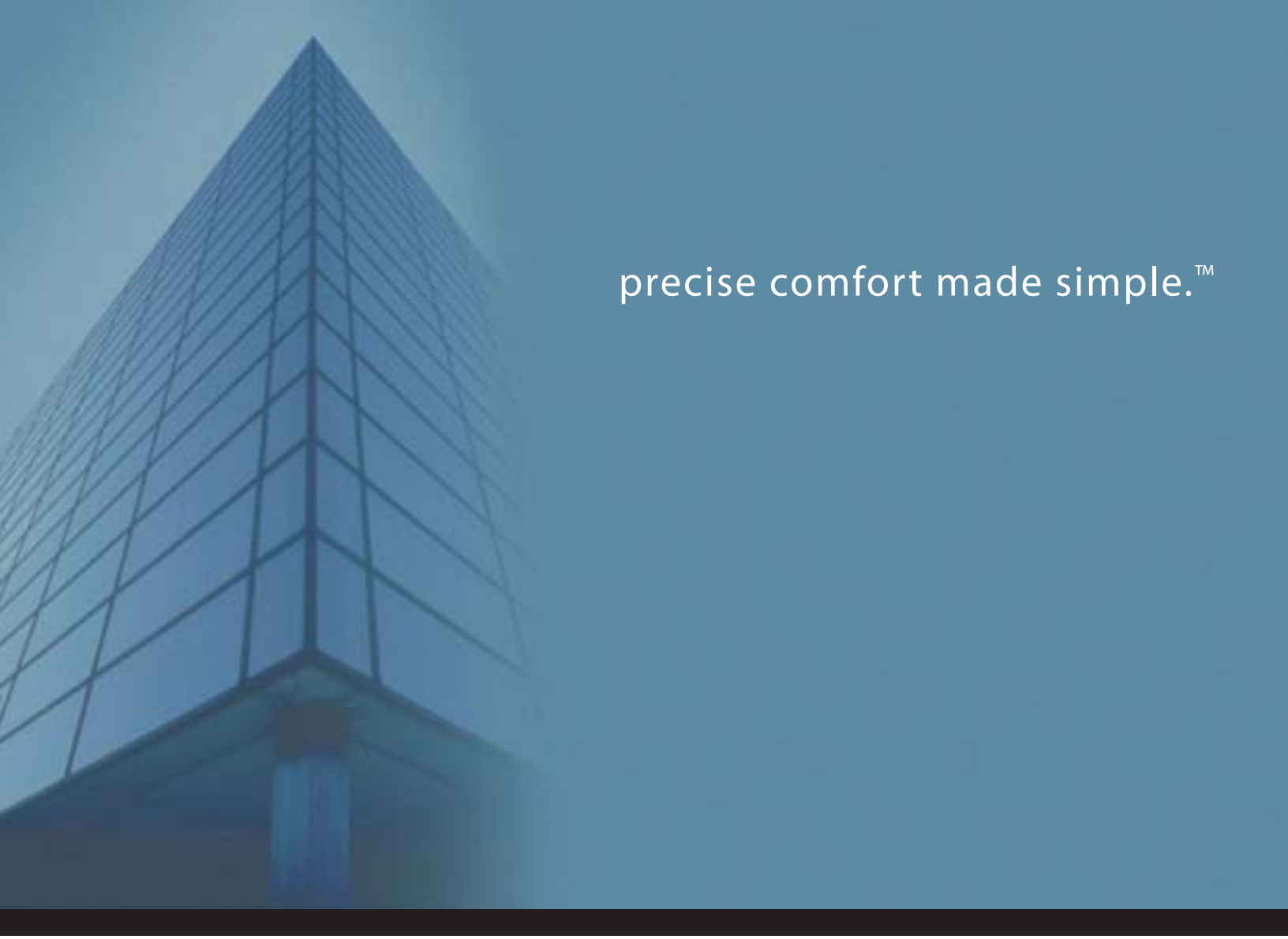


precise comfort made simple.™

REVOLUTION®

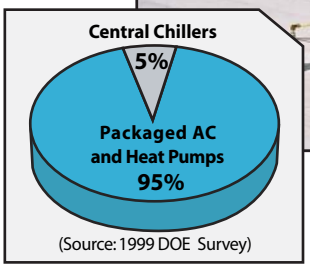
Active Desiccant - Vapor Compression Hybrid Rooftop

SEMCO® INCORPORATED

OVERVIEW

The Challenge

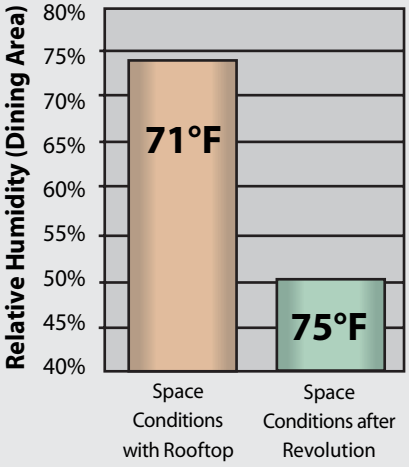
More than 95% of all commercial buildings in the U.S. are air conditioned with some type of packaged equipment - mainly rooftop units - and with good reason. This equipment is compact, reliable and cost effective. Unfortunately, this type of equipment is often unable to accommodate the increased quantities of outdoor air, which must now be delivered continuously to be in compliance with all major building codes and the ASHRAE 62 Ventilation Standard.



Over-sizing this type of equipment in an attempt to deliver the outdoor air quantities required by the building codes at peak cooling conditions results in compressor "short cycling" during off-peak conditions. This causes extended periods of high space humidity, driving space occupants to lower thermostat settings in an attempt to reach comfort - creating the all too familiar "cold and clammy" conditions experienced in many facilities (Figure 1). Lowering space thermostat settings significantly increases cooling energy costs.

SEMCO, with the assistance of the U.S. Department of Energy and Oak Ridge National Laboratories, has invested 4 years of research and development to produce the first packaged rooftop unit that can maintain both temperature and humidity, independently, while delivering any outdoor air percentage desired. Now, a system can finally be selected and specified that will actually match the sensible and latent loads required by the space (Figure 2), rather than meeting just the sensible load and then hoping for the best when it comes to humidity.

Figure 1: At a DOE sponsored restaurant pilot site, the owner/operator was able to raise the space thermostat by four degrees after installing Revolution to control space humidity. This improved comfort and reduced cooling energy costs by 30%.

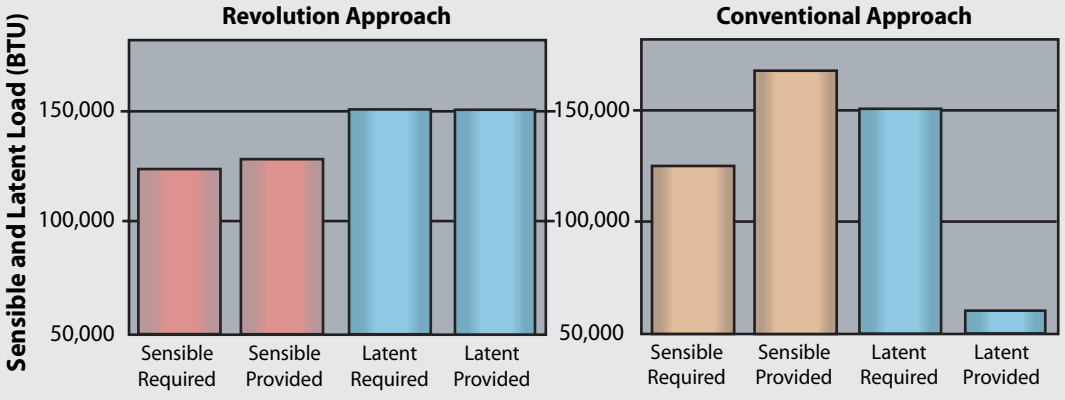


The Solution

Introducing Revolution® - SEMCO's integrated active desiccant - vapor compression rooftop system. This breakthrough technology combines the strengths of an advanced DX cooling cycle, utilizing variable speed compressors and optimal control strategies, with the unique dehumidification capability offered by an active desiccant wheel. By combining these technologies into a novel packaged system arrangement; a compact, cost effective and extremely energy efficient system has been created. One that can be applied as a dedicated outdoor air system (DOAS) handling 100% outdoor air, or as a total conditioning system (TCS) - replacing a conventional packaged system and handling both the outdoor air and space cooling and heating loads. When an exhaust air stream is available for recovery, the SEMCO FV total energy recovery module is easily integrated into the Revolution, further increasing the system operating efficiency. With variable speed compressors, variable airflow capability and modulated regeneration energy input, Revolution offers virtually unlimited comfort controllability in an energy efficient package.

With Revolution it is easy to design and operate facilities in accordance with the building codes - eliminating the liability of non-compliance while improving comfort, indoor air quality and energy efficiency.

Figure 2: With Revolution, the conditions delivered to the space can be controlled to match those required by the space. With conventional systems they cannot. As a result, miss-matched loads produce frequent humidity control problems and low thermostat settings (data for a typical school classroom).



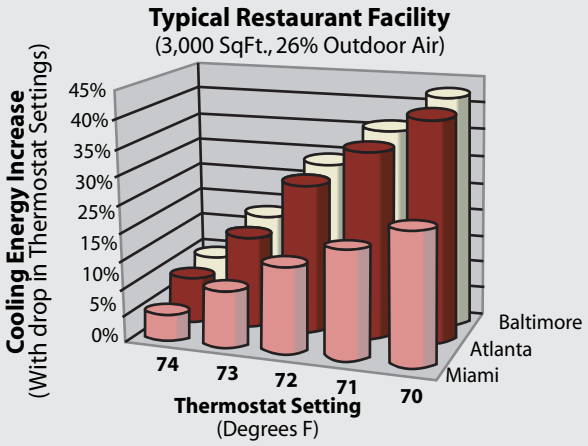
Simple and Effective Compliance with ASHRAE 62 and 90.1 Standards and the Major Building Codes

Revolution handles the increased outdoor air percentages and space humidity requirements recommended by ASHRAE Standard 62 and required by all major building codes. It provides unprecedented dehumidification capacity and allows for the incorporation of effective total energy recovery as required by ASHRAE Standard 90.1.

Reduced Energy Costs

By using variable supply air volume (VAV), variable speed compressors, modulating gas valves and DDC logistics, the Revolution operates energy efficiently while accommodating essentially any design condition. Research has shown that by effectively controlling space humidity, occupants will reach comfort at higher space thermostat settings. Figure 3 summarizes DOE 2.1 modeling that correlates reduced thermostat settings with the corresponding increase in energy costs for a typical restaurant facility.

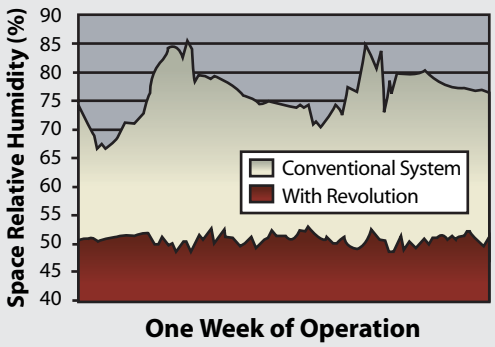
Figure 3: The high cost of reducing the space thermostat setting in an attempt to reach comfort at elevated humidity conditions.



Complete HVAC Solution

Revolution can be applied as a dedicated outdoor air system (DOAS) - to manage all of the outdoor ventilation requirements and to deliver low dew point air to manage the entire outdoor and space latent loads. Revolution can also be applied as a total conditioning system (TCS) - to handle all of the building HVAC requirements, and can function as a true VAV system.

Figure 4: Control Space Humidity as Desired with the Revolution.



Enhanced Comfort Control and Indoor Air Quality

Revolution delivers precise, independent temperature and humidity supply air conditions with continuous outdoor air fractions as high as 100%. For the first time, designers can match the sensible and latent performance of the rooftop unit to actual space load conditions, providing efficient temperature and humidity control. Figure 4 shows results from a DOE pilot project comparing the space humidity conditions in a restaurant facility before and after a Revolution retrofit.

Avoids Expensive "Over-Cool and Reheat"

Revolution mixes the "bone dry" air leaving the active desiccant wheel with bypass air leaving the cooling coil, so low dew point conditions are provided at the desired temperature. This eliminates the need for the otherwise extremely cold coil leaving air temperatures (low suction pressures and lower operating efficiency) and costly reheat, prohibited in most cases by the ASHRAE 90.1 energy standard.

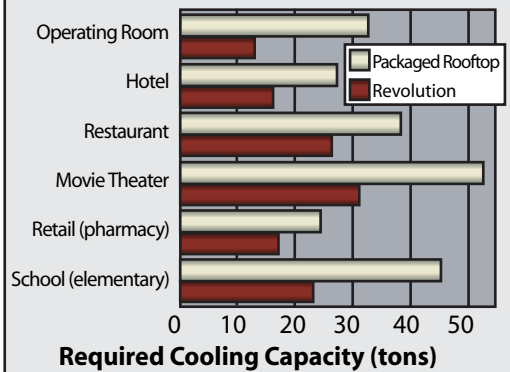
Addresses Microbial Concerns (mold and mildew)

By providing effective control of space humidity at all conditions, the risk of mold growth within the space, ceiling tiles and carpeting often linked to the HVAC system is eliminated. Revolution delivers air to the space that is seldom saturated, thereby greatly reducing the risk of microbial growth within the ductwork .

Enhanced Cooling Capacity Output

Revolution uses fewer tons of mechanical cooling capacity to deliver a desired supply air dew point - up to 70% less than conventional systems when integrating SEMCO's FV total enthalpy recovery module. This is accomplished by processing much of the latent load with the active desiccant wheel and employing a high efficiency refrigeration cycle. Figure 5 reflects typical cooling capacity reductions possible for facilities designed and operated in accordance with ASHRAE Standards 62 and 90.1.

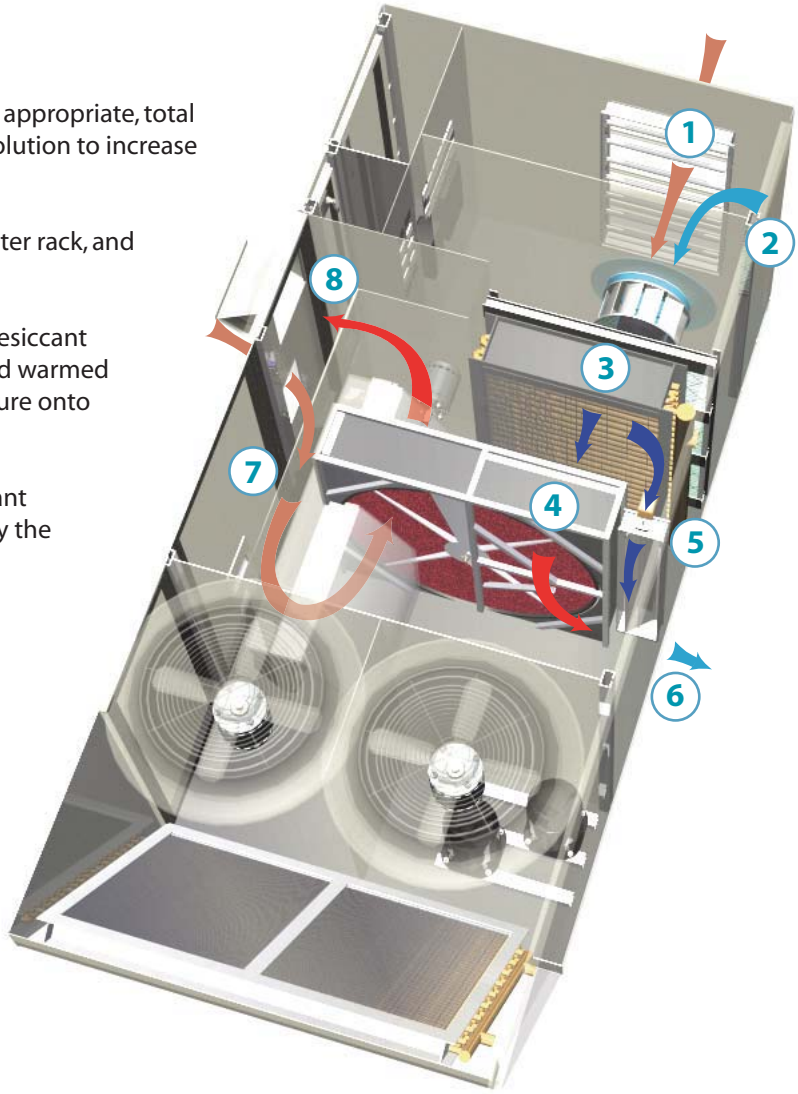
Figure 5: Typical Cooling Capacity Reduction Possible with Revolution vs. Rooftop.



HOW IT WORKS

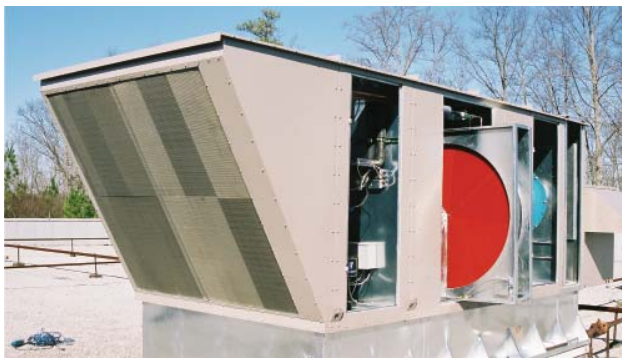
Revolutionary by design - 8 steps to precise comfort

1. Fresh outdoor air enters the Revolution system.
2. Return air from the space can also be used. Where appropriate, total energy recovery can be incorporated into the Revolution to increase the overall operating efficiency.
3. Outside air and/or return air is passed through a filter rack, and then conditioned by a DX cooling coil.
4. The cool, saturated air passes through the active desiccant wheel where it is dried to a very low dew point, and warmed by the energy released by adsorption of the moisture onto the wheel's desiccant surface.
5. A portion of the air is bypassed around the desiccant wheel through a modulating damper controlled by the DDC system.
6. The warm, very dry air from the wheel is mixed with the cool, moderately dry bypass air leaving the cooling coil to provide supply air at the humidity condition (dew point) and supply air temperature required by the space.
7. Outside air enters the regeneration side of the Revolution system, and air passes through a modulating direct-fired burner (or optional hot water coil) to be processed for the regeneration of the active desiccant wheel.
8. Regeneration air exits the system.



Advanced Cooling Circuit

Variable speed compressor, multi-row evaporator coil, condenser side capacity control, thermal expansion valves and novel DDC control strategies optimize energy efficiency and accommodate 100% outdoor air.



Easy to Service

Easy access to all components through access doors or removable panels. Separate high and low voltage control panels and slide-out wheel design.

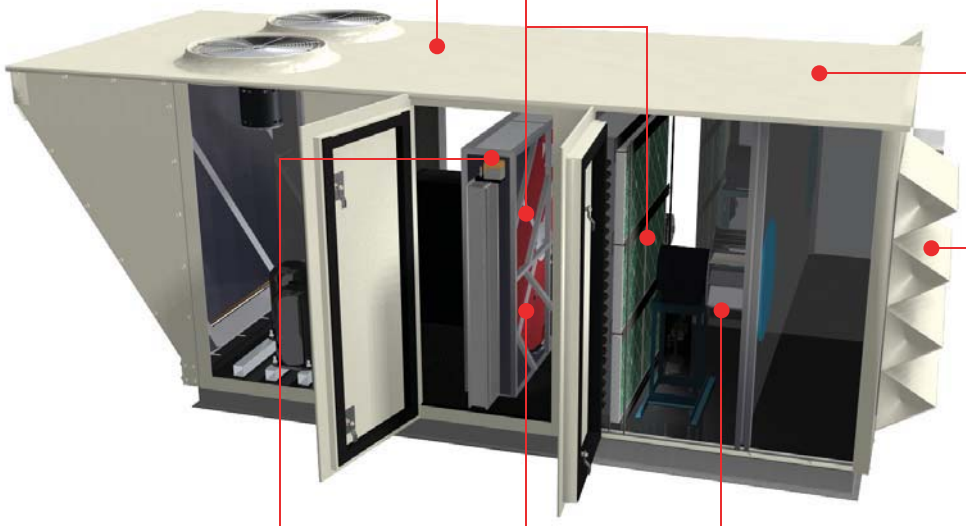
Integrated DDC Contro

The integral DDC controls automa the conditions leaving the Revolu comfort conditions needed by the most energy efficient operation. trending capabilities can be used the performance of the system inc humidity, energy consumption effectiveness (CO_2), and supply co

Hybrid technology
Integrated rooftop unit combines and optimi es the strengths of advanced, variable speed DX cooling technology with the low dew point dehumidification capability offered by an active desiccant wheel.

Unoccupied "Dehumidification/Recirculation Mode"
When the space is unoccupied, the outdoor air quantity is reduced and the cooling coil and/or dehumidification wheel are cycled to maintain space humidity while the space temperature is allowed to rise.

Compact
Dimensions and weights similar to conventional packaged equipment si ed to deliver a like latent cooling capacity.



Variable outdoor air percentage
Handles any percentage of outdoor air (0% to 100%).

Wide control flexibility (variable SHR)
By modulating the bypass damper, cooling input, regeneration energy and wheel speed, almost any supply air temperature or humidity level can be delivered.

Variable airflow (VAV) standard
Backward curve airfoil supply air fan, inverter driven to provide true VAV with DX vapor compression cooling.

Advanced active desiccant integration
Low pressure loss media, low regeneration energy input and low regeneration temperatures (200 F), allowing the use of direct fired gas, hot water, steam or waste heat from a power generation source.

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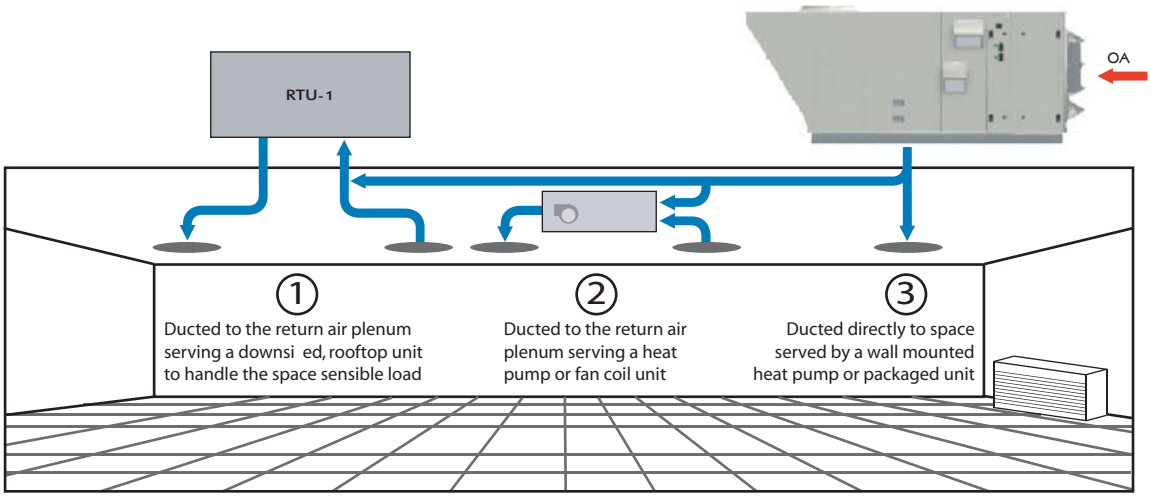
Total Energy Recovery Option
The SEMCO FV Series energy recovery module integrates seamlessly into the Revolution system for applications where an exhaust air path is available.

Unprecedented Dehumidification Capacity
Uses the active desiccant wheel in its most energy efficient range of operation, processing saturated air, to supply air at dew points as low as 35°F (30 grains), with system grain depressions of up to 100 grains.

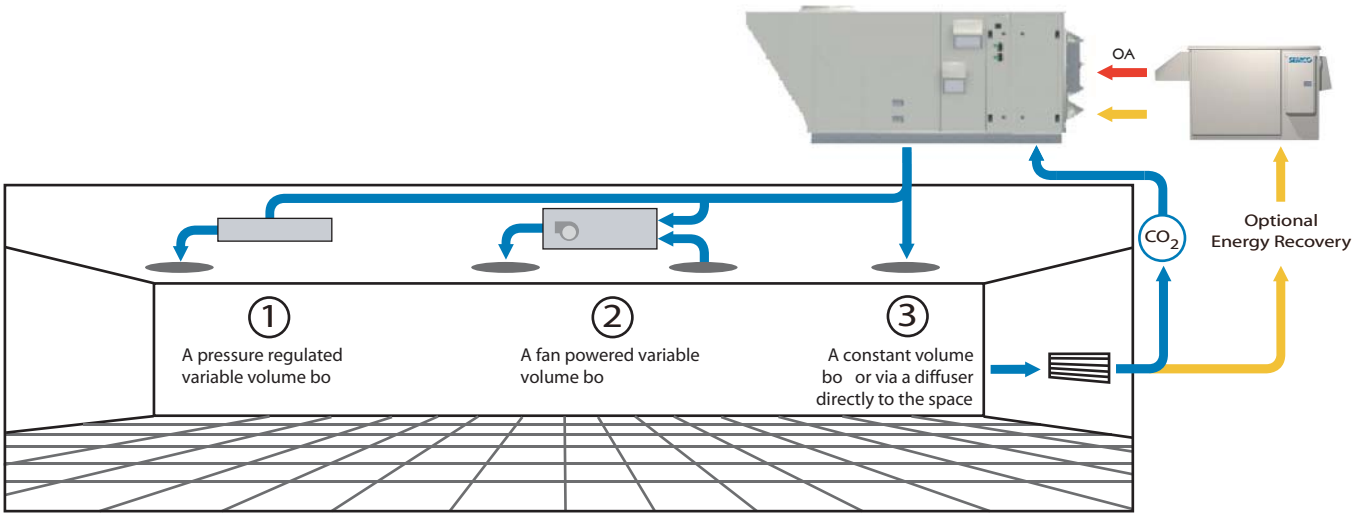
Revolution as a Dedicated Outdoor Air System (DOAS)

When the Revolution is applied as a DOAS it is typically sized to condition all of the outdoor air delivered to a facility or space. As a result, in the cooling mode, the outdoor air is dehumidified to a level that is dry enough to handle (a) the outdoor air latent load, (b) the humidity generated within the space by the occupants or moisture generating equipment and (c) any infiltration. In addition to handling the entire latent load, the Revolution typically will also handle the sensible load associated with the outdoor air. Since the outdoor air volume is generally small relative to the total airflow volume required to cool the facility, the Revolution system must deliver air at dew points much lower than attainable with conventional cooling systems.



Revolution as a Total Conditioning System (TCS)

When applied in the total conditioning mode the Revolution system delivers both outdoor air and recirculated air, in whatever proportions required to condition the occupied space. The capacity of the Revolution system is sized to handle all of the sensible and latent loads associated with a facility or space, and it has the unique capability of delivering the specific temperature and humidity necessary to maintain the desired space condition (variable sensible heat ratio).



Variable Air Volume and Total Energy Recovery Options

The variable airflow capability associated with the Revolution will also allow for the use of demand control ventilation, were appropriate, so that the amount of outdoor air delivered to the occupied space can be modulated based on the indoor carbon dioxide level. Where appropriate, total energy recovery (passive desiccant wheel) can also be incorporated into the Revolution to increase the overall operating efficiency.

Application Type	Outdoor Air	Supply Conditions (5)		Tons Required (6)		
		Temperature	Humidity	Revolution	Conventional	Increase
School (elementary) (1,4)	34%	64°F	57 grains (52° dpt.)	23	45	96%
Retail (pharmacy) (2,4)	22%	65°F	59 grains (53° dpt.)	17	24	41%
Movie Theater (3,4)	100%	75°F	44 grains (45° dpt.)	31	52	68%
Restaurant (2,4)	49%	64°F	56 grains (51° dpt.)	26	38	35%
Hotel (3,4)	100%	75°F	52 grains (49° dpt.)	16	27	69%
Hospital (operating suites) (1,4)	50%	59°F	47 grains (47° dpt.)	13	33	154%

Notes:
1) Includes the addition of the SEMCO FV total energy recovery module since exhaust air path is generally available.
2) Revolution applied to a portion of the facility, providing all outdoor air and handling all of the outdoor air and space latent load.
3) Revolution applied as a dedicated outdoor air system (DOAS) sized to handle all outdoor and space latent loads.
4) Hospital example assumes a space condition of 68°F/50%RH, all others are assumed to be 75°F/50%RH.
5) Supply conditions necessary to maintain the space at 75°F/50%RH. Assumes outdoor design of 85°F/130 grains, typical building size and construction used for each application and high efficiency lighting in accordance with ASHRAE 90.1 (dpt. = Dew point).
6) Revolution is compared with a conventional cooling system sized to cool air to the required dew point, the regeneration energy required by the Revolution is equal to or less than the reheat energy required by the conventional system.

Schools

High occupancy levels demand high outdoor air percentages. Humidity problems have caused many schools to be operated with insufficient outdoor air quantities, with detrimental impact on indoor air quality and therefore the learning environment. Revolution solves these problems. By using its VAV capability and optional FV total energy recovery module, project first cost can be significantly reduced when compared to many conventional design approaches.

Retail

By selecting Revolution to handle all of the outdoor air load in addition to the space latent load, the remaining rooftop units can be operated to control temperature only, significantly reducing the installed cooling capacity and cost of operation. In facilities where refrigerated casings are used, ideal humidity control will eliminate most sweating problems and reduce the need for expensive defrost/anti-sweat heater operation.

Movie Theaters

The high latent to sensible loads and outdoor air fractions in movie theaters present a significant challenge to conventional systems. Revolution can handle all the latent load, from the outdoor air and building occupants. This allows the use of smaller rooftop units for each theater, reduces duct size, improves humidity control and indoor air quality resulting in increased customer comfort.

Restaurants

Revolution easily accommodates the high quantity of makeup air needed to compensate for the kitchen hood exhaust. This solves the frequent "thermostat wars" that occur between the active restaurant employees and the sedentary customers. Raised thermostat settings and lower space humidity levels make everyone more comfortable, and at the same temperature. The strategic placement of the conditioned outdoor air can be effectively used to segregate smoking and non-smoking sections, significantly enhancing indoor air quality and customer satisfaction.

Hotels, Dormitories and Nursing Homes

Revolution can deliver very dry and moderately cool air to the corridors to makeup for the air exhausted from the individual guest rooms. This eliminates the cold-clammy conditions and associated odors often experienced in hotel facilities. Research has shown that improved humidity control in the guest rooms can minimize the risk of mold growth and extend the useful life of wall-covering and furnishings.

Hospitals

Revolution can deliver high percentages of outdoor air at the very low dew points required to maintain operating rooms at the temperature desired by the surgeons (typically 65-68 degrees) and at the 50% relative humidity levels mandated by the hospital design codes.

SPECIFICATIONS

Specifications	REV-2250	REV-3000	REV-4500	REV-6000
Airflow Information				
Nominal Supply Airflow (cfm)	2,250	3,000	4,500	6,000
Maximum Supply Airflow (cfm)	3,600	4,800	7,200	9,600
Maximum Outdoor Airflow (cfm)	2,250	3,000	4,500	6,000
Cooling-Dehumidification Performance (note 1)				
	Maximum Supply Flow with 30% Outdoor Air (note 2,3,4)			
Range of Sensible Cooling Output (btu/hr)	50,000-82,000	67,000-110,000	100,000-165,000	133,000-220,000
Range of Latent Cooling Output (btu/hr)	80,000-56,000	107,000-75,000	160,000-112,000	213,000-150,000
Range of SHR (sensible heat ratio)	.38 - .60	.38 - .60	.38 - .60	.38 - .60
Supply Humidity (note 5) (grains/dewpoint °F)	51/49	51/49	51/49	51/49
	Nominal Supply Flow with 30% Outdoor Air (note 2,3,4)			
Range of Sensible Cooling Output (btu/hr)	34,000-70,000	46,000-95,000	68,000-140,000	90,000-185,000
Range of Latent Cooling Output (btu/hr)	73,000-58,000	97,000-77,000	145,000-115,000	195,000-155,000
Range of SHR (sensible heat ratio)	.32 - .55	.32 - .55	.32 - .55	.32 - .55
Supply Humidity (note 5) (grains/dewpoint °F)	36/39.5	36/39.5	36/39.5	36/39.5
	100% Outdoor Air (note 2,3,4)			
Range of Sensible Cooling Output (btu/hr)	34,000-76,000	46,000-101,000	68,000-151,000	91,000-201,000
Range of Latent Cooling Output (btu/hr)	110,000-75,000	147,000-100,000	220,000-150,000	293,000-200,000
Range of SHR (sensible heat ratio)	.24 - .50	.24 - .50	.24 - .50	.24 - .50
Supply Humidity (note 5) (grains/dewpoint °F)	48/47	48/47	48/47	48/47
Maximum Heating Performance: Indirect Gas Option (note 6,7)				
Maximum Heating Capacity (btu/hr)	175,000	227,000	280,000	280,000
Temperature Rise (nominal supply airflow, °F)	72	70	58	43
Temperature Rise (maximum supply airflow, °F)	45	44	36	27
Maximum Heating Performance: Heat Pump Option (note 8,9,10)				
Maximum Heating Capacity (btu/hr)	165,625	231,875	331,250	397,500
Temperature Rise (nominal supply airflow, °F)	68	72	68	61
Temperature Rise (maximum supply airflow, °F)	43	45	43	38
Compressor Information				
Maximum (tons)	12.5	17.5	25	30
Minimum (tons)	10	15	20	25
Refrigerant Used	R-22	R-22	R-22	R-22
Capacity Control	Variable speed compressor			
Regeneration Information (note 11)				
Maximum Regeneration Airflow (cfm)	660	880	1,320	1,760
Maximum Regeneration Energy (btu/hr)	89,100	118,800	178,200	237,600
Fuel Utilized	Direct fired natural gas			
Maximum Regeneration Temperature(°F)	210	210	210	210
System Information (note 12)				
Dimensions (L x W x H)	171" x 65" x 48"	186" x 67" x 57"	197" x 80" x 71"	213" x 90" x 74"
Weight (pounds)	2,400	3,400	4,200	5,200
Voltage Options	208/230/460/3Ø			

Notes:

1) Other conditions available - see SEMCO performance model
2) Sample performance only, any OA percentage can be utilized
3) Performance shown based on maximum compressor size
4) Based on 95db/78wb outdoor and 78db/62.5wb return
5. Humidity/dewpoint with 50% flow through DH wheel
6) More heating capacity may be available, contact factory
7) A modulating gas valve is provided
8) Heat output shown does not reflect defrost cycle and may be reduced at extreme outdoor conditions
9) Gas assist is always provided with heat pump to work in conjunction with defrost cycle
10) Modulation of heat pump output is controlled effectively by variable speed compressor
11) Regeneration energy is variable, maximum shown
12) Does not include optional FV recovery module

1800 East Point Drive • Columbia, MO 65201
(P) 573-443-1481 • (F) 573-886-5408
www.semcorevolution.com

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