Appendix G: Basis of Design BoD (Example)

General - Mechanical

The building will be new construction of a 32,000 square foot, two story double loaded corridor multifamily housing located in South Burlington, VT. The building will contain 48 apartments, consisting of 24 one bedroom, 16 two bedroom and 8 three bedroom apartments. Occupancy type will be low income family.

Codes, Standards and Guidelines

Vermont Residential Building Energy Standards 2005

International Plumbing Code 2009, with VT Amendments

Vermont Public Building Code Requirements, 2009

ASHRAE Standard 62.2-2010, “Ventilation for Acceptable Air Quality”

ASHRAE Standard 90.2-2007, “Energy Efficient Design of Low-Rise Residential Buildings”

ASHRAE Handbook 2007 HVAC Applications, Chapter 49, “Service Water Heating”

MSOB Mechanical Optimization Guide

Load Calculations

Design conditions assumed for load calculations:

Winter: -11F w/ 15 Mph wind

Infiltration: 0.10 air changes per hour. (At winter design conditions)

Interior: 70F Relative humidity: N/A

Internal load assumptions: Heat gains from interior loads are excluded from design heating load sizing calculations.

Heating load safety factor: 5%

Boilers and Heating Water System

Each apartment will be an individual heating zone having one thermostat. Apartments having two stories will have two zones; upper and lower floors.

The design heating load for the building is calculated to be 208,000 Btuh. The heating load calculations are based on all zones calling for heat concurrently.

Central heating plant will consist of three natural gas boilers. Each boiler will be sized for 33% of design heating load.

Boilers will have the following features:

Modulating burner capacity, capable of operating at 30% of rated maximum output capacity

Condensing type

95% AFUE efficiency

Minimum boiler entering water temperature of 50F (per manufacturer criteria)

Boiler minimum water flow rate of 25% of full design flow rate

Rated for ASME 50 PSI operation

Utilize 130F maximum heating hot water supply temperature

Specified boilers: Buderus Model Logamax Plus GB142 and Weil-McLain Ultra

Central heating plant will operate upon demand from any zone calling. Central heating will be locked out in summer whenever the outside air temperature exceeds 65F.

Boilers will operate in parallel so as to optimize combustion efficiency. Boilers will be staged sequentially such that when the boiler(s) capacity reaches 90%, the next boiler will fire, until all boilers are on; and all operating boilers will operate in unison at the same capacity.

The terminal heating equipment will utilize perimeter finned tube radiation. Terminal equipment will be selected to operate during design conditions with a heating hot water supply (HWS) temperature no hotter than 130F to optimize combustion efficiency by enhancing the condensing effect to reduce fuel consumption.

The HWS temperature setpoint will be reset from 130F to 100F reset proportionally based on outside air temperatures of 0F to 55F, again to optimize combustion efficiency.

Piping & Pumping

Two heating hot water pumps will be used; one operating at a time, with run time equalized over time automatically.

Heating HW will be variable flow. Pump capacity will be controlled by a piping differential pressure (dP) sensor located near the end of supply and return mains for pump variable speed/capacity control.

Terminal heating equipment within living units will be fitted with light commercial grade, two-port, and two position (non-modulating) control valves for durability. Control valves will be line sized (to minimize water friction) and will be normally closed, spring return closed.

The HRV hot water reheat coil will utilize a small ECM variable speed injection pump, so as to enhance part load operating efficiency by avoiding parasitic piping resistance from modulating control valves.

Minimum pump and system flow during low load conditions will be maintained by maintaining constant flow cabinet heaters at building entrances or at unit heaters (installed without control valves) and/or three port control valves installed at ends of long piping runs. Maintaining a limited volume of constant water flow at a few terminals will reduce first construction costs and eliminate the expense and complexity of differential by-pass valve assemblies.

Distribution piping configuration will be direct return.

Piping sizing will be based on a friction rate not to exceed 3 feet of head per 100 equivalent feet of piping.

A pump sizing safety factor of 5% will be applied to pump head calculations, to account for uncertainties in piping construction.

A diversity factor of 90% (actual peak expected load vs. connected load) is applied to sizing the pump capacity.

Balance valves for variable water flow terminal equipment will be automatic, self contained pressure independent so as to ensure design flow to any terminal heating equipment, regardless of the system load. Manual balance valves will not be applied anywhere in the variable flow system. Pump discharge triple duty valves will be avoided because they add avoidable cost and impose permanent system resistance. Avoidance of manual balance valves will minimize the restriction (head loss) of balancing valves and circuit setters which impose a permanent resistance to water flow.

A Btu meter will monitor heating plant water flow and temperature difference (HWS and HWR) and totalize heating plant generated Btu's.

Controls

The boiler plant will have low water cut-off controls.

Boiler plant control will be fully automatic with manual override capability. A Tekmar® boiler plant controller will control the central heating plant.

The plant controls will have the following capabilities:

- Start/stop and control boiler burner firing capacity
- Assigns the lead boiler
- Assigns the lag boilers

The controls will have the capability to change:

- HWS temperature (HWST) setpoints
- HWS temperature reset parameters
- Water pumping pressure setpoints (via pump VFD's)

The control will monitor, via remote internet access, the following:

Boiler plant controller and all associated parameters (temperatures, boiler status, etc.)

Pump VFD and all associated parameters

Injection pumps

Heating plant Btu meter flow (gpm), HWS/HWR temperatures, and Btu totalization.

Domestic Hot Water

Domestic hot water sizing calculations are based on ASHRAE 2007 HVAC Applications Handbook, Chapter 49, "Service Water Heating".

Domestic water sizing is based on:

- 24 one bedroom apartments having 48 occupants
- 16 two bedroom apartment having 64 occupants

- 8 three bedroom apartments having 48 occupants
- Total number of occupants for DHW load purposes: 160 occupants

Occupant usage classification: High use

Demographic classifications: High percentage of children, low income, on public assistance, families

Each apartment will have a kitchen dishwasher, one shower/bath combination per apartment. No clothes washing machines.

DHW peak demand calculations are based on the number of people.

Peak one hour DHW demand:

- 8.5 gallons per person
- 1,428 gallons total

Peak 15 minute DHW demand:

- 3.0 gallons per person
- 504 gallons total

Design one hour DHW demand: 1,428 gallons per hour

DHW entering water temperature: 45F

DHW tank storage temperature: 140F

DHW water delivery temperature: 120F (Using mixing valve)

DHW BTUH generation capacity: 1,130,000 BTUH

DHW Tank storage volume: two, heater/tank units, each having 80 gallons (Stored at 140F)

DHW recirculation flow rate: 8 gpm

Domestic hot water will be generated by direct fired domestic water heater/tank assemblies. The plant will utilize natural gas fired condensing water heaters. Water heater efficiency will vary based on entering water temperature. Efficiency will be rated for 96%.

A Btu meter will monitor solar DHW system performance in a manner similar to that described for the central heating plant. The DHW Btu meter will be connected to the building internet router to enable remote monitoring.

Solar DHW

Rooftop flat plate solar panels consisting of ### square feet of flat plate panel area will be used to preheat domestic hot water.

The solar preheat system will utilize a counter flow heat exchanger to transfer energy from the solar heating loop to the DHW preheat tanks.

DHW solar preheat tanks will be sized based on 2.0 gallons of storage per square foot of solar panel. Maximum pre heat tank storage temperatures will be 160F.

Solar system panels storage tank sizing is based on providing 50% of DHW load during the months of November, December, January, February; 100% of DHW load during all other months.

A Btu meter will monitor solar DHW system performance in a manner similar to that described for the central heating plant.

The solar system controller and Btu meter will be connected to the building internet router to enable remote monitoring.

Ventilation

Ventilation calculations are based on The VT Residential Energy Guideline 2005.

Supply air ventilation to individual apartments will be provided on the basis of .05 cfm per square foot. Central corridors will be provided with ventilation at a rate of .05 cfm per square foot. Corridor will not have exhaust registers, so as to maintain a positive pressure relative to apartments, to help mitigate odor transfer from one apartment to another.

Ventilation will operate continuously. Exhaust volumes will match supply air volumes within apartments.

Total ventilation will be 1,650 cfm. Ventilation will be continuous.

Supply air to each apartment will be ducted and terminate in bedrooms. Exhaust air will be captured in bathrooms.

A manual volume damper in supply and exhaust duct runouts to each apartment will be provided to facilitate air balancing.

Heat Recovery Ventilation (HRV) Unit

Ventilation will be provided by a central HRV unit. The HRV unit will be an air to air plate type exchanger to avoid any odor cross contamination from exhaust side to fresh air side. Operation will be continuous and constant volume.

The HRV sizing will be as follows:

Outside Air Volume (100% OA): 1,650 cfm

Exhaust Air Volume: 1,650 cfm

The supply air temperature setpoint will be 65F (constant).

A heating hot water reheat coil will be provided to maintain supply air temperature setpoint when the HRV is not capable of discharging the supply air temperature setpoint and during defrost mode, when HRV recovery capacity is diminished. A low energy variable speed injection pump will be utilized for coil capacity control.

Factory packaged controls will be utilized.