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must have water conditions with less than 11 grains of hardness

savings falls far short of a payback

COVER STORY

Tankless vs. Tank Type Storage Water Heater Efficiency Comparison Testing

January 7, 2005

Find out where tankless water heaters offer the best efficiency from testing done by a provider of both tankless and tank-type units.

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The recent increase in popularity of tankless water heaters, alternately known as instantaneous, has given rise to claims of super efficiency and huge savings on utility bills. While no single water heater type is a panacea for every application, each should have its place in the engineer's and contractor's arsenal.

The ongoing, recent fascination with tankless water heaters prompted Bradford White Corp., the provider of the EverHot® line of tankless water heaters, to initiate head-to-head comparison testing. The hypothesis was that because of the recent increases in minimum DOE efficiency requirements for tank-type models, the disparity might not be as wide as previously claimed. Inside their state-of-the-art research and development facility in Middleville, MI, four water heaters were efficiency-tested under exactly the same conditions.

Background

Bradford White engineers designed a test based upon information in ASHRAE Project Report #1172. Test parameters simulate hot water usage for a family of four in a 2,100-sq.-ft., two-bathroom residential unit. Additionally, testing took into account the popularity of whirlpool tubs and master baths.

Testing was also designed to reflect the standard peak hour demand times of morning and evening when a family of four is most likely at home. It also reflected a rise in demand on weekends. Overall, test conditions were set to mimic as closely as possible the actual hot water requirements of a typical contemporary household (748 gallons/week).

BRADFORD WHITE'S RESEARCH AND DEVELOPMENT LABORATORY IN MIDDLEVILLE, MI, ENCOMPASSES NEARLY 12,000 SQ. FT. AND IS DEDICATED COMPLETELY TO THE DEVELOPMENT AND TESTING OF WATER AND HYDRONIC HEATING PRODUCTS.

Products selected for the test included Bradford White's M-I-40T6FBN (Residential Energy Saver Natural Gas Upright—40,000 Btu) and M-4-40T6FBN5 (Residential Energy Saver Natural Gas Upright with two inches of non-CFC foam insulation —40,000 Btu), a standard model tankless water heater (Tankless #1) of 117,000 Btus with a standing pilot, purchased at a retail home center, and a higher end tankless model (Tankless #2) with 180,000 Btus and a direct spark ignition (no pilot) system. Tankless #2 was also power-vented with a modulating combustion blower and used a more sophisticated electronic control system than the mechanically modulating gas valve used in Tankless #1. Tankless #2 also required 120 VAC electrical power as part of the installation.

Test Set Up

The cold-water inlet temperature for testing was approximately 58˚F. The water was classified as hard with over 15 grains of hardness. The tankless water heaters were "de-limed" by circulating vinegar through the coil for one hour between the two-week tests. The efficiency declined somewhat as scale accumulated in the heat exchanger coil. All thermostats were set to provide an average outlet water temperature of 130˚F. The outlet water temperature of the storage water heaters varied more from the average tank setting, but the outlet water did not drop below 120˚F during most of the draws.

Inlet and outlet water temperatures were measured regularly, with readings recorded 15 seconds after the start of the draw and every 5 seconds thereafter. The water use was measured using calibrated water meters. Gas use was measured with calibrated gas meters. The barometer and gas temperatures were measured and recorded for correction factors to the cubic feet of gas used. The calculations were very straightforward. The heat delivered by the water heater (hot water draws) was divided by the heat input of the gas used.

After a two-week test interval, test stations were switched between the two storage water heaters and tankless water heaters to account for any differences in the instrumentation. The results of the two tests were averaged for the final result.

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Test Results

The test results for the storage water heaters showed a considerably higher energy factor (0.6714 for MI40T and 0.6917 for M440T) than previously seen in the 24-hour DOE Simulated Use Test. This was most likely a result of the test's higher overall hot water consumption, which is more typical of common household use. ASHRAE Project Report #1172 supports higher consumption rates. The simpler method of calculating the energy factor did not bias the standby loss or recovery portion of the test.

TANKLESS WATER HEATERS FROM BRADFORD WHITE HAVE MAXIMUM INPUTS RANGING FROM 180,000 TO 199,000 BTUS.

The Tankless #1 unit tested only slightly higher, with an average energy factor of 0.7091. The standing pilot proved to be a disadvantage for this model. Unlike storage water heaters, the standing pilot represents a complete energy loss during idle periods and contributed to the lower energy factor compared with Tankless #2. The energy factor for Tankless #1 represented only a 2.5% energy savings (or $8.06 in annual natural gas savings) over the M440T and a 5.3% ($18.00) annual savings over a MI40T. Tankless #2 did have a high average energy factor rating of 0.7999, which represents an annual operating cost savings of $40.14 (about 12.2%) over the M440T model and a cost savings of $50.08 (14.8%) over the MI40T. This cost includes an annual electrical cost of $4.31 to operate the water heater using the national average electrical rate of $0.086 per kilowatt hour.

Testing showed that lime scale build-up is a major concern in hard water areas with tankless water heaters. Lime scale did not flush out of the heat exchanger from the water velocity through the coil, but accumulated in a very short period of time. Lime scale can also accumulate on the base of storage water heaters, but much more gradually, making storage water heaters more tolerant of hard water conditions. Adding a water softener on the water supply would prevent the quick accumulation of scale on the heat exchanger. Tankless #2 started out with a higher efficiency rating, but dropped off for the two-week period of operation due to scale buildup in the heat exchanger. The efficiency rating could be up to two points higher using softened water. Tankless #1 was less sensitive to scale build-up, but still lost about 1.75% operating efficiency after a two-week period of hard water conditions. Both tankless water heaters have a procedure to remove the lime scale from the heat exchanger by flushing with vinegar using a circulator. This requires at least one hour of service time, adding to the life-cycle cost of the tankless water heaters in hard water areas. To maintain peak efficiency, the tankless models must have water conditions with less than 11 grains of hardness. The MI40T and M440T models did not show a noticeable drop in efficiency during the test program.

Cost Analysis

Cost estimates were obtained from professional contractors throughout the country for installing the MI40T and Tankless #2. Total installed costs included price of water heater, materials and labor. The tank-type MI40T model averaged a final cost of $850.00. This cost estimate included the average cost for a venting system and plumbing work where a water heater was not previously installed (new construction).

A comparable cost estimate for installing Tankless #2 is broken into segments as follows:

- Replacement of tank-type products versus new construction.
- Indoor units versus outdoor units.

For new construction, the average labor costs can be $350 to $500, with the price for the water heater as high as $1,000. These costs would cover installation of the outdoor unit. The cost for the venting materials for the indoor unit can run anywhere from $100 to $250, depending on venting distance and configuration. The necessary pipe thread installation kit, including the pressure relief valve, shut-off valves and other materials, is about $100. The total estimated installation cost for Tankless #2 indoor model in new construction was approximately $700. Including the cost of the unit, the total price for an indoor unit installation in new construction would be about $1,700. Installation costs for a replacement of a tank-type water heater with a tankless model would increase dramatically when larger gas piping is required. Installation costs can be as much as $1,000 higher for a replacement installation, pushing the total cost with indoor unit, venting material, labor and installation kit to as high as $2,500.

An average cost estimate for replacing a MI40T using an existing B venting system is about $560.00. Tankless #1 was purchased from a retail home center for a cost of $485. The installation cost is comparable to that of Tankless #2. Tankless #1 required through-the-roof venting 5" diameter B vent or connection to a chimney. In some cases, the present venting system may not be adequate for the water heater requiring a separate venting system. This will add to the installation cost dramatically. The tankless water heaters will require some gas pipe plumbing to increase the size of the pipe to the water heater to 3/4" diameter. In some cases, where the gas supply piping does not have excess capacity due to the other appliances in the building, the pipe and meter size into the building may have to be increased, also adding to the installation cost.

The operating cost savings for Tankless #2 over a M440T is $603.14 over 12 years, assuming a 4% inflation rate for energy costs. It also assumes that the water system has been softened or that Tankless #2's heat exchanger is periodically de-limed. This savings falls far short of a payback. The venting system material cost makes the economics unfavorable over a storage water heater for residential use. The service costs are an unknown factor for tankless products over this 12-year period. The Tankless #2 heat exchanger has a 10-year warranty, provided the water conditions meet the warranty requirements of fewer than 11 grains for hardness. If any servicing is required, the repair cost is likely to be higher due to the complexity of the controls and higher skill levels required for diagnosing problems.

General Summary

The testing showed that tankless water heaters can save more energy when compared to storage water heaters. However, the energy savings are dependent on the system design and water usage (see Figure 1). Efficiency differences become greater in single-person households with relatively low water usage due to the higher standby loss of a storage water heater. A higher water usage rate may increase the level of energy (cost) savings necessary to offset the cost of the tankless water heaters.

The best application for a tankless model is where long continuous hot water draws are required, as long as draws do not exceed the capacity of the water heater (Tankless #2 was rated 4 gpm at 77˚F rise) and where installation space is limited or an outdoor installation is desired.

There is no doubt that tankless water heaters are benefiting from an increase in popularity and are providing fine service in selected applications. The higher Btu inputs and improved design features of today's tankless models are vastly superior to those on the scene decades ago. However, many prevalent field conditions can work against operational efficiencies to reduce output, and thereby reduce customer satisfaction. Despite the specific application requirements, the importance of tankless technology and the installation flexibility it allows cannot be understated. Therefore, Bradford White continues to educate engineers and contractors across the country regarding best applications and the proper installation and maintenance of tank-type and tankless water heaters.

Figure 1

ANNUAL OPERATING COST BASED UPON THE WATER HEATER ENERGY FACTOR, WATER USAGE OF 748 GALLONS/WEEK, AN AVERAGE INLET TEMPERATURE OF 58˚F, OUTLET TEMPERATURE OF 130˚F, AND THE

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AVERAGE NATIONAL NATURAL GAS COST PER THERM (100,000 BTU) OF $0.91. TANKLESS #2 WATER HEATER INCLUDES THE ELECTRICAL CONSUMPTION USING THE NATIONAL ELECTRICAL COST OF $0.086 PER KW/HR.

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