2 Energy-Using Systems

2.1 Lyman Gilmore Middle School

Heating, Ventilation, and Air Conditioning Units

The heating system throughout the GMS campus is primarily a two-pipe hydronic system using terminal fan coils in the classrooms (Figure 2.1) and office spaces, and air handlers which serve some areas, all fed from a central boiler plant located in the MPR building. The fan coils and air handlers have outside supply air (OSA) dampers and actuators, but these have poor (failing) controls and are suspect, at best, as to the current sequence of operations and whether or not they operate as designed. A sampling of several units indicated that most, if not all, of these OSA actuators have failed.

As discussed with site personnel, and witnessed during the site audit, the sequence of operation for the system, including boiler, fan coils, and air handlers can be summarized as follows:

- The system fan coils are commanded on based on building occupancy time schedules.
- Based on OSA, the boiler is enabled, supplying the two-pipe hydronic loop with hot water.
- Pneumatic thermostats in each space command a hydronic valve to open, supplying hot water to the respective fan coils and air handlers for space heating.

There is a legacy CSI control system which controls the boiler and fan coils throughout the campus. The system is currently used for scheduling purposes only. There is also a pneumatic air compressor (located in the boiler room) which controls hot water valves via wall-mounted thermostats (Figure 2.2).

Wall-mounted, multi-position, manual switches control rooftop swamp coolers provide cooling and/or ventilation when needed. These are typically restricted to use during summer months.

There are two packaged rooftop HVAC units on the office/administration building, in addition to two split systems serving the band and choir rooms. Wall-mounted heat pumps serve the portable classrooms and are typically controlled by 7-day programmable thermostats.

Common HVAC Terms

Package Unit – A package unit provides air conditioning and ventilation to a space. Package units can provide both heating and cooling or cooling only. The fans, cooling, and any heating equipment are packaged into a single unit.

Split System – A split system provides air conditioning, but not ventilation to a space. Split systems can provide heating and cooling or cooling only. A split system is comprised of a separate indoor and outdoor piece of equipment.

Air Handler – An air handler provides air conditioning and ventilation to a space. Unlike a package unit, an air handler may work with separate equipment like boilers and chillers to provide cooling and heating to a space. The term air handler typically refers to larger units serving large spaces or multiple spaces.

Heat Pump – A heat pump is a device that employs a refrigerant cycle to provide heating and cooling to a space. Split systems and package units can be referred to as heat pumps.

Fan Coil – A fan coil is an indoor unit that provides heating and/or cooling. A fan coil unit is comprised of a fan that blows air over hot or cold pipes (coils) to provide hot or cold air to the space.

Figure 2.1: Typical Unit Ventilator Fan Coil (L) and Hydronic Valve (R) Used in Classrooms

Boiler-fed hot water circulates through the heating coils in the unit ventilators. The school has two identical Kewanee hot water boilers that are connected, via two-pipe system, to the unit ventilators and air handlers. The details on the boilers are listed in Table 2.1.

Table 2.1: Boiler Details

Boiler Tag	Boiler Manufacturer & Model No.	Boiler Input	Efficiency
Boiler 1	Kewanee M-265	2,650 kBtu/h	80%
Boiler 2	Kewanee M-265	2,650 kBtu/h	80%

The boilers use two circulation pumps to circulate heating hot water throughout the campus. The pumps are operated by two older constant speed Open Drip Proof (ODP) 5-hp motors. All equipment related to boiler system operation appears to be beyond expected useful life and should either be replaced or retro-commissioned. Given the condition and life expectancy of the boiler plant, replacement may be necessary.

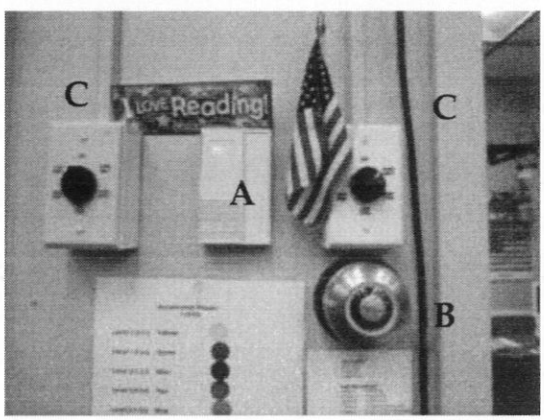

Figure 2.2: CSI Temperature Sensor (A), Pneumatic Thermostat (B) and Swamp Cooler Control Switch (C) Located in the Library

EEM-7: Install High Efficiency Condensing Boilers and VFDs on Primary Pumps at GMS

Annual Savings				Payback			
Peak Period Savings (kW)	Electricity Savings (kWh/yr)	Gas Savings (therms/yr)	Annual Cost Savings	Potential Incentive	Net Measure Cost	SIR	Simple Payback (years)
-	16,500	3,500	$5,900	$10,600	$114,400	1.29	19.4

Observations

The GMS building is heated using two hot water boilers. The two boilers provide hot water to the heating coils throughout the school. The boilers are identical Kewanee atmospheric natural gas boilers, rated at 2,650 kBtu/h input with a rated thermal efficiency of 80 percent. The boilers are original to the building and are approaching the end of their useful life. Hot water is supplied to the heating coils via constant-volume circulating pumps using two dedicated 5-hp motors.

Figure 4.7: Existing, Natural Gas Boiler Nameplate

Recommendations

It is recommended that the district replace the boilers with high-efficiency condensing boilers. New high-efficiency condensing boilers are available at efficiencies of 95 percent or higher.

The highest operating efficiencies of condensing boilers are realized when the return water temperature (RWT) is as low as possible. It is recommended that the district rework the water heating system to operate at lower flows and lower return water temperatures. It is recommended that the district design for a RWT of 120 °F when using a condensing boiler, but further energy savings is achieved with even lower temperatures.

Implementation Notes

Some condensing boilers can be maintenance intensive. Boilers with cast-iron sectional heat exchangers are more rugged than copper or nickel-based heat exchangers and require much less maintenance. Examples of boilers with cast-iron heat exchangers include the Hydrotherm KN and the Patterson-Kelly Mach series.

The installation of condensing heating hot water boilers will require a new, corrosion resistant flue stack. The improved efficiency of condensing hot water boilers is due largely to the increased heat transfer between the hot water and the exiting flue gas. The temperature of the flue gas is low enough that vapor in the air stream condenses and reacts with the combustion byproducts to create acids that speed the deterioration of conventional stack materials. Typical condensing boiler stacks are made out of stainless steel to prevent corrosion and extend the stack life.

Methodology

The energy savings for this measure are calculated using building and equipment specifications, a temperature bin simulation and ASHRAE design criteria to estimate the heating load and calculate the energy savings. The loads have been adjusted until the modeled energy use matched the site's natural gas usage. Manufacturer specifications for a sample condensing boiler and DOE-2 curves are used to model the performance of the condensing boiler.

Costs and Incentives

Boiler cost estimates are provided by an installation and service vendor[17]. The material and installation cost for the new primary pump motor and a VFD are estimated using RSMeans plus a 10 percent contingency and commissioning.

The potential incentive is based on the PG&E deemed rebate rate of $2 per Mbtu/h (HV019) for a space heating condensing boiler.

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