ELECTRIC WATER HEATER STANDBY LOSSES: COMPARISON OF CONSERVATION STRATEGIES AND THEIR ENERGY SAVINGS

Calvin W. Ek, P.E. and C. Douglas Auburg, P.E., CEM
Bonneville Power Administration

ABSTRACT

An examiniation of the standby energy losses of conventional and high efficiency electric water heaters, including a comparison of losses resulting from various piping configurations. Pipe configurations are representative of high level and low level piping found in garage, crawlspace and basement water heater installations. Savings resulting from retrofit insulation wraps, insulated bases, insulated piping and anticonvection valves are compared.

Estimates of savings associated with the use of an energy-efficient water heater compared to a conventional one averaged 46 percent, with projected annual savings of 481 kWh. For tanks with an external insulation blanket, the energy-efficient tank saves approximately 28.5 percent, with projected annual savings of 168 kWh.

Additional energy losses due to overhead and low-level piping ranged from 12-1/2 percent for the conventional tank to 20 percent for the high efficiency tank when compared to the bare-tank standby loss condition. However, piping losses were found to be reduced by approximately 50 percent by the installation of pipe insulation, or approximately 40 percent by the use of anticonvection valves.

Under-tank board insulation can achieve 53 kWh annual savings, and R-11 external wrap can save 168 to 502 kWh per year for energy-efficient and conventional water heaters respectively.

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INTRODUCTION

Standby energy losses from electric domestic water heaters represent a significant portion of the total electrical energy consumed in a home. Annual energy consumption due to tank standby losses can range up to 1500 kWh, depending upon the tank location, temperature setting, etc.

A series of tests to evaluate tank losses under varying conditions of piping and conservation strategies was conducted in order to develop empirical data for use in utility conservation program planning.

Tests performed on both a typical conventional water heater and a typical high-efficiency water heater included: bare tank standby losses (without any piping in place), retrofit external insulation (R-11), under-tank insulation (R-7.2), low-level and overhead piping (simulating typical installation patterns), and pipe loss control techniques using anticonvection valves and external pipe insulation (R-2.6).

Measurements of delivered water temperature using various piping configurations were also examined. A water-use sequence was selected to approximate the use pattern of a typical kitchen dishwasher.

A series of seventeen tests was designed to determine the incremental effects of the conditions listed above. A bare tank was chosen as the basic test condition since it represents a minimum-possible heat loss situation. As a result savings associated with various piping schemes in Table II are expressed as negative numbers (i.e. they are additional losses to the bare tank loss). Testing commenced in September, 1983 and concluded in April, 1984. A total of 117 days of measured losses formed the basis for comparing the seventeen test configurations. Testing was done in the basement of the Mangan Mechanical Test Laboratory at the Bonneville Power Administration's Ross Complex in Vancouver, Washington.

DISCUSSION

Materials and Equipment

Water heaters The water heaters used for the tests were 52-gallon domestic dual-element (4000W) heaters with the following characteristics:

	Height	Diameter	Radial Insulation	Top Insulation	Bottom Insulation
Standard Tank	49.5 in.	21 in.	1.5 in. fiberglass	1.12 in. fiberglass	none
Energy-Efficient Tank*	49.5 in.	23 in.	2.5 in. urethane	3.00 in. urethane	2.0 in. fiberglass

*Rated at "R-20 Insulated Factor" by manufacturer.

Anti-convection valves The in-line anti-convection valves contained plastic liners and balls which provided a one-way check valve in the inlet and outlet ports of the tanks. The valve body was of a copper-based alloy, and was supplied with 3/4 inch male pipe threads on each end. The manufacturer's claim was "up to 12% reduction in standby heat loss."

Pipe insulation Commercially available closed-cell rubber tubing with a nominal wall thickness of 0.75 inch was installed. Material density was listed as 4.5-8.5 pounds per cubic foot. Thermal conductivity was listed by the manufacturer as 0.28 Btu/hr ft^2 °F/in at a temperature of 75°F.

Under tank insulation A nominal one-inch thick foil-covered insulation board was used. The material was polyurethane. The manufacturer's marking showed a rating of R-7.2 at 75°F. The material is commercially available in 4 x 8 foot sheets.

Clock/Timer A 24-hour electro-mechanical timer with adjustable switching tabs was used to de-energize the tanks during test number 2. The timer was capable of carrying the current load to both water heaters simultaneously. The timer was set for an "off" period from 10 p.m. until 5 a.m. each day.

Watt-hour meter A General Electric IB-10 Watt-hour Meter Standard was used in each tank circuit to record the cumulative power consumption during each test. The meters are accurate to within 0.1 percent. A manual re-set allows each test to begin with a zero meter reading.

Ambient temperature recorder A 7-day recording thermograph was used to monitor ambient temperature.

Water thermometer A portable thermocouple-type digital thermometer with a immersion probe was used to measure the water temperature through the outlet port of the tank. The accuracy and resolution of the thermometer was ± 1°F.

Chart recorder A 2-channel strip chart recorder was used to monitor the time of energization. Clamp-on ammeter probes on the wiring to the two tanks provided input signals to activate the recorder pens during power use. With a chart speed of 1mm/minute energization times could be determined to within one minute, allowing accurate calculation of elapsed standby time between energizations.

Hot Water Use: Delivered Water Temperature

A water use sequence typical of a kitchen dishwasher cycle was selected for a comparison of bare pipe, insulated pipe, and piping equipped with anticonvection valves. The objective of this series of tests was to determine the effect of short-term standby periods on the temperature of the subsequent water use. The kitchen dishwasher cycle was selected for the test sequence due to the high temperature requirements required for satisfactory washing of dishes and utensils soiled with cooking oils and grease.

Three two-gallon water draws were made with standby times of seven and three minutes, respectively, between draws. Temperatures of the mixed two-gallon volumes were recorded, as well as the temperature of the delivered water at the end of the draw.

It is apparent that simple pipe insulation is quite effective in reducing thermal losses from hot water pipes between water draw intervals. In terms of overall water heating efficiency, this technique not only reduces long-term standby losses by about 50%, but also raises the delivered water temperature by a significant amount after short-term standby periods.

For the kitchen dishwasher cycle, the 2 degree increase in wash water temperature on the second draw may be significant for improved performance of the dishwasher.

Ambient Temperature Variations

It should be pointed out that the test results have been adjusted to conditions of 140°F water temperature and 70°F ambient, unless otherwise noted. The tabulated standby losses are normalized to watts per degree temperature differential, and are considered linear with temperature. Therefore, by applying the local temperature conditions (both water and air) the standby loss can be calculated in watts.

RESULTS

Tank Losses

Tables I and II show tabulated results of standby losses for all tests.

Losses for both the standard tank and the efficient tank are shown in Table I in units of watts per degree Fahrenheit temperature differential between the water and ambient. Losses have been annualized for three levels of temperature differential.

Similarly, annual savings comparisons between the various conservation measures are shown in Table II in the same units as in Table I. Savings have likewise been annualized for three levels of temperature differential.

Losses or savings associated with any other level of temperature differential may be obtained by a simple multiplication of the appropriate value in watts/°F (in Tables I and II) by the factor: (8760 x desired temp. diff.) - 1000.

Figure 1 shows a graphical presentation of the average effects of external R-11 tank insulation, under-tank insulation, and pipe insulation on standby losses of both the standard and energy-efficient tanks. The base condition for Figure 1 is a bare tank on a concrete floor, with fifteen feet of both inlet and outlet piping installed.

Conservation Measures - Tank

R-11 External Insulation. As shown in Table II, the average effect of an R-11 insulation blanket installed on a standard 52 gallon water heater is a reduction of standby loss equivalent to 0.8185 watts per degree. This represents annual savings of 502 to 645 kWh for temperature differentials of 70 and 90 degrees respectively. Standard tank standby losses can be reduced by approximately 48 percent through the use of an R-11 blanket.

Savings achieved by wrapping an "energy-efficient" tank were 0.2740 watts per degree. Annual savings of 168 to 216 kWh can be realized at temperature differentials of 70 and 90 degrees respectively. Standby losses for the efficient tank can be reduced by approximately 30 percent by application of an R-11 blanket.

It was found that losses from a standard tank with an R-11 blanket were nearly equal to the losses from an un-wrapped efficient tank.

Under-tank Insulation. The addition of a one-inch thick polyurethane foil-lined board under the tanks resulted in average savings of 0.0858 watts per degree. Average annual savings of 53 to 68 kWh are projected for temperature differentials of 70 and 90 degrees.

Experimental error due to varying temperatures, etc., may explain why the observed savings range from nearly zero to 0.1416 W/°F.

Circuit Clock/Timer

It was found that the use of a circuit timer to de-energize the water heater tank elements from 10 p.m. until 5 a.m. each day resulted in very small reductions in standby losses. Under no-flow conditions, the effect of the timer was simply to delay the energization of the tanks until 5 a.m., allowing the average tank temperature to drop slightly during the night.

As expected, the energy-efficient tank maintains its temperature for an extended period between energizations, typically about 8 hours under no-flow conditions. For this reason, the timer would have little or no effect on standby losses when the tank is energized just prior to 10 p.m. This is in fact what happened during the test. The standard efficiency tank cycled more frequently than the other, resulting in higher savings.

Piping Losses

Losses due to exposed copper piping were found to average 0.2045 W/°F with fifteen feet of horizontal piping installed. Both inlet and outlet pipes were used. Very little (less than 4 percent) difference was observed between overhead piping and low level piping. Approximately fifteen percent more pipe loss was observed for the standard tank than for the energy efficient tank.

Losses observed with low level piping, which represents typical crawl-space piping, ranged from 0.1031 to 0.2624 watts per degree. Overhead piping, representing a typical basement installation, had losses ranging from 0.1422 to 0.2271 watts per degree. Tabulated piping losses are shown in Table II.

Conservation Measures - Piping

Anticonvection Valves. Anticonvection valves, sometimes referred to as "heat trap" valves, were installed between the water heaters and the connected piping. Commercially-available valves with gravity-activated ball poppets were used to restrict the convective flow of water in both inlet and outlet pipes.

With 30 feet of bare copper inlet and outlet piping, the anticonvection valves resulted in average power savings of 0.0814 W/°F. Annual savings of 50 to 64 kWh are projected for temperature differentials of 70 and 90 degrees.

Anticonvection valves appear to reduce pipe losses by approximately 40 percent compared with bare pipe losses.

Overhead and low-level piping appeared to benefit an equal amount by the use of anticonvection valves.

Pipe Insulation. The addition of 3/4 inch thick tubular closed-cell pipe insulation on the inlet and outlet pipes reduced the pipe losses by 0.1046 W/°F. The insulation has a manufacturer claimed "k-value" of 0.28 Btu/hr ft^2°F/in at a temperature of 75° F.

Projected annual savings of 64 to 82 kWh are made for temperature differentials of 70 and 90 degrees.

Delivered Water Temperatures

A water-use sequence typical of a kitchen dishwasher rinse-wash-rinse cycle was selected as follows:

Time (minutes)	Flow Rate (gpm)
0-1	2
1-8	0
8-9	2
9-12	0
12-13	2

Average results of tests using bare pipe, anticonvection valves, and pipe insulation were as follows (also see Figure 2):

Initial water draw. With normalized conditions of 140°F water and 70°F ambient, the initial two-gallon mixed temperature was 115.5°F with anticonvection valves, 117.8°F with pipe insulation installed, and 118.7°F for bare pipe. Since the volume of water in 20 feet of 3/4 inch copper piping is about 3/8 gallon, the initial water draw is significantly affected by the temperature of the pipe prior to the first draw. The above pattern is to be expected, since the nominal temperature of the water in the pipe initially is lower for piping with anticonvection valves.

Second water draw. The effect of the insulation becomes apparent during the second draw. The mixed water temperature was three degrees higher in the insulated pipe, when compared with either bare pipe or the anticonvection valved pipe. The latter two were essentially equal, as would be expected, since in both cases the pipe surface was able to radiate freely to the ambient air. In all three instances, the final water temperature was 140°F. The estimated water temperature in the pipe just prior to beginning the second draw is 104°F for both the bare and anticonvection valved pipes and 116.5°F for insulated pipe. These temperatures reflect the standby losses during the transient decay after the first draw. The seven-minute wait period resulted in an estimated drop of 35°F in the exposed copper piping, compared to 23°F in the insulated pipe.

Third water draw. After a three-minute wait period, the 2-gallon mixed temperatures showed 136.5°F with insulated pipes, 136.1°F with bare pipes, and 135.5°F with anticonvection valves. The maximum delivered water temperature in each case was 140°F, the temperature of the water in the water heater tank. The estimated water temperature in the pipes just prior to beginning the third draw is as follows: 121°F for insulated pipe, 119°F for bare pipe, and 115.5°F for the pipe with the anticonvection valve. The temperature drop during the three-minute standby period appeared to be 19°F for the insulated pipe, 21°F for the bare pipe, and 24.5°F for the pipe with an anticonvection valve.

The results shown in tabular form below and in Figure 2 have been normalized to an ambient temperature of 70°F, with a water temperature of 140°F.

	Bare Pipe			A/C Valves			Pipe Insulation		
Water use No.	1	2	3	1	2	3	1	2	3
Max. water temp	139.6	140.0	140.0	139.1	140.0	140.0	139.1	140.0	140.0
2-gallon mixed temp	118.7	133.5	136.1	115.5	133.2	135.5	117.8	135.6	136.5

CONCLUSIONS

Tank Losses

The use of an energy-efficient water heater reduces the average standby losses from 1.711 to 0.926 W/°F. Net savings of 0.785 W/°F can be achieved, for a 46 percent reduction of losses.

R-11 external insulation blankets reduce losses by 0.818 and 0.274 W/°F for the standard and energy-efficient models respectively. Loss reductions are 48 and 30 percent respectively.

The use of an insulation board under the tank saves 0.115 W/°F for the standard model and 0.057 W/°F for the energy-efficient model. Loss reduction is between 6 and 7 percent of the bare tank standby loss.

Circuit Clock/Timer

A clock-timer, used to de-energize the tanks from 10 p.m. until 5 a.m. each day, was found to reduce losses by 0.050 and 0.025 W/°F for the standard and energy-efficient models respectively. The timer served to delay night-time energizations of the tanks until morning. However, the slight reduction of tank temperature during the night resulted in savings of only 3 percent of total standby losses.

It is apparent that for no-flow standby loss reduction, the use of a clock-timer is marginal at best. A more appropriate test sequence would be one which represents a typical household water use pattern, allowing the tank to be de-energized prior to the final hot water use during the day. Under idealized conditions, the upper limit of savings achievable with a clock-timer would be to reduce standby losses to zero for the duration of the "off" time by completely using the last tankful of heated water. A more realistic limit would be to use the last tankful down to about 100°F which would reduce the temperature differential to about 30 degrees over ambient for the off period.

Estimated annual savings under the following conditions are made for the standard and energy-efficient tanks:

Normal water temperature:	140°F
Normal ambient temperature:	70°F
Nighttime "off" period:	7 Hr
Initial tank temperature:	100°F

Annual estimated savings:	200 kW/Hr	Standard tank (unwrapped)
	96 kW/Hr	Standard tank (R-11 wrap)
	115 kW/Hr	Efficient tank (unwrapped)
	70 kW/Hr	Efficient tank (R-11 wrap)

At a marginal power rate of 5 cents per kW/Hr, annual cost savings would range from $3.50 to $4.80 for insulated tanks and from $5.75 to $10.00 for uninsulated tanks.

Pipe Losses

Standby losses from exposed piping averaged 0.204 W/°F. Piping losses were approximately 12 percent of the losses from a standard un-wrapped tank, and approximately 22 percent of the losses from an energy-efficient tank. No significant difference was observed between basement (overhead) and crawl space type plumbing.

Pipe insulation appears to reduce standby pipe losses by over 50 percent. In addition, pipe insulation appears to be nearly 30 percent more effective than anticonvection valves.

Pipe losses can be reduced with external pipe insulation and with anticonvection valves. Average savings observed with pipe insulation was 0.105 W/°F. Savings observed with anticonvection valves was 0.081 W/°F.

1928A

THE LISTED LOSSES ARE THE ENTIRE TANK FOR EACH LISTED MEASURE.
LOSSES AND SAVINGS ARE FOR TEMPERATURE DIFFERENCES OF 70, 80, AND 90 DEGREES FAHRENHEIT FOR BOTH STANDARD & EFFICIENT TANKS.

Table I - Standby Losses

1	2	3	4	5	6	7	8	9	10
MEASURE NUMBER	INSTALLED MEASURES	LOSSES STANDARD W/DEG F	LOSSES EFFICIENT W/DEG F	DELTA=70 LOSSES STANDARD KWH/YR	DELTA=70 LOSSES EFFICIENT KWH/YR	DELTA=80 LOSSES STANDARD KWH/YR	DELTA=80 LOSSES EFFICIENT KWH/YR	DELTA=90 LOSSES STANDARD KWH/YR	DELTA=90 LOSSES EFFICIENT KWH/YR
WATER HEATER LOSSES - WITHOUT PLUMBING:									
1	NONE	1.7113	.9263	1049.37	568.01	1199.28	649.15	1349.19	730.29
2	UNDER TANK	1.6234	.8127	995.47	498.35	1137.68	569.54	1279.89	640.73
3	1 + R-11	.9844	.6478	603.63	397.23	689.87	453.98	776.10	510.73
4	2 + R-11	.8428	.6475	516.80	397.04	590.63	453.77	664.46	510.49
5	2 + CL TIMER	1.5735	.7879	964.87	483.14	1102.71	552.16	1240.55	621.18
WATER HEATER LOSSES - WITH CRAWLSPACE TYPE PLUMBING:									
6	2 + CRWLSPC	1.8858	1.0647	1156.37	652.87	1321.57	746.14	1486.76	839.41
7	6 + HT TRAPS	1.8128	.9800	1111.61	600.94	1270.41	686.78	1429.21	772.63
8	6 + PIPE WR	1.7764	.9211	1089.29	564.82	1244.90	645.51	1400.51	726.20
9	8 + R-11	.9067	.6445	555.99	395.21	635.42	451.67	714.84	508.12
10	7 + R-11	.9415	.6675	577.33	409.31	659.80	467.78	742.28	526.26
11	6 + R-11	1.0279	.7506	630.31	460.27	720.35	526.02	810.40	591.77
WATER HEATER LOSSES - WITH BASEMENT TYPE PLUMBING:									
12	2 + BASEMENT	1.8246	1.0757	1118.84	659.62	1278.68	753.85	1438.51	848.08
13	12 + PIPE WR	1.7668	.9699	1083.40	594.74	1238.17	679.71	1392.95	764.67
14	12 + HT TRAP	1.8553	.9505	1137.67	582.85	1300.19	666.11	1462.72	749.37
15	12 + R-11	1.0699	.7897	656.06	484.24	749.79	553.42	843.51	622.60
16	15 + PIPE WR	.9652	.7014	591.86	430.10	676.41	491.54	760.96	552.98
17	15 + HT TRAP	.9701	.6603	594.87	404.90	679.85	462.74	764.83	520.58

WATER HEATER MEASURES INSTALLED:

1 = BASIC STANDBY LOSSES (NO TANK MODIFICATION)
2 = ADD INSULATION BOARD UNDER THE TANK
3 = ORIGINAL TANK (NO. 1) = R-11 TANK WRAP
4 = UNDER TANK INSULATION + R-11 TANK WRAP
5 = UNDER TANK + CLOCK TIMER
6 = UNDER TANK + CRAWLSPACE TYPE PLUMBING
7 = UNDER TANK + CRAWLSPACE + ANTI-CONVECTION VALVES (HEAT TRAPS)
8 = UNDER TANK + CRAWLSPACE + PIPE WRAP
9 = UNDER TANK + CRAWLSPACE + PIPE WRAP + R-11 TANK WRAP
10 = UNDER TANK + CRAWLSPACE + ANTI-CONVECTION + R-11 TANK WRAP
11 = UNDER TANK + CRAWLSPACE + R-11 TANK WRAP
12 = UNDER TANK + BASEMENT PLUMBING + NO TANK WRAP
13 = UNDER TANK + BASEMENT + NO TANK WRAP + PIPE WRAP
14 = UNDER TANK + BASEMENT + NO TANK WRAP + ANTI-CONVECTION VALVES
15 = UNDER TANK + BASEMENT + R-11 TANK WRAP
16 = UNDER TANK + BASEMENT + R-11 TANK WRAP + PIPE WRAP
17 = UNDER TANK + BASEMENT + R-11 TANK WRAP + ANTI-CONVECTION VALVES

Table II. Energy Savings

THE SAVINGS ARE DELTAS, CALCULATED FROM THE LOSSES SHEET MEASURES SHOWN IN THE LAST COLUMN

1 MEASURES	2 SAVINGS STANDARD W/DEG F	3 SAVINGS EFFICIENT W/DEG F	4 DELTA=70 SAVINGS STANDARD KWH/YR	5 DELTA=70 SAVINGS EFFICIENT KWH/YR	6 DELTA=80 SAVINGS STANDARD KWH/YR	7 DELTA=80 SAVINGS EFFICIENT KWH/YR	8 DELTA=90 SAVINGS STANDARD KWH/YR	9 DELTA=90 SAVINGS EFFICIENT KWH/YR	10 CALCULATE SAVINGS AS SHOWN BELOW
SAVINGS FOR WATER HEATERS WITHOUT PLUMBING:									
UNDER TNK	.0879	.1136	53.90	69.66	61.60	79.61	69.30	89.56	(1-2)
	.1416	.0003	74.42	0.18	99.23	0.21	111.64	0.24	(3-4)
	.0900	.0436	55.19	26.74	63.07	30.55	70.96	34.37	(1-2)*
CL TIMER	.0499	.0248	30.60	15.21	34.97	17.38	39.34	19.55	(2-5)
R-11 TK WR	.7269	.2785	445.74	170.78	509.41	195.17	573.09	219.57	(1-3)
	.7806	.1652	478.66	101.30	547.04	115.77	615.43	130.24	(2-4)
AVG R-11 WR	.7538	.2219	462.23	136.07	528.26	155.51	594.30	174.95	R-11 AVG
SAVINGS FOR CRAWLSPACE PLUMBING:									
CS PLMBG	-.2624	-.252	-160.90	-154.53	-183.89	-176.60	-206.88	-198.68	(2-6)
	-.1851	-.1031	-113.50	-63.22	-129.72	-72.25	-145.93	-81.28	(4-11)
HEAT TRAPS	.073	.0847	44.76	51.94	51.16	59.36	57.55	66.78	(6-7)
	.0864	.0831	52.98	50.96	60.55	58.24	68.12	65.52	(11-10)
PIPE WR	.1094	.1436	67.08	88.06	76.67	100.63	86.25	113.21	(6-8)
	.1212	.1061	74.32	65.06	84.94	74.35	95.55	83.65	(11-9)
R-11 WR	.8697	.2766	533.30	169.61	609.49	193.84	685.67	218.07	(8-9)
	.8713	.3125	534.28	191.63	610.61	219.00	686.93	246.38	(7-10)
	.8579	.3141	526.06	192.61	601.22	220.12	676.37	247.64	(6-11)
AVG R-11 WR	.8663	.3011	531.22	184.63	607.10	211.01	682.99	237.39	AVG R-11
SAVINGS FOR BASEMENT PLUMBING:									
BSMT PLMBG	-.2012	-.263	-123.38	-161.27	-141.00	-184.31	-158.63	-207.55	(2-12)
	-.2271	-.1422	-139.26	-87.20	-159.15	-99.65	-179.05	-112.11	(4-15)
HEAT TRAPS	.0998	.1294	61.20	79.35	69.94	90.68	78.68	102.02	(15-17)
	-.0307	.1252	-18.83	76.77	-21.51	87.74	-24.20	98.71	(12-14)
PIPE WRAP	.1047	.0883	64.20	54.15	73.37	61.88	82.55	69.62	(15-16)
	.0578	.1058	35.44	64.88	40.51	74.14	45.57	83.41	(12-13)
R-11 WRAP	.7547	.286	462.78	175.38	528.89	200.43	595.01	225.48	(12-15)
	.8016	.2685	491.54	164.64	561.76	188.16	631.98	211.69	(13-16)
	.8852	.2902	542.80	177.95	620.35	203.37	697.89	228.79	(14-17)
AVG R-11 WR	.8138	.2816	499.02	172.68	570.31	197.35	641.60	222.01	AVG R-11
COMBINED AVERAGE SAVINGS FOR ALL TANK CONFIGURATIONS:									
AVG HEAT TRP	.057125	.1056	35.03	64.75	40.03	74.00	45.04	83.26	
AVG PIPE WRP	.098275	.11095	60.26	68.03	68.87	77.75	77.48	87.47	
AVG R-11 WRP	.8184875	.27395	501.90	167.99	573.60	191.98	645.30	215.98	
AVG UNDR TNK	.1065	--	64.63	--	73.87	--	83.10	--	
AVG UNDR TNK	--	.0525	--	31.86	--	36.41	--	40.97	

*DATA FROM REPEAT TEST, NOT ON DATA SHEETS

ELECTRIC WATER HEATER STANDBY LOSSES. WATTS PER DEGREE F.

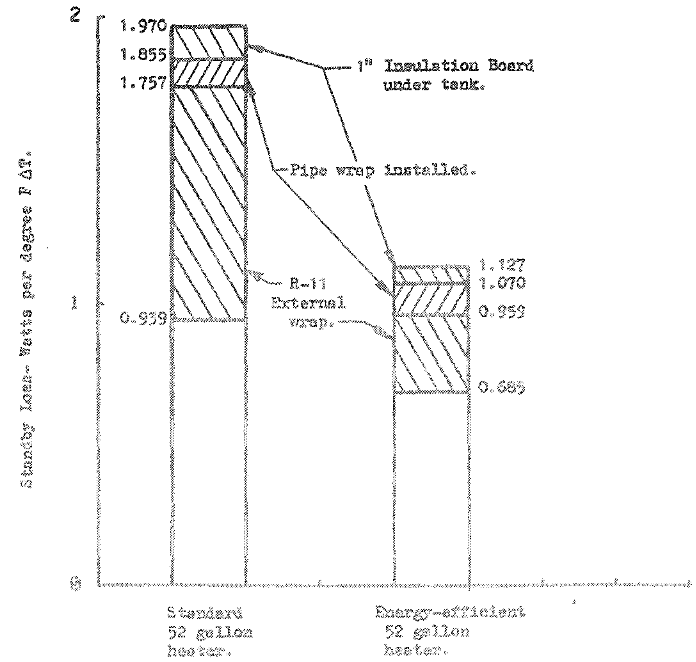
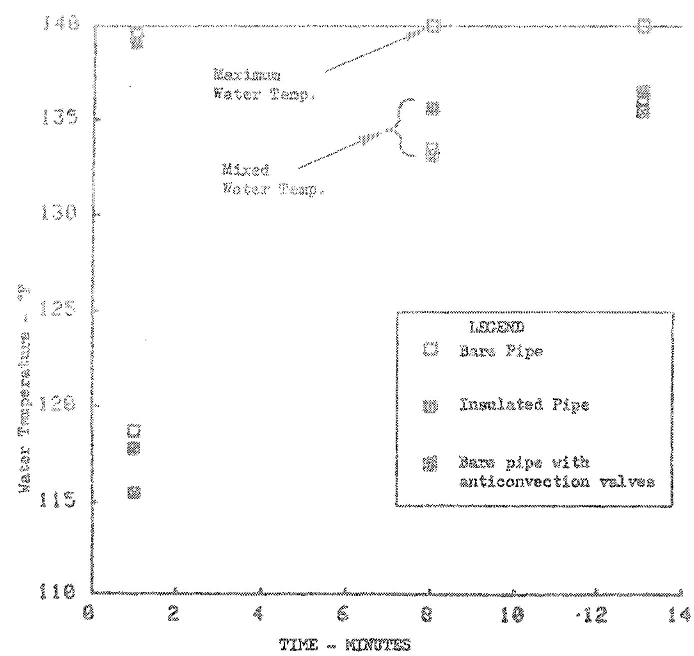


FIGURE 1

Maximum Delivered Water Temperature and Mixed Water Temperature for Three 2-Gallon Water Draws at Selected Intervals.



NOTE: Test data normalized to 140°F tank temperature and and 70°F ambient.

FIGURE 2

BPA 787 A
REV 9-79

U.S. DEPARTMENT OF ENERGY
BONNEVILLE POWER ADMINISTRATION
DATA SHEET A

PAGE ____ OF ____

TESTED BY C. Ek DATE 9/83 to 4/84 LR NO. 45811

APPARATUS TESTED 52 gallon electric water heater - Standard efficiency model.

SUMMARY DATA

Test No.	Total Energy (Whr)	Test Duration (hr)	Avg. Power (W)	Avg. Water Temp (°F)	Avg. Air Temp (°F)	Avg. Temp Diff. (°F)	Standby Loss (W/°F)
1	46669.2	376.13	124.07	140.0	67.5	72.5	1.7113
2	34186.6	284.57	120.14	140.0	66.0	74.0	1.6230
3	6969.1	95.67	72.85	138.5	64.5	74.0	0.9844
4	11818.1	215.73	65.74	140.0	62.0	78.0	0.8428
5	36241.6	311.25	116.44	140.0	66.0	74.0	1.5735
6	24600.0	168.32	146.15	140.0	62.5	77.5	1.8858
7	17378.4	120.58	144.12	140.0	60.5	79.5	1.8128
8	29569.8	195.55	151.21	140.0	54.9	85.1	1.7764
9	12017.2	170.56	70.45	138.5	60.8	77.7	0.9067
10	12005.4	161.40	74.38	140.0	61.0	79.0	0.9415
11	9993.2	123.85	80.69	140.0	61.5	78.5	1.0279
12	10140.2	71.25	142.32	140.0	62.0	78.0	1.8246
13	9770.8	70.90	137.81	138.5	60.5	78.0	1.7668
14	10332.4	72.80	141.93	140.0	63.5	76.5	1.8553
15	10906.4	135.93	80.24	138.5	63.5	75.0	1.0699
16	8726.3	120.55	72.39	138.5	63.5	75.0	0.9652
17	8280.5	111.58	74.21	140.0	63.5	76.5	0.9701
Overall Average		116.94 days	106.77			77.0	1.3868

FIGURE 3 -- SUMMARY DATA

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TESTED BY C. Ek DATE 9/83 to 4/84 LR NO. 45811

APPARATUS TESTED 52 gallon electric water heater - High efficiency model

SUMMARY DATA

Test No.	Total Energy (Whr)	Test Duration (hr)	Avg Power (W)	Avg. Water Temp (°F)	Avg. Air Temp (°F)	Avg. Temp Diff. (°F)	Standby Loss (W/°F)
1	24948.0	376.65	66.24	138.5	67.0	71.5	0.9263
2	16446.0	279.12	58.92	138.5	66.0	72.5	0.8127
3	4619.4	96.34	47.95	138.5	64.5	74.0	0.6478
4	10580.6	213.62	49.53	138.5	62.0	76.5	0.6475
5	18131.3	317.42	57.12	138.5	66.0	72.5	0.7879
6	13468.4	166.45	80.92	138.5	62.5	76.0	1.0647
7	9152.2	119.73	76.44	138.5	60.5	78.0	0.9800
8	15008.5	194.86	77.02	138.5	54.9	83.6	0.9211
9	8611.4	171.99	50.07	138.5	60.8	77.7	0.6445
10	9964.3	192.62	51.73	138.5	61.0	77.5	0.6675
11	7181.4	124.25	57.80	138.5	61.5	77.0	0.7506
12	5668.3	68.88	82.29	138.5	62.0	76.5	1.0757
13	5062.2	66.92	75.65	138.5	60.5	78.0	0.9699
14	4329.4	60.74	71.28	138.5	63.5	75.0	0.9505
15	6996.1	118.10	59.23	138.5	63.5	75.0	0.7897
16	6471.8	123.03	52.60	138.5	63.5	75.0	0.7014
17	6171.0	124.62	49.52	138.5	63.5	75.0	0.6603
Overall Average		117.30 days	62.61			76.0	0.8238