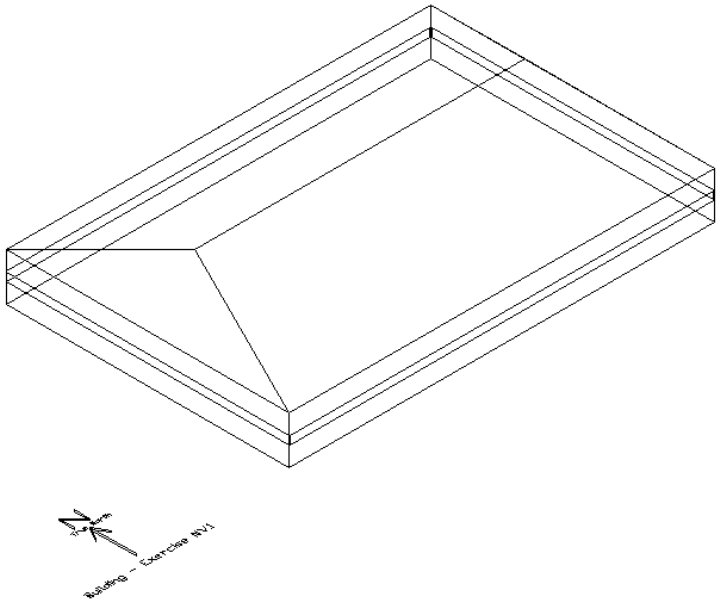
Introduction to EnergyPlus - Exercise NV1

Natural Ventilation – Envelope Cracks and Openings, HVAC Controls

Last revised November 2012 for EnergyPlus v7.2.0.006

General Description

This exercise will introduce you to adding natural ventilation to the building envelope using cracks and openings such as windows and doors. It will also show how to control the HVAC system to provide "hybrid" ventilation (automatically shut off HVAC when natural ventilation is adequate to meet cooling requirements).



Basic File Description

Single story, one zone office building. Area = 511 m2 (5,503 ft2); Number of Stories = 1; Shape = rectangle, Aspect ratio = 1.5.

Opaque constructions: mass walls; attic roof; slab-on-grade floor.

Windows: window-to-wall ratio = 18%, equal distribution of windows

Internal gains: lights = 10.76 W/m2 (1.0 W/ft2)
electric plug loads = 8.07 W/m2 (0.75 W/ft2)
people = 20 total; 3.91 persons/100 m2 (3.63 persons/1000 ft2)

Environment
Location: Chicago, IL USA (O'hare Airport)
Annual Simulation Period: Jan 1-31, Apr 1-30, Jul 1-31

HVAC System Description

Packaged single zone DX cooling with gas heat. All equipment is autosized.

Instructions

Part1 – Add cracks for infiltration

1. Run Exercise-NV1.idf and open the Tables and Variables (csv) output files. Keep these open to use as a baseline for comparison.
2. Open Exercise-NV1.idf in IDF Editor, save as Exercise-NV1A.idf, and change the name in the Building object to "Exercise NV1A".
3. Locate the two existing ZoneInfiltration:DesignFlowRate objects and review them.
   These objects show the "simple" form of infiltration modeling in EnergyPlus. When an Airflownetwork:SimulationControl object is present in the idf (to be added in this exercise) that object controls whether simple ZoneInfiltration:DesignFlowRate objects are active.
4. In IDF Editor search (ctl-F) for "Airflownetwork" to find the group of objects used for natural ventilation, including infiltration and flow between zones.
5. In the Class List, select "Airflownetwork:SimulationControl" and create a new object named "Infiltration Model". Keep the defaults, except the following fields:
   - AirflowNetwork Control = MultizoneWithoutDistribution
     This simulates envelope and interzone cracks and openings without simulating HVAC system duct leakage. This option also turns off the simple ZoneInfiltration:DesignFlowRate objects.
   - Azimuth Angle of Long Axis of Building = 90
   - Ratio of Building Width Along Short Axis to Width Along Long Axis = 0.67
6. Create two new Airflownetwork:Multizone:Zone objects for the "Office" and "Attic" zones. Keep all of the defaults.
   The default Ventilation Control Mode is NOVENT, which means all of the large openings (windows and doors) in this zone remain closed for the entire simulation.
7. Create five Airflownetwork:Multizone:Surface:EffectiveLeakageArea objects with the following names and leakage areas (keep other defaults):
   - "North-South Office Wall Leakage", 0.005 m2
   - "East-West Office Wall Leakage", 0.0075 m2
   - "North-South Attic Roof Leakage", 0.015 m2
   - "East-West Attic Roof Leakage", 0.02 m2
   - "Office to Attic Leakage", 0.01 m2
8. Create two Airflownetwork:Multizone:Component:SimpleOpening objects with the following names and fields:

- "North-South Office Window Opening", fields=0.00025, 0.667, 0.0001, 0.55
- "East-West Office Window Opening", fields=0.0004, 0.667, 0.0001, 0.55

9. Create the following new Airflownetwork:Multizone:Surface objects. Set the Leakage Component Name as listed below, set the Window/Door Opening Factor, or Crack Factor = 1.0, and let everything else default:
   - Office_Wall_North, North-South Office Wall Leakage
   - Office_Ceiling, Office to Attic Leakage
   - Office_Wall_East, East-West Office Wall Leakage
   - Office_Wall_South, North-South Office Wall Leakage
   - Office_Wall_West, East-West Office Wall Leakage
   - *Note for interior surfaces between zones, only one of the pair of interzone surfaces gets an airflownetwork:multizone:surface object. So, skip Attic_Floor.*
   - West-Roof, East-West Attic Roof Leakage
   - East-Roof, East-West Attic Roof Leakage
   - South-Roof, North-South Attic Roof Leakage
   - North-Roof, North-South Attic Roof Leakage
   - Office_Wall_North_Window, North-South Office Window Opening
   - Office_Wall_East_Window, East-West Office Window Opening
   - Office_Wall_South_Window, North-South Office Window Opening
   - Office_Wall_West_Window, East-West Office Window Opening
10. Find the Output:Table:Monthly object named "Outdoor Air Summary", and change "Zone Infiltration Air Change Rate" to "AirflowNetwork Zone Infiltration Air Change Rate" in Variable 01 and 05.
11. Run the simulation and open the rdd output file (it will open in a text editor). Also open Exercise-NV1A in IDF Editor. Search the rdd file for "AirflowNetwork Zone Infiltration Air Change Rate", select the entire row (which represents a complete Output:Variable object), copy, then past into IDF Editor.
    NOTE: IDF Editor accepts complete object(s) from the clipboard. It does not matter what class is selected at the time you paste, the new objects will show up in their respective classes.

    Repeat this for any other AirflowNetwork variables of interest.
12. Run the simulation again and compare results with Exercise-NV1. Results should be similar for the two cases.

Part2 – Add ventilation controls

1. Open Exercise-NV1A.idf in IDF Editor, save as Exercise-NV1B.idf, and change the name in the Building object to "Exercise NV1B".
2. Create a Schedule:Compact object named "Always_23" which is always = 23C.
   Hint: Go to the first schedule object, duplicate it, change the name, schedule type, and value.

3. Find the Airflownetwork:Multizone:Zone objects for the "Office", and make the following changes:
   - Ventilation Control Mode = Temperature
   - Ventilation Control Zone Temperature Setpoint Schedule Name = "Always_23"
   - Lower Limit on Inside/Outside Temperature Difference for Maximum Venting Open Factor = 2C
4. Find the HVACTemplate:System:Unitary object and change the Cooling Coil Availability Schedule to ALWAYS_OFF.
5. Create an Output:Variable object for "Window/Door Venting Opening Factor", reported every timestep with output reporting schedule set to OUTVAR_SCHED.
6. Change the reporting frequency of all other Output:Variable objects from hourly to timestep.
7. Run the simulation and compare results with Exercise-NV1A. In July, natural ventilation alone is not adequate to cool the office.
   See the SETPOINTS NOT MET WITH TEMPERATURES report in the table output file.

Part3 – Add hybrid ventilation controls

1. Open Exercise-NV1B.idf in IDF Editor, save as Exercise-NV1C.idf, and change the name in the Building object to "Exercise NV1C".
2. Find the HVACTemplate:System:Unitary object and change the Cooling Coil Availability Schedule to ALWAYS_ON.
3. Add an AvailabilityManager:HybridVentilation object, name it "Hybrid Ventilation Control" and edit the following fields:
   - HVAC Air Loop Name = Office PSZ
   - Controlled Zone Name = Office
   - Ventilation Control Mode Schedule Name = ALWAYS_ON
     Note: This schedule is always 1, which is the control type for temperature control for the hybrid ventilation.
   - Maximum Outdoor Enthalpy = 290,000.
   - Minimum Outdoor Air Ventilation Schedule = ALWAYS_ON
4. Add an Output:Variable object for "Hybrid Ventilation Control Status" reported every timestep with output reporting schedule set to OUTVAR_SCHED.
5. Run the simulation and compare results with Exercise-NV1A and Exercise-NV1B.

List of New or Modified Objects

This is a listing of new objects added or modified in this Exercise.

Exercise NV1A

New objects:

```
AirflowNetwork:SimulationControl,
    Infiltration Model,            !- Name
    MultizoneWithoutDistribution,  !- AirflowNetwork Control
. . .
    90,          !- Azimuth Angle of Long Axis of Building {deg}
    0.67;        !- Ratio of Building Width Along Short Axis to Width Along Long Axis

AirflowNetwork:MultiZone:Zone,
    Office,      !- Zone Name
    NoVent,      !- Ventilation Control Mode
    ,            !- Ventilation Control Zone Temperature Setpoint Schedule Name
    ,            !- Minimum Venting Open Factor {dimensionless}
    ,            !- Indoor and Outdoor Temperature Difference Lower Limit For Maximum
Venting Open Factor {deltaC}
    100,         !- Indoor and Outdoor Temperature Difference Upper Limit for Minimun
Venting Open Factor {deltaC}
    ,            !- Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum
Venting Open Factor {deltaJ/kg}
    300000;      !- Indoor and Outdoor Enthalpy Difference Upper Limit for Minimun
Venting Open Factor {deltaJ/kg}

AirflowNetwork:MultiZone:Zone,
    Attic,       !- Zone Name
    NoVent,      !- Ventilation Control Mode
    ,            !- Ventilation Control Zone Temperature Setpoint Schedule Name
    ,            !- Minimum Venting Open Factor {dimensionless}
    ,            !- Indoor and Outdoor Temperature Difference Lower Limit For Maximum
Venting Open Factor {deltaC}
    100,         !- Indoor and Outdoor Temperature Difference Upper Limit for Minimun
Venting Open Factor {deltaC}
    ,            !- Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum
Venting Open Factor {deltaJ/kg}
    300000;      !- Indoor and Outdoor Enthalpy Difference Upper Limit for Minimun
Venting Open Factor {deltaJ/kg}

AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea,
    North-South Office Wall Leakage,  !- Name
    0.005,                    !- Effective Leakage Area {m2}
    1,                        !- Discharge Coefficient {dimensionless}
    4,                        !- Reference Pressure Difference {Pa}
    0.65;                     !- Air Mass Flow Exponent {dimensionless}

AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea,
    East-West Office Wall Leakage,  !- Name
    0.0075,                   !- Effective Leakage Area {m2}
    1,                        !- Discharge Coefficient {dimensionless}
    4,                        !- Reference Pressure Difference {Pa}
    0.65;                     !- Air Mass Flow Exponent {dimensionless}

AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea,
    North-South Attic Roof Leakage,  !- Name
    0.015,                    !- Effective Leakage Area {m2}
    1,                        !- Discharge Coefficient {dimensionless}
    4,                        !- Reference Pressure Difference {Pa}
    0.65;                     !- Air Mass Flow Exponent {dimensionless}
```

```
AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea,
    East-West Attic Roof Leakage,  !- Name
    0.02,                     !- Effective Leakage Area {m2}
    1,                        !- Discharge Coefficient {dimensionless}
    4,                        !- Reference Pressure Difference {Pa}
    0.65;                     !- Air Mass Flow Exponent {dimensionless}

AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea,
    Office to Attic Leakage, !- Name
    0.01,                     !- Effective Leakage Area {m2}
    1,                        !- Discharge Coefficient {dimensionless}
    4,                        !- Reference Pressure Difference {Pa}
    0.65;                     !- Air Mass Flow Exponent {dimensionless}

AirflowNetwork:MultiZone:Component:SimpleOpening,
    North-South Office Window Opening,  !- Name
    0.00025,          !- Air Mass Flow Coefficient When Opening is Closed {kg/s-m}
    0.667,            !- Air Mass Flow Exponent When Opening is Closed
{dimensionless}
    0.0001,           !- Minimum Density Difference for Two-Way Flow {kg/m3}
    0.55;             !- Discharge Coefficient {dimensionless}

AirflowNetwork:MultiZone:Component:SimpleOpening,
    East-West Office Window Opening,  !- Name
    0.0004,           !- Air Mass Flow Coefficient When Opening is Closed {kg/s-m}
    0.667,            !- Air Mass Flow Exponent When Opening is Closed
{dimensionless}
    0.0001,           !- Minimum Density Difference for Two-Way Flow {kg/m3}
    0.55;             !- Discharge Coefficient {dimensionless}
```

New objects (repeated for 13 occurrences):

```
AirflowNetwork:MultiZone:Surface,
    Office_Wall_North,       !- Surface Name
    North-South Office Wall Leakage,  !- Leakage Component Name
    ,              !- External Node Name
    1,             !- Window/Door Opening Factor, or Crack Factor {dimensionless}
    ZoneLevel,     !- Ventilation Control Mode
    ,              !- Ventilation Control Zone Temperature Setpoint Schedule Name
    ,              !- Minimum Venting Open Factor {dimensionless}
    ,              !- Indoor and Outdoor Temperature Difference Lower Limit For
Maximum Venting Open Factor {deltaC}
    100,           !- Indoor and Outdoor Temperature Difference Upper Limit for
Minimun Venting Open Factor {deltaC}
    ,              !- Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum
Venting Open Factor {deltaJ/kg}
    300000;        !- Indoor and Outdoor Enthalpy Difference Upper Limit for Minimun
Venting Open Factor {deltaJ/kg}
```

Modified objects:

```
Output:Table:Monthly,
    Outdoor Air Summary,     !- Name
    3,                       !- Digits After Decimal
    AirflowNetwork Zone Infiltration Air Change Rate,  !- Variable or Meter 1 Name
    SumOrAverage,            !- Aggregation Type for Variable or Meter 1
    Zone People Number of Occupants,  !- Variable or Meter 2 Name
    HoursNonZero,            !- Aggregation Type for Variable or Meter 2
    Zone People Number Of Occupants,  !- Variable or Meter 3 Name
    SumOrAverageDuringHoursShown,  !- Aggregation Type for Variable or Meter 3
    Zone Mechanical Ventilation Air Change Rate,  !- Variable or Meter 4 Name
    SumOrAverageDuringHoursShown,  !- Aggregation Type for Variable or Meter 4
    AirflowNetwork Zone Infiltration Air Change Rate,  !- Variable or Meter 5 Name
    SumOrAverageDuringHoursShown;  !- Aggregation Type for Variable or Meter 5
```

Exercise NV1B

New objects:

```
Schedule:Compact,
    ALWAYS_23,              !- Name
    Any Number,             !- Schedule Type Limits Name
    Through: 12/31,         !- Field 1
    For: AllDays,           !- Field 2
    Until: 24:00, 23;       !- Field 4

Output:Variable,*,Window/Door Venting Opening Factor,Timestep,OUTVAR_SCHED;
```

Modified objects:

```
Output:Variable,*,Outdoor Dry Bulb,Timestep,OUTVAR_SCHED;
Output:Variable,*,Zone Mean Air Temperature,Timestep,OUTVAR_SCHED;
Output:Variable,*,DX Cooling Coil Runtime Fraction,Timestep,OUTVAR_SCHED;
Output:Variable,*,Heating Coil Runtime Fraction,Timestep,OUTVAR_SCHED;
Output:Variable,*,On/Off Fan Runtime Fraction,Timestep,OUTVAR_SCHED;
Output:Variable,*,Zone Infiltration Air Change Rate,Timestep,OUTVAR_SCHED;
Output:Variable,*,Zone Infiltration Sensible Heat Loss,Timestep,OUTVAR_SCHED;
Output:Variable,*,Zone Infiltration Sensible Heat Gain,Timestep,OUTVAR_SCHED;
Output:Variable,*,AirflowNetwork Zone Infiltration Air ChangeRate,
                      Timestep,OUTVAR_SCHED;

AirflowNetwork:MultiZone:Zone,
    Office,           !- Zone Name
    Temperature,      !- Ventilation Control Mode
    ALWAYS_23,        !- Ventilation Control Zone Temperature Setpoint Schedule Name
    ,                 !- Minimum Venting Open Factor {dimensionless}
    2,                !- Indoor and Outdoor Temperature Difference Lower Limit

HVACTemplate:System:Unitary,
    Office PSZ,             !- Name
. . .
    ALWAYS_OFF,             !- Cooling Coil Availability Schedule Name
```

Exercise NV1C

Modified objects:

```
HVACTemplate:System:Unitary,
    Office PSZ,             !- Name
. . .
    ALWAYS_ON,              !- Cooling Coil Availability Schedule Name
```

New objects:

```
AvailabilityManager:HybridVentilation,
    Hybrid Ventilation Control,  !- Name
    Office PSZ,             !- HVAC Air Loop Name
    Office,                 !- Controlled Zone Name
    ALWAYS_ON,              !- Ventilation Control Mode Schedule Name
    Yes,                    !- Use Weather File Rain Indicators
    40,                     !- Maximum Wind Speed {m/s}
    -100,                   !- Minimum Outdoor Temperature {C}
    100,                    !- Maximum Outdoor Temperature {C}
    ,                       !- Minimum Outdoor Enthalpy {J/kg}
    290000,                 !- Maximum Outdoor Enthalpy {J/kg}
    -100,                   !- Minimum Outdoor Dewpoint {C}
    100,                    !- Maximum Outdoor Dewpoint {C}
    ALWAYS_ON;              !- Minimum Outdoor Ventilation Air Schedule Name

Output:Variable,*,Hybrid Ventilation Control Status,Timestep,OUTVAR_SCHED;
```