Efficient HVAC Design in Helena, MT

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Introduction

- New office building construction in Helena, MT
  - Approximately 55 workers
  - Four private offices, large open office space with cubicles

- Needs a complete heating, ventilation, and air conditioning (HVAC) system
  - Boiler and associated hot water system
  - Air handling unit (AHU) and associated ductwork
  - Cooling system

- Provide a recommendation for six or twelve south facing windows

- Implement a solar wall into the design
Design Criteria

• Office building to be built in Helena, MT
  • Occupied design temperatures: 72F heating, 75F cooling
  • Unoccupied design temperatures: 64F heating, 82F cooling

• Must adhere to IECC – 2012
  • Provides required insulation R values

• Must adhere to ASHRAE 62.1 – 2013
  • Provides minimum ventilation requirements

• Maximum and minimum outside temperatures according to ASHRAE 90.1 – 2013
  • 90.5F maximum, -12.5F minimum
Design Constrains

- Additional heating and cooling due to added windows
- Solar wall
  - Additional ductwork and control systems
  - Complicates control sequence
- Physical design constraints
  - 3 ft. plenum space
Preliminary Design Analysis

- **AHU – Constant volume vs variable volume**
  - Constant air volume system
    - Inexpensive and simple
    - Not very efficient
    - Imprecise temperature control
  - Variable air volume system
    - More expensive and complicated
    - More efficient
    - Precise temperature control

- **Boiler – Condensing vs non-condensing**
  - Condensing
    - More efficient 91+%
    - Higher initial cost
  - Non-condensing
    - Less efficient ~80%
    - Lower initial cost

<table>
<thead>
<tr>
<th>Boiler Type</th>
<th>Eff.</th>
<th>Gas BTU</th>
<th>Therms</th>
<th>Fuel Price/year</th>
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<tbody>
<tr>
<td>Condensing</td>
<td>91%</td>
<td>209623540</td>
<td>2096.24</td>
<td>$ 1,320.63</td>
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<td>Non-C</td>
<td>80%</td>
<td>238446776</td>
<td>2384.47</td>
<td>$ 1,502.21</td>
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</table>
Preliminary Design Analysis Cont.

• Six vs twelve south facing windows
  • Sunlight is better than artificial light
  • More sunlight means lower light usage
  • More windows increases heating and cooling loads
  • An additional six windows adds:
    • 1.5 tons (of 5.9 total) in peak cooling load
    • $78 to yearly heating and cooling bill
Recommended Design

- Single duct VAV system with seven heating and cooling zones
  - Direct expansion unit for cooling
  - Bathroom air supplied via door vents

- Hot water system
  - Condensing boiler
  - Distribution system uses primary-secondary loop and reverse return
  - All hot water pumps fitted with variable flow devices, redundant circulation pump
  - Bathrooms and entryway heated with fin tube
  - Maintenance room heated with a hydronic unit heater

- Twelve south facing windows
Environmental and Societal Impacts

- System has been made as efficient as possible to reduce carbon footprint
- Since this is a new construction, the public will not be affected or hindered by this installation
- VAV system provides better temperature control and more comfort to building occupants
- Larger number of south facing windows provides better lighting for occupants
Sustainability Evaluation

- Variable air volume system
  - Variable fan speed reduces electricity use during non-peak operation
  - Lower fan speeds increases motor life

- Pumps outfitted with variable frequency drives
  - Reduced pump speed during low demand saves electricity
  - Lower pump speeds increases pump life

- Condensing boiler reduces natural gas consumption

- Solar wall provides substantially preheated air reducing the amount of heat required from the hot water system
## Cost Estimate

<table>
<thead>
<tr>
<th>Cost Estimate Summary</th>
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<tbody>
<tr>
<td>Water side Total</td>
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<tr>
<td>Air side Total</td>
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<td>Balancing Total</td>
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<td>Controls Total</td>
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<td>Sub-Total</td>
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<td>Contingency 10%</td>
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<td>Permit &amp; Bonds 5%</td>
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<td>Grand Total</td>
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References

Christopher Batson – Project Sponsor


