftop units. Similar logic applies to the other HVAC configurations shown.

Variable Descriptions:

Test Spaces Having HVAC Configuration Shown shows a breakdown of the types of HVAC systems and components serving the BASE test spaces. The following categories apply:

Rooftop Units are the central units located on the roof that cool or heat the air and then distribute it to the space or terminal boxes.
Air-Water Induction Units are terminal units that receive chilled or hot water from a central plant as well as ventilation air from a central air handling unit.
Fan Coil Units consist of a finned-tube coil supplied with hot or chilled water from a central source and a fan that circulates room air over the coil. These units are sometimes provided with an outdoor air connection through the exterior wall.
Unit Ventilators have components similar to fan-coil units except the units are usually larger and designed to provide up to 100% outdoor air via integral dampers. Since they are frequently installed as perimeter units, outside air is commonly introduced through the outside wall.
Fin-Tube Radiators are hydronic terminal units equipped with metal fins that dissipate the heat from the hot water in the piping through natural convection.
Electric Baseboard are electric terminal units that heat by electrical resistance and natural convection.
Packaged AC Units are factory assembled air conditioning units equipped with the ability to heat or cool. Cooling is provided using a direct expansion refrigeration cycle. Heating is generally provided using gas fired heat exchanger or electric resistance heating coils.
Heat Pumps are factory assembled units with the capacity to heat and cool. A single system can be used to condition an entire building or individual zones. Heat pump types include air-to-air, water-to-air, air-to-water, and water-to-water. Ventilation air may be supplied by a central system to the individual units through a system of ductwork or the individual units may provide ventilation.
Evaporative Coolers (direct or indirect) are non-refrigerant systems that cool air by exchanging sensible heat for latent heat, reducing temperatures, but raising humidity. In a direct evaporative air cooler, heat in the incoming airstream evaporates water from a wetted element or an air spray.
Other refers to any other HVAC configuration that is not otherwise defined.

BASE Buildings Test Space HVAC Characteristics: Outdoor Air Intake Strategy

Outdoor Air Intake Strategy	Number of Buildings Reporting[1]
Conditioned Positive	11
Unconditioned Positive	10
Unconditioned Suction	46
Unconditioned Suction, No Duct	38
Total Number of Buildings Reporting	97

Notes:

[1]This table describes the number of outdoor air intake strategies for 97 mechanically ventilated BASE building test spaces. Three naturally ventilated test spaces have been excluded. Note that some test spaces relied on more than one intake strategy. Therefore, column total will not equal the total number of buildings.

Variable Descriptions:

Outdoor Air Intake Strategy describes the outdoor air intake strategy used by the air handling systems serving the BASE test spaces. The following categories apply:

Conditioned Positive , a separate fan is used to bring in the required amount of outdoor air. The air is filtered, possibly dehumidified, and perhaps heated or cooled prior to being delivered to the air handler.
Unconditioned Positive uses a separate fan to bring in outdoor air, but this air is not treated before it is delivered to the air handler.
Unconditioned Suction draws outdoor air into the building through a separate duct by the suction induced by the supply fan. This air is not treated prior to its delivery to the air handler.
Unconditioned Suction with No Duct draws outdoor air directly into the air handler using supply fan suction.

BASE Buildings Test Space HVAC Characteristics: Outdoor Air Intake Strategy

Outdoor Air Intake Strategy	Number of Buildings Reporting[1]
Conditioned Positive	11
Unconditioned Positive	10
Unconditioned Suction	46
Unconditioned Suction, No Duct	38
Total Number of Buildings Reporting	97

Notes:

[1]This table describes the number of outdoor air intake strategies for 97 mechanically ventilated BASE building test spaces. Three naturally ventilated test spaces have been excluded. Note that some test spaces relied on more than one intake strategy. Therefore, column total will not equal the total number of buildings.

Variable Descriptions:

Outdoor Air Intake Strategy describes the outdoor air intake strategy used by the air handling systems serving the BASE test spaces. The following categories apply:

Conditioned Positive , a separate fan is used to bring in the required amount of outdoor air. The air is filtered, possibly dehumidified, and perhaps heated or cooled prior to being delivered to the air handler.
Unconditioned Positive uses a separate fan to bring in outdoor air, but this air is not treated before it is delivered to the air handler.
Unconditioned Suction draws outdoor air into the building through a separate duct by the suction induced by the supply fan. This air is not treated prior to its delivery to the air handler.
Unconditioned Suction with No Duct draws outdoor air directly into the air handler using supply fan suction.

BASE Buildings Test Space HVAC Characteristics: Outdoor Air Control Strategy

Outdoor Air Control Strategy	Number of Buildings Reporting[1]
100% Outdoor Air Intake	5
Economizer Cycle	52
Fixed Minimum Outdoor Air Intake	73
Enthalpy Economizer Cycle	21
Building Pressure Control	4
Total Number of Buildings Reporting	97

Notes:

[1]This table describes the number of outdoor air intake control strategies for 97 mechanically ventilated BASE building test spaces. Three naturally ventilated test spaces have been excluded. Note that some test spaces relied on more than one intake control strategy. Therefore, column total will not equal the total number of buildings.

Variable Descriptions:

Outdoor Air Control Strategy describes the outdoor air control strategy used by the air handling systems serving the BASE test spaces. The following categories apply:

100% Outdoor Air Intake provides 100% outdoor air at all times with no recirculation of return air.
Economizer Cycle checks the outdoor temperature against a pair of setpoints. Intake dampers modulate according to the outdoor temperature, reducing air intake when the outdoor temperature is below a low temperature setpoint or above a high temperature setpoint.
Fixed Minimum Outdoor Air Intake ensures the rate of outdoor air intake is constant whenever the air handler is operating. Supply air consists of constant proportions of outdoor air and recirculated return air.
Enthalpy Economizer Cycle adjusts air intake in accordance with outdoor air enthalpy readings.
Building Pressure Controls modulate air intake according to air pressure within the building.

BASE Buildings Test Space HVAC Characteristics: Outdoor Air - Means of Maintaining Minimum Outdoor Air

Outdoor Air - Means of Maintaining Minimum Outdoor Air	Number of Buildings Reporting[1]
Fixed Damper Positions	88
Intake Airflow Monitoring	2
Supply/Return Fan Tracking	5
Total Number of Buildings Reporting	97

Notes:

[1]This table describes the number of outdoor air intake control information strategies for 97 mechanically ventilated BASE building test spaces. Three naturally ventilated test spaces have been excluded. Note that some test spaces relied on more than one intake strategy while some test spaces did not specify the outdoor air control information. Therefore, column totals will not equal the total number of spaces.

Variable Descriptions:

Means of Maintaining Minimum Outdoor Air describes the methods employed by BASE test space air handling units to control the minimum volume of outdoor air supplied. The following categories apply:

Fixed Damper Position method determines the outdoor air intake rate by creating a pressure in the fixed air plenum with the damper position.

Intake Airflow Monitoring requires an airflow station and control system to modulate intake dampers based on the measured airflow rate as compared to a setpoint.

Supply/Return Fan Tracking method uses the difference between the supply and return fan airflow rates to modulate intake dampers and provide a constant outdoor air intake rate.

BASE Buildings Test Space HVAC Characteristics: Additional Outdoor Air Ventilation Control Strategies

	Number of Buildings Reporting[1]		
	Morning Warm-up Cycle	Morning Purge Cycle	Night Cool-Down Cycle
Number of Test Spaces Having Outdoor Air Ventilation Control Strategies Shown	24	5	5

Notes:

[1]This table describes the number of mechanically ventilated BASE building test spaces (n=97) implementing the additional outdoor air control strategies shown. Three naturally ventilated test spaces have been excluded from the analysis.

Variable Descriptions:

Morning Warm-up Cycle Control Strategy describes the number of BASE test spaces that use this control strategy. Morning warm-up cycle operates the system with no outdoor air intake to warm-up the building prior to occupancy.

Morning Purge Cycle Control Strategy describes the number of BASE test spaces that use this control strategy. Morning purge cycle operates the system at a high level of outdoor air intake to purge the building of any contaminants that may have built up overnight.

Night Cool-Down Cycle Control Strategy describes the number of BASE test spaces that use this control strategy. Night cool-down cycle runs the system at 100% outdoor air intake in order to cool-down the building prior to occupancy.

BASE Buildings Test Space HVAC Characteristics: Number of Supply Vents in Test Space

	Number of Supply Vents in Test Space	
	Total in Test Space	Per 100 m^2 of Gross Floor Area [1,2]
Number of Buildings Reporting	100	87
Mean (Arithmetic)	102	5.8
Standard Deviation	55	2.7
Minimum	0	0.0
10th Percentile	43	2.7
25th Percentile	70	4.1
50th Percentile	96	5.5
75th Percentile	130	7.6
90th Percentile	166	9.2
Maximum	281	16.1

Notes:

[1]Gross floor space not reported for 13 buildings surveyed in 1994 as the building survey software was did not include this variable at that time.

[2]Conversion: 1 m^2 equals 10.764 ft^2.

Variable Descriptions:

Total Number of Supply Vents in Test Space describes the number of supply air diffusers or supply air vents located within the bounds of the test space.

Number of Supply Vents per 100 m^2 of Gross Floor Area was calculated by dividing the total number of supply vents in the test space by the test space gross floor area.

BASE Buildings Test Space HVAC Characteristics: Types of Supply Vents

Supply Vent Type	Number of Buildings Reporting[1]	
	Primary Supply Vent Type[2]	Secondary Supply Vent Type[3]
Linear Ceiling Diffusers	40	5
Sidewall Diffusers	0	1
High Sidewall Diffusers	1	3
Floor Registers	0	0
Perforated Ceiling Panels	5	2
Square or Round Ceiling Diffusers	51	17
Floor or Near-Floor Diffusers	0	1
Low Sidewall Grilles	1	1
Fan Coil Units or Unit Ventilators	2	0
Slots Around Ceiling Luminaires	11	0
Other	4	1
Total Number of Buildings Reporting	97	97

Notes:

[1]Number of buildings based on all test spaces served by mechanical ventilation (n=97).

[2]Number of buildings within column may add up to greater than the total number of buildings if some buildings had more than one primary supply vent type.

[3]Number of buildings within column do not add up to the total number of buildings as some buildings reported no secondary supply vent type.

Variable Descriptions:

Primary Supply Vent Type describes the primary type of supply vent installed throughout the test space.

Secondary Supply Vent Type describes the secondary type of supply vent installed throughout the test space.

The following categories apply:
Linear Ceiling Diffusers are long strip-shaped supply air vents with one or more narrow openings, depending on the number of bars or vanes.
Sidewall Diffusers are supply air vents located on a wall that consist of a series of separate concentric rings or louvers that distribute the air equally in all directions.
High Sidewall Diffusers are supply air vents located near the ceiling on a wall that consist of a series of separate concentric rings or louvers that distribute the air equally in all directions.
Floor Registers are grilles located in the floor with volume control dampers mounted behind the grille.
Perforated Ceiling Panels are usually found as part of a suspended ceiling system where there are slots or perforations throughout the ceiling, which serve as air outlets.
Square or Round Ceiling Diffusers are supply air vents located in the ceiling that consist of a series of separate concentric rings or louvers that distribute the air equally in all directions.
Floor or Near-Floor Diffusers are supply air vents located near the floor on a wall or on the floor that consist of a series of separate concentric rings or louvers that distribute the air equally in all directions.
Low Sidewall Grilles are supply vents located on the wall near the floor that consist of frames with parallel bars which may be fixed or adjustable that deflect the air.
Fan Coil Units or Unit Ventilators consist of a finned-tube coil supplied with hot or chilled water from a central source and a fan that circulates room air over the coil. These units are sometimes provided with an outdoor air connection through the exterior wall.
Slots Around Ceiling Luminaries are supply vents that are cut into the light fixtures in the ceiling.
Other are supply air vents that are not otherwise defined.

BASE Buildings Test Space HVAC Characteristics: Number of Return Vents in Test Space

	Number of Return Vents in Test Space	
	Total in Test Space[1]	Per 100 m^2 of Gross Floor Area [2,3]
Number of Buildings Reporting	99	86
Mean (Arithmetic)	128	7.3
Standard Deviation	137	6.8
Minimum	0	0.0
10th Percentile	7	0.4
25th Percentile	25	1.6
50th Percentile	85	5.1
75th Percentile	214	10.9
90th Percentile	283	18.3
Maximum	744	28.0

Notes:

[1]One building did not report the total number of return vents in the test space.

[2]Gross floor space not reported for 13 buildings surveyed in 1994 as the building survey software was did not include this variable at that time.

[3]Conversion: 1 m^2 equals 10.764 ft^2.

Variable Descriptions:

Total Number of Return Vents in Test Space describes the number of return air grills or vents located within the bounds of the test space.

Number of Return Vents per 100 m^2 of Gross Floor Area was calculated by dividing the total number of return vents in the test space by the test space gross floor area.

BASE Buildings Test Space HVAC Characteristics: Types of Return Vents

	Number of Buildings Reporting[1]	
Return Vent Type	Primary Return Vent Type[2]	Secondary Return Vent Type[3]
Ceiling Grilles	37	21
Ceiling Slots	8	0
Low Sidewall or Floor Grilles	3	1
Slots Around Ceiling Luminaires	45	2
High Sidewall Grilles	0	4
Other	7	1
Total Number of Buildings Reporting	97	97

Notes:

[1]Number of buildings based on all test spaces served by mechanical ventilation systems (n=97).

[2]Number of buildings within column may add up to greater than the total number of buildings as some buildings had more than one primary return vent type.

[3] Number of buildings within column may add up to less than the total number of buildings as some buildings reported no secondary type of return vent.

Variable Descriptions:

Primary Supply Vent Type describes the primary type of return vent installed throughout the test space.

Secondary Supply Vent Type describes the secondary type of return vent installed throughout the test space.

The following categories apply:

Ceiling Grilles are return vents located in the ceiling that consist of frames with parallel bars which may be fixed or adjustable.
Ceiling Slots are long strip shaped return air vents with one or more narrow openings, depending on the number of bars or vanes.
Low Sidewall or Floor Grilles are return vents located on the wall near the floor or on the floor that consist of frames with parallel bars which may be fixed or adjustable.
Slots Around Ceiling Luminaries are return vents that are cut into the light fixtures in the ceiling.
High Sidewall Grilles are return air vents located near the ceiling on a wall that consist of frames with parallel bars which may be fixed or adjustable.
Other are return air vents that are not otherwise defined.

BASE Buildings Test Space HVAC Characteristics: Type of Central Air Handling Ductwork

	Number of Test Space Air Handlers	
Type of Duct Work[1]	Supply Ducting	Return Ducting
Galvanized	135	30
Flexible	2	0
Fiberboard	4	0
No ducting	2	106
Other	0	3
Total Number of Test Space Air Handlers	141	141

Notes:

[1]These numbers describe the primary type of supply and return airflow ducting reported for 141 study space air handling units. "Secondary" types of duct work are not included in this analysis. Note that in some cases the sum of each column may exceed the total number indicating that, for individual AHUs, more than one type of duct system was reported as "primary".

Variable Descriptions:

Supply Ducting describes the primary type of supply airflow ducting for the BASE test space air handling units.

Return Ducting describes the primary type of return airflow ducting for the BASE test space air handling units.

The following categories apply:

Galvanized ducts are made of steel sheet metal that is treated with zinc.
Flexible are ducts can be made of metal, plastic or a combination that are flexible and can be bent around corners without having to cut or alter the material.
Fiberboard ducts are made of rigid fiberglass insulation.
No Ducting refers to air handling systems that move air without using duct work.
Other refers to a type of ductwork not otherwise specified.

BASE Buildings Test Space HVAC Characteristics: Central Air Handling and Distribution Systems - Return Air Fan

	Number of Test Space Air Handlers[1]
Central Air Handling and Distribution System Incorporates a Return Air Fan	45

Notes:

[1]As reported for a total of 141 study space air handling units.

Variable Description:

System Incorporates a Return Air Fan describes the number of BASE test space air handling units that were equipped with a return air fan.

BASE Buildings Test Space HVAC Characteristics: Test Space Air Handling Unit (AHU) General Specifications, Return Air Systems

	AHU Return Airflow Capacity (m^3/min) [1]	Floor Area Served By AHU Return Airflow System (m^2) [2]
Number of Test Space Air Handlers	41	136
Mean (Arithmetic)	1,322	3,085
Standard Deviation	1,443	4,267
Minimum	72	0
10th Percentile	220	503
25th Percentile	418	995
50th Percentile	765	1,602
75th Percentile	1,827	3,412
90th Percentile	2,832	7,798
Maximum	6,683	33,783

Notes:

[1]Data represent statistics for 41 study space air handling units equipped with a return air fan. Ninety-six of the air handling units were not equipped with a return air fan, while return fan capacity information were not reported for four air handling units.

Conversion: 1 m^3 equals 35.311 ft^3.

[2]Data represent statistics for 136 study space air handling units. Return airflow area was not reported for 5 air handling units.

Conversion: 1 m^2 equals 10.764 ft^2.

Variable Descriptions:

AHU Return Airflow Capacity describes the design return airflow delivery rate for each BASE test space air handling unit equipped with a return air fan. Statistics are reported in m^3/min. Note that all return airflow was not from the test space when an air handling unit also served other areas outside the test space.

Floor Area Served By AHU Return Airflow System describes the floor area served by each BASE test space air handling unit's return airflow system. Statistics are reported in m^2. This includes floor area outside the test space when an air handling unit also served other areas.

BASE Buildings Test Space HVAC Characteristics: Central Air Handling and Distribution Systems - Variable Supply Air Temperature Setpoint

	Number of Test Space Air Handlers[1]
Central Air Handling and Distribution System Incorporates Variable Supply Air Temperature Setpoint	49

Notes:
[1] As reported for 91 AHUs indicating VAV as system type.

Variable Description:

Central Air Handling and Distribution System Incorporates Variable Supply Air Temperature Setpoint describes the number of test space air handling that are eligible to incorporate variable supply air temperature setpoint control, and the number of eligible air handling units that use this control. This control strategy applies to variable air volume (VAV) air handling units.

BASE Buildings Test Space HVAC Characteristics: Humidification System Types

Humidification System Types	Number of Test Space Air Handlers[1]
Heated Pan	1
Steam Type, Enclosed Steam Grid	2
Steam Type, Cup or Pot-Type	1
Steam Type, Jacketed Dry-steam	6
Steam Type, Self-contained	5
Atomizing	0
Wetted Element	0
Ultrasonic Atomizing Nozzle Humidifier	0
Pneumatic Atomizing Nozzle Humidifier	2
Total Number of Test Space Air Handlers	17

Notes:
[1]Data represent statistics for 17 study space air handling units equipped with humidification systems.

Variable Descriptions:

Humidification System Types describes the specific humidifier system type for those BASE test space air handling units equipped with humidifiers. The following categories apply:

Heated Pan is a humidification system that uses a heated pan of water that is exposed to the air duct and water evaporates directly into the airstream.
Steam Type, Enclosed Steam Grid is a humidification system where a steam pipe passes through an enclosure within the duct and releases steam into this enclosure. Condensate is drained from the enclosure and dry steam is released into the airstream.
Steam Type, Cup or Pot-Type is a humidification system where steam is fed into a cup attached under an air duct. Condensate drains from the cup and steam is released into the airstream.
Steam Type, Jacketed Dry-steam is a humidification system where steam is supplied to a perforated tube after passing through a condensate separator. This perforated discharge tube is located within a jacket fed by the steam before it passes through the separator. The perforations face into the airstream.
Steam Type, Self-contained is a humidification system where tap water is converted into steam by electrical energy and the steam is injected directly into the airstream.
Atomizing is a humidification system where a high speed disk slings water through a fine comb to create a mist that is introduced directly into the airstream, where it evaporates.
Wetted Element is a humidification system where air is circulated over or through a wetted element, and water evaporates into the airstream.
Ultrasonic Atomizing Nozzle Humidifier generates a water mist without raising its temperature. An electronic oscillation is converted to a mechanical oscillation using a piezo disk immersed in a reservoir of water. The mechanical oscillation is directed at the surface of the water, where at very high frequencies it creates a very fine mist of water droplets.
Pneumatic Atomizing Nozzle Humidifier uses pneumatic air to create a water mist that evaporates into the air.

BASE Buildings Test Space HVAC Characteristics: Filtration System Types, Panel vs. Roll

Filtration System Type	Number of Test Space Filtration Systems[1]
Panel	162
Roll	29
Total Number of Test Space Filtration Systems	191

Notes:
[1]Data represent statistics for 191 study space air handling unit air filtration systems.

Variable Descriptions:

Filtration System Type describes the type of particulate air filters for those test space air handling units equipped with particulate type filtration systems. The following categories apply:

Panel filters are manufactured in rectangular panels that are placed alongside each other in the filter bed. They are removed and either replaced or cleaned when dirty.
Roll filters consist of a fabric roll mounted on a spool that moves across the airstream. The media is wound on a take up spool to expose new filter material when necessary.

BASE Buildings Test Space HVAC Characteristics: Filtration Systems - Panel and Roll Filter Types, Dry vs. Viscous

	Number of Test Space Filtration Systems	
Filter Types, Dry vs. Viscous	Panel Filter Type[1]	Roll Filter Type[2]
Dry	159	20
Viscous	3	9
Total Number of Test Space Filtration Systems	162	29

Notes:
[1]Summary based on the total number of filter systems designated as "panel filters."
[2]Summary based on the total number of filter systems designated as "roll filters."

Variable Descriptions:

Panel Filter Type describes the number of panel filters of either the dry or viscous type. Panel filters are manufactured in rectangular panels that are placed alongside each other in the filter bed. They are removed and either replaced or cleaned when dirty.

Roll Filter Type describes the number of roll filters of either the dry or viscous type. Roll filters consist of a fabric roll mounted on a spool that moves across the airstream. The media is wound on a take up spool to expose new filter material when necessary.

The following categories apply:

Dry , A dry filter is one that consists of uncoated fiber mats as filter media.
Viscous , A viscous filter is one that is coated with a viscous adhesive.

BASE Buildings Test Space HVAC Characteristics: Filtration Systems - Dry Filter Types

Filtration Systems - Dry Filter Types	Number of Test Space Filtration Systems[1]
Flat	40
Pleated	86
Bag	33
HEPA	0
Total Number of Test Space Filtration Systems	159

Notes:
[1]Summary based on the total number of filter systems designated as "dry panel filters."

Variable Descriptions:

Dry Filter Types describes a breakdown of the different types of dry filter systems associated with BASE test space air handling units. These include:

Flat filters are air filters where the filter media is layered into a frame.
Pleated filters are air filters where the filter media is installed in the filter frame in a zig-zag fashion. Generally referred to as extended surface filters.
Bag filters are air filters equipped with an extended surface inflated by airflow across the filter.
HEPA filters are high efficiency particulate air filters that are capable of removing small particles.

BASE Buildings Test Space HVAC Characteristics: Filtration Systems - Roll Filter Advancement Methods

Filtration Systems - Roll Filter Advancement Methods	Number of Test Space Filtration Systems[1]
Automatic	4
Manual	25
Total Number of Test Space Filtration Systems	29

Notes:

[1]Summary based on the total number of filter systems designated as “roll filters.”

Variable Descriptions:

Roll Filter Advancement Methods describes the methods used for advancing roll filtration systems for those BASE test space air handling units equipped with these filters. The following categories apply:

Manual roll filters consist of a fabric roll mounted on a spool that moves across the airstream. The media is manually wound on a take up spool to expose new filter material, when necessary.

Automatic roll filters consist of a fabric roll mounted on a spool that moves across the airstream. The media is automatically wound on a take up spool to expose new filter. The movement of the media is often controlled by a pressure switch which senses the pressure drop across the media or by an automatic timer.

BASE Buildings Test Space HVAC Characteristics: Filtration Systems - Types of Filter Media

Filtration Systems - Types of Filter Media	Number of Test Space Filtration Systems[1]
Cotton	16
Cellulose	12
Cotton/Synthetic	72
Fiberglass	72
Foam Media	1
Metallic	2
Synthetic Fiber	13
Total Number of Test Space Filtration Systems	188

Notes:

[1]Summary based on total number of filtration systems for which filter media material type was specified.

Variable Descriptions:

Types of Filter Media describes a breakdown of the different types of filter media associated with test space air handling units. These include:

Cotton
Cellulose (wood fibers or paper)
Cotton/Synthetic (combination of cotton fibers and synthetic fibers)
Fiberglass
Foam Media
Metallic (metal fibers or metal mesh)
Synthetic Fiber (man-made material)

BASE Buildings Test Space HVAC Characteristics: Filtration Systems - Filter Ratings

Filtration System Filter Ratings	Number of Test Space Filtration Systems[1]
0-20 percent	38
20-40 percent	95
40-60 percent	7
60-80 percent	15
80-99 percent	27
Total Number of Test Space Filtration Systems	182

Notes:

[1]Summary based on total number of filtration systems for which filter efficiency ratings were specified.

Variable Descriptions:

Filtration System Filter Rating as determined from the manufacturer's specifications. Values reported as average efficiency in accordance with ASHRAE Standard 52-76.

BASE Buildings Test Space HVAC Characteristics: Exhaust Fans - General Specifications

	Exhaust Fan Airflow Rate (m^3/min) [1]	Floor Area Served By Exhaust Fan (m^2) [2]
Number of Test Space Exhaust Fans	129	159
Mean (Arithmetic)	138	333
Standard Deviation	197	1,490
Minimum	3	2
10th Percentile	11	15
25th Percentile	24	30
50th Percentile	57	87
75th Percentile	157	259
90th Percentile	299	609
Maximum	1,274	18,375

Notes:

[1]Data represent statistics for 129 test space exhaust air fans where design airflow capacity was reported. Exhaust airflow rate values were not reported for 43 test space exhaust fans. Conversion: 1 m^3 equals 35.311 ft^3.

[2]Data represent statistics for 159 test space exhaust air fans where floor area was reported. Floor area served was not reported for 13 test space exhaust fans. Conversion: 1 m^2 equals 10.764 ft^2.

Variable Descriptions:

Exhaust Fan Flow Rate describes the design airflow delivery rate for each exhaust fan. Statistics are reported in m^3/min. Note that all exhaust airflow was not from the test space when an exhaust fan also served other areas outside the test space.

Floor Area Served By Exhaust Fan describes the floor area served by the exhaust fan. Statistics are reported in m^2. This includes floor area outside the test space when an exhaust fan also served other areas.

BASE Buildings Test Space HVAC Characteristics: Exhaust Fans - Control Strategy

Exhaust Fans - Control Strategy	Number of Test Space Exhaust Fans[1]
Manual	95
Time of Day	49
Temperature	2
Equipment Operation	16
Building Pressure	2
Total Number of Test Space Exhaust Fans	161

Notes:

[1]Data represent statistics for 161 test space exhaust air fans reporting a control strategy. The total in this column may exceed the number of exhaust fans reported as more than one control strategy may have been reported for each exhaust fan.

Variable Descriptions:

Exhaust Fan Control Strategy refers to the strategy that controls the operation of the exhaust fan. The following categories apply:

Manual operation occurs when the fan is manually turned on when the fan is needed.
Time of Day operation occurs automatically per a time schedule that is programmed into a fan controller or time clock.
Temperature operation occurs automatically when the space that the exhaust fan serves is outside a programmed temperature range.
Equipment Operation occurs automatically when another specified piece of equipment is in operation.
Building Pressure operation occurs automatically when the building pressure is outside a programmed pressure range.