## Membrane Heat Pump Cooling Only

### Author

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### Description

Unlike a standard heat pump with an electric compressor, a membrane heat pumps works in two stages. First, latent cooling (moisture removal) is performed by using a vacuum pump to extract moisture from the airstream via a membrane that is moisture permeable but not air permeable. Second, sensible cooling is provided via a chilled water loop, which is itself cooled by using the same vacuum pump to perform forced evaporative cooling via another membrane. Moisture is rejected to the outdoor air via a third membrane. The entire system has peak EER of about 26, which is significantly higher than traditional DX cooling equipment. However, the evaporative cooling process that cools the chilled water loop consumes roughly 3 gallons of water per ton-hour of sensible cooling.

### Modeler Description

Each DX cooling coil in the model is replaced by a membrane heat pump. To represent the membrane heat pump, the DX cooling coil COP is increased to 7.62 (26 EER). Additionally, add a water use equipment object to account for the 3 gallons of water used per ton\*hr of sensible cooling process.

### Use Case Types

Retrofit, New Construction

### Arguments

“run\_measure” is a choice argument that determines whether or not the Measure is applied during a given run.

### Initial Condition Message

The initial model contained X DX cooling coils.

### Final Condition Message

The efficiency of the following coils were increased to SEER 26 to reflect the replacement of these coils with membrane heatpumps: #{Coil1}, #{Coil2}...

### Not Applicable Messages

Not applicable if no DX cooling coils were found.

### Warning Messages

Warn if this measure was not applicable to any coil.

### Information Messages

Show the initial and final COPs for each coil.

### Error Messages

### Code Outline

* Find all Coil:Cooling:DX:SingleSpeed and Coil:Cooling:DX:TwoSpeed objects
  + Change their rated COP (hi and low for 2spd) to 7.62.
* For each coil, create the following:
  + A sensor to read the amount of cooling energy used, to determine water use.

EnergyManagementSystem:Sensor,

MembraneHP{#}SensibleClgJ,

{NAME OF DX COIL},

Cooling Coil Sensible Cooling Energy;

* + A water use equipment and a sensor to control it via a schedule

WaterUse:Equipment,

MembraneHP{#}WaterUse, !- Name

Membrane HP Cooling, !- End-Use Subcategory

0.003155, !- Peak Flow Rate {m3/s} = 3000 gal/hr

MembraneHP{#}WaterUseSchedule; !- Flow Rate Fraction Schedule Name

Schedule:Constant,

MembraneHP{#}WaterUseSchedule, !- Name

, !- Schedule Type Limits Name

1; !- Hourly Value

EnergyManagementSystem:Actuator,

MembraneHP{#}WaterUseCtrl,

{MembraneHP{#}WaterUseSchedule},

Schedule:Constant,

Schedule Value;

* Create a single program and calling manager to operate the water use equipment.

EnergyManagementSystem:ProgramCallingManager,

MembraneHPWaterUseProgramControl, !- Name

AfterPredictorBeforeHVACManagers, !- EnergyPlus Model Calling Point

MembraneHPWaterUseProgram; !- Program Name 1

EnergyManagementSystem:Program,

MembraneHPWaterUseProgram, !- Name

SET TimeStepsPerHr = {FROM TIMESTEP OBJECT}

SET MembraneHP{#}SensibleClgTonHr = MembraneHP{#}SensibleClgJ \* 0.0000007898,

SET MembraneHP{#}SensibleWtrGal = MembraneHP{#}SensibleClgTonHr \* 3.0,

SET MembraneHP{#}SensibleWtrGalPerHr = MembraneHP{#}SensibleWtrGal \* TimeStepsPerHr,

SET MembraneHP{#}WaterUseCtrl = MembraneHP{#}SensibleWtrGalPerHr / 3000.0,

...repeat these 4 lines for each coil

SET UnusedLine = 0;

### Tests

**This measure applies to:**

1. Large Office
2. Medium Office
3. Primary School
4. Secondary School
5. Large Hotel
6. Hospital
7. Small Office
8. Stand-Alone Retail
9. Strip Mall
10. Supermarket
11. Quick Service Restaurant
12. Full Service Restaurant
13. Small Hotel
14. Outpatient Healthcare
15. Warehouse
16. Midrise Apartment

**Test results:**

### References

1. <http://energy.gov/sites/prod/files/2014/03/f12/Non-Vapor%20Compression%20HVAC%20Report.pdf>