APPENDIX D-6. METHOD FOR DETERMINING THE INPUT ENERGY CONSUMPTION OF SIDE ARM GAS STORAGE WATER HEATER DESIGNS

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Because the TANK simulation model cannot simulate the performance of water heaters equipped with side arm heaters, the WHAM energy calculation method was used to estimate its energy performance.[1] If both the energy factor and recovery efficiency are known, WHAM can determine the UA of the water heater and, in turn, its energy consumption. According to the WHAM energy calculation method, the equation for determining the average daily energy input is as follows:

$$Q_{in} = \frac{vol \cdot dens \cdot C_p \cdot (T_{tank} - T_{in})}{RE} \cdot \left[1 - \frac{UA \cdot (T_{tank} - T_{amb}}{P_{on}} \right] + 24 \cdot UA \cdot (T_{tank} - T_{amb})$$

where;

Q_{in} = average daily energy input,
RE = recovery efficiency from test procedure,
UA = standby heat loss coefficient from test procedure,
P_{on} = rated input,
vol = average volume of water drawn in 24 hr,[5]
$dens$ = density of water,
C_p = specific heat of water,
T_{tank} = tank thermostat set point,
T_{in} = inlet water temperature, and
T_{amb} = ambient air temperature surrounding the water heater

Because the energy output (the energy delivered to the water) can be expressed as

$$Q_{out} = M \cdot C_p \cdot (T_{tank} - T_{in})$$

where;

Q_{out} = daily energy output, and
M = $vol \cdot dens$,

the daily energy input can be expressed as follows:

$$Q_{in} = \frac{Q_{out}}{RE} - \frac{Q_{out} \cdot UA \cdot (T_{tank} - T_{amb})}{RE \cdot P_{on}} + 24 \cdot UA \cdot (T_{tank} - T_{amb})$$

The energy factor (*EF*) is the ratio of the energy output (Q_{out}) to the energy input (Q_{in}). Thus, using the above expression for Q_{in}, as well as DOE test procedure values of 135EF (57.2EC), 67.5EF (19.7EC), and 41094 Btu (43356 kJ) for T_{tank}, T_{amb}, and Q_{out}, the energy factor can be expressed with the following equation:

$$EF = \frac{RE \cdot P_{on}}{P_{on} + UA \cdot 67.5 \cdot \left[RE \cdot P_{on} \cdot \frac{24}{41094} - 1 \right]}$$

Solving the above expression for UA yields the following equation:

$$UA = \frac{P_{on} \cdot \left[\frac{RE}{EF} - 1 \right]}{67.5 \cdot \left[RE \cdot P_{on} \cdot \frac{24}{41094} - 1 \right]}$$

Thus, knowing EF and RE and assuming DOE test procedure values for T_{tank}, T_{amb}, and Q_{out}, the UA can be determined. With UA established, the daily energy input, Q_{in}, can be calculated. This was the procedure used for establishing the total daily energy input for water heaters equipped with side arm heaters.

REFERENCE

1. Lutz, J., C. D. Whitehead, A. Lekov, D. Winiarski, and G. Rosenquist, WHAM: A Simplified Energy Consumption Equation for Water Heaters. In *1998 ACEEE Summer Study on Energy Efficiency in Buildings*. 1998. Asilomar, CA, August 23-28, 1998: American Council for an Energy-Efficient Economy. 1: p. 1.171-1.183.