### HeatExchanger:AirToAir:SensibleAndLatent

The sensible and latent air-to-air heat exchanger is an HVAC component typically used for exhaust or relief air heat recovery (Figure 150). Heat exchanger performance can be specified to transfer sensible energy, latent energy or both between the supply and exhaust air streams. The input requires no geometric data. Performance is defined by specifying sensible and/or latent effectiveness at 75% and 100% of the nominal (rated) supply air flow rate at two operating conditions as shown in Table 30.

Figure 150. Schematic of the Sensible and Latent Air-to-Air Heat Exchanger

Table 30. Operating Conditions for Defining Heat Exchanger Performance

|  |  |  |
| --- | --- | --- |
| Parameter | Conditions | |
| Heating | Cooling |
| Entering supply air temperature:  Dry-bulb  Wet-bulb | 1.7ºC (35ºF)  0.6ºC (33ºF) | 35ºC (95ºF)  26ºC (78ºF) |
| Entering exhaust air temperature:  Dry-bulb  Wet-bulb | 21ºC (70ºF)  14ºC (58ºF) | 24ºC (75ºF)  17ºC (63ºF) |

Note: Conditions consistent with the Air-Conditioning and Refrigeration Institute’s (ARI) Standard 1060-2001.

This object models the basic operation of an air-to-air heat exchanger. Heat exchange between the supply and exhaust air streams occurs whenever the unit is scheduled to be available (Availability schedule) and supply/exhaust air flow is present. This heat exchanger object can be used in conjunction with a conventional air-side economizer (i.e., specify ModulateFlow in the Controller:OutdoorAir object), whereby heat exchange is suspended whenever the air-side economizer (or high humidity control) is active (i.e., air flow is fully bypassed around a fixed-plate heat exchanger or the rotation of a rotary heat exchanger is stopped). This object is also able to suspend heat exchange for the purpose of providing free cooling operation in the absence of a conventional air-side economizer (i.e., specify MinimumFlowWithBypass in the Controller:OutdoorAir object).

During winter weather, humid exhaust air entering the heat exchanger can form frost on the cold heat exchanger surfaces, which can reduce air flow and the amount of energy recovery. Several methods are used to control or eliminate frost formation, and the following types can be modeled for this heat exchanger object: supply air preheat, minimum exhaust air temperature, exhaust air recirculation and exhaust only. For preheat frost control, a separate heating coil object must be placed in the supply inlet air stream to keep the air temperature above the frost threshold temperature. The other frost control types are modeled within this object itself (i.e., do not require a separate object to be defined) based on alpha and numeric inputs to this heat exchanger object.

Air-to-air heat exchangers are sometimes controlled to maintain a fixed supply air outlet temperature to avoid overheating when the heat exchanger is heating the supply (primary) air or avoid overcooling when the heat exchanger is cooling the supply air. To model this control in EnergyPlus, a set point manager object is used to establish a temperature set point at the supply air outlet node of the heat exchanger. Wheel speed modulation or plate supply air bypass is used to control the supply air exiting conditions to this set point. The set point for supply air temperature control should be set at the minimum economizer temperature set point if an air-side economizer is also being used by the air system. If frost control and supply air outlet temperature control are used, frost control takes precedence over supply air temperature control (e.g., frost control defrost time fraction is determined as if wheel speed modulation or plate supply air bypass is not used).

To model a sensible and latent air-to-air heat exchanger located in an air loop, the input data file should include the following objects:

* AirLoopHVAC:OutdoorAirSystem
* Controller:OutdoorAir
* OutdoorAir:Mixer
* HeatExchanger:AirToAir:SensibleAndLatent
* Coil:Heating:Water, Coil:Heating:Electric or Coil:Heating:Gas (if preheat frost control is to be modeled)
* SetpointManager:Scheduled (if supply air outlet temperature control is used)

The sensible and latent air-to-air heat exchanger can also be used in a number of other applications, including conditioning outdoor ventilation air and supplying it directly to a zone without an air loop. See object ZoneHVAC:EnergyRecoveryVentilator for further details on this specific application.

A description of each input field for this object is provided below.

#### Field: Name

A unique user-assigned name for a particular sensible/latent air-to-air heat exchanger. Any reference to this heat exchanger by another object will use this name.

#### Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can operate during a given time period. A schedule value of less than or equal to 0 indicates that the unit is off for that time period. A schedule value greater than 0 indicates that the unit can operate during the time period. If this field is blank, the schedule has values of 1 for all time periods.

#### Field: Nominal Supply Air Flow Rate

The nominal primary side (supply) air flow rate in cubic meters per second. The actual supply and exhaust air flow rates must be between 50% and 130% of this value or a warning will be issued.

#### Field: Sensible Effectiveness at 100% Heating Air Flow

The sensible heat exchange effectiveness at the *heating* condition defined in Table 30 above with both the supply and exhaust air volume flow rates equal to 100% of the nominal supply air flow rate specified in the previous input field. The default value for this field is 0.

#### Field: Latent Effectiveness at 100% Heating Air Flow

The latent heat exchange effectiveness at the *heating* condition defined in Table 30 with both the supply and exhaust air volume flow rates equal to 100% of the nominal supply air flow rate. Specify this value as 0.0 if the heat exchanger does not transfer latent energy. The default value for this field is 0.

#### Field: Sensible Effectiveness at 75% Heating Air Flow

The sensible heat exchange effectiveness at the *heating* condition defined in Table 30 with both the supply and exhaust air volume flow rates equal to 75% of the nominal supply air flow rate. The default value for this field is 0.

#### Field: Latent Effectiveness at 75% Heating Air Flow

The latent heat exchange effectiveness at the *heating* condition defined in Table 30 with both the supply and exhaust air volume flow rates equal to 75% of the nominal supply air flow rate. Specify this value as 0.0 if the heat exchanger does not transfer latent energy. The default value for this field is 0.

#### Field: Sensible Effectiveness at 100% Cooling Air Flow

The sensible heat exchange effectiveness at the *cooling* condition defined in Table 30 with both the supply and exhaust air volume flow rates equal to 100% of the nominal supply air flow rate. The default value for this field is 0.

#### Field: Latent Effectiveness at 100% Cooling Air Flow

The latent heat exchange effectiveness at the *cooling* condition defined in Table 30 with both the supply and exhaust air volume flow rates equal to 100% of the nominal supply air flow rate. Specify this value as 0.0 if the heat exchanger does not transfer latent energy. The default value for this field is 0.

#### Field: Sensible Effectiveness at 75% Cooling Air Flow

The sensible heat exchange effectiveness at the *cooling* condition defined in Table 30 with both the supply and exhaust air volume flow rates equal to 75% of the nominal supply air flow rate. The default value for this field is 0.

#### Field: Latent Effectiveness at 75% Cooling Air Flow

The latent heat exchange effectiveness at the *cooling* condition defined in Table 30 with both the supply and exhaust air volume flow rates equal to 75% of the nominal supply air flow rate. Specify this value as 0.0 if the heat exchanger does not transfer latent energy. The default value for this field is 0.

#### Field: Supply Air Inlet Node Name

The name of the HVAC system node from which the unit draws its supply (primary) inlet air.

#### Field: Supply Air Outlet Node Name

The name of the HVAC system node to which the unit sends its supply (primary) outlet air.

#### Field: Exhaust Air Inlet Node Name

The name of the HVAC system node from which the unit draws its exhaust (secondary) inlet air.

#### Field: Exhaust Air Outlet Node Name

The name of the HVAC system node to which the unit sends its exhaust (secondary) outlet air.

#### Field: Nominal Electric Power

The electric consumption rate of the unit in watts. Electric power is considered constant whenever the unit operates. This numeric input can be used to model electric power consumption by controls (transformers, relays, etc.) and/or a motor for a rotary heat exchanger. None of this electric power contributes thermal load to the supply or exhaust air streams. The default value for this field is 0.

#### Field: Supply Air Outlet Temperature Control

This alpha field determines if the heat exchanger’s supply air outlet is controlled to a temperature set point when the heat exchanger is cooling or heating the supply (primary) air. The choices for this input field are “Yes” or “No”, with the default being “No”. When supply air outlet temperature control is used, the wheel rotational speed modulates or supply air is bypassed around the plate heat exchanger to maintain the desired setpoint temperature. A setpoint manager object is required to establish the desired set point at the supply air outlet node (reference: SetpointManager:Scheduled). When an air-side economizer is also being modeled for this air system, the set point for the supply air outlet temperature control should be equal to the economizer outdoor air temperature lower limit (reference: Controller:OutdoorAir, field Economizer Minimum Limit Dry-Bulb Temperature).

#### Field: Heat Exchanger Type

This alpha field denotes the type of heat exchanger being modeled: Plate (e.g., fixed plate) or Rotary (e.g., rotating cylinder or wheel). The default choice for this field is “Plate”. The heat exchanger type affects the modeling of frost control options and supply air outlet temperature control. For rotary heat exchangers, rotational speed is varied to control frost formation or the supply air outlet temperature. For plate exchangers, air bypass around the heat exchanger is used to obtain the desired effect.

#### Field: Frost Control Type

This alpha field has four choices: None, ExhaustAirRecirculation, ExhaustOnly and MinimumExhaustTemperature. If this field is left blank, the default frost control type is “None”. For modeling preheat frost control, specify “None” for this input field and insert a separate heating coil object in the supply inlet air stream to keep the air temperature above the desired frost threshold temperature.

*ExhaustAirRecirculation*: dampers are used to direct exhaust air back into the zone through the supply side of the heat exchanger when the supply (outdoor) air inlet temperature falls below a threshold temperature (defined in the next input field). The fraction of time that exhaust air is circulated through the supply side of the heat exchanger is dependent on the supply (outdoor) air inlet temperature with respect to the threshold temperature, the initial defrost time fraction, and the rate of change of defrost time fraction (see *Field: Rate of Defrost Time Fraction Increase*). When exhaust air is being recirculated, no supply (outdoor ventilation) air is being provided through the heat exchanger unit (which may or may not be acceptable regarding ventilation for occupants).

*ExhaustOnly (supply air bypass)*: this control cycles off the supply air flow through the heat exchanger for a certain period of time while the exhaust air continues to flow through the exhaust side of the heat exchanger. The fraction of time that the supply flow through the heat exchanger is cycled off is dependent on the supply (outdoor) air inlet temperature with respect to the threshold temperature, the initial defrost time fraction, and the rate of change of defrost time fraction (see *Field: Rate of Defrost Time Fraction Increase*). When implemented in real applications, provisions are usually made to avoid building depressurization when this frost control is operating (automatic or pressure-operated dampers, or a bypass air damper around the supply side of the heat exchanger). For this frost control type, it is assumed that the supply air is bypassed around the heat exchanger during frost control operation (i.e., the total supply flow is not reduced during defrost, but merely bypassed around the heat exchanger).

*MinimumExhaustTemperature*: the temperature of the exhaust air leaving the heat exchanger is monitored and the heat exchanger effectiveness is decreased (by slowing heat exchanger rotation or bypassing supply air around the plate exchanger) to keep the exhaust air from falling below the threshold temperature.

#### Field: Threshold Temperature

This numeric field defines the dry-bulb temperature of air which is used to initiate frost control. The default value is 1.7ºC. For ExhaustAirRecirculation and ExhaustOnly frost control, the threshold temperature defines the supply (outdoor) air inlet temperature below which frost control is active. For MinimumExhaustTemperature frost control, heat exchanger effectiveness is controlled to keep the exhaust air outlet temperature from falling below this threshold temperature value.

The appropriate threshold temperature varies with exhaust (inlet) air temperature and humidity, frost control type, heat exchanger type, and whether the heat exchanger transfers sensible energy alone or both sensible and latent energy (enthalpy). Typical threshold temperatures are provided in Table 31 below. However, it is recommended that the user consult manufacturer’s information for the specific air-to-air heat exchanger being modeled.

Table 31. Typical threshold temperatures

|  |  |  |  |
| --- | --- | --- | --- |
| Frost control type | Heat exchanger type | Energy exchange | Threshold temperature |
| Exhaust air recirculation | Plate | Sensible-only | -1.1ºC (30ºF) |
| Sensible + latent | -12.2ºC (10ºF) |
| Rotary | Sensible-only | -12.2ºC (10ºF) |
| Sensible + latent | -23.3ºC (-10ºF) |
| Exhaust only | Plate | Sensible-only | -1.1ºC (30ºF) |
| Sensible + latent | -12.2ºC (10ºF) |
| Rotary | Sensible-only | -12.2ºC (10ºF) |
| Sensible + latent | -23.3ºC (-10ºF) |
| Minimum exhaust temperature | Plate | Sensible-only | 1.7ºC (35ºF) |
| Sensible + latent | 1.7ºC (35ºF) |
| Rotary | Sensible-only | 1.7ºC (35ºF) |
| Sensible + latent | 1.7ºC (35ºF) |
| Preheat\*\* | Plate | Sensible-only | -1.1ºC (30ºF) |
| Sensible + latent | -12.2ºC (10ºF) |
| Rotary | Sensible-only | -12.2ºC (10ºF) |
| Sensible + latent | -23.3ºC (-10ºF) |

Source: Indoor Humidity Assessment Tool, U.S. Environmental Protection Agency, <http://www.epa.gov/iaq/schooldesign/saves.html>

\*\* To model preheat frost control, specify frost control type as “None” and place a heating coil in the supply inlet air stream controlled to the keep the air temperature above the frost threshold temperature.

#### Field: Initial Defrost Time Fraction

This numeric field defines the fraction of the simulation timestep when frost control will be invoked when the threshold temperature is reached. This field is only used for the ExhaustAirRecirculation and ExhaustOnly frost control types. The value for this field must be ≥ 0 and ≤ 1. The default time fraction is 0.083 (e.g., 5 min / 60 min) which is typical for ExhaustAirRecirculation frost control. Higher initial defrost time fractions (e.g., 0.167 = 10 min / 60 min) are typically required for ExhaustOnly frost control. For best results, the user should obtain this information from the manufacturer.

#### Field: Rate of Defrost Time Fraction Increase

This numeric field defines the rate of increase in the defrost time fraction as the supply (outdoor) air inlet temperature falls below the threshold temperature. This field is only used for the ExhaustAirRecirculation and ExhaustOnly frost control types. The value for this field must be ≥ 0. The default value is 0.012 (e.g., 0.72 min / 60 min per degree C temperature difference) which is typical for ExhaustAirRecirculation frost control. Higher values (e.g., 0.024 = 1.44 min / 60 min per degree C temperature difference) are typically required for ExhaustOnly frost control. For best results, the user should obtain this information from the manufacturer.

This value is used to determine the total defrost time fraction as follows:

Total defrost time fraction = Initial Defrost Time Fraction +

Rate of Defrost Time Fraction Increase \* (Tthreshold – Tsupply air inlet)

The model does not allow the total defrost time fraction to exceed 1.0 or be less than 0.

#### Field: Economizer Lockout

This input denotes whether the heat exchanger unit is locked out (bypassed for plate type heat exchangers or the rotation is suspended for rotary type heat exchangers) when the air-side economizer is operating. Both the economizer and high humidity control (Ref. Controller:OutdoorAir) activate the heat exchanger lockout as specified by this input. The input choices are *Yes* (meaning locked out) or *No*. The default input for this field is Yes.

Following is an example input for this heat exchanger object:

HeatExchanger:AirToAir:SensibleAndLatent,

OA Heat Recovery 1, !- Name

FanAndCoilAvailSched, !- Availability Schedule Name

0.4333, !- Nominal Supply Air Flow Rate {m3/s}

.76, !- Sensible Effectiveness at 100% Heating Air Flow {dimensionless}

.68, !- Latent Effectiveness at 100% Heating Air Flow {dimensionless}

.81, !- Sensible Effectiveness at 75% Heating Air Flow {dimensionless}

.73, !- Latent Effectiveness at 75% Heating Air Flow {dimensionless}

.76, !- Sensible Effectiveness at 100% Cooling Air Flow {dimensionless}

.68, !- Latent Effectiveness at 100% Cooling Air Flow {dimensionless}

.81, !- Sensible Effectiveness at 75% Cooling Air Flow {dimensionless}

.73, !- Latent Effectiveness at 75% Cooling Air Flow {dimensionless}

Outside Air Inlet Node Preheated, !- Supply Air Inlet Node Name

Heat Recovery Outlet Node, !- Supply Air Outlet Node Name

Relief Air Outlet Node, !- Exhaust Air Inlet Node Name

Heat Recovery Secondary Outlet Node, !- Exhaust Air Outlet Node Name

200.0, !- Nominal Electric Power {W}

No, !- Supply Air Outlet Temperature Control

Plate, !- Heat Exchanger Type

None; !- Frost Control Type

### HeatExchanger:AirToAir:SensibleAndLatent Outputs

HVAC,Average,Heat Exchanger Sensible Heating Rate [W]

HVAC,Sum,Heat Exchanger Sensible Heating Energy [J]

HVAC,Average,Heat Exchanger Latent Gain Rate [W]

HVAC,Sum,Heat Exchanger Latent Gain Energy [J]

HVAC,Average,Heat Exchanger Total Heating Rate [W]

HVAC,Sum,Heat Exchanger Total Heating Energy [J]

HVAC,Average,Heat Exchanger Sensible Cooling Rate [W]

HVAC,Sum,Heat Exchanger Sensible Cooling Energy [J]

HVAC,Average,Heat Exchanger Latent Cooling Rate [W]

HVAC,Sum,Heat Exchanger Latent Cooling Energy [J]

HVAC,Average,Heat Exchanger Total Cooling Rate [W]

HVAC,Sum,Heat Exchanger Total Cooling Energy [J]

HVAC,Average,Heat Exchanger Electric Power[W]

HVAC,Sum,Heat Exchanger Electric Energy [J]

HVAC,Average,Heat Exchanger Sensible Effectiveness[]

HVAC,Average,Heat Exchanger Latent Effectiveness[]

HVAC,Average,Heat Exchanger Supply Air Bypass Mass Flow Rate [kg/s]

HVAC,Average,Heat Exchanger Exhaust Air Bypass Mass Flow Rate [kg/s] HVAC,Average,Heat Exchanger Defrost Time Fraction[]

#### Heat Exchanger Sensible Heating Rate [W]

This output is the sensible heating rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, the supply air inlet and outlet conditions, and the specific heat of the inlet supply air. A positive value is reported if the supply air is heated by the heat exchanger, else the rate is set to zero.

#### Heat Exchanger Sensible Heating Energy [J]

This output is the sensible heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

#### Heat Exchanger Latent Gain Rate [W]

This output is the latent heating rate (humidification) of the supply air by the heat exchanger in Watts. This rate is determined by taking the difference between the Heat Exchanger Total Heating Rate and the Heat Exchanger Sensible Heating Rate. A positive value is reported if the supply air is humidified by the heat exchanger, else the rate is set to zero.

#### Heat Exchanger Latent Gain Energy [J]

This output is the latent heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

#### Heat Exchanger Total Heating Rate [W]

This output is the total heating rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, and the enthalpy of the supply air entering and leaving the unit. A positive value is reported if the enthalpy of the supply air is increased by the heat exchanger, else the rate is set to zero.

#### Heat Exchanger Total Heating Energy [J]

This output is the total heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported. This output is also added to a meter with ResouceType = EnergyTransfer, EndUseKey = HeatRecoveryforHeating, GroupKey = System (ref. Output:Meter objects).

#### Heat Exchanger Sensible Cooling Rate [W]

This output is the sensible cooling rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, the supply air inlet and outlet conditions, and the specific heat of the inlet supply air. A positive value is reported if the supply air is cooled by the heat exchanger, else the rate is set to zero.

#### Heat Exchanger Sensible Cooling Energy [J]

This output is the sensible cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

#### Heat Exchanger Latent Cooling Rate [W]

This output is the latent cooling rate (dehumidification) of the supply air by the heat exchanger in Watts. This rate is determined by taking the difference between the Heat Exchanger Total Cooling Rate and the Heat Exchanger Sensible Cooling Rate. A positive value is reported if the supply air is dehumidified by the heat exchanger, else the rate is set to zero.

#### Heat Exchanger Latent Cooling Energy [J]

This output is the latent cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

#### Heat Exchanger Total Cooling Rate [W]

This output is the total cooling rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, and the enthalpy of the supply air entering and leaving the unit. A positive value is reported if the enthalpy of the supply air is decreased by the heat exchanger, else the rate is set to zero.

#### Heat Exchanger Total Cooling Energy [J]

This output is the total cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported. This output is also added to a meter with ResouceType = EnergyTransfer, EndUseKey = HeatRecoveryforCooling, GroupKey = System (ref. Output:Meter objects).

#### Heat Exchanger Electric Power [W]

This output is the electric consumption rate of the unit in Watts. This rate is applicable whenever the unit operates (i.e., whenever the unit is scheduled to be available and supply and exhaust air flows exist).

#### Heat Exchanger Electric Energy [J]

This output is the electric consumption of the unit in Joules for the timestep being reported. This ouput is also added to a meter with ResourceType = Electricity, EndUseKey = HeatRecovery, GroupKey = System (ref. Output:Meter objects).

#### Heat Exchanger Sensible Effectiveness []

This output is the average sensible effectiveness of the heat exchanger (excluding bypass air, if any) over the timestep being reported.

#### Heat Exchanger Latent Effectiveness []

This output is the average latent effectiveness of the heat exchanger (excluding bypass air, if any) over the timestep being reported.

#### Heat Exchanger Supply Air Bypass Mass Flow Rate [kg/s]

This output is the average mass flow rate in kg/second of the supply (primary) air stream that is bypassing the heat exchanger over the timestep being reported. This flow rate is equal to the total supply mass flow rate through the heat exchanger **unit** minus the amount passing through the supply side of the heat exchanger **core**.

#### Heat Exchanger Exhaust Air Bypass Mass Flow Rate [kg/s]

This output is the average mass flow rate in kg/second of the exhaust (secondary) air stream that is bypassing the heat exchanger over the timestep being reported. This flow rate is equal to the total exhaust mass flow rate through the heat exchanger **unit** minus the amount passing through the exhaust side of the heat exchanger **core**.

#### Heat Exchanger Defrost Time Fraction []

This output is the average fraction of the reporting timestep when frost control is being implemented.

### HeatExchanger:Desiccant:BalancedFlow