EVALUATING THE PERFORMANCE OF A NEW HIGH EFFICIENCY COMMERCIAL TANK WATER HEATER

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INTRODUCTION

Domestic hot water heating is typically the second largest end use of natural gas in multifamily buildings located in the Minneapolis/St. Paul area. The vast majority of rental properties utilize natural gas fired commercial tank water heaters to produce domestic hot water. Because tank water heaters are relatively inexpensive to purchase and install, they are widely used as replacement equipment and for new construction. Limited data collected by the Energy Resource Center (ERC) suggests that the overall system efficiency of existing commercial tank heaters is quite low, on the order of fifty-five (55) to sixty (60) percent (Robinson et al., 1987).

Within the past few years, many manufacturers of commercial tank water heaters have offered higher efficiency models which incorporate electronic ignition and an electric flue damper. The flue damper is installed upstream of the draft divertor to maximize the reduction of stack related standby losses. Unlike electric vent dampers which are installed downstream of the draft divertor, flue dampers cannot be installed on a retrofit basis and must be part of the original factory design.

Local heating contractors interviewed by the ERC have indicated that few property owners have installed these new models because of the lack of reliable performance data. Research by the Minneapolis Energy Office suggests that adding electric vent dampers to water heaters where a boiler vent damper is already present, produces positive energy savings (Hewett et al., 1988). However, direct measurement of water heater performance with flue dampers and electronic ignition has not been conducted.

This paper examines the performance of a new high efficiency tank water heater installed in a 24 unit steam heated apartment building. Estimates of appliance efficiency, system efficiency, and standby losses are presented, as well as annual use estimates for the new equipment.

METHODOLOGY

A new 365,000 Btu/hr (70 gallon) water heater with electronic ignition and flue damper was installed in parallel with an existing 2 year old 360,000 Btu/hr (69 gallon) standard commercial tank heater. The existing water heater had a thermally activated vent damper already installed downstream of the draft divertor. Shut off valves were installed to allow each appliance to serve the building independently. The heating system in the building consists of a 1.2 million Btu/hr packaged atmospheric cast iron steam boiler with a quick closing electric vent damper. The water heaters and boiler share a common masonry chimney.

Each water heater was run for alternating one week periods over a 4 month period between February and May 1988. The new water heater was run in 2 separate modes; one mode with the flue damper operational and the other mode with the flue damper disconnected and open. Data collection consisted of weekly submetered gas meter readings, as well as daily average hot water usage, inlet and outlet water temperatures, and gas valve run times monitored by a data acquisition system. Water heater efficiencies were calculated using a least squares methodology to fit measured input per day to measured daily output based on the average hot water use and temperature rise. The inverse of the slope of this least squares line is equal to the production efficiency of the appliance, and the intercept at the zero usage point represents the daily system standby loss.

RESULTS

Figure 1 shows the daily average performance of the new water heater, both with and without the flue damper operating. The two lines in Figure 1 are essentially parallel - indicating similar production efficiencies (an expected result since we are looking at the same appliance) and differing standby losses. Table I summarizes the estimated production efficiency, input standby loss and system efficiency of both water heaters. System efficiencies were calculated using a daily output energy of 500,000 Btu/day, the approximate measured daily use in the building over the 4 month testing period.

The production efficiencies of both water heaters were measured at approximately 70 percent. This figure closely matches measured production efficiencies of similar tank heaters found by Robinson (1987). The input standby losses for the new water heater was estimated to be .046 million Btu/day. When the flue damper was disconnected, the standby loss increased to .113 million Btu/day. The standby loss of the existing water heater with the thermal damper was estimated to be .103 million Btu/day, only slightly less than the new tank without the flue damper.

Table I. Measured efficiencies and standby losses.

Water Heater	Production Efficiency	Standby Loss (MBtu/day)	System Efficiency	Hot Water Use (gal/person-day)
New Tank (without damper)	.70	.113	.61	24.7
New Tank (with damper)	.69	.046	.65	24.8
Standard Tank (with thermal damper)	.71	.103	.62	23.4

In order to verify the relative accuracy of the estimated standby losses for the new tank, a one-time measurement of the off-cycle flue air flow rate and temperature, and tank surface temperature was performed. This methodology yielded measured output standby losses of .02 and .09 million Btu/day for the two modes of operation. Dividing these numbers by the production efficiency of 70 percent provides measured input standby losses of .03 and .13 million Btu/day, in reasonable agreement with the new tank figures shown in Table I.

The estimated annual performance of the water heaters is presented in Table II. Table II shows that the electric flue damper reduced annual energy use for the new tank heater by a statistically significant 18.9 million Btu or 6.3 percent. At an added installed cost of $500 ($150 labor and $350 materials) for a new efficient tank heater over a standard model, this yields a simple payback of approximately 5.3 years. However, this analysis does not include the potential savings associated with elimination of the pilot light. Assuming that approximately 50 percent of a standard .024 million Btu/day (1,000 Btu/hr) pilot light is lost up the flue, this increases savings due to the new tank by 4.4 million Btu/year. Including this additional savings reduces the simple payback of the new tank heater to 4.3 years.

Table II. Annual energy use of water heaters tested.

Water Heater	Annual Use (MBtu)	Std Err (MBtu)	Savings (MBtu)	Simple Payback On Added Cost
New Tank (without damper)	300.5	1.6		
New Tank (with damper)	281.6	1.7	18.9 ($94.50 @ $5/MBtu)	5.3 yrs
Standard Tank (with thermal damper)	293.2	2.2		

The data indicate that standby losses for a commercial tank water heater can be significantly reduced with an electric flue damper. The simple payback on the marginal cost of installing a new tank heater with a flue damper and electronic ignition was measured to be between 4 and 5 years, a reasonably attractive investment for a building owner in need of new water heater.

A common and less expensive water heater retrofit is to install a thermal vent damper downstream of the draft divertor. Thermal dampers are usually installed on standard tank water heaters because these appliances lack the 24 volt controls necessary to operate an electric damper. While less expensive to install, thermal dampers do not close as tightly or as quickly as electric dampers. In order to analyze the performance of a thermal vent damper, the Energy Resource Center plans to continue research in the same building over the next heating season. The impact of a thermal damper will be examined by removing the thermal damper from the existing water heater, and by adding a thermal damper to the new tank, in place of the electric flue damper. Performance of the water heaters in this configuration will then be compared to the results above.

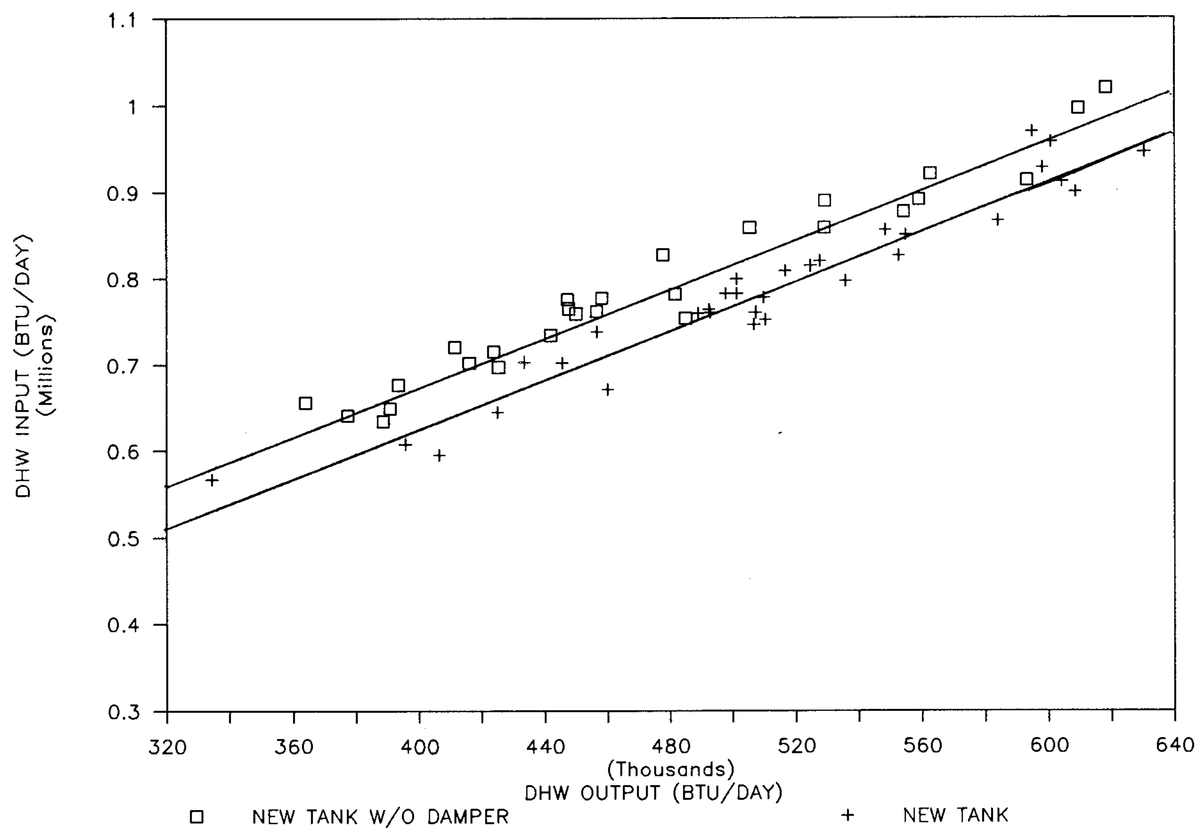

FIGURE 1. Performance of new tank water heater.

REFERENCES

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