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A TEST METHOD AND CALCULATION PROCEDURE FOR DETERMINING ANNUAL EFFICIENCY FOR VENTED HOUSEHOLD HEATERS AND FURNACES EQUIPPED WITH MODULATING-TYPE CONTROLS MAMONAL BJREAL OF STANDARLS INBLARY DEG 101982 NOT acc. - Ref. QC 100 , USLO 82-2497 1982

Esher Kweller Robert L. Palla, Jr.

U.S. DEPARTMENT OF COMMERCE National Bureau of Standards National Engineering Laboratory Center for Building Technology Building Equipment Division Washington, DC 20234

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

ABSTRACT

As annual operating efficiency of vented heating equipment is affected by burner fuel and combustion air modulation, it is important to differentiate between the various types of controls in determining annual energy requirements. Test procedures for evaluating annual efficiency have already been developed and implemented by the Department of Energy (DoE) for furnaces with single-stage thermostat control. A modified test procedure is necessary to account for operation with fuel modulation. A revised procedure which accommodates two types of fuel modulating controls has recently been developed. Tests are conducted at reduced and maximum firing rates, and along with typical derived values, from a bin analysis of weather data, the fraction of the total hours for each operating mode is obtained to calculate a weighted annual efficiency. These test methods and calculation procedures are based on and are an extension to the current DoE test procedures for the single-stage type of thermostat control of central warm air furnaces.

By using the procedures developed in the report, the energy savings impact of fuel modulating controls when combined with the use of modulated combustion air is evaluated. Energy savings from 6 percent to 20 percent were determined from the increase in efficiency with both fuel and combustion air modulation. Improved efficiency was dependent on the type of thermostat control and the minimum-to-maximum fueled input; i.e., turndown ratio.

Key Words: annual efficiency; household heaters and furnace test procedures; hydraulic thermostat control; modulating control gas-fueled; two-stage thermostat.

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NOMENCLATURE

EFFYA	Annual Fuel Utilization Efficiency, in %
L _{I,OFF}	Off-cycle infiltration loss, in % of the fuel input rate
LI,ON	On-cycle infiltration loss, in % of the fuel input rate
LI,ON,min	On-cycle infiltration loss, in % of the fuel input rate at minimum input rate
L _{I,ON,max}	On-cycle infiltration loss, in % of the fuel input rate at maximum input rate
LL	Latent heat loss, in % of the fuel input rate
Ls,OFF	Off-cycle sensible heat loss, in % of the fuel input rate
Ls,on	On-cycle sensible heat loss, in % of the fuel input rate
LS,SS,A	Sensible heat loss at steady-state operation, in % of the fuel input rate
PF	Ratio of $Q_P \div Q_{in} = pilot$ fraction
Q _{in}	Fuel energy input rate at steady-state operation (including any pilot light input), in Btu/h, Q _{in,min} at minimum input, Q _{in,max} at maximum input rate.
Qout	Fuel energy output rate - Q _{out,min} at minimum input rate, Q _{out,max} at maximum input rate.
QP	Fuel energy input rate to pilot light in Btu/h
t _{OFF}	Off-time per cycle, in minutes
toN	On-time per cycle, in minutes
T _C	Balance point outdoor air temperature
T _{oa}	Average outdoor air temperature applicable to heater operation at minimum firing rate
Toa'	Average outdoor air temperature applicable to heater operation between minimum and maximum rate
T _{RA}	Laboratory room temperature, in °F
n _{ss}	Steady-state efficiency, in % of fuel input rate

η _u	Part-load fuel utilization efficiency, in %
α	Oversizing factor
^ŋ ss,min	Steady-state efficiency at minimum input rate
ⁿ ss,max	Steady-state efficiency at maximum input rate
ⁿ ss,hi	Average steady-state efficiency between minimum and maximum input rates
ⁿ ss,wt	Weighted average steady-state efficiency
^η μ, ε ο	Part load efficiency at the minimum input rate
^η μ,hi	Part load efficiency at the maximum input rate for two-stage thermostats or for the non-cycling mode for step-modulating thermostats
η _μ ,WT	Weighted part-load efficiency
R _{lo}	Percentage of operating time at the low input firing rate
R _{hi}	Percentage of operating time in the non-cycling mode

1. INTRODUCTION

As annual operating efficiency of vented heating equipment is affected by burner operating modes, it is important to differentiate between the various types of controls in determining annual energy requirements. Test procedures for evaluating annual efficiency have already been developed and implemented by the Department of Energy (DoE) for heaters with single-stage control [3]*. For two-stage and step-modulating units, however, a modified test procedure is necessary to account for operation at multiple firing rates. A revised procedure which accommodates modulating-type units has recently been developed and recommended to DoE [1, 2]. A detailed review of the background for the recommendations of tests for modulating heaters in that procedure is the subject of this report.

Modulating controls investigated in this study are generally used with vented household heaters other than furnaces. However, the methods of test and the bin analysis procedures developed in this report for vented heaters are also applicable to central heating systems using the types of modulating controls described here. The only adjustment that would be needed to these procedures would be to use bin data based on the population of central furnaces in order to arrive at a national average annual efficiency specific to furnaces.

Three types of thermostatic controls are commonly used on automaticallycontrolled heating equipment. These are:

- a. single-stage control, which cycles the heater between full input (100 percent of rating) and off;
- b. two-stage control, which operates in an on-off cycling mode at either maximum input or at some reduced input which can be as low as 20 percent of maximum; and
- c. step-modulating control, which steps on to a low input and then either cycles off and on at the low input if the heating load is light, or gradually increases the heat input to meet any higher heating load that cannot be met with the low firing rate.

Figure 1 illustrates the burner heat output rate and burner on periods (shaded) area) in response to increasing heating loads for each of these three types of controls.

The assumptions made in previous work [4] and as depicted by figure 1 that outdoor temperatures below 65°F would be directly proportional to heating load is valid only in a broad statistical sense. It should be understood that procedures developed here for calculating annual efficiency as well as current DoE test procedures for determining annual efficiency of the conventional type on-off thermostatically controlled heaters is intended for comparison purposes

Numbers in brackets indicate references in section 6.

between equipment tested only under laboratory test conditions. A comprehensive treatment to include internal heat gains, solar radiation, wind, etc., would be needed in order to be valid for small time thermostatic cycling of the installed heating system. These procedures should not be considered as being predictive of the installed annual energy use. It should be understood that a comprehensive treatment of the building and furnace interaction to predict operating costs after installation is beyond the scope of this work.

2. STEP-MODULATING CONTROLS

2.1 MODE OF OPERATION

One representation of the operating mode for the step-modulating type control is its response to room temperature (see figure 2 where room temperature and outlet gas pressure supplied to the burner from the thermostat control are shown).

Under normal operating conditions, as the ambient air temperature surrounding the liquid-filled thermostat sensing bulb drops to point A on figure 2, the control opens to allow minimum fuel flow (point B). When room air temperature rises to point C, the valve closes (point D). Operations on the ABCD rectangle is termed the "cycling" mode.

If more severe weather is encountered while the valve is open to minimum flow (point B), room temperature may continue to drop until point E is reached, at which time any further drop in room temperature would result in an increasing fuel flow. If the heating demand continues to increase with subsequent lower room temperature, fuel flow would gradually increase to maximum flow (from E to G). In another situation, if the heating demand should just equal heater out-put for a prolonged time, the manifold could remain partially open (point F or any other point between low fire and high fire) until the heating demand changes. Operation at the various firing rates from point B to G is termed the "noncycling" mode or modulating mode.

2.2 ENERGY CONSIDERATIONS

In developing test procedures for modulating type heaters, operation in both the cycling and non-cycling modes must be addressed. The importance of addressing both modes separately is apparent when one considers the difference in efficiency between the two modes as illustrated in figure 3. The part-load efficiency curve of figure 3 was plotted using data obtained with a room heater having a maximum rated input of 35,000 Btu/h and minimum adjusted input of 21,000 Btu/h and with a balance point temperature (T_c) of 36°F. (See section 2.2.1 for discussion of T_c .)

Annual efficiency for step-modulating units depends upon several factors including:

- percentage of the heating season operating time in each of the two modes,
- average outdoor temperature for each mode,
- average steady-state efficiency over the various firing rates in the non-cycling mode,
- infiltration loss in the non-cycling mode, and
- part-load efficiency in the cycling mode.

The first two factors can be developed by considering heater sizing and through analysis of representative weather data. The remaining factors are determined via additional test measurements and calculations. Each of the factors is described in detail in the sections that follow.

2.2.1 Percent of Operating Time in Each Mode

Two assumptions provide a basis for defining the percent of operating time spent in each of the two modes: (1) at an outdoor temperature of 65°F, heating requirements no longer exist, and (2) at the outdoor design temperature for vented room heaters of 15°F (see appendix A for development of this value) the heater output rate needed to meet the heating requirement is equal to the maximum heater output rate divided by $(1+\alpha)$ where α is the heater oversize fraction. Here output rate is defined as the product of input rate and steady-state efficiency. A relationship between heater output and outdoor temperature can then be expressed:

$$\frac{Q_{\text{out,max}/(1+\alpha)}}{Q_{\text{out,min}}} = \frac{65-15}{65-T_{\text{c}}}$$
(1)

where

Q_{out,max} is rated maximum output rate, Q_{out,min} is rated minimum output rate.

 T_c is the outdoor temperature where the modulating mode begins (see figure 4). This implies that heating load is a linear function of outdoor temperature. In these test procedures α is assigned a value of zero. Under this assignment, at outdoor design temperature of 15°F the heater operates at maximum firing rate.

A plot of T_c versus the ratio of minimum to maximum output is shown in figure 5 for fixed values of α . The cycling mode (as shown in figure 4) is between outdoor temperature T_c and 65°F. The modulating mode is between T_c and the minimum outdoor temperature, which for household heaters is typically 15°F. Through analysis of typical weather data, the time in each mode can then be defined as a fraction of total heating season degree hours. The analysis involves a bin method calculation of hours in various temperature ranges. The steps in the calculation are presented in the column headings of table 1. See column (14) and columns (1) through (5) of table 1. A graphical example is also shown in figure 6.

2.2.2 Average Outdoor Temperature in Each Mode

The average outdoor temperature in the cycling and non-cycling modes T_{oa} and T_{oa} ', respectively (as shown in figures 7 and 8) are developed from representative national average weather data. Tabulated data and temperature calculations for one city having a 4200 degree day heating season are shown in table 1. The average of calculated values for eight cities and the basis for figures 7 and 8 are presented in table two. The eight cities are listed in appendix, table A2. These eight cities all fall within a range of +5 percent of the national average (heater population weighted) of 4400 degree days.

Referring to table 1, calculation of T_{Oa} and T_{Oa} ' is as follows: for each temperature range, the mean temperature (col. 2) and number of hours spent in the range (col. 3) are determined from a compilation of historial weather data [5]. From this the number of degree hours in each range (col. 5) is obtained. T_{oa} represents the average outdoor temperature between 65°F and T_{c} . To obtain Toa, col. 5 and col. 3 are therefore summed cumulatively (upward in table 1) from $62^{\circ}F$ to T_c yielding col. 6 and col. 7, respectively. For each T_c given in col. 2, col. 6 divided by col. 7 represents the corresponding number of degrees below 65°F. This number is given in col. 8. T_{Oa} (col. 9) is 65°F minus col. 8. The same approach is taken in calculating T_{Oa} ' except that the cumulative summation is from 15°F to T_c rather than from 65°F to T_c . The result of these calculations is a value of T_{oa} and T_{oa} ' for each T_c . A plot of these parameters for the values in table 2 is shown in figure 7. For any given heater, equation (1) can be used to determine T_c , for which values of T_{oa} and Toa' can be obtained from figure 7. Alternatively, equation (1) and the results of the previous temperature calculations can be combined to eliminate the intermediate calculations of T_c . T_{oa} and T_{oa} ' can be obtained from figure 8 where percent of time in cycling modes, T_{oa} and T_{oa} ' (columns 5, 6a, and 6b of table 2, respectively) are plotted vs the min/max heater output ratio (col. 7 of table 2).

2.2.3 Average Steady-State Efficiency

Due to an increase in excess air at below maximum firing rates, there is usually a drop in steady-state efficiency in the non-cycling mode as fuel input rate is reduced. An average steady-state efficiency is, therefore, needed to represent operation in this mode. The average steady-state efficiency is calculated by linear interpolation between the steady-state efficiency at the minimum rated input, which corresponds to temperature, T_c , and the steady-state efficiency at the maximum rated input for the heater, which corresponds to a temperature of 15°F. These efficiencies are determined in accordance with the DoE test procedure using α =0.* The average efficiency (n_{SS}) will correspond to the efficiency when firing at temperture T_{oa} ' and is given by

$$n_{ss} = \left[n_{ss,max} - n_{ss,min}\right] \frac{T_c - T_{oa}'}{T_c - 15} + n_{ss,min}$$
(2)

In general, the arithmetic mean of the steady-state efficiencies may be used in place of equation (2) with a resulting error of about one percentage point.

^{*} The DoE test procedure [3] lists a value of α =0.7 which was applicable to central furnaces, and was originally adopted for use with vented heaters. Since the typical oversize factor is unknown for vented heaters the use of α =0.7 would be arbitrary. In order to reduce the complexity of the calculation procedures for modulating type heaters, a value of α =0 is applied for all calculated efficiencies reported here.

2.2.4 Infiltration Loss in the Modulating Mode

On-period infiltration loss $(L_{I,ON})$ is an energy efficiency debit for heaters using indoor air for combustion and draft hood dilution. The loss of efficiency due to infiltration of outdoor air at T_{Oa} ' (which is subsequently heated to an indoor temperature of typically 70°F) is subtracted from the weighted average steady-state efficiency calculated by the above procedure. Average onperiod infiltration loss is calculated in the same manner as steady-state efficiency. On-period infiltration losses are obtained via the current DoE test procedure [3] and the average infiltration is taken to be the arithmetic mean of the values determined at the maximum and minimum input rates.

3. TEST PROCEDURE AND CALCULATION

3.1 CURRENT TEST PROCEDURE

The current test procedure for determining the annual efficiency of vented heaters [3] applies only to units equipped with single-stage controls. While not directly applicable to modulating-type units, only minor modifications to the procedure are necessary to accommodate these types of controls. A cursory review of the procedure will, therefore, be provided here. A more detailed description of the procedure is provided in references [3, 4].

The existing procedure involves conducting a steady-state performance test on the heater, plus measuring flue gas temperatures at specific times during the heat-up and cool-down from steady-state conditions. Specific measurements at steady-state include flue and stack gas temperature and CO_2 concentration. Two temperature measurements during heat-up and three during cool-down provide the basis for exponential approximations for the temperature-time profiles.

In addition to the above experimental data, a knowledge of several factors describing mass flow rates through the flue and stack during on- and off-periods is required. Values for these factors may be either measured or assigned according to the type of unit under test.

Based upon the experimental data and assigned system factors, thermal losses associated with heater operation are determined. These losses expressed as a percentage of the fuel input rate are:

- LL = Latent Heat Loss due to the presence of uncondensed water vapor in the flue gas.
- L_{S,ON} = On-cycle Sensible Heat Loss due to the venting of combustion products and excess air at a temperature above room temperature.
- $L_{L,ON} = On-cycle$ Infiltration Loss due to heating the on-period combustion and draft control air from outdoor temperature (T_{OA}) to room temperature.
- L_{S,OFF} = Off-period Sensible Heat Loss due to heating the off-period room air discharged at a temperature in excess of the room temperature.
- L_{I,OFF} = Off-period Infiltration Heat Loss due to heating the off-period room air loss from outdoor temperature to room temperature.

Steady-state efficiency is given in terms of latent heat loss, L_L , and on-period sensible heat loss at steady-state, $L_{S,ON,ss}$. Part-load efficiency, n_u , is expressed as a function of the five losses:

$$\eta_{u} = 100 - L_{L} - \frac{t_{on}}{t_{on} + PF \times t_{off}}$$
 (L_{S,ON} + L_{S,OFF} + L_{I,ON} + L_{I,OFF}) (3)

ton = typical on-period time - minutes,

toff = typical off-period time - minutes,

PF = Pilot fraction (as fraction of total fuel input rate).

The part-load efficiency is then combined with the steady-state efficiency (n_{SS}) and pilot fraction to yield the annual fuel utilization efficiency.

EFFYA =
$$\frac{n_{ss} \times n_{u} \times 4400}{n_{ss} \times 4400 + 2.5 \times n_{u} \times PF \times 4600}$$
(4)

where the additional parameters are:

4400 = average annual degree days for vented heaters (see appendix A)

4600 = average non-heating season hours per year that all the energy to the pilot is assumed wasted.

3.2 MEASUREMENTS AND CALCULATIONS FOR HEATERS WITH STEP-MODULATING CONTROLS

For single-stage heaters there is only one fuel input rate at which measurements can be made (the maximum input rate). Modulating-type heaters, however, operate both at reduced firing rate during the cycling mode and anywhere between the reduced and maximum rates during the non-cycling mode. Accordingly, test measurements must be made at the maximum input rate as well as the reduced setting. Since the heater with step-modulating control cycles on-off only at the reduced input rate, all part-load cycling losses must be determined at the reduced input. In addition, to account for operation in the non-cycling mode, as described in sections 2.2.3 and 2.2.4, $L_{S,ON}$ and $L_{I,ON}$ must be determined at maximum fire as well. It is not necessary to know either of the off-cycle losses at high fire ($L_{S,OFF}$ and $L_{I,OFF}$) because no off period loss occurs at that input rate with the step-modulating-type control.

The recommended procedure for calculating the annual fuel utilization efficiency for modulating type heaters essentially involves determination of losses and efficiencies for each of the operating modes -- cycling and noncycling and weighting of these parameters according to the fraction of time spent in each mode.

The procedure for calculating annual efficiency for the step-modulating heaters is summarized below in nine steps. The detailed procedure consisting of 20 steps is included in appendix B, along with a sample calculation. A computer program (FBVH) for conducting the complete calculation applicable to furnaces, boilers, and vented heaters is included in appendix C.

 (a) Determine minimum and maximum heater outputs from the minimum and maximum input rates and measured steady-state efficiency at these two input rates. (For details see steps 1-7 of appendix B.)

- (b) Using minimum/maximum heater output from step (a), determine the percent of heating season in each mode. Find the percent of time in cycling mode from figure 8. Percent of non-cycling mode is 100 percent less the percentage of cycling mode.
- (c) Determine the average outdoor temperature in the cycling mode, T_{oa}, and in the non-cycling mode, T_{oa}', from figure 8 at the point corresponding to the min/max output determined from (a).
- (d) Determine part-load efficiency in the cycling mode using the value of T_{Oa} and the prescribed DoE test procedure [3].
- (e) Determine the average steady-state efficiency in the non-cycling mode. Use the average of steady-state efficiency measured at the maximum and minimum input rates from step (a).
- (f) Determine part-load efficiency in the non-cycling mode by subtracting infiltration loss, L_{I,ON}, from the average steady-state efficiency in step (e). Use T_{oa}', to calculate infiltration loss in the non-cycling mode.
- (g) Determine weighted average steady-state efficiency using steady-state efficiencies at the minimum input rate from step (a) and the average determined for the non-cycling mode from step (e). Weight each by the percent of heating season in each mode (determined from step (b)).
- (h) Determine average part-load efficiency for the heating season using the corresponding part-load efficiencies for the cycling and non-cycling modes and the percent of heating season in each mode.
- Determine annual efficiency using average part-load efficiency and average steady-state efficiency.

3.3 CALCULATIONS FOR HEATERS WITH TWO-STAGE CONTROLS

This type of control cycles the burner at low fire for outside air temperatures between 65°F and T_c and at higher fire for temperatures T_c and below (see figure 1). Evaluation of the annual fuel efficiency of heaters with two-stage controls involves the same test measurements required for step-modulating type units, and only slightly different calculations. The calculations are described in detail in appendix B.

4. IMPACT OF MODULATING CONTROLS ON ENERGY CONSUMPTION

4.1 PRESENT DESIGN

Figure 3 shows that modulating controls will indeed affect annual efficiency as evidenced by the variation in part load efficiency with heating load. As shown, efficiency improves as the heating load is increased. This is due both to a reduction in heater cycling (see Modulating Mode of figure 4) and therefore, off-cycle losses, and also in the higher steady-state efficiency at the higher full input rates. The maximum efficiency of currently designed heaters is realized in the non-cycling mode.

4.2 HEATERS EQUIPPED WITH THERMAL DAMPERS

Measured on-period and off-period stack losses of a room heater with and without a thermal stack damper installed were measured. Detailed test results and data are in tables 3 & 4. Data for damper A is presented graphically in figure 9. See [6] for additional information including description of tracer gas test method use to measure the off period losses. The shaded area represents energy savings due to the damper. Figure 9 shows for that heater, as fuel input rate is reduced from maximum to lower input rates, energy savings due to the damper continuously increase. The significance of these findings is that a test conducted per the DoE test procedure [3] only at the maximum input rate does not reflect the potential energy savings of the thermal type stack damper when it is installed on a heater having a step-modulating or two-stage thermostat control.

A summary of energy savings calculated using the calculation procedure of appendix C for three heaters with three different models of thermal dampers is shown in table 5. Results presented in table 5 show that energy savings is dependent on type of heater and stack damper as well as type of thermostat used, and the reduced fuel input rate of the step-modulating type thermostat.

4.3 HEATERS WITH REDUCED COMBUSTION AIR AT REDUCED HEAT INPUT RATES

Although heaters tested have shown a reduced part-load efficiency at reduced input rates, it is possible that heaters can be designed to use less excess air at the reduced input rate, thereby, actually increasing part-load cycling mode efficiency at the lower rate to above the non-cycling mode operating efficiency. This is possible because at reduced input rates the ratio of heat transfer surface area to combustion products mass flow rate is greater. Test procedures outlined here will allow credit for any such innovative designs that result in reduced excess combustion air at reduced fuel input rate.

The potential for energy savings with reduced excess air has been demonstrated in the laboratory by intentionally reducing the excess air at reduced input rate. The excess combustion air values at a minimum input are presented in table 6 for a heater in "as received" condition and after reducing excess combustion air. Excess air was reduced in these test by using a flue baffle placed in the exit of the heat exchanger. Baffling of the heat exchanger was limited in order not to increase carbon monoxide in the flue gases above the amounts found prior to any restriction of the flue. Data obtained at the maximum firing rate and at the minimum input rate with restricted excess combustion air is shown in table 6.

The effect of reduced excess air on efficiency can be quite significant. As shown in table 6, energy savings of from 6 to 22 percent were calculated.

5. CONCLUSIONS

A procedure for evaluating the annual operating efficiency of vented heating equipment with a step-modulating thermostat or two-stage control has been developed. This procedure is essentially the same as the existing DoE test procedure for vented heaters, but calls for tests and calculations to be performed at maximum as well as minumum firing rates. Analyses of weather data for typical cities, and assumptions concerning heater sizing, provide a means of combining the cycling and non-cycling efficiencies to yield a "weighted" annual fuel efficiency.

This rated annual efficiency is considered to be reflective of the differences inherent with cycling and non-cycling modes of operation which apply with modulating-type controls. Since procedures developed here are an extension of current DoE test procedures, these procedures are believed to be useful for comparing the annual efficiency of heaters with modulating type controls vs the conventional on-of thermostat control used with some types of vented heaters. The bin calculation procedures developed here are also expected to be applicable to certain furnaces equipped with the types of fuel modulating controls investigated in this study. Predicted annual energy with any of these procedures should be considered valid only for comparison purposes between equipment tested under laboratory conditions. These procedures as well as the current DoE test procedures should not be considered predictive of installed annual operating costs. Comprehensive treatment of the building and furnace interaction which are unique to each installation would be needed for that prediction and is beyond the scope of these procedures.

Comparison of heater efficiencies with single-stage and with step-modulating controls indicates that substantial improvements can be made. Maintaining the combustion air to fuel ratio with reduced input rate is a promising means of reducing energy consumption for heaters with step-modulating and two-stage controls.

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(1)	(2)	(3)	(4)	(5)		$T_{A}^{(7)} = 0^{\circ} F$	(8)	(6)	(10) T - 65°F	(11) T _ 65°F	(12)	(13)	(14)
				(3)x(4)		T =65°F	(6) ÷(7)		$\sum_{i=1}^{L} \sum_{i=1}^{n-1} \sum_$	$\sum_{i=1}^{4} \sum_{j=1}^{2} \sum_{i=1}^{4} \sum_{j=1}^{4} \sum_{j=1}^{4} \sum_{i=1}^{4} \sum_{j=1}^{4} \sum_{j$	(11) + (01)		
Outdoor Temperature	T _C	Total			T _A =65°F	Cumu-		T oa	T _A = 0°F Cumulative	TA = 0°F		n oa'	Z Cveline Mode
Range °F	Midpoint	Hours	65°-(2)	Deg. Hours	Cumulative Deg. Hours	lative Hours		65-(8)	Deg. Hours	Cumutacive Hours		65°-(12)	[(6) ÷100,784]
0-4	2	2	63	126	100778	5114	19.7	45.3	126	2	63	2.0	
5-9	2	Ś	58	290	100652	1115	19.7	45.3	416	7	59.4	5.6	
10-14	12	32	53	1690	100362	5106	19.7	45.3	2106	39	54.2	10.8	
15-19	. 17	70	48	3360	98672	5074	19.4	45.6	5466	109	50.2	14.8	982
20-24	22	179	43	7697	95312	5004	19.0	46.0	13163	288	45.7	19.3	95%
25-29	27	346	38	13148	87615	4825	18.1	46.9	26311	634	41.5	23.5	87%
30-34	32	677	33	14817	74467	4479	16.6	48.4	41128	1083	38.0	27.0	792
25-39	37	563	28	15764	59650	4030	14.8	50.2	56892	1646	34.6	30.4	592
40-44	42	634	23	14582	43886	3467	12.7	52.3	71474	2280	31.4	33.6	242
45-49	47	676	18	12168	29304	2833	10.3	54.7	83642	2956	28.3	36.7	292
50-54	52	698	13	9074	17136	2157	7.9	57.1	92716	3654	25.4	39.4	172
55-59	57	737	80	5896	8062	1459	5.5	59.5	98612	4391	22.5	42.5	87
60-64	62	722	ũ	2166	2166	722	3.0	62.0	100778	5113	19.7	45.3	2%

Table 1. Development of outdoor temperatures and time in each mode from weather data for one city (Bishop, California)

14

E 1

Outdoor temperatures and time on each mode -- an average of eight cities having total heating requirements of approximately 4400 degree days Table 2.

 $(5) = (4) \div 108,368$ (6) = 7_{-2} = average

 Γ_{oa} = average time weighted outdoor temperature in cycling mode between Γ_{c} and 65°F - See equation below = T_{oa}' = average temperature in steady state mode between T_C and 5°F - See equation below, see note below. Col (7) is obtained from equation (1) with = 0)) Co Co

											Г	3)		-
(7) Min Output	Max Output	0.86	0.76	0.66	0.56	0.46	0.36	0.26		ł		² (65-T _c) (col	τ Σ ^c (co1 3)	-
(a) (6) (b) Da T _{0a} '	Cycling	<u>+</u> 6[23	27	31	34	37	39					= 65 =	
(a) ((T _{Oa}	Cyclic	45	46	47	49	51	54	56					tate mode	
(5) % of Time in	Mode	95	88	76	59	42	26	14	9	2			. @ steady-state mode	
(4) T _C .	E degree Hrs. 62 108368	103376	95077	81853	63637	45185	28395	15309	6430	1662	F	(col 3)	Toa	-1
(3)	Hours	193	348	552	659	730	727	683	596	554		65 - T _C) (col 3)	1 (3)	
(2)	- C	22	27	32	37	42	47	52	57	62		2 2 2 2 2 2 2 2 2 2 6 2 6 2		2.2
(1) Temperature	Kange (°F) 15_10	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64			cyclic mode = 65	
													сy	

All calculated values in this table are based on no oversizing ($\alpha = 0$) Each line of Col. 6 represents the average from eight cities with individually calculated values from specific data for each city. NOTE:

o Toa Summary of stack losses and efficiencies for a room heater rated 45,000 Btu/h (13,185W) Table 3.

- - - E	Ls, on	L _S , off	L_{I} , on	LI, OFF	Weighted Average	Part-Load	Annual	2
lest Condition	%	24	62	84	steady- State n _{ss} (%)	LIIICIENCY (Weighted Avg) (n _u) %	EFFYA EFFYA %	Energy Savings %
	(1)	Operating a	as single s	tage thermos	tate (cycling	stage thermostate (cycling mode at 41,000 Btu/h only)	u/h only)	
No Damper	17.1	2.7	1.8	2.9	73.0	66.7	61.6	ł
Damper A	15.3	2.2	0.8	2.5	74.8	72.5	65.2	9
Damper B	16.1	2.2	0.5	2.1	73.9	71.9	64.2	4
	(2)	Operating in	step	modulating mode	- low fire	at 26,000 Btu/h		
No Damper	20.8	2.9	2.3	3.7	69.7	63.8	58.8	ł
Damper A	17.0	1.9	6*0	2.5	73.4	69.8	64.2	ω
Damper B	16.6	2.0	0.6	2.1	73.4	70.5	64.8	6
	(3)	Operating :	in step mod	Operating in step modulating mode	- low fire a	- low fire at 10,000 Btu/h		
No Damper	22.7	7.2	2.6	4.1	6.9	65.2	60.1	ł
Damper A	19.5	4.3	1.2	1.5	72.4	70°1	64.1	9
Damper B	23.7	2.9	0.7	2.3	69.7	67.9	62.3	m
*Energy Saving = 100	g = 100	$\left[1 - \frac{\text{EFFYA}}{\text{EFFYA}}\right]$	EFFYA no damper EFFYA with damper	·)				

16

~		= 1	0		5	
85W		With Damper "A" "B"	4.1	ŝ	г.	
(13,1	S/F*	Wi Dan "A"	4.3 4.0	3.5 3.1	3.5 1.5	
and CO2 values and stack to flue mass flow (S/F) for room heater rated 45,000 Btu/h (13,185W)	S,	No Damper	6.1	5.7	4.2	
45,0	년 년 1 0	Damper "B" S) (F)	671	547	316	
rated	(F) ture	Damper "B" (S) (F)	259	239	194	
heater	Steady State Flue (F) and Stack (S) Temperature °F	Damper "A") (F)	662	504	320	
room	dy Sta k (S)	$\frac{\text{Damper}}{"A"}(S)$	252	212	167	
/F) for	Stea nd Stac	o (F)	662	550	320	
W (S)	. ai	No Damper (S) (J	207	190	136	
mass flo		er (F)	7.2	4.7	2.0	
flue m	Steady State Flue (F) and Stack (S) - CO_2 - $\%$	Damper "B" (S) ()	2.3	2.0	1.7	
ack to	ate Flu (S) - (Ther (F)	7.7	4.3	2.6	
ind st	ldy St Stack	Damper "A" (S) (F)	2.4	1.6	1.0	
lues a	- Stea and S	o (F)	1.6 7.4	1.1 4.9	0.6 1.8	
02 va	i l	No Damper (S) (F)	1.6	1.1	0.6	
and C		Firing Rate % of Rated Input	16	58	22	

Effect of stack damper and operating input rate on the stack (S) and Flue (F) temperature

Table 4.

st These values are calculated using the CO $_2$ (F) and CO $_2$ (S) values, the equation is:

 $S/F = 1.3 [R_T, S/R_T, F]$

where the \mathbb{R}_T values are the ratios of combustion air mass flow rate to stoichiometric air mass flow. \mathbb{R}_T values are inversely proportional to CO_2 values.

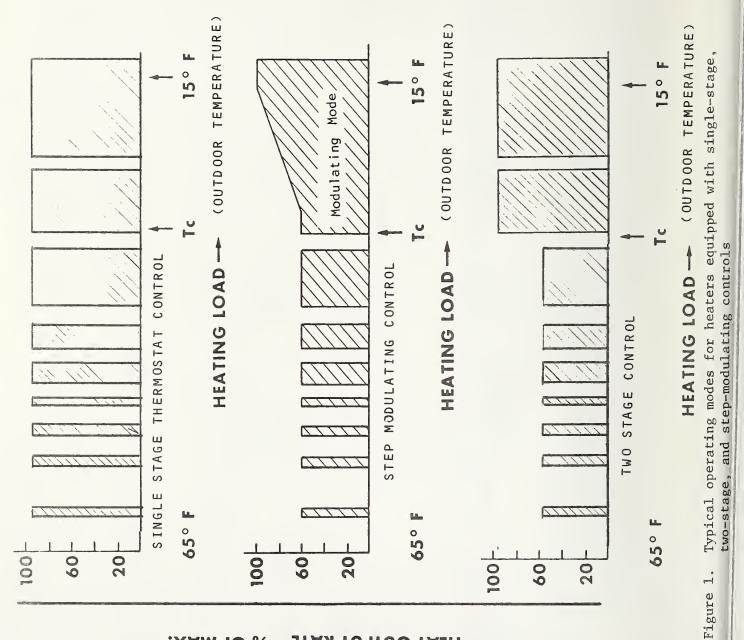
17

Effect of type of thermostat control on energy saving potential of thermal dampers Table 5.

,	- Calculated	- Calculated Percent Energy Savings -	avings –	
Type Thermostat	Type <u>Damper</u>	Room Heater No. 1	Room Heater No. 2	Wall Furnace
Single Stage	А	9	4	1
Thermostat High Fire Only	В	4	ç	Ŋ
Cycling Mode	C	ę	S	2
Step Modulating Thermostat				
Adjusted to	A	8	4	-1
Cycle at 60%	В	6	S	2
of Maximum Fire	C		£	1
Adjusted to 25%	A	9	6	1
of Maximum Fire	в	ę	9	ı
	С	11	2	I

NOTE: For additional details on test results and calculation procedures for heaters equipped with thermal dampers, see Ref [6]. Effect of reduced excess combustion air on efficiency of a 35,000 Btu/h room heater (10,255W) equipped with (1) stepi-modulating thermostat, or (2) two-stage thermostat Table 6.

Steady StateExcess AirEnergy SavingsEfficiency %%Annual Efficiency %%I InputMaxReduced-Control TypeControl Type-StackInputInputInputStep-Modulating Two-StageModulating Two-Stage	1.6 70 64 60 185 59 59	2.1 70 77 60 60 70 68 16 13	0.7 70 58 60 600 58 62	1.4 70 85 60 150 74 66 22 6
2 - % Reduced Flue	3.9	7.2	1.6	4.6
CO ₂ - Max Input Flue Stack	19.1 7.2 2.5	19.1 7.2 2.5	7.8 7.2 2.5	7.8 7.2 2.5
P ()	1.91	1.91	7.8	7.8
Input Rate Max Reduce (Btu/h X1000	33.3	33.3	33.3	33.3
Test Condition	 With heater as received 	 After reducing excess combustin air at reduced input 	 With reduced input adjusted to minimum 	<pre>4) Reduced excess combustion air at minimum input</pre>



.XAM 70 % 3TAR TU9TUO TA3H

20

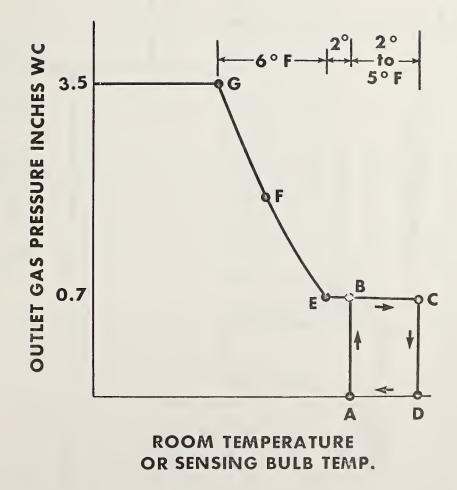
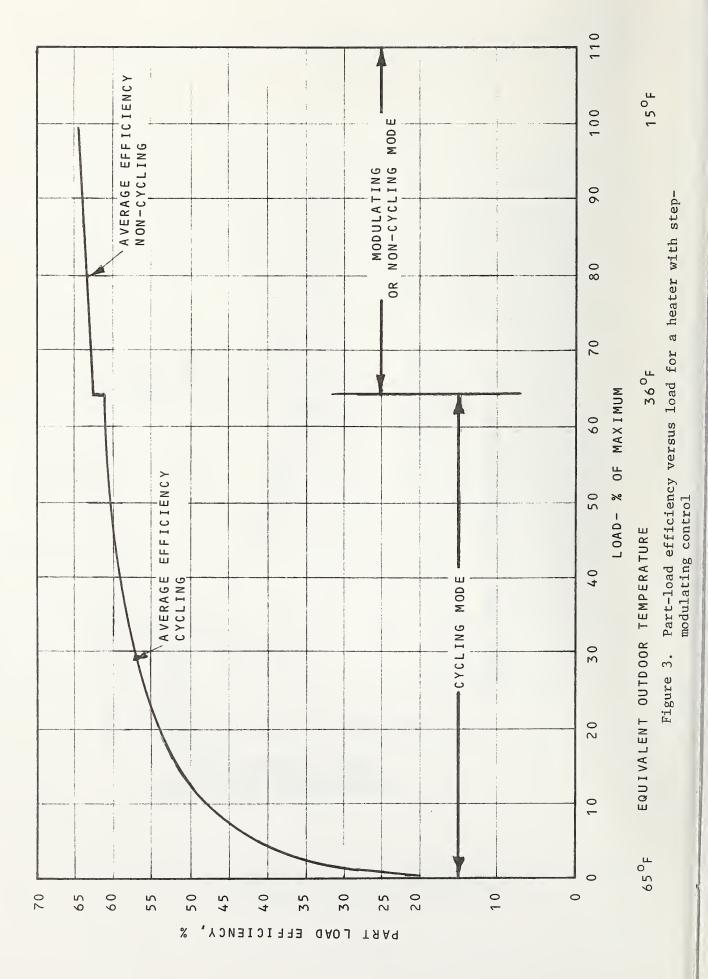
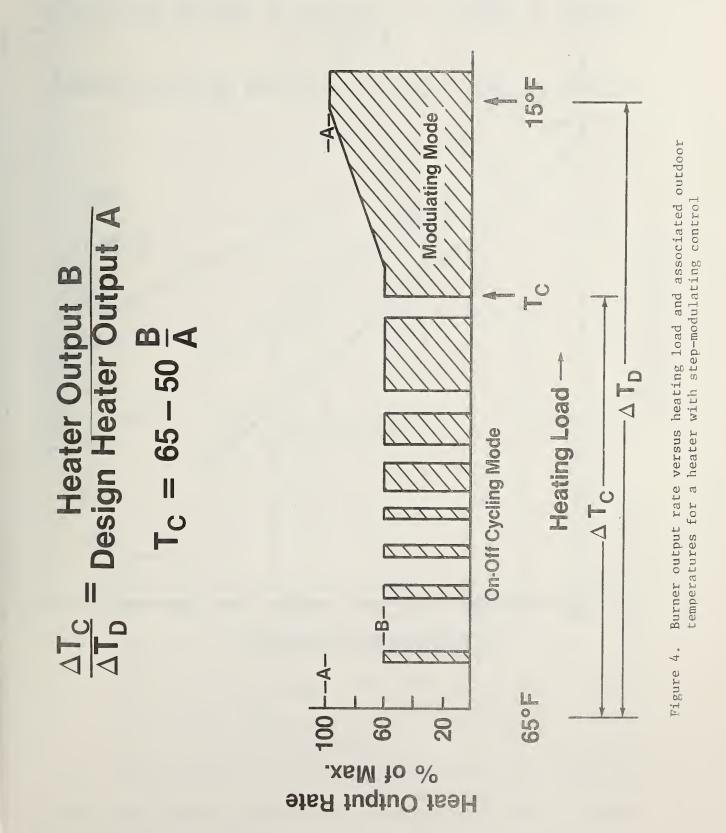
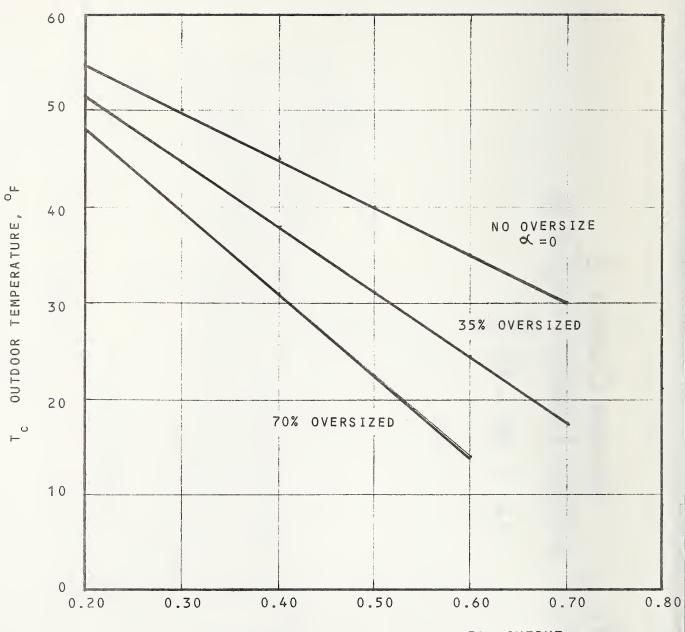


Figure 2. Outlet gas pressure from a step-modulating thermostat control in response to changing room temperature







MINIMUM HEAT OUTPUT/MAXIMUM HEAT OUTPUT

Figure 5. Balance point temperature as a function of heater output ratio

Cycling Mode Fraction = $2530 \div 4400$ or 58%Non-Cycling Mode = 100 - 58 = 42%

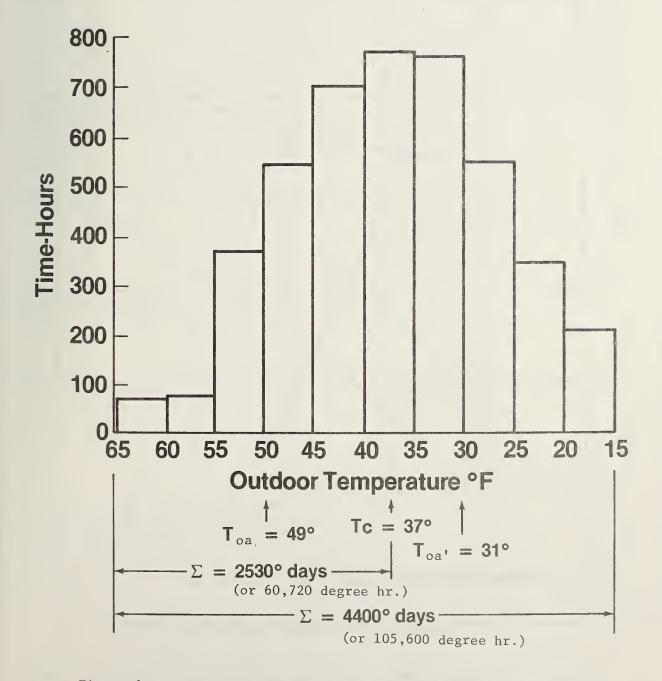


Figure 6. Example of bin method used to determine percentage of time in cycling mode

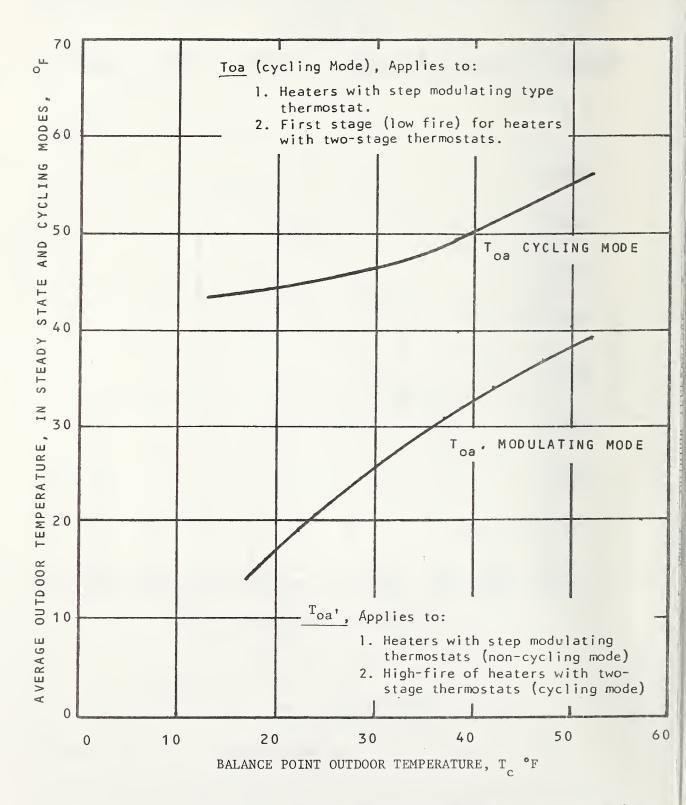
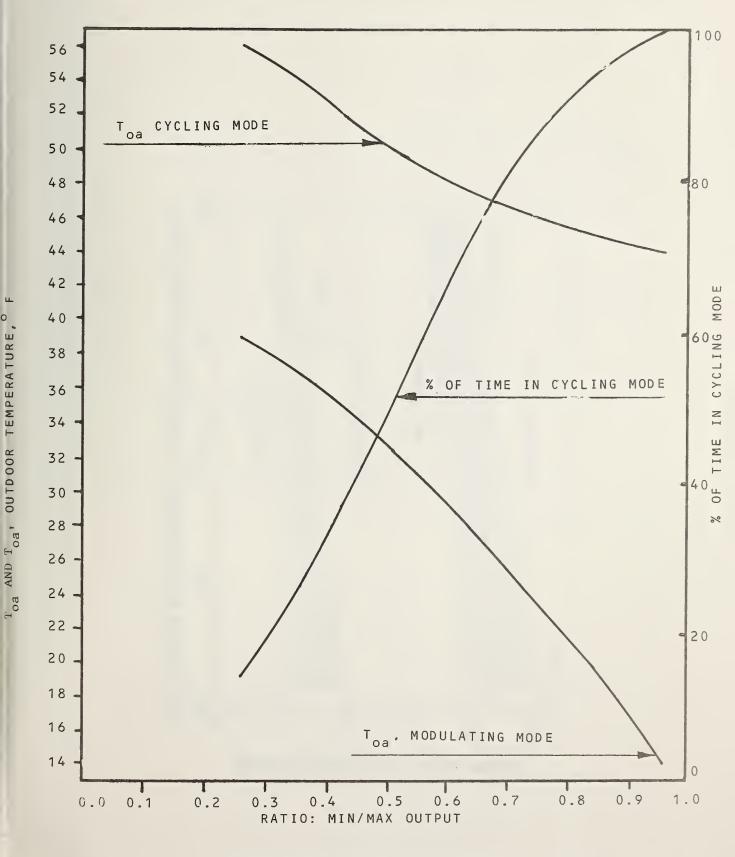
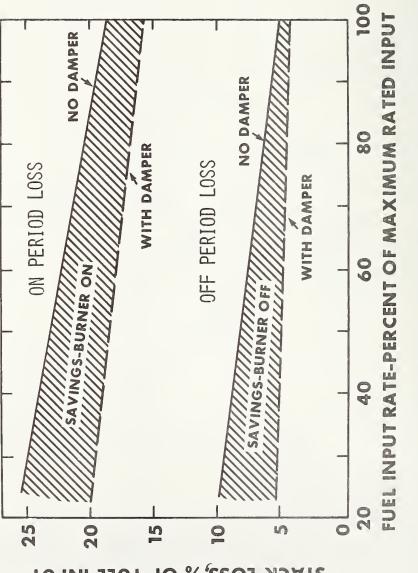


Figure 7. Average outdoor temperature in cycling and non-cycling modes versus balance point temperature (T_c)



0

Average outdoor temperature and percent of time in cycling Figure 8. mode as a function of heater output ratio





С The effect of burner fuel input rate on the part-load loss of room heater with and without a thermal damper Figure 9.

APPENDIX A

Determination of Outdoor Design Temperature and Typical Annual Heating Degree Days for Vented Household Heaters

Appendix A

Determination of Average Heating Degree Days and Design Temperature for Vented Room Heaters

The 97 1/2 winter design temperature is that dry-bulb temperature which will probably be exceeded 97 1/2 percent of the time for winter months (December, January, February). Through consideration of the geographic distribution of vented room heaters throughout the U.S., combined with analyses of weather data, a single value or design temperature, representative of a "<u>National</u> Average" condition, can be obtained. This value will be different than the corresponding value of 5°F for furnaces used in [4], since the geographic distribution of furnaces and room heaters is not the same.

Based on 1970 census data, the total number of room heaters installed in each of the nine geographic regions of the United States is presented in table A1. Also presented in table A1 are representative average number of heating season degree days for each of the nine regions. Based on these two pieces of information, a heater population weighted average of space heating degree days for room heaters can be obtained. Results of the average are presented at the bottom line of column (4) (4438 is rounded to 4400 degree-days, as the weighted national average). Although these data are based on the 1970 census now 11 years old, results are expected to be little affected if more recent census data were to be used since most vented heaters sold are replacement units for existing installations.

The outdoor design temperature can be approximated as the average of the design temperatures of a representative number of cities having heating seasons of about 4200 to 4600 degree-days. The heating degree-days and outdoor design temperatures for 13 cities falling in this range are presented in table A2. The average design temperature for the group is 15.7°F.

	(1)	(2)	(3)	(4)
Census Region	Population of Vented Heaters	% of Total	Regional Average Degree Days	Population Weighted Degr ee Days
Pacific	3,672,950	26.6	3820	1016
Mountain	649,618	4.7	5780	271
East So. Cntrl.	1,007,956	7.3	3795	277
So. Atl.	2,683,320	19.5	3380	659
W. No. Cntrl.	1,179,377	8.6	6825	587
E. No. Cntrl.	1,640,383	11.9	6610	787
Mid. Atl.	800,859	5.8	6100	354
New Eng.	369,041	2.7	6820	184
W. So. Cntrl.	1,783,762	12.9	2350	303
Total	13,787,266			4438

Population Weighted Average Space Heating Degree Days

Table A-1

CITY	DESIGN TEMP °F	DEGREE DAYS
Charlestown, SC	14	4476
Huntington, WV	14	4446
Philadelphia, PA	15	4486
St. Louis, MO	8	4484
Albuquerque, NM	17	4348
Evansville, IN	10	4435
Bishop, CA	15	4275
Washington, DC	15	4551
Sandberg, CA	25	4209
Eureka, CA	35	4643
Prescott, AZ	15	4654
Dover, DE	12	4660
Louisville, KY	9	4620

Table A-2	Design Temperatures	from	97 1/2%	Column	of	ASHRAE
	Handbook of Fundamer	ntals	(1972)			

DECOFE

Avg.

15.7

APPENDIX B

Detailed Stepwise Procedure for Calculation of Annual Efficiency for Heaters Equipped with Step-Modulating or Two-Stage Thermostat Controls

Appendix B

Detailed Stepwise Procedure for Calculation of Annual Efficiency for Heaters Equipped with Step-Modulating or Two-Stage Thermostat Controls

The first ll steps deal with the calculation of minimum and maximum heat outputs, and fraction of time and outdoor temperature in each mode. Each of the following steps refers to a similarly numbered block in figure B-1.

- Enter the maximum fuel input rate (including fuel supply to pilot flame).
- 2. Enter the steady state efficiency at the maximum input rate (determined in accordance with the DoE test procedure).*
- 3. Calculate and enter the maximum heat output rate = $\frac{\text{Step 1 X Step 2}}{100}$.
- 4. Enter the minimum (reduced) fuel input rate (including fuel supply to pilot flame).
- 5. Enter the steady state efficiency at reduced fuel input rate (determined in accordance with the DoE test procedure).*
- 6. Calculate and enter the minimum heat output rate = $\frac{\text{Step 4 X Step 5}}{100}$
- 7. Calculate and enter ratio of minimum to maximum output

RATIO =
$$\frac{Q_{\text{out,min}}}{Q_{\text{out,max}}}$$
 or $\frac{\text{Step 6}}{\text{Step 3}}$

- 8. Read the percentage of time in the low fire cycling mode (R₁) from the graph of figure 7 for the minimum/maximum ratio corresponding to the ratio determined in step (7).
- 9. Calculate percentage of time in the non-cycling mode (R_{hi}).

$$R_{hi} = 100 - R_{10}$$
 (Step 8)

- 10, Read the average outdoor temperatures for the cycling and non-cycling
- 11. mode, T and T_{oa} ' respectively, from figure 7 at the point corresponding to min/max ratio determined in step (7).

In the next four steps, the average steady state efficiency and on-cycle infiltration losses for the non-cycling mode are determined.

^{*}References 1 and 3.

12. Calculate and enter average steady state efficiency (%) for the noncycling mode, n ss. hi

 $\eta_{ss, hi} = \frac{\eta_{ss, min} + \eta_{ss, max}}{2}$ or $\frac{\text{Step 5 + Step 2}}{2}$

- Enter the on-period infiltration loss (L_{I,ON},min) at the minimum input rate (determined in accordance with the DoE test procedure for an outdoor temperature equal to T_{oa}, (Step 11),
- Enter the on-cycle infiltration loss at the maximum input rate (determined in accordance with the DOE test procedure for an outdoor temperature equal to T_{oa}, (Step 11).
- 15. Calculate and enter the average on-cycle infiltration loss (%) for the non-cycling mode

$$L_{I,ON,avg} = \frac{L_{I,ON,min} + L_{I,ON,max}}{2} \text{ or } \frac{\text{Step } 13 + \text{Step } 14}{2}$$

The part load efficiency, n_{11} , for both the cycling and non-cycling modes are determined next, and the weighted average efficiencies are then calculated.

 Calculate and enter the part load efficiency for the non-cycling mode

 $\eta_{u,hi} = \eta_{ss,hi} (\text{Step 12}) - L_{I,ON, av} (\text{Step 15})$

17. Calculate and enter the percentage part load efficiency (%) for the cycling mode:

$$\eta_{u,10} = 100 - L_L - \frac{20}{t_{ON} + PF \times t_{OFF}} (L_{S,ON} + L_{I,ON} + L_{S,OFF} + L_{I,OFF})$$

where the thermal losses are determined in accordance with the DOE procedure for the minimum firing rate, at outdoor temperature equal to T (Col 10), and $t_{ON} = t_{OFF} = 20$ min. Alternatively, $L_{S,OFF}$ and $L_{I,OFF}$ can be measured using the tracer gas technique [6]. PF is the pilot fraction (the ratio of pilot input Q_p to total fuel input Q_{in}).

18. Calculate and enter the weighted average part load efficiency for the cycling and non-cycling modes

 $\eta_{u,wt} = R_{10} \times \eta_{u,10} + R_{hi} \times \eta_{u,hi}$

or Step 8 X Step 17 + Step 9, Step 16

Appendix B (cont)

19. Calculate and enter the weighted average steady state efficiency for the cycling and non-cycling modes.

 $\eta_{ss,wt} = R_{1o} \times \eta_{ss,min} + R_{hi} \times \eta_{ss,hi}$ or Step 8 X Step 5 + Step 9 X Step 12

The annual fuel efficiency for modulating type heaters is finally calculated using the weighted efficiencies from steps 18 and 19.

20. EFFYA =
$$\frac{\eta_{ss,wt X} \eta_{u,wt} X 4400}{\eta_{ss,wt} X 4400 + 2.5 \eta_{u,wt} X PF X 4600}$$

Procedure for Calculating Annual Efficiency for Heaters with Two-Stage Controls

The calculations listed above for heaters with step-modulating controls will, with slight modification, accommodate heaters with two-state controls. The modifications are as follows:

- o replace step (12) with the equality: $\eta_{ss,hi} = \eta_{ss,max}$
- o delete steps (13) through (15), and
- o replace step (27) with a calculation similar to that of step (26) but for the maximum input rate and an outdoor temperature equal to Topa'.

17

The annual fuel efficiency given by step (20) will then be for a heater with two-stage contol.

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For Step Modulating Type Heaters (Operating in a Cycling Mode at Reduced Input Rate (Low Fire) and Non-Cycling Mode at Intermediate Input Rates Between Low and Maximum Rated Input

ø	X of Time @ Reduced Input Cycling Mode from (7) & fig. 7
2	Max It
6	cput];100
5	n _{ss} @ Reduced Reduced Input Rate [(4)x(5)
4	Reduced Input Rate Btu/h
3	Max. Heat Output Rate [(1)x(2)]+100
2	n 8 Max. Input Rate %
-	Maximum Fuel Input Btu/h

15	Average L _{I;ON} put [(13)+(14)]+2 %
14	L _I ON [@] MÄÅ. Input %
13	L _I ,ON @ Reduced Input %
12	Average n _{ss} in Non-Cycle Mode [(2)+(5)]:2
11	Average T _{oa'} Modulating Mode From Fig. 7
10	Average T _{oa} Cycling Mode From Fig. 7
0	% of Time @ Non-Cycling Mode = 100%-(8)

20	EFFYA From (18)δ (19) %
19	Average nss = [(12)(9)+(5)(8)]+100 %
18	Average n _u = [(9)(16)+(17)(8)]+1.00 %
17	n - % cycling mode
16	$N - %$ $N_{On-Cycling}$ $Mode$ (12) - (15)

APPENDIX C

Computer Program for the Evaluation of Annual Fuel Utilization Efficiency and Energy Consumption of Vented Heating Equipment With Single-Stage, Two-Stage, and Step-Modulating Thermostats

Appendix C

Computer Program for the Evaluation of Annual Fuel Efficiency of Heating Equipment With Single-Stage, Two-Stage, and Step-Modulating Control

Program Description

The computer program to be described here is based on the original program NBSFBS5 developed in 1978 by Kelly, et al [2]. While maintaining the previous structure of NBSFBS5, the present program handles heating equipment with singlestage, two-stage, and step-modulating input, and permits the use of tracer gas measurements in determining off-cycle losses (see Reference). The computer program consists of a main program, entitled FBVH, and four subroutines: SENLOS,* WEIGHT, OFFLOS, and FUNT4. It is written in ASCII Fortran and should be compatible with most Fortran V processors with a minimum of change.

The main program FBVH, as its predecessor, chooses calculation paths, makes appropriate calls to subroutines, and performs calculation steps based on input information. The theoretical calculations and the order in which the calculations proceeds are essentially the same as in NBSFBS5. For single-stage controls, a straight-through path, identical to that in NBSFBS5, is taken. For step-modulating and two-stage controls, outdoor temperatures and time in each mode are determined via a call to WEIGHT, and two passes through the calculation stream are then taken. In the first pass, input data for the maximum firing rate and outdoor temperature T_{oa} , are used. In the second pass, required parameters are saved, and data for the minimum firing rate and outdoor temperature T_{oa} , are used. Weighted efficiencies are calculated in accordance with section 3.2.

Subroutine SENLOS determines values for steady state: latent heat loss L_L , sensible heat loss $L_{S,ON}$, ss, and steady state efficiency η_{SS} as well as other parameters. This SENLOS version contains the stack to flue mass flow ratio S/F (SFR) computed from stoichiometric relationships and is used in place of the input value of SFR for all calculations (the computed value was previously used only if it was greater than the input value of SFR).

Subroutine WEIGHT assigns values for average outdoor temperatures in the cycling and non-cycling modes (T_{oa} and T_{oa} ' respectively), and the fraction of time in the cycling mode. WEIGHT is called only for step-modulating and two-stage heaters.

The subroutine OFFLOS calculates off-cycle sensible heat and infiltration losses based on the tracer gas technique described in Reference 6. For this calculation, which is optional, twenty measurements of tracer concentration in stack gas are required at one-minute intervals, along with the initial tracer concentration, and tracer gas flow rate and temperature.

Subroutine FUNT 4 calculates functions required for the analytical determination of off-cycle stack losses (the current DOE and default means of calculating off-cycle losses). FUNT 4 is unchanged from the NBSFBS5 version.

*SENLOS used in this procedure is modified from another form of the SENLOS given in Reference 2 with NBSFBS5. A flow chart of FBVH including corresponding statement numbers from the program listing, is shown in figure Cl. This figure does not include all program details but only those essential differences between FBVH and NBSFBS5. The majority of the theoretical calculations are performed in statements 132 through 256 and are described in detail in Reference 4. The complete program listing, with subroutines, is shown in figure C2.

Input Data Format

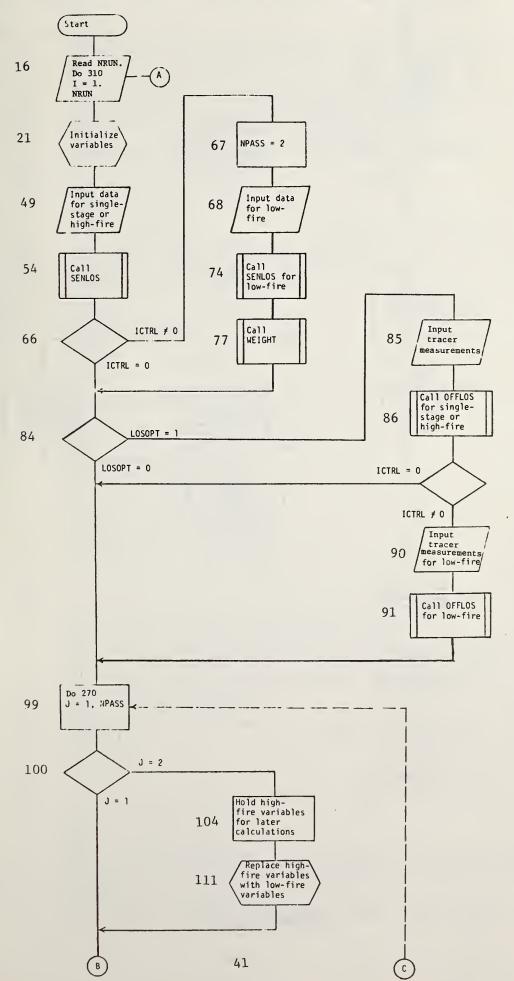
The input data file or element for FBVH must be consistent with the format shown in figure C3. A sample data form is presented as figure C4 for comparison. It should be noted that when ICTRL and LOSOPT are selected such that some lines in figure C3 are omitted in the data file, blank lines should not be inserted; the line numbers in the data file will therefore differ from those in figure C3 in certain cases.

Sample Input and Output

Sample sets of computer program output for a heater with a step-modulating and with a two-stage control are presented in figures C4 and C5 respectively.

Appendix C (cont)

Figure Cl. Flow chart of main program, FBVH



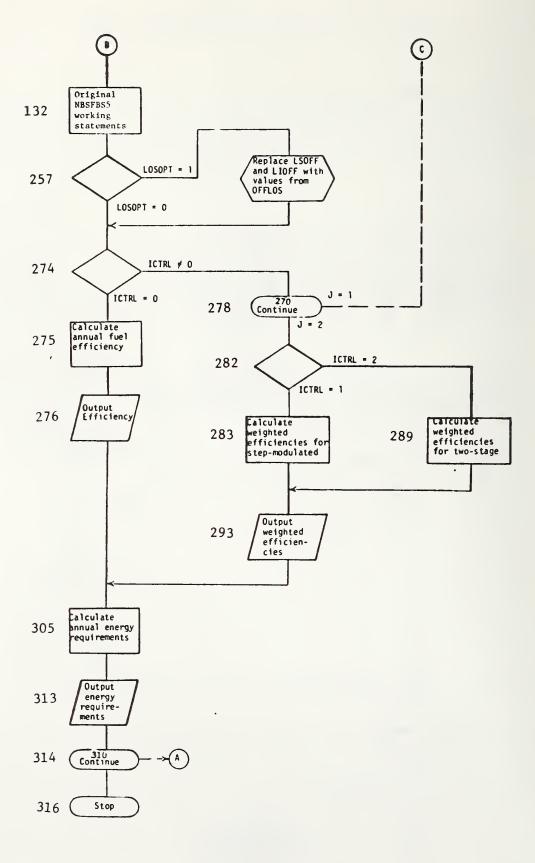


Figure Cl (cont)

Figure C2. Main program and subroutine listings; main program FBVH HTRS*BOIL6A(1).FBVH(3) PROGRAM FOR THE EVALUATION OF FURNACE/BOILER/VENTED HEATER 1 C 2 SYSTEMS WITH SINGLE, TWO-STAGE, OR STEP-MODULATED INPUT. С 3 С THIS PROGRAM IS BASED ON THE ORIGINAL PROGRAM NBSFBVH 4 С (BOILS) DEVELOPED IN 1978 BY KELLY, CHI, AND KUKLEWICZ. 5 С WHILE MAINTAINING THE STRUCTURE OF BOIL6, THE PRESENT 6 С PROGRAM PERMITS THE USE OF TRACER GAS MEASUREMENTS IN 7 С DETERMINING OFF-CYCLE LOSSES, AND HANDLES HEATING EQUIP-8 С MENT WITH SINGLE, TWO-STAGE, OR STEP-MODULATED INPUT. 9 С 10 DIMENSION TITLE(20.2).CONC(20).TS(20).CONCM(20).TSM(20) DATA PHI, REFTRM /0.7,70./ 11 12 С 13 С INPUT NUMBER OF DATA SETS 14 С 15 WRITE (6,500) 16 READ (5,*) NRUN 17 DO 310 I=1, NRUN С 18 19 С INITIALIZE COUNTER AND HIGH-FIRE VARIABLES 20 C 21 NPASS=1 22 QSOFFH=0. 23 OICFFH=0. 24 QSOFFM=0. 25 QIOFFM=0. 26 QINH=0. 27 EFYSSH=0. 28 EFFYUH=0. 29 OIONH=0. 30 С 31 С I/O SYSTEM PARAMETERS Ċ 32 33 READ (5,510) TITLE 34 WRITE (6,520) ((TITLE(II,JJ),II=1,20),JJ=1,2) 35 READ (5,*) IFB, INST, ICTRL, LOSOPT 36 IF (IFB.EQ.1) WRITE (6.530) 37 IF (IFB.EQ.2) WRITE (6,540) 38 IF (IFB.EQ.3) WRITE (6.550) IF (INST.EQ.1) WRITE (6,560) 39 40 IF (INST.EQ.2) WRITE (6,570) 41 (ICTRL.EQ.O) WRITE (6,5BO) IF. 42 (ICTRL.EQ.1) WRITE (6,590) IF 43 IF (ICTRL.EQ.2) WRITE (6,600) 44 IF (LOSOPT.EQ.O) WRITE (6,610) 45 IF (LOSOPT.EQ.1) WRITE (6,620) 46 С 47 С I/O DATA FOR MAXIMUM FIRING RATE AND CALL SENLOS 48 С 49 READ (5,*) NSYS, IFUEL, HHV, QIN, QP, PE, BE, XCO2S 50 WRITE (6,630) NSYS, IFUEL, HHV, QIN, QP, PE, BE, XCO2S 51 READ (5,*) TSSSX, XCO2F, TFSS, TFON1, TFON2, TFOFF3. TFOFF4, TFOFF5 52 WRITE (6,640) TSSSX, XCO2F, TFSS, TFON1, TFON2, TFOFF3, TFOFF4, TFOFF5 53 READ (5,*) TRA, QJ, SFR, DF, DS, Y 54 CALL SENLOS (IFUEL, NSYS, XCO2S, TSSSX, XCO2F, TFSS, HHVA, AFR, QL, RT, 55 2 QSSS, EFFYSS, TRA, IFB, SFR) 56 WRITE (3,650) TRA,QJ.SFR,DF,DS,Y READ (5.*) TON, TOFF, TOA WRITE (6,650) TON, TOFF, TOA 57 58 59 PF=QP/QIN 60 CJ=3.3 61 IF (IFB.EQ.2) CJ=4.7 62 IF (INST.EQ.1) CJ=0. 63 С 64 С I/O DATA FOR MINIMUM FIRING RATE, CALL SENLOS AND WEIGHT 65 С 66 IF (ICTRL.EQ.O) GO TO 10 67 NPASS=2 68 READ (5,*) QINM, XCO2SM WRITE (6,670) QINM, XCO2SM 69 70 READ (5,*) TSSSXM, XCO2FM, TFSSM, TFON1M, TFON2M, TFOF3M, TFOF4M, TFOF5M 71 WRITE (6,640) TSSSXM, XCO2FM, TFSSM, TFON1M, TFON2M, TFOF3M, TFOF4M, 72 2 TECESM 73 READ (5,*) TRAM, SERM, DEM, DSM 74 CALL SENLOS (IFUEL, NSYS, XCO2SM, TSSSXM, XCO2FM, TFSSM, HHVA, AFR, QL, 75 2 RTM, QSSSM, EFYSSM, TRAM, IFB, SFRM)

76		WRITE (6,680) TRAM,SFRM,DFM,DSM
77		CALL WEIGHT (QIN.EFFYSS.QINM.EFYSSM.RLOW.TOALO.TOAHI)
78		RHIGH=1RLOW
79		WRITE (6,690) RLOW, RHIGH, TOALO, TOAHI
80	~	THAOT=ACT
81 82	с с	I/O TRACER GAS DATA AND CALCULATED OFF-CYCLE LOSS IF LOSOPT=1
82 83	c	1/0 TRACER GAS DATA AND CALCULATED OFF-CTCLE LOSS IF LOSOFIET
84	10	IF (LOSOPT, EQ. 0) GO TO 20
85		READ (5,*) (CONC(J), TS(J), J=1,20), CONCI, VTTT, TROOM
86		CALL OFFLOS (CONC.TS.CONCI.VTTT.TROCM.TOA.QIN.QSOFFH.QIOFFH)
87		WRITE (6,700) (CONC(J), J=1,10), (TS(J), J=1,10), (CONC(J), J=11,20).
88		2 (TS(J), J=11,20), CONCI.VTTT, TROOM, QSOFFH, QIOFFH
89		IF (ICTRL.EQ.O) GO TO 20
90		READ (5,*) (CONCM(J),TSM(J),J=1,20),CONCIM,VTTTM,TROOMM
91		CALL OFFLOS (CONCM.TSM.CONCIM.VTTTM.TROOMM.TOALO.QINM.QSOFFM.
92		2 QIOFFM)
93		WRITE (6,710) (CONCM(J), J=1,10), (TSM(J), J=1,10), (CONCM(J), J=11,20)
94		2 , (TSM(J), J=11,20), CONCIM, VTTTM, TROOMM, QSOFFM, QIOFFM
95	20	WRITE (6,720)
96	C	
97	C	LOOP THRU BOILG WORKING CALCULATIONS NPASS TIMES
98	С	DO 270 J=1.NPASS
99 100		IF $(J.EQ.1)$ GO TO 30
100	С	IF (0.EQ.1) GO TO 30
102	č	HOLD NECESSARY VARIABLES FOR MODULATING AND TWO STAGE CALCULATIONS
103	č	HOLD RECESSART VARIABLES FOR MODELATING AND THE STACE CALEGOLATIONS
104	Ŭ	OINH=QIN
105		EFYSSH=EFFYSS
106		EFFYUH=EFFYU
107		QIONH=QION
108	С	
109	С	REPLACE MAXIMUM FIRE VARIABLES WITH MINIMUM FIRE VARIABLES
110	C	
111		QIN=QINM
112		TFSS=TFSSM
113		TFON1=TFON1M
114		TFON2=TFON2M
115		TFOFF3=TFOF3M
116 117		TFOFF4=TFOF4M
118		TFOFF5=TFOF5M TRA=TRAM
119		SFR=SFRM
120		DF=DFM
121		DS=DSM
122		RT=RTM
123		QSSS=QSSSM
124		EFFYSS=EFYSSM
125		TOA=TOALO
126		WRITE (6,730)
127	30	REFTOA=TOA
128		WRITE (6,740) PF.HHVA.AFR.QL.CJ.RT.QSSS.EFFYSS
129	C	
130	С	*** COLUMNS 31 THROUGH 43 IN NBSIR 78-1543 ***
131	С	
132 133		TSSS=(TFSS-TRA)/SFR+TRA IF (IFB.EQ.2) GO TO 40
134		C1=2.
135		C2=0.5
136		C3=7.5
137		C4=1.5
138		GO TO 50
139	- 40	C1=4.5
140		C2=1.
141		C3=18.75
142		C4=3.75
143	50	IF (TFSS.EQ.TFON1.AND.TFSS.EQ.TFON2) GO TO 60
144		TAON=C1/ALOG((TFSS-TFON1)/(TFSS-TFON2))
145		ZETFOX=(TFSS-TFON1)*EXP(C2/TAON)
146 147	60	GO TO 70 TAON=0.
147	00	ZETFOX=0.
148	70	CONTINUE
150		TAGFF≈C3/ALOG((TFOFF3-TFOFF5)/(TFOFF4-TFOFF5))

Figure C2 (cont)

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151		SIFOX=(TFOFF3-TFOFF5)*EXP(C4/TAOFF)
152		SIFIX=TFOFF5-TRA
153		IF (NSYS.GT.8) GO TO 90
154		IF (NSYS.GT.4.AND.DS.LE.(DF/SFR)) GO TO 80
155 156		DSF=DF/(SFR*DS) SISIX=DSF*SIFIX
150		SISOX=DSF*SIFOX
158		GO TO 100
159	80	SISIX=SIFIX
160		SISOX=SIFOX
161 162	90	GO TO 100 SISIX=0.
163	50	SISOX=0.
164	100	CS=1.+(REFTRM-REFTOA)*EFFYSS/(100.*(TFSS-REFTRM))
165		IF (NSYS.LT.9) CS=0.
166 167		CSON=24.*(1.+RT*AFR)/HHVA IF (NSYS.GT.B) GO TO 120
168		IF (NSYS.GT.4) GO TO 110
169		CSOFF=DF*CSON*(TFSS+460.+REFTRM-TRA)**1.19/(TFSS-TRA)**0.56
170	110	GO TO 130 CSOFF=DS*SFR*CSON*(TSSS+460.+REFTRM-TRA)**1.19/(TSSS-TRA+REFTRM-
171 172	110	2 REFTOA)**0.56
173		GO TO 130
174	120	CSOFF=DF*CSON*(TFSS+460.+REFTRM-TRA)**1.19/(TFSS-TRA+REFTRM-
175 176	120	2 REFTOA)**0.56
177	130	IF (NSYS.GT.8) GO TO 140 CION=PHI*SFR*CSON
178		CIOFF=DS*CION*(TSSS-TRA+530.)**1.19/(TSSS-TRA+REFTRM-REFTOA)**0.56
179		GO TO 150
180	140	CION=0.
181 182	150	CIOFF=0. WRITE (6,750) TSSS,TAON,ZETFOX,TAOFF,SIFOX,SIFIX,SISIX,SISOX
183		WRITE (6,760) CS.CSON.CSOFF.CION.CIOFF
184	С	
185	C C	*** COLUMNS 44 THROUGH 53 IN NBSIR 78-1543 ***
186 187	C	IF ((HHV/HHVA).LE.0.95) WRITE (6,770)
188		IF ((HHV/HHVA).GE.1.05) WRITE (6.780)
189		IF (TFSS.EQ.TFON1.AND.TFSS.EQ.TFON2) GO TO 160
190 191		TTON=TON/TAON
192	160	GO TO 170 TTON=10.**20
193	170	TTOFF=TOFF/TAOFF
194		FON=SIFOX*EXP(-TTOFF)/(TFSS-TFOFF5)
195 196		FOFF=ZETFOX*EXP(-TTON)/(TFSS-TFOFF5) FONOF=1FON*FCFF
197		FFON=(1FON)/FONOF
198		FFOFF=(1FOFF)/FONOF
199	С	*** CII=.90 IF IID EQUIPPED UNIT ***
200 2©1		IF (QP.LT.O.1) FFOFF=FFOFF*.90 IF (NSYS.GT.8) GO TO 180
202		ZETFO=FFON*ZETFOX
203		SIFO=FFOFF*SIFOX
204 205		SIFI=SIFIX SISO-FEOFE+SISON
205		SISO=FFOFF*SISOX SISI=SISIX
207		GO TO 190
208	180	ZETFO=CS*FFON*ZETFOX
209 210		SIFO=1.22*SIFOX*FFOFF SIFI=1.22*SIFIX
211		SISO=0.
212		SISI=0.
213 214	190	WRITE (6,790) TOA.TON,TOFF,TTON,TTOFF,ZETFO,SIFO,SIFI
215	с с	*** COLUMNS 54 THROUGH 59 IN N8SIR 78-1543 ***
216	c	
217		IF (NSYS.GT.8) GO TO 210
218 219		IF (NSYS.GT.4) GO TO 200 N=4
219		N=4 CALL FUNT4 (N.SIFO,TTOFF,REFTOA,REFTRM,F3,F4)
221		F5=0.
222 223		F6=0.
224		N=8 CALL FUNT4 (N,SISO,TTOFF,REFTOA,REFTRM,F7,F8)
225		QSON=QSSS-CSON*ZETFO*(1EXP(-TTON))/TTON

226		QSOFF=CSOFF*(F3+SIFI*F4)*TOFF/TON
227		QION=CION*(REFTRM-REFTOA)
228		QIOFF=CIOFF*(REFTRM-REFTOA)*(F7+SISI*F8)*TOFF/TON
229		GO TO 220
230	200	CONTINUE
231	200	F3=0.
232		F4=0.
233		
234		CALL FUNT4 (N,SISO,TTOFF,REFTOA,REFTRM,F5,F6)
235		N=8
236		CALL FUNT4 (N.SISO.TTOFF.REFTOA.REFTRM.F7.F8)
237		QSON=QSSS-CSON*ZETFO*(1EXP(-TTON))/TTON
238		QSOFF=CSOFF*(F5+SISI*F6)*TOFF/TON
239		QION=CION*(REFTRM-REFTOA)
240		QIOFF=CIOFF*(REFTRM-REFTOA)*(F7+SISI*F8)*TOFF/TON
241		GO TO 220
242	210	CONTINUE
	210	
243		F3=0.
244		F4=0.
245		F7=0.
246		F8=0.
247		N=6
248		CALL FUNT4 (N,SIFO,TTOFF,REFTOA,REFTRM,F5,F6)
249		QSON=CS*QSSS-CSON*ZETFO*(1EXP(-TTON))/TTON
250		QSOFF=CSOFF*(F5+SIFI*F6)*TOFF/TON
251		OION=0.
252		QIOFF=0.
	200	
253	220	CONTINUE
254	С	
255	С	USE MEASURED VALUES FOR OFF-CYCLE LOSS IF LOSOPT=1
256	С	
257		IF (LOSOPT.EQ.O) GO TO 240
258		IF (J.EQ.2) GO TO 230
259		QSOFF=QSOFFH
260		QIOFF=QIOFFH
261		GO TO 240
262	220	
	230	QSOFF=QSOFFM
263		QIOFF=QIOFFM
264	240	IF (NSYS.GT.8) QIOFF=0.
264 265	С	IF (NSYS.GT.8) QIOFF=O.
	C C	IF (NSYS.GT.8) QIOFF=0. FINISH UP BOIL6 CALCULATIONS
265	С	
265 266	C C	FINISH UP BOIL6 CALCULATIONS
265 266 267 268	C C	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250
265 266 267 268 269	C C	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF)
265 266 267 268 269 270	C C C	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260
265 266 267 268 269 270 271	с с 250	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF)
265 266 267 268 269 270 271 272	C C C	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TGN+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6,800) SISO,SISI,F3,F4,F5,F6,F7,F8
265 266 267 268 269 270 271 272 273	с с 250	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6,800) SISO.SISI.F3,F4.F5.F6.F7.F8 WRITE (6,810) QSON.QSOFF.QION.QIOFF.EFFYU
265 266 267 268 269 270 271 272 273 273	с с 250	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6,800) SISO.SISI.F3,F4,F5,F6,F7,F8 WRITE (6,810) QSON.QSOFF,QION,QIOFF,EFFYU IF (ICTRL.GE.1) GO TO 270
265 266 267 268 269 270 271 272 273 273 274 275	с с 250	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6,800) SISO.SISI.F3,F4,F5,F6,F7,F8 WRITE (6,810) QSON.QSOFF,QION,QIOFF,EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600)
265 266 267 268 269 270 271 272 273 274 275 276	с с 250	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6,800) SISO.SISI.F3,F4,F5,F6,F7,F8 WRITE (6,810) QSON.QSOFF,QION,QIOFF,EFFYU IF (ICTRL.GE.1) GO TO 270
265 266 267 268 269 270 271 272 273 273 274 275	с с 250	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6,800) SISO.SISI.F3,F4,F5,F6,F7,F8 WRITE (6,810) QSON.QSOFF,QION,QIOFF,EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600)
265 266 267 268 269 270 271 272 273 274 275 276	с с 250	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6,800) SISO.SISI.F3,F4,F5,F6,F7,F8 WRITE (6,810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6,820) EFFYA
265 266 267 268 269 270 271 272 273 273 274 275 276 277 278	C C 250 260 270	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300
265 266 267 268 269 270 271 272 273 273 274 275 276 277 278 279	C C 250 260 270 C	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TCN+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300 CONTINUE
265 266 267 268 270 271 272 273 274 275 276 277 278 279 280	C C 250 260 270 C C	FINISH UP BOIL6 CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300
265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281	C C 250 260 270 C	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300 CONTINUE CALCULATE WEIGHTED EFFICIENCIES FOR MODULATING AND TWO-STAGE
265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282	C C 250 260 270 C C	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300 CONTINUE CALCULATE WEIGHTED EFFICIENCIES FOR MODULATING AND TWO-STAGE IF (ICTRL.EQ.2) GO TO 280
265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283	с с 250 260 270 с	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300 CONTINUE CALCULATE WEIGHTED EFFICIENCIES FOR MODULATING AND TWO-STAGE IF (ICTRL.EQ.2) GO TO 280 EFYSSA=(EFYSSH+EFYSSM)/2.
265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284	с с 250 260 270 с	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TON+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300 CONTINUE CALCULATE WEIGHTED EFFICIENCIES FOR MODULATING AND TWO-STAGE IF (ICTRL.EQ.2) GO TO 280 EFYSSA=(EFYSSH+EFYSSM)/2. QIONA=(QIONH+QION)/2.
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265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 285 286 287 288 289 291 292 293 294 295 296 297 298	с с 250 260 270 с с 270 с с 280 290 с	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TCN+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300 CONTINUE CALCULATE WEIGHTED EFFICIENCIES FOR MODULATING AND TWO-STAGE IF (ICTRL.EQ.2) GO TO 280 EFYSSA=(EFYSSH+EFYSSM)/2. QIONA=(QIONH+QION)/2. EFYU=EFYSSA-OIONA EFYU=EFYU*RHIGH+EFFYU*RLOW EFYSSW=EFYSSA*RHIGH+EFFYU*RLOW EFYSSW=EFYSSA*RHIGH+EFFYU*RLOW EFYSSW=EFYSSH*RHIGH+EFFYU*RLOW EFYSW=EFYUH*RHIGH+EFFYU*RLOW EFYSW=EFYUH EFFYAW=EFYUH EFFYAW=EFYUW*EFYSSW*4400/(EFYSSW*4400+2.5*EFYUW*PF*4600) WRITE (6.830) EFYU.EFYU.FYUW WRITE (6.840) EFYSSH.EFYSSM WRITE (6.840) EFYSSH.EFYSSW WRITE (6.850) EFFYAW
265 266 267 268 269 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 285 286 287 289 290 291 292 293 294 295 296 297	с с 250 260 270 с с 270 с с 280 290 с с	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TCN+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYSS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300 CONTINUE CALCULATE WEIGHTED EFFICIENCIES FOR MODULATING AND TWO-STAGE IF (ICTRL.EQ.2) GO TO 280 EFYSSA=(EFYSSH+EFYSSM)/2. QIONA=(QIONH+QION)/2. EFYU=EFYSSA-OIONA EFYU=EFYU*RHIGH+EFFYU*RLOW EFYSSW=EFYSSA*RHIGH+EFFYU*RLOW EFYSSW=EFYSSA*RHIGH+EFFYU*RLOW EFYSSW=EFYSSH*RHIGH+EFFYU*RLOW EFYSW=EFYUH*RHIGH+EFFYU*RLOW EFYSW=EFYUH EFFYAW=EFYUH EFFYAW=EFYUW*EFYSSW*4400/(EFYSSW*4400+2.5*EFYUW*PF*4600) WRITE (6.830) EFYU.EFYU.FYUW WRITE (6.840) EFYSSH.EFYSSM WRITE (6.840) EFYSSH.EFYSSW WRITE (6.850) EFFYAW
265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 285 286 287 288 289 291 292 293 294 295 296 297 298	с с 250 260 270 с с 270 с с 280 290 с с	FINISH UP BOILG CALCULATIONS IF (INST.EQ.2) GO TO 250 EFFYU=100QL-TON*(QSON+QSOFF+QION+QIOFF)/(TCN+PF*TOFF) GO TO 260 EFFYU=100QL-CJ*QJ-TON*(QSON+QSOFF)/(TON+PF*TOFF) WRITE (6.800) SISO.SISI.F3.F4.F5.F6.F7.F8 WRITE (6.810) QSON.QSOFF.QION.QIOFF.EFFYU IF (ICTRL.GE.1) GO TO 270 EFFYA=EFFYU*EFFYS*4400/(EFFYSS*4400+2.5*EFFYU*PF*4600) WRITE (6.820) EFFYA GO TO 300 CONTINUE CALCULATE WEIGHTED EFFICIENCIES FOR MODULATING AND TWO-STAGE IF (ICTRL.EQ.2) GO TO 280 EFYSSA=(EFYSSH+EFYSSM)/2. QIONA=(QIONH+QION)/2. EFYU=EFYSSA-QIONA EFYUW=EFYSSA*RHIGH+EFFYU*RLOW EFYSSW=EFYSSA*RHIGH+EFFYU*RLOW EFYSSW=EFYSSA*RHIGH+EFFYU*RLOW EFYSW=EFYSSH*RHIGH+EFFYU*RLOW EFYUW=EFFYUH*RHIGH+EFFYU*RLOW EFYUW=EFFYUH*RHIGH+EFFYU*RLOW EFYUW=EFFYUH*RHIGH+EFFYU*RLOW EFYUW=EFFYUH*EFYSSW*4400/(EFYSSW*4400+2.5*EFFYUW*PF*4600) WRITE (6.830) EFFU.EFFYU.EFYUW WRITE (6.840) EFFYSSM*END WRITE (6.850) EFFYAW RELOAD HIGH-FIRE VARIABLES

301		EFFYU=EFYUW
302 303	с с	CALCULATE ANNUAL FUEL REQUIREMENTS
304 305	C 300	A=100000./(341300.*(PE+Y*BE)+(QIN-QP)*EFFYU)
306	000	B=2.*A*QP*EFFYU/100000.
307 308		IF (QP.LT.O.1) 8=0. C=0.38
309		DHR=EFFYSS*QIN/100000.
310 311		80H=2080.*(A*C*DHR-8) AFUEL=(QIN-QP)*80H+8760.*QP
312		AELEC=(PE+Y*BE)*80H
313 314	310	WRITE (6,860) AFUEL,AELEC CONTINUE
315	••••	WRITE (6,870)
316 317	с	STOP
318	С	FORMAT STATEMENTS
319 320	C 500	FORMAT (/5X,31HINPUT DATA @ADD FILE.ELEMENT/)
321	510	FORMAT (20A4)
322 323	520 530	FORMAT (//2(5X.20A4/)) FORMAT (/5X.7HFURNACE)
324	540	FORMAT (/5X,6HBOILER)
325 326	550 560	FORMAT (/5X,13HVENTED HEATER) FORMAT (5X,16HINSTALLED INDOOR)
327	570	FORMAT (5X, 17HINSTALLED OUTDOOR)
328 329	580 590	FORMAT (5X,18HSINGLE STAGE INPUT) FORMAT (5X,20HSTEP MODULATED INPUT)
330	600	FORMAT (5X, 15HTWO STAGE INPUT)
331 332	610 620	FORMAT (5X,30HASSIGNED VALUES FOR OFF-LOSSES) FORMAT (5X,30HMEASURED VALUES FOR OFF-LOSSES)
333	630	FORMAT (///5X.13HINPUT VALUES //5X.6H1)NSYS4X.7H2)IFUEL3X.
334 335		2 5H3)HHV5X,5H4)QIN5X,4H5)QP6X,4H6)PE6X,4H7)BE6X,7H8)XC02S/I7,I10, 3 6X,8(1PE10.2))
336	640	FORMAT (/5x,6H9)TSSS4X,8H10)XC02F2X,7H11)TFSS3X.8H12)TFON12X,
337 338		2 8H13)TFON22X,9H14)TFOFF31X,9H15)TFOFF41X,9H16)TFOFF5/3X, 3 8(1PE10.2))
339	650	FORMAT (/5X,6H17)TRA4X,5H18)QJ5X,6H19)S/F4X,5H20)DF5X,5H21)DS.5X,
340 341	660	2 8H22)Y /3X,8(1PE10.2)) FORMAT (/5X,4HTON=F6.2,4X,5HTOFF=F6.2,5X,4HTOA=F5.1)
342	670	FORMAT (///5X,47HADDITIONAL INPUT VALUES FOR MINIMUM FIRING RATE//
343 344		2 5X,6H1)NSYS4X,7H2)IFUEL3X,5H3)HHV5X,5H4)QIN5X,4H5)QP6X,4H6)PE6X, 3 4H7)BE6X,7H8)XC02S/3(7X,3H),3X,1PE10.2,4X,3H,2(7X,3H),
345	680	4 3X, 1PE10.2)
346 347	680	FORMAT (/5X,6H17)TRA4X,5H18)QJ5X,6H19)S/F4X,5H20)DF5X,5H21)DS,5X, 2 8H22)Y /3X,1PE10.2,4X,3H,3X,3(1PE10.2),4X,3H)
348	690	FORMAT (//5x.49HFRACTION OF TIME IN LOW FIRE/CYCLING MODE = .
349 350		2 F5.3/5X,49HFRACTION OF TIME IN HIGH FIRE/NON-CYCLING MODE = F5.3/ 3 5X,40HOUTDOOR AIR TEMP FOR CYCLING MODE = F6.2/5X,
351	500	4 40HOUTDOOR AIR TEMP FOR NON-CYCLING MODE = F6.2)
352 353	700	FORMAT (///5X,22HFLUE LOSS MEASUREMENTS// 2 63H TIME 0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8
354		3 13H 8-9 9-10/6H CONC 10(1X,F6.1)/6H TEMP 10(1X,F6.1)//
355 356		4 63H TIME 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18 5 13H 18-19 19-20/6H CONC 10(1X,F6.1)/6H TEMP 10(1X,F6.1)//5X,
357		6 26HINITIAL CONC(ENTRATION) = 1PE10.2/5X,
358 359		7 27HMETER VOLUME/BUBBLE TIME = 1PE10.2/5X, 8 24HTEST ROOM TEMPERATURE = 1PE10.2//5X,
360 361	710	9 17HQSOFF MEASURED = 1PE10.2/5X,17HQIOFF MEASURED = 1PE10.2)
362	/10	FORMAT (//5X,19HMINIMUM FIRE VALUES// 2 63H TIME 0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8
363 364		3 13H 8-9 9-10/6H CONC 10(1X,F6.1)/6H TEMP 10(1X,F6.1)// 4 63H TIME 10-11 11-12 12-13 13-14 14-15 15-16 16-17 17-18
365		5 13H 18-19 19-20/6H CONC 10(1X,F6.1)/6H TEMP 10(1X,F6.1)//5X,
366 367		6 26HINITIAL CONC(ENTRATION) = 1PE10.2/5X, 7 27HMETER VOLUME/BUBBLE TIME = 1PE10.2/5X,
368		8 24HTEST ROOM TEMPERATURE = 1PE10.2//5X,
369 370	720	9 17HQSOFF MEASURED = 1PE10.2/5X.17HQIOFF MEASURED = 1PE10.2) FORMAT (///5X.18HCALCULATED VALUES-/)
371	730	FORMAT (///5X,40HCALCULATED VALUES MINIMUM FIRING RATE/)
372 373	740	FORMAT (/5x,5H23)PF5x,7H24)HHVA3x.6H25)A/F4x,5H26)QL5X,5H27)CJ5X, 2 5H23)RT5x,7H29)QSSS3X,9H30)EFFYSS/3X,8(1PE10.2))
374	750	FORMAT (/5X,7H31)TSSS3X,8H32)TAUON2X,9H33)ZETFOX1X,9H34)TAUOFF,1X,
375		2 9H35)PSIFOX1X,9H36)PSIFIX1X,9H37)PSISIX1X,9H38)PSISOX/3X,

.

376		3 B(1PE10.2))
37 7	760	FORMAT (/5X,5H39)CS5X,7H40)CSON3X,8H41)CSOFF2X,7H42)CION3X,
378		2 8H43)CIOFF/3X.5(1PE10.2))
379	770	FORMAT (///5X.46H*** WARNING-HEATING VALUE OF TEST FUEL IS TOO ,
380		2 7HLOW ***///)
381	780	FORMAT (///5X.46H*** WARNING-HEATING VALUE OF TEST FUEL IS TOO .
382		2 8HHIGH ***///)
3 83	790	FORMAT (/5X,6H44)TOA4X.6H45)TON4X.7H46)TOFF3X.7H47)TTON3X,
384		2 8H48)TTOFF.2X.8H49)ZETF02X.8H50)PSIF02X.8H51)PSIFI/3X.
385		3 8(1PE10.2))
386	800	FORMAT (/5X,8H52)PSISO2X.8H53)PSISI2X,5H54)F35X,5H55)F45X,
387		2 5H56)F55X,5H57)F65X,5H58)F75X,5H59)F8/3X,8(1PE10.2))
388	810	FORMAT (/5X,7H60)QSON3X,8H61)QSOFF2X,7H62)QION3X,8H63)QIOFF2X,
389		2 8H64)EFFYU/3X.5(1PE10.2))
390	820	FORMAT (///5X,25HANNUAL FUEL EFFICIENCY = F6.2)
391	830	FORMAT (///5X.36HPART-LOAD EFFICIENCY HIGH FIRE = F6.2/5X.
392		2 35HPART-LOAD EFFICIENCY LOW FIRE = F6.2/5X.
393		3 40HWEIGHTED AVERAGE PART-LOAD EFFICIENCY = F6.2)
394	840	FORMAT (/5X.39HSTEADY-STATE EFFICIENCY HIGH FIRE = F6.2/5X,
395		2 38HSTEADY-STATE EFFICIENCY LOW FIRE = F6.2/5X.
396		3 43HWEIGHTED AVERAGE STEADY-STATE EFFICIENCY = F6.2)
397	850	FORMAT (/5x.42HWEIGHTED AVERAGE ANNUAL FUEL EFFICIENCY = F6.2)
398	860	FORMAT (5X.33HANNUAL FUEL ENERGY CONSUMPTION = 1PE10.3,1X,3HBTU/
399		2 5X,39HANNUAL ELECTRICAL ENERGY CONSUMPTION = 1PE10.3,1X,3HBTU)
400	870	FORMAT (///5X,16HPROGRAM COMPLETE//)
401		END

Subroutine WEIGHT

)

HTRS*BOIL6	A(1).W	VEIGHT(3)
1		SUBROUTINE WEIGHT (QIN, EFFYSS, QINM, EFYSSM, RLOW, TCALO, TOAHI)
2	С	
3	С	SUBROUTINE TO DETERMINE THE FRACTION OF HEATING SEASON IN
4	С	MINIMUM FIRE/CYCLING MODE AND IN MAXIMUM FIRE/NON-CYCLING
5	С	MODE, AS WELL AS THE CORRESPONDING OUTDOOR AIR TEMPERATURE
6	C C	FOR EACH MODE, I.E., TOALO AND TOAHI
7	С	
8		DIMENSION RLO(9), TOAL(9), TOAH(9)
9		DATA RL0/0.01,0.09,0.21,0.33,0.45,0.57,0.69,0.81,0.89/
10		DATA TOAL/59.4,57.9,55.2,53.0,51.1,49.5,47.7,45.9,45.0/
11		DATA TOAH/42.1.40.6.38.2.36.1.33.9.31.6.28.6.24.3.21.7/
12	С	
13		HIMAX=QIN*EFFYSS/100.
14		$HIMIN \neq QINM \neq EFYSSM / 100.$
15		RATIC=HIMIN/HIMAX
16		N=O
17	С	
18	С	ASSIGN VALUES FOR RLOW, TOALO, AND TOAHI
19	С	
20		IF(RATIO.LE.O.15) N=1
21		IF(RATIO.LE.O.26.AND.RATIO.GT.O.15) N=2
22		IF(RATIO.LE.O.35.AND.RATIO.GT.O.26) N=3
23		IF(RATIO.LE.C.43.AND.RATIO.GT.0.35) N=4
24		IF(RATIO.LE.O.50.AND.RATIO.GT.O.43) N=5
25		IF(RATIO.LE.O.57.AND.RATIO.GT.O.50) N=6
26		IF(RATIO.LE.O.G6.AND.RATIO.GT.O.57) N=7
27		IF(RATIO.LE.O.79.AND.RATIO.GT.O.66) N=8
28		IF(RATIO.GT.0.79) N=9
29		RLOW=RLO(N)
30		TOALO=TOAL(N)
31		TOAHI=TOAH(N)
32		RETURN
33		END

Subroutine SENLOS

<pre>SUBROUTINE SENLOS(IFUEL.NSYS.XCO25.TSSSX.XCO2F.TESS.HHVA.AFR.OL.RT</pre>	HTRS*BOIL6	A(1).S	ENLOS(1)
<pre>3 C ***CALCULATION OF HWW AFR OL RT OSSS EFFVSS *** 4 C ***APRIL 1978*** FOR USE WITH NSFRES 5 *** 5 DINKENSION HWV(6).AF(6).0(6).ART(6).BRT(6).CG(5).CF(6.5) 6 DATA (HW(U).J=1.6)/19800.19500.20120.18500.20120.2009./ 7 DATA (AF(U).J=1.6)/14.56.14.49.14.45.11.81.15.58.15.36/ 8 DATA (QU).J=1.6)/14.56.14.49.14.45.11.81.15.58.15.36/ 9 DATA (AF(U).J=1.6)/14.22.14.34.10.96.10.10.12.60.12.93/ 10 DATA (BRT(U).J=1.5)/2.54621214.1.3.020126E-5.2.7608571E-87.4253 12 *321E-12.6.4307377E-16/ 13 DATA (CF(1)K, 1K=1.5)/2.4461834E-01.3.3711449E-6.8.B906305E-91.36 14 *19015C-12.1.4367410E-16/ 15 DATA (CF(1)K, 1K=1.5)/2.49478E-014.9475802E-06.1.3885838E-82. 16 *055094E-12.1.502209E-16/ 17 DATA (CF(1)K, 1K=1.5)/2.569442E-1.7.7561435E-6.1.5833852E-83.41 20 *055094E-12.3.7682444E-17/ 19 DATA (CF(1)K, 1K=1.5)/2.501247E-1.1.77561435E-6.1.5833852E-83.41 20 *56792E-125.4897330E-17/ 21 DATA (CF(1)K, 1K=1.5)/2.501247E-1.1.7737005E-7.1.0820337E-82.06 22 *56792E-125.4897330E-17/ 23 DATA (CF(1)K, 1K=1.5)/2.501247E-1.1.7737005E-7.1.0820337E-81.922 24 *0641E-127.3013274E-17/ 25 HWVA=HW(IFUEL) 26 AFR=127.3013274E-17/ 27 DATA (CF(1K, 1)K=1.5)/2.501247E-1.1.7737005E-7.1.0820337E-81.922 24 *0641E-127.3013274E-17/ 25 HWVA=HW(IFUEL) 26 AFR=137.40127AE-17/ 27 DATA (CF(1K, 1)K=1.5)/2.501247E-1.1.7737005E-7.1.0820337E-81.922 24 *0641E-127.3013274E-17/ 25 HWVA=HW(IFUEL) 26 AFR=137.40127AE-17/ 26 HTVEL/VCO25)+ART(IFUEL) 27 OL=0(IFUEL) 28 XC02×C02F 29 STESSTHASS-6.9 30 C TSS=FRS556.459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(1FUEL)/XC025)+ART(IFUEL) 33 ARTS (BRT(IFUEL)/XC02) 34 CC2×C02F 35 SSX+459.69 35 C CONTINUE 35 SFR = CALSFR 36 O IF(XC02S)+ART(IFUEL) 36 AFR=1.3*(RTS/R) 37 ACC2+C025 37 ARTC1FUEL)(CC2S)+ART(IFUEL) 37 ACC2+C025 38 TSSS+1459.69 39 50 CONTINUE 35 SFR = CALSFR 36 O IF(1FUEL)+(BRT(IFUEL)/XC02) 36 ACC2+C025 37 ACC2+C025 38 TSSS+1459.69 39 50 CONTINUE 35 AFR = CALSFR 36 ACC2 36 ACC2+C025 37 ACC2+C025 38 ARTC1FUEL)+(CR1(IFUEL)/XC02) 39 ACC2+C02(1)*(TS*+1-(TRA+459.69)**1)) 3</pre>			
<pre>3 C ***CALCULATION OF HWW AFR OL RT OSSS EFFVSS *** 4 C ***APRIL 1978*** FOR USE WITH NSFRES 5 *** 5 DINKENSION HWV(6).AF(6).0(6).ART(6).BRT(6).CG(5).CF(6.5) 6 DATA (HW(U).J=1.6)/19800.19500.20120.18500.20120.2009./ 7 DATA (AF(U).J=1.6)/14.56.14.49.14.45.11.81.15.58.15.36/ 8 DATA (QU).J=1.6)/14.56.14.49.14.45.11.81.15.58.15.36/ 9 DATA (AF(U).J=1.6)/14.22.14.34.10.96.10.10.12.60.12.93/ 10 DATA (BRT(U).J=1.5)/2.54621214.1.3.020126E-5.2.7608571E-87.4253 12 *321E-12.6.4307377E-16/ 13 DATA (CF(1)K, 1K=1.5)/2.4461834E-01.3.3711449E-6.8.B906305E-91.36 14 *19015C-12.1.4367410E-16/ 15 DATA (CF(1)K, 1K=1.5)/2.49478E-014.9475802E-06.1.3885838E-82. 16 *055094E-12.1.502209E-16/ 17 DATA (CF(1)K, 1K=1.5)/2.569442E-1.7.7561435E-6.1.5833852E-83.41 20 *055094E-12.3.7682444E-17/ 19 DATA (CF(1)K, 1K=1.5)/2.501247E-1.1.77561435E-6.1.5833852E-83.41 20 *56792E-125.4897330E-17/ 21 DATA (CF(1)K, 1K=1.5)/2.501247E-1.1.7737005E-7.1.0820337E-82.06 22 *56792E-125.4897330E-17/ 23 DATA (CF(1)K, 1K=1.5)/2.501247E-1.1.7737005E-7.1.0820337E-81.922 24 *0641E-127.3013274E-17/ 25 HWVA=HW(IFUEL) 26 AFR=127.3013274E-17/ 27 DATA (CF(1K, 1)K=1.5)/2.501247E-1.1.7737005E-7.1.0820337E-81.922 24 *0641E-127.3013274E-17/ 25 HWVA=HW(IFUEL) 26 AFR=137.40127AE-17/ 27 DATA (CF(1K, 1)K=1.5)/2.501247E-1.1.7737005E-7.1.0820337E-81.922 24 *0641E-127.3013274E-17/ 25 HWVA=HW(IFUEL) 26 AFR=137.40127AE-17/ 26 HTVEL/VCO25)+ART(IFUEL) 27 OL=0(IFUEL) 28 XC02×C02F 29 STESSTHASS-6.9 30 C TSS=FRS556.459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(1FUEL)/XC025)+ART(IFUEL) 33 ARTS (BRT(IFUEL)/XC02) 34 CC2×C02F 35 SSX+459.69 35 C CONTINUE 35 SFR = CALSFR 36 O IF(XC02S)+ART(IFUEL) 36 AFR=1.3*(RTS/R) 37 ACC2+C025 37 ARTC1FUEL)(CC2S)+ART(IFUEL) 37 ACC2+C025 38 TSSS+1459.69 39 50 CONTINUE 35 SFR = CALSFR 36 O IF(1FUEL)+(BRT(IFUEL)/XC02) 36 ACC2+C025 37 ACC2+C025 38 TSSS+1459.69 39 50 CONTINUE 35 AFR = CALSFR 36 ACC2 36 ACC2+C025 37 ACC2+C025 38 ARTC1FUEL)+(CR1(IFUEL)/XC02) 39 ACC2+C02(1)*(TS*+1-(TRA+459.69)**1)) 3</pre>			
 C ***APRIL 1978** FOR USE WITH NSFES 5 *** DIRNSION HWY(6).4F(6).7(6).4RT(6).RAT(6).RAT(6).CA(5).CF(6.5) DATA (HWY(J).J=1.6)/19800.,19500.,2012018500.,20800./ DATA (IAT(J).J=1.6)/14.56.14.49,14.45.11.81.15.36./ DATA (IAT(J).J=1.6)/14.56.14.49,14.45.11.81.15.36/ DATA (IAT(J).J=1.6)/14.25.14.49,14.45.10.86.10.10.12.60.12.93/ DATA (IAT(J).J=1.6)/14.22.14.34,10.96.10.10.12.60.12.93/ DATA (CF(1.K).K=1.5)/2.4416834E-01.3.3711449E-6.8.8906305E-91.36 TOATA (CF(2.K).K=1.5)/2.4416834E-01.3.3711449E-6.8.7098897E-91.309 TOATA (CF(2.K).K=1.5)/2.4361163E-1.3.6702686E-6.8.7098897E-91.309 *4375E-12.1.5022009E-16/ DATA (CF(3.K).K=1.5)/2.5949478E-014.9475802E-06.1.3865838E-82. *605994E-12.3.768244E-17/ DATA (CF(6.K).K=1.5)/2.5106392E-16.4144604E-7.1.1315073E-83.41 *94210E-12.1.2158977E-16/ DATA (CF(6.K).K=1.5)/2.5106392E-16.4144604E-7.1.1315073E-82.06 *56792E-125.4897330E-17/ DATA (CF(6.K).K=1.5)/2.5101247E-1.1.7737005E-7.1.0820337E-81.922 *0641E-127.3013274E-17/ HWYAEHW(IFUEL) AFR=AF(1FUEL) C ** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** IF(1FB.NE.3.0R.XC025.LT.0.1) GO TO 30 RTS= (BRT(1FUEL)/XC02F)+ART(1FUEL) C AAFS F155+459.69 C CONTINUE RTS= CALSFR O CONTINUE RTS= CALSFR O CONTINUE ACDSFR 5.1.0.1.0.R.TSSSX.LT.0.1) GO TO 50 CCONTINUE CALSFR = CALSFR O CONTINUE C AFR=AF(1FUEL)/XC025) + ART(1FUEL) CALSFR = CALSFR O CONTINUE C AFR=AF(1FUEL)/XC025) CATS=CRSF O CONTINUE C AFR=AF(1FUEL)/XC025) C CONTINUE		С	***CALCULATION OF HHVA AFR OL BT OSSS EFFYSS ***
 DINENSIÓN HHV(6), AF(6) O(6), AFT(6), BFT(6), CA(5), CF(6, 5) DATA (HHV(J), J=1, 6)/(1,450, 1,4,49, 1,4,45, 11,41, 15,58, 15,36/ DATA (IQ(J), J=1,6)/(1,450, 1,4,49, 1,4,45, 11,41, 15,58, 15,36/ DATA (Q(J), J=1,6)/(1,450, 1,44,9, 1,4,45, 11,41,15,58, 15,36/ DATA (Q(J), J=1,6)/(1,2,546,1212+1,-3,0260126E-5,2,7608571E-8,-7,4253 *321E-12,6,4307377E-16/ DATA (CF(1,K), K=1,5)/2,5462121E-1,-3,0260126E-5,8,7098897E-9,-1,309 *19015E-12,-1,302909E-16/ DATA (CF(2,K), K=1,5)/2,5943478E-01,-4,9475802E-06,1,3885838E-8,-2,19,205994-12,3,77622442E-17,-7.7561435E-6,1,5833852E-8,-3,41 *005994E-12,3,77622442E-17,-7.7561435E-6,1,5833852E-8,-3,41 *005994E-12,3,27632442E-17,-7.7561435E-6,1,5833852E-8,-3,41 *0592E-12,-1,2158977E-16/ DATA (CF(5,K),K=1,5)/2,5163639E-1,-6,4144604E-7,1,1315073E-8,-2,06 *592E-12,-5,4897330E-17/ DATA (CF(6,K),K=1,5)/2,5011247E-1,1,7737005E-7,1,0820337E-8,-2,06 *630 T5S=TFSS+459.69 Cold IE-12,-7,3013274E-17/ HVA=HHV(IFUEL) AFRAF(IFUEL) AFRAF(IFUEL) Calfer = 1,37(RTS/RT) SF = CALSFR G TF(KD2S), LT,0,1) GO TO 30 RT=(BT(IFUEL)/K025)+ART(IFUEL) CALSFR = 1,37(RTS/RT) SF = CALSFR G TF(AC25, LT,0,1,0R,TSS5X,LT,0,1) GO TO 50 XC02=XC02F CONTINUE RT=ART(IFUEL)/(RBT(IFUEL)/XC02) QF=0, QA=0, CHUEN QA			
<pre>6 DATA (HHV(J), J=1, 6)/19500, 19500, 20120, 19500, 20500, / DATA (LF(U), J=1, 6)/14, 56, 14, 49, 14, 45, 11, 81, 15, 58, 15, 33/ DATA (Q(J), J=1, 6)/6, 55, 6, 50, 9, 55, 10, 14, 7, 99, 7, 79/ DATA (LART(U), J=1, 6)/14, 22, 14, 49, 14, 49, 10, 46, 10, 10, 12, 60, 12, 93/ DATA (CA(U), J=1, 6)/14, 22, 14, 34, 10, 96, 10, 10, 12, 80, 12, 93/ DATA (CA(U), J=1, 5)/2, 5482121E-1, -3, 0250128E-5, 2, 7608571E-8, -7, 4253 2, 232(E-12, 6, 4307377E-16/ DATA (CF(1, K), K=1, 5)/2, 4416634E-01, 3, 3711449E-6, 8, 8906305E-9, -1, 36 4, 475E-12, -1, 4367410E-16/ DATA (CF(2, K), K=1, 5)/2, 4416634E-01, -3, 3711449E-6, 8, 8906305E-9, -1, 309 16, 4375E-12, -1, 5022009E-16/ DATA (CF(3, K), K=1, 5)/2, 5949478E-01, -4, 9475802E-06, 1, 3885938E-8, -2, -1, 15052902E-12, 3, 7682444E-17/ DATA (CF(3, K), K=1, 5)/2, 5949478E-01, -4, 9475802E-06, 1, 3885938E-8, -2, -1, 205994210E-12, 1, 2159977E-16/ DATA (CF(5, K), K=1, 5)/2, 55105442E-1, -7, 7561435E-6, 1, 5833852E-8, -3, 41 20, 505992E-12, 1, 2159977E-16/ 21, DATA (CF(6, K), K=1, 5)/2, 25105639E-1, -6, 4144604E-7, 1, 1315073E-8, -2, 06 22, *56792E-12, -5, 4897330E-17/ 23, DATA (CF(6, K), K=1, 5)/2, 25101247E-1, 1, 7737005E-7, 1, 0820337E-8, -1, 922 4, 6641E-12, -7, 3013274E-17/ 4, HVYA=HW(IFUEL) 24, AFR=AF(IFUEL) 25, AFR=AF(IFUEL) 26, AFR=AF(IFUEL) 27, OL=Q(IFUEL) 27, OL=Q(IFUEL) 28, CA25C02F 30, T5S=TFSS+459, 69 31, C, ** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 34, CA5FR = 1, 3+(RTS/KT) 35, SFR = CAL5FR 36, TSS=TSSS+459.69 36, C, CNTINUE 37, CA25C02F 38, TSS=TSSS+459.69 39, 50, CONTINUE 34, CA15FR = 1, 3+(RTS/KT) 35, SFR = CAL5FR 36, G, CONTINUE 37, CA25C02 36, TSS=TSSS+459.69 39, 50, CONTINUE 37, CA25C02, IT, 0, 1, 00, TO 50, CA25C02F 36, TSS=TSSS+459.69 39, 50, CONTINUE 34, CA15FR = 1, 3+(RTS/KT) 35, SFR = CAL5FR 36, SSS, +4459.69] **1] 36, CONTINUE 37, CA25C02, CONTINUE 37, CA25C02, CONTINUE 37, CA25C02, CONTINUE 36, CONTINUE 37, CA25C02, CONTINUE 37, CA25C02, CONTINUE 37, CA25C02, CONTINUE 37, CA25C02, CONTINUE 37, CA25C02, CONTINUE 37, CA25C02, CONTINUE 37, CA25C0</pre>		Ŭ	
<pre>7 DATA (AF(J), J=1, 6)/14, 56, 14, 49, 14, 45, 11, 61, 15, 58, 15, 36/ DATA (Q(J), J=1, 6)/, 655, 6, 50, 95, 51, 01, 14, 7, 99, 7, 79/ DATA (ART(U), J=1, 6)/, 0679, 06668, 09194, 09546, .0841, .0808/ DATA (BRT(U), J=1, 6)/, 14, 22, 14, 34, 10, 96, 10, 10, 12, 60, 12, 93/ DATA (BRT(U), J=1, 6)/, 12, 2546212E-1, -3, 025012E-5, 2, 7608571E-8, -7, 4253 *321E-12, 6, 4307377E-16/ DATA (CF(1, K), K=1, 5)/2, 4416834E-01, 3, 3711449E-6, 8, 8906305E-9, -11, 36 *18015E-12, -1, 4367410E-16/ DATA (CF(2, K), K=1, 5)/2, 4361163E-1, 3, 6702686E-6, 8, 7098897E-9, -1, 309 *4376E-12, -1, 5029209E-16/ DATA (CF(3, K), K=1, 5)/2, 53949478E-01, -4, 9475802E-06, 1, 3885838E-8, -2. *055994E-12, 3, 7682444E-17/ DATA (CF(3, K), K=1, 5)/2, 53949478E-01, -4, 9475802E-06, 1, 3885838E-8, -2. *055994E-12, 1, 2158977E-16/ DATA (CF(5, K), K=1, 5)/2, 5163639E-1, -6, 4144604E-7, 1, 1315073E-8, -2, 06 *22 *55792E-12, -5, 489730E-17/ DATA (CF(6, K), K=1, 5)/2, 5011247E-1, 1, 7737005E-7, 1, 0820337E-8, -2, 06 22 *55792E-12, -5, 3497374E-17/ DATA (CF(6, K), K=1, 5)/2, 5011247E-1, 1, 7737005E-7, 1, 0820337E-8, -1, 922 *0 DATA (CF(6, K), K=1, 5)/2, 5011247E-1, 1, 7737005E-7, 1, 0820337E-8, -1, 922 *0 CA1E-12, -7, 3013274E-17/ DATA (CF(1, FUEL) CA1FR=XFISTS04495.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** IF(1FB.NE.3, 0R, XCO25, LT.0, 1) GO TO 30 RTS= (BRT(1FUEL)/XCO25) + ART(1FUEL) CALSFR = 1, 3*(RTS/RT) SFR = CALSFR 36 30 IF(XCO25, LT, 0, 1, 0R, TSSSX, LT, 0, 1) GO TO 50 XCO2+XCO25 37 TS=155X+459.69 39 50 CONTINUE 40 RTX=ART(1FUEL)+(BRT(1FUEL)/XCO2) 41 QF=0, 42 QA=0, 43 DO 100 I=1,5 44 QC=0, 44 QA=0, 45 DO 100 I=1,5 45 CONTINUE 46 DO 100 I=1,5 46 CONTINUE 47 QSS=1(0, -025S)/HVA 48 EFFYSS=100, -01-QSSS 49 RETURN 48 EFFYSS=100, -01-QSSS</pre>			
 B DATA (Q(J), J=1, 6)/6.55.6, 50, 9, 55, 10, 14, 7, 99, 7, 79/ DATA (ART(J), J=1, 6)/(14, 22, 14, 34, 10.96, 10, 10, 12, 60, 12, 93/ DATA (CA(U), J=1, 5)/2, 5462121E-1, -3.0250126E-5, 2, 7608571E-8, -7, 4253 * 321E+12, 6.4307377E-16/ DATA (CF(1, K), K=1, 5)/2, 4416634E-01, 3, 3711449E-6, 8, 8906305E-9, -1, 36 * 1301SE-12, -1, 4367410E-16/ DATA (CF(2, K), K=1, 5)/2, 43661163E-1, 3, 6702686E-6, 8, 7098897E-9, -1, 309 * 4376E+12, -1, 502902E+16/ DATA (CF(4, K), K=1, 5)/2, 4361163E-1, 3, 6702686E-6, 8, 7098897E-9, -1, 309 * 4376E+12, -1, 502902E+16/ DATA (CF(4, K), K=1, 5)/2, 598447E-01, -4, 9475802E-06, 1, 3885838E-8, -2. * 0055994E-12, 3, 76624442E-17/ DATA (CF(5, K), K=1, 5)/2, 5163639E-1, -7, 7561435E-6, 1, 5833852E-8, -3, 41 * 94210E-12, 1, 2158977E-16/ DATA (CF(6, K), K=1, 5)/2, 5163639E-1, -6, 4144604E-7, 1, 1315073E-8, -2, 06 * 56792E-12, -5, 4897330E-17/ DATA (CF(6, K), K=1, 5)/2, 5011247E-1, 1, 7737005E-7, 1, 0820337E-8, -2, 06 * 56792E-12, -5, 3013274E-17/ DATA (CF(6, K), K=1, 5)/2, 5011247E-1, 1, 7737005E-7, 1, 0820337E-8, -1, 922 * 0641E-12, -7, 3013274E-17/ HWX=HWY (FUEL) AFR=AF(1FUEL) XC02=XC02F TC *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** IF(1FB.NE.3, 0R, XC025, LT, 0, 1) GO TO 50 XC02=XC02F GATS= TSSSX-459.69 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** IF(1FB.NE.3, 0R, XC025, LT, 0, 1) GO TO 50 XC02=XC02F GALSFR = 1, 3*(RTS/RT) SF FSSSX-459.69 C CMTINUE RTx=ART(1FUEL)/XC02) QF=0. QA=0. QA=0. QA=0. QA=0. QA=0. QA=0. QA=0. <			
<pre>9 DATA (ART(J), J=1,6)/.0679,.06668091940964608410808/ DATA (BRT(J), J=1,6)/14.22,14.34,10.96,10.10.12.60,12.93/ DATA (CA(J), J=1,5)/2.5462121E-1,-3.0260126E-5,2.7608571E-8,-7.4253 *321E-12,6.4307377E-16/ DATA (CF(1,K),K=1,5)/2.4416834E-01,3.3711449E-6,8.8906305E-9,-1.36 *18015E-12,-1.4367410E-16/ DATA (CF(2,K),K=1,5)/2.4361163E-1,3.6702686E-6,8.7098897E-9,-1.309 *4376E-12,-1.5029209E-16/ DATA (CF(2,K),K=1,5)/2.361163E-1,3.6702686E-6,8.7098897E-9,-1.309 *4376E-12,3.7682444E-17/ DATA (CF(4,K),K=1,5)/2.509442E-1,-7.7561435E-6,1.5833852E-8,-3.41 *005994E-12,3.7682444E-17/ DATA (CF(5,K),K=1,5)/2.501247E-1,-7.7561435E-6,1.5833852E-8,-3.41 DATA (CF(6,K),K=1,5)/2.501247E-1,1.7737005E-7,1.0820337E-8,-2.06 *56792E-12,-5.4897330E-17/ DATA (CF(6,K),K=1,5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.622 *56792E-12,-7.3013274E-17/ HAVA=KHV(IFUEL) ZC *5675554459.69 ZC *5675554459.69 ZC *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** IF(IFE,K,3.0R,XC025,LT.0.1) GO TO 30 RT5= (BRT(IFUEL)/XC025)+ART(IFUEL) XC02=XC025 SF = CALSFR 30 IF(XC025,LT.0.1.0R,TSSX,LT.0.1) GO TO 50 XC02=XC025 SF = CALSFR 30 IF(XC025,LT.0.1.0R,TSSX,LT.0.1) GO TO 50 XC02=XC024 CQ = 0. QA=</pre>			
<pre>10 DATA (DRT(u), u=1, 6)/14.22, 14.34, 10.96, 10.10, 12.60, 12.93/ 11 DATA (CA(U), u=1, 5)/2, 5462121E+1, -3.0250126E-5, 2.7608571E-8, -7, 4253 12 * 321E-12, 6.4307377E-16/ DATA (CF(1,K), K=1, 5)/2, 4416834E-01, 3.3711449E-6, 8.8906305E-9, -1.36 14 * 1901SE-12, -1.4367410E-16/ 15 DATA (CF(2,K), K=1, 5)/2, 4361163E-1, 3.6702686E-6, 8.7098897E-9, -1, 209 16 * 4375E-12, -1.502209E-16/ DATA (CF(3,K), K=1, 5)/2, 559944EE-01, -4.9475802E-06, 1.3885838E-8, -2. 17 DATA (CF(3,K), K=1, 5)/2, 559944E-01, -4.9475802E-06, 1.3885838E-8, -3.41 20 *95994E-12, 3.7682444E-17/ 19 DATA (CF(4,K), K=1, 5)/2, 5598442E-1, -7.7561435E-6, 1.5833852E-8, -3.41 20 *9592E-12, -5.4897330E-17/ 21 DATA (CF(6,K), K=1, 5)/2, 5501247E-1, 1.7737005E-7, 1.0820337E-8, -2.06 22 *55792E-12, -5.4897330E-17/ 23 DATA (CF(6,K), K=1, 5)/2, 5011247E-1, 1.7737005E-7, 1.0820337E-8, -1.922 4 *0641E-12, -7, 3013274E-17/ HHVA=HHV(IFUEL) 24 *0641E-12, -7, 3013274E-17/ HHVA=HHV(IFUEL) 25 AFR=45/1FUEL) 26 AFR=45/(IFUEL) 27 OL=0(IFUEL) 28 XC02=XC02F 30 TS=r15554459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFIG.NC, SL, T, 0, 1.0R, TSSSX, LT, 0, 1) GO TO 30 33 RTS= (BRT(IFUEL)/XC02S) + ART(IFUEL) 34 C02=XC025 35 CONTINUE 36 30 IF(XC02S, LT, 0, 1.0R, TSSSX, LT, 0, 1) GO TO 50 37 XC02=XC025 38 TS=TSSSX+459.69 39 SO CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 OF=0. 42 OA=0. 43 DO 100 I=1, 5 44 OF=0. 44 OF=0. 45 C02=C025 45 C00=C0SSS(HHVA CSSS) 49 RETURN 40 RETURN</pre>	-		
<pre>11 DATA (CA(J)_J=1,5)/2,5462121E-1,-3.0250126E-5,2.7608571E-8,-7.4253 12 *321E-12,6.4307377E-16/ 13 DATA (CF(1,K),K=1,5)/2,4416834E-01,3.3711449E-6,8.8906305E-9,-1.36 14 *19015E-12,-1.4367410E-16/ 15 DATA (CF(2,K),K=1,5)/2,4361163E-1,3.6702686E-6,8.7098897E-9,-1.309 16 *4378E-12,-1.4367410E-16/ 17 DATA (CF(3,K),K=1,5)/2,5949478E-01,-4.9475802E-06,1.3885838E-8,-2. 18 *D059994E-12,3.7682444E-17/ 19 DATA (CF(3,K),K=1,5)/2.5949478E-01,-7.7561435E-6,1.5833852E-8,-3.41 20 *94210E-12,1.2158977E-16/ 21 DATA (CF(5,K),K=1,5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 17 *0ATA (CF(6,K),K=1,5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 18 *05792E-12,-5.489730E-17/ 23 DATA (CF(6,K),K=1,5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-2.06 24 *0641E-12,-7.3013274E-17/ 25 H4V4=H4V(IFUEL) 26 AFR=AF(IFUEL) 27 OL=Q(IFUEL) 27 OL=Q(IFUEL) 28 RT=(ERT(IFUEL)/XC02F)+ART(IFUEL) 29 XC02=XC02F 30 TS=TFS54459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3)0R.XC025.LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XC02S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC025.LT.0.1.0R.TSSX.LT.0.1) GO TO 50 37 XC02=XC025 38 TS=TSSX+459.69 39 50 CCNTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 OF=0. 42 OA=0. 43 DO 100 I=1,5 44 CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 OA=0A+CA(I)*(TSS*I-(TRA+459.69)**I) 46 OSS5/HHVA 47 OSS5/HHVA 48 EFVYS=1000L-OSS5 49 RETURN 40 AFTURN 40 CATSCA</pre>			
<pre>12 *321E-12.6.4307377E-16/ DATA (CF(1,K),K=1,5)/2.4416B34E-01.3.3711449E-6.8.B906305E-9,-1.36 *19015E-121.4367410E-16/ DATA (CF(2,K),K=1.5)/2.4361163E-1.3.6702686E-6.8.7098B97E-9,-1.209 *0478E-121.502209E-16/ DATA (CF(3,K),K=1.5)/2.55949478E-014.9475802E-06.1.3865838E-82. *0050994E-12.3.7682444E-17/ DATA (CF(4,K),K=1.5)/2.5594478E-014.9475802E-06.1.5833852E-83.41 *045902E-12.1.2158977E-16/ DATA (CF(5,K),K=1.5)/2.5163639E-1,-6.4144604E-7.1.1315073E-82.06 *56792E-125.4897330E-17/ DATA (CF(6,K),K=1.5)/2.5101247E-1.1.7737005E-7.1.0820337E-82.06 *56792E-125.4897330E-17/ DATA (CF(6,K),K=1.5)/2.5011247E-1.1.7737005E-7.1.0820337E-81.922 *0641E-127.3013274E-17/ HHVA=HHV(1FUEL) AFR=AF(1FUEL) CO_1EQ0(1FUEL) CO_2XC02F CO_2XC02F CO_2XC02F CALSFR = 1.3*(RT5/RT) SFR = CALSFR SG 30 IF(XC02S,LT.0.1) GO TO 30 RTS= (BRT(1FUEL)/XC02S)+ ART(1FUEL) XC02=XC02S SG TS=TSS5X+459.69 CO_1F(1EUE) CO_1F(1EUE) CO_1F(1EUE) CO_1F(1EUE) CO_2XC02S SG TS=TSS5X+459.69 CO_1INUE RTX=ART(1FUEL)+(BRT(1FUEL)/XC02) CALSFR = 1.3*(RT5/RT) SFR = CALSFR CO_1F(XC02S)+ ART(1FUEL) CO_3SS-(1.4,AER)0-69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CO_2TC02S SG TS=TSS5X+459.69 CO_1INUE CG=CF(CF(1FUEL)+(BRT(1FUEL)/XC02) CG=CF(CG) CO_1INUE CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CF(1FUEL)+(RT(1FUEL)/XC02) CG=CF(CG</pre>			
<pre>13 DATA (CF(1,K),K=1,5)/2.4416834E-01,3.3711449E-6,8.8906305E-9,-1.36 14 *19015E-12,-1.4367410E-16/ 15 DATA (CF(2,K),K=1,5)/2.4361163E-1,3.6702686E-6,8.7098897E-9,-1.309 16 *4376E-12,-1.5029209E-16/ 17 DATA (CF(3,K),K=1,5)/2.5949478E-01,-4.9475802E-06,1.3865838E-8,-2. 18 *005994E-12,3.7682444E-17/ 19 DATA (CF(5,K),K=1,5)/2.50598442E-1,-7.7561435E-6,1.5833852E-8,-3.41 20 *56792E-12,-5.4897330E-17/ 21 DATA (CF(5,K),K=1,5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 22 *56792E-12,-5.4897330E-17/ 23 DATA (CF(6,K),K=1,5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.922 44 *0641E-12,-7.3013274E-17/ HVA=HHV(1FUEL) 26 AFR=AF(1FUEL) 27 OL=Q(1FUEL) 28 TS=FSS+459.69 29 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 29 IF(1FB.NE.3.0R.XC025.LT.0.1) GO TO 30 20 RTS= (BRT(1FUEL)/XC02F)+ART(1FUEL) 21 CALSFR 1.3*(RTS/ART) 23 SFR = CALSFR 34 OCMTINUE 40 RTX=ART(1FUEL)/(CO2F)+ART(1FUEL) 41 CALSFR 1.3*(RTS/ART) 42 SFTSS5X+459.69 43 O IF(XC025.LT.0.1.0R.TSSX.LT.0.1) GO TO 50 44 C02 AC025 45 CONTINUE 40 RTX=ART(1FUEL)+(BRT(1FUEL)/XC02) 41 Of=0. 42 QA=0. 43 DD 100 I=1,5 44 CF-0. 44 OCX=CACA(1)*(TSS**I-(TRA+459.69)**I) 45 100 QA=CA+CA(I)*(TSS*I-(TRA+459.69)**I) 46 CF=FFC(FIFUEL,1)*(TSS*I-(TRA+459.69)*I) 47 QSS=100.*0SS/HHVA 48 EFFYSS=1000L-0SSS 49 RETURN 40 FFURN</pre>			
<pre>14 *1001SE-12,-1,4367410E-16/ 15 DATA (CF(2,K),K=1,5)/2.4361163E-1,3.6702686E-6,8.7098897E-9,-1,309 *4376E-12, -1,5029209E-16/ 17 DATA (CF(3,K),K=1,5)/2.5949478E-01,-4.9475802E-06,1.3685838E-8,-2. 18 *0050994E-12,3.7682444E-17/ DATA (CF(4,K),K=1,5)/2.6598442E-1,-7.7561435E-6,1.5633852E-8,-3.41 *94210E-12,1,2158977E-16/ 10 DATA (CF(5,K),K=1,5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 22 *56792E-12,-5.4897330E-17/ 23 DATA (CF(6,K),K=1,5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.922 *0641E-12,-7.3013274E-17/ HHVA=HHV(1FUEL) 24 *0641E-12,-7.3013274E-17/ HHVA=HHV(1FUEL) 25 HAVA=KHV(1FUEL) 26 AFR=AF(1FUEL) 27 OL=O(1FUEL) 28 KT=CET(1FUEL)/XC02F)+ART(1FUEL) 29 XC02=XC02F 30 TS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(1FR.NE.3.0R.XC02S,LT.0.1) GO TO 30 33 RTS= (BRT(1FUEL)/XC02F)+ART(1FUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC02S,LT.0.1.0R.TSSX.LT.0.1) GO TO 50 37 XC02=XC025 38 TS=TSSX+459.69 39 50 CONTINUE 40 RTX=ART(1FUEL)+(BRT(1FUEL)/XC02) 41 OF=0. 42 OA=0. 43 D0 100 I=1,5 44 GF=0. 45 100 QA=0A+CA(1)*(TSS**I-(TRA+459.69)**I) 45 100 QA=0A+CA(1)*(TSS*+I-(TRA+459.69)**I) 46 CSS=100.*0SS/HHVA 47 GSSS=100.*0SSS/HHVA 48 EFFYSS=1000L-OSSS 49 RETURN</pre>			
<pre>15 DATA (CF(2,K), K=1,5)/2.4361163E-1,3.6702686E-6,8.7098897E-9,-1.309 16 *4372E-12,-1.5029209E-16/ 17 DATA (CF(3,K),K=1,5)/2.5949478E-01,-4.9475802E-06,1.3885838E-8,-2. 18 *0059994E-12,3.7682444E-17/ 19 DATA (CF(4,K),K=1.5)/2.5598442E-1,-7.7561435E-6,1.5833852E-8,-3.41 20 *94210E-12,1,2158977E-16/ 21 DATA (CF(5,K),K=1,5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 22 *56792E-12,-5.4897330E-17/ 23 DATA (CF(6,K),K=1,5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.922 24 *0641E-12,-7.3013274E-17/ 19 HVXa-HW(1FUEL) 26 AFR=AF(1FUEL) 27 OL=0(1FUEL) 27 OL=0(1FUEL) 28 XC02=XC02F 29 XC02=XC02F 30 TSS=TFS5+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(1FUEL)/XC025)+ART(1FUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC025,LT,0.1).0R.TSSSX.LT.0.1) GO T0 30 37 XC02=XC025 38 TSS=TSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(8RT(1FUEL)/XC02) 41 OF=0. 42 OA=0. 43 D0 100 1=1.5 44 CG=0. 42 OA=0. 43 D0 100 1=1.5 44 CG=0.4CA(1)*(TSS*1-(TRA+459.69)*1) 45 100 QA=0A+CA(1)*(TSS*1-(TRA+459.69)*1) 46 OSS=100.*0SSS/HHVA 48 EFFYSS=100.*0L-0SSS 49 RETURN 45 CALSFR 46 CFVSSE100.*0L-0SSS 47 CO2SS 49 RETURN 45 CALSFR 45 CFVSSE100.*0L-0SSS 45 CFVSSE100.*0L-0SSS</pre>			
<pre>16 *43782-121.502920E-16/ 17 DATA (CF(3,K),K=1.5)/2.5949478E-01,-4.9475802E-06.1.3885838E-8,-2. 18 *0055994E-12.3.7682444E-17/ DATA (CF(4,K),K=1.5)/2.6598442E-1,-7.7561435E-6.1.5833852E-8,-3.41 20 *94210E-12.1.2158977E-16/ DATA (CF(5,K),K=1.5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 21 DATA (CF(6,K),K=1.5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 22 *56792E-125.4897330E-17/ 23 DATA (CF(6,K),K=1.5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.922 4 *0641E-127.3013274E-17/ HVVA=HHV(IFUEL) 26 AFR=AF(IFUEL) 27 OL=Q(IFUEL) 28 CO2=XCO2F 30 TSS=TFSS459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 17 (IFB.NE.3.0R.XCO2S.LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.0.1.0R.TSSX.LT.0.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSS4459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 OF=0. 42 QA=0. 43 D0 100 I=1.5 44 CF=0. 44 CF=0. 45 CP+CF(IFUEL.1)*(TSS*1-(TRA+459.69)**1) 45 IO0 QA=0A+CA(1)*(TSS*1-(TRA+459.69)**1) 46 QSS=110.*QSSS/HVA 47 QSSS=100.*QSSS/HVA 48 EFFYSS=100.*QL-QSSS 49 RETURN </pre>			
<pre>17 DATA (CF(3,K),K=1.5)/2.5949478E-01,-4.9475802E-06,1.3885838E-8,-2. * C055994E-12,3.7682444E-17/ DATA (CF(4,K),K=1.5)/2.6598442E-1,-7.7561435E-6,1.5833852E-8,-3.41 * 94210E-12,1.2158977E-16/ 21 DATA (CF(5,K),K=1.5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 * 56792E-12,-5.4897330E-17/ DATA (CF(6,K),K=1.5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.922 * 0641E-12,-7.3013274E-17/ HVA=HV(IFUEL) 26 AFR=AF(IFUEL) 27 OL=O(IFUEL) 29 XC02F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 1F(IFB.NE.3.0R.XC02S,LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XC02F) + ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC02S,LT.0.1.0R.TSSSX.LT.0.1) GO TO 50 XC02=XC025 38 TSS=TSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 OF=0. 42 QA-0. 43 DD 100 I=1,5 44 CF=OF+CF(IFUEL)+(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 CSS=100.*QSSS/HHVA 47 CSSS=100.*QSSS/HHVA 48 CFFYSS=100.*QL-9SSS 49 RETURN</pre>			
<pre>18 *0059994E-12,3.7682444E-17/ 19 DATA (CF(4,K),K=1.5)/2.6598442E-1,-7.7561435E-6,1.5833852E-8,-3.41 20 *94210E-12,1.2158977E-16/ 21 DATA (CF(5,K),K=1.5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 22 *56792E-12,-5.4897330E-17/ 23 DATA (CF(6,K),K=1.5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.922 24 *0641E-12,-7.3013274E-17/ 25 HAVA=HHV(IFUEL) 26 AFR=AF(IFUEL) 27 QL=0(IFUEL) 20 RT=(DRT(IFUEL)/XC02F)+ART(IFUEL) 20 XC02=XC02F 30 T5S=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.0R.XC02S.LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XC02S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 I7(XC02S.LT.0.1.0R.TSSX.LT.0.1) GO TO 50 37 XC02=XC025 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 QF=0. 42 QA=0. 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 QF=0. 42 QA=0. 43 DD 100 I=1.5 44 CF=0.4(I)*(TSS*1-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS*1-(TRA+459.69)**I) 46 QSS=100.*QSSS/HHVA 47 QSSS=100.*QSSS/HHVA 48 CFFYSS=100.*QL-9SSS 49 RETURN</pre>			
19 DATA (CF(4,K),K=1.5)/2.6598442E-1,-7.7561435E-6,1.5833852E-8,-3.41 20 *9410E-12,1.2158977E-16/ 21 DATA (CF(5,K),K=1.5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 22 *56792E-12,-5.4897330E-17/ 23 DATA (CF(5,K),K=1.5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.922 24 *0641E-12,-7.3013274E-17/ 25 HHVA=HHV(IFUEL) 26 AFR=AF(IFUEL) 27 OL=0(IFUEL) 28 XC02=XC02F 29 XC02=XC02F 30 TS=TFSS+469.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3,OR.XC02S,LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XC02S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC02S,LT.0.1.0R.TSSSX.LT.0.1) GO TO 50 37 XC02=XC02S 38 TS=TSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(RET(IFUEL)/XC02) 41 QF=0. 42 QA=0. 43 D0 100 I=1,5 44			
<pre>20 *94210E-12.1.2158977E-16/ 21 DATA (CF(5,K).K=1.5)/2.5163639E-1,-6.4144604E-7,1.1315073E-8,-2.06 22 *56792E-125.48973302-17/ 23 DATA (CF(6,K).K=1.5)/2.5011247E-1.1.7737005E-7,1.0820337E-8,-1.922 24 *0641E-127.3013274E-17/ 46 H4V4.H4V(IFUEL) 26 AFR=AF(IFUEL) 27 OL=Q(IFUEL) 28 RT=(CBT(IFUEL)/XC02F)+ART(IFUEL) 29 XC02=XC02F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.0R.XC02S.LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XC02S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC02S.LT.0.1.0R.TSSX.LT.0.1) GO TO 50 37 XC02=XC02S 38 TSS=TSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 OF=0. 42 QA=0. 43 DO 100 I=1.5 44 CF=QF+CF(IFUEL.)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSS=100.+QCSSS/HHVA 47 QSSS=100.+QL-QSSS 49 RETURN</pre>			
<pre>21 DATA (CF(5,K),K=1,5)/2.5:63639E-1,-6.4144604E-7,1.1315073E-8,-2.06 22 *56792E-12,-5.4897330E-17/ 23 DATA (CF(6,K),K=1,5)/2.5011247E-1,1.7737005E-7,1.0620337E-8,-1.922 24 *0641E-12,-7.3013274E-17/ 25 HAWA=KHW(IFUEL) 26 AFR=AF(IFUEL) 27 OL=0(IFUEL) 20 RT=(ERT(IFUEL)/XCO2F)+ART(IFUEL) 29 XCO2=XCO2F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.0R.XCO2S.LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.0.1.0R.TSSSX.LT.0.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSS+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 OF=0. 42 QA=0. 43 DO 100 I=1.5 44 C7=OF+CF(IFUEL)*(TSS*TI-(TRA+459.69)*TI) 45 100 QA=CA+CA(I)*(TSS*TI-(TRA+459.69)*TI) 45 100 QA=CA+CA(I)*(TSS*TI-(TRA+459.69)*TI) 46 QSS=(1.+AFR)*OF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100QL-QSSS 49 RETURN</pre>			
<pre>22 *56792E-12,*5.4897330E-17/ 23 DATA (CF(6,K),K=1,5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,*1.922 *0641E-12,*7.3013274E-17/ HHVA=KHW(IFUEL) 24 *0641E-12,*7.3013274E-17/ HHVA=KHW(IFUEL) 25 AFR=AF(IFUEL) 26 AFR=AF(IFUEL) 27 QL=Q(IFUEL) 29 XC02=XC02F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 30 FTS= (BRT(IFUEL)/XC02S)+ ART(IFUEL) 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.0R.XC02S.LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XC02S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC02S.LT.0.1.0R.TSSSX.LT.0.1) GO TO 50 37 XC02=XC02S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 QF=0. 42 QA=0. 43 DO 100 I=1.5 44 Cf=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 CFFYSS=100QL-QSSS 49 RETURN</pre>			
<pre>23 DATA (CF(6,K).K=1,5)/2.5011247E-1,1.7737005E-7,1.0820337E-8,-1.922 24 *0641E-12,-7.3013274E-17/ 25 HHVA=HHV(IFUEL) 26 AFR=AF(IFUEL) 27 QL=Q(IFUEL) 27 QL=Q(IFUEL) 28 RT=(ERT(IFUEL)/XC02F)+ART(IFUEL) 29 XC02=XC02F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 31 F(IFB.NE.3, QR.XC02S.LT.0.1) GO TO 30 32 RTS= (BRT(IFUEL)/XC02S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC02S.LT.0.1.0R.TSSSX.LT.0.1) GO TO 50 37 XC02=XC025 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 QF=0. 42 QA=0. 43 DO 100 I=1,5 44 CF=CF(IFUEL,I)*(TSS*XI-(TRA+459.69)**I) 45 100 QA=CA+CA(I)*(TSS*XI-(TRA+459.69)**I) 46 QSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100QL-QSSS 49 RETURN 41 CF=CALSFA 41 CF=CALSFA 43 CALSFA 44 CALSFA 45 CALSFA 45 CALSFA 46 CF=CALSFA 46 CALSFA 47 CALSFA 48 CF=CALSFA 49 RETURN 40 CALSFA 41 CALSFA 42 CALSFA 43 CALSFA 44 CALSFA 45 CF=CALSFA 45 CALSFA 45 CALSFA 45 CALSFA 46 CALSFA 47 CALSFA 47 CALSFA 48 CEFFYSS=100QL-QSSS 49 CALSFA 49 CALSFA 40 CALSFA 41 CALSFA 41 CALSFA 42 CALSFA 43 CALSFA 44 CALSFA 45 CALSFA</pre>			
<pre>24 *0641E-12,-7.3013274E-17/ 25 HHVA=HHV(IFUEL) 26 AFR=AF(IFUEL) 27 OL=0(IFUEL) 28 RT=(ERT(IFUEL)/XCO2F)+ART(IFUEL) 29 XCO2=XCO2F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.0R.XCO2S.LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.0.1.0R.TSSSX.LT.0.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 OF=0. 42 QA=0. 43 DO 100 I=1.5 44 CF=0F+CF(IFUEL.I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=CA(I)*(TSS*I-(TRA+459.69)**I) 46 QSS=(1.+AFR)*OF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 CFFYSS=100.*QL-QSSS 49 RETURN</pre>			
<pre>25 HHVA=HHV(IFUEL) 26 AFR=AF(IFUEL) 27 QL=Q(IFUEL) 28 RT=(DRT(IFUEL)/XCO2F)+ART(IFUEL) 29 XCO2=XCO2F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.OR.XCO2S.LT.O.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.O.1.OR.TSSSX.LT.O.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 DO 100 I=1.5 44 CF=0. 42 GA=0. 43 DO 100 I=1.5 44 CF=0. 45 100 QA=QA+CA(I)*(TSS*I-(TRA+459.69)*I) 45 100 QA=QA+CA(I)*(TSS*I-(TRA+459.69)*I) 46 QSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 CFFYSS=100.*QL-QSSS 49 RETURN</pre>			
26 AFR=AF(IFUEL) 27 QL=Q(IFUEL) 28 RT=(DRT(IFUEL)/XC02F)+ART(IFUEL) 29 XC02=XC02F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.0R.XC02S.LT.0.1) GO TO 30 33 RTS= (DRT(IFUEL)/XC02S) + ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC02S.LT.0.1.0R.TSSSX.LT.0.1) GO TO 50 37 XC02=XC02S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 QF=0. 42 QA=0. 43 D0 100 I=1.5 44 QF=CFCF(IFUEL.I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100QL-QSS 49 RETURN			
<pre>27 OL=Q(IFUEL) 28 RT=(ERT(IFUEL)/XCO2F)+ART(IFUEL) 29 XCO2=XCO2F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.OR.XCO2S.LT.O.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.O.1.OR.TSSSX.LT.O.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 DO 100 I=1.5 44 GF=CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS*I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS*I-(TRA+459.69)**I) 46 QSSS=1(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QL-QSSS 49 RETURN</pre>			•
28 RT=(ERT(IFUEL)/XCO2F)+ART(IFUEL) 29 XCO2=XCO2F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.OR.XCO2S.LT.O.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.O.1.OR.TSSSX.LT.O.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 D0 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS*I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100QL-QSSS 49 RETURN			
29 XC02=XC02F 30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.OR.XC02S.LT.O.1) GO TO 30 33 RTS= (BRT(IFUEL)/XC02S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XC02S.LT.O.1.OR.TSSSX.LT.O.1) GO TO 50 37 XC02=XC02S 38 TSS=TSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 QF=0. 42 QA=0. 43 D0 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100QL-QSSS 49 RETURN			
30 TSS=TFSS+459.69 31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.0R.XCO2S.LT.0.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.0.1.0R.TSSSX.LT.0.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTx=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 D0 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS*I-(TRA+459.69)**I) 46 QSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSS=100.*QSSS 48 EFFYSS=100.*QL-QSSS 49 RETURN			
31 C *** SFR TEST ONLY FOR VENTED HEATERS WITH DRAFT HOODS *** 32 IF(IFB.NE.3.OR.XCO2S.LT.O.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.O.1.OR.TSSSX.LT.O.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSSX+459.69 39 50 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 D0 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			
32 IF(IFB.NE.3.OR.XCO2S.LT.O.1) GO TO 30 33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.O.1.OR.TSSSX.LT.O.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 D0 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN		_	
33 RTS= (BRT(IFUEL)/XCO2S)+ ART(IFUEL) 34 CALSFR = 1.3*(RTS/RT) 35 SFR = CALSFR 36 30 IF(XCO2S.LT.O.1.OR.TSSSX.LT.O.1) GO TO 50 37 XCO2=XCO2S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 DO 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN		С	
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36 30 IF(XC02S.LT.0.1.0R.TSSSX.LT.0.1) G0 T0 50 37 XC02=XC02S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XC02) 41 QF=0. 42 QA=0. 43 D0 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			
37 XCO2=XCO2S 38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 DO 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS*I-(TRA+459.69)**I) 45 100 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			
38 TSS=TSSSX+459.69 39 50 CONTINUE 40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 DO 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS*I-(TRA+459.69)**I) 45 100 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QL-QSSS 49 RETURN		30	
39 50 CCNTINUE 40 RTx=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 DO 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			
40 RTX=ART(IFUEL)+(BRT(IFUEL)/XCO2) 41 QF=0. 42 QA=0. 43 D0 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			
41 QF=0. 42 QA=0. 43 DO 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN		50	
42 QA=0. 43 D0 100 I=1.5 44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			
43 D0 100 I=1.5 44 Qf=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			•
44 QF=QF+CF(IFUEL,I)*(TSS**I-(TRA+459.69)**I) 45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			
45 100 QA=QA+CA(I)*(TSS**I-(TRA+459.69)**I) 46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100.*QL-QSSS 49 RETURN			
46 QSSS=(1.+AFR)*QF+(RTX-1.)*AFR*QA 47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100QL-QSSS 49 RETURN			
47 QSSS=100.*QSSS/HHVA 48 EFFYSS=100QL-QSSS 49 RETURN		100	
48 EFFYSS=100QL-QSSS 49 RETURN			
49 RETURN			
50 END			
	50		END

Subroutine OFFLOS

HTRS*801L6	A(1).0F	FFLOS(2)
1		SUBROUTINE OFFLOS(CONC.TS.CONCI.VTTT.TROOM.TOA.QIN.QSOFF.QIOFF)
2	С	
3	С	SUBROUTINE TO CALCULATE OFF-CYCLE FLUE LOSSES BASED ON MEASURED
4	С	VALUES OF TRACER GAS CONCENTRATION AND STACK TEMPERATURE
5	С	
6		DIMENSION CONC(20), TS(20)
7		OFFLS=0.0
8		OFFLI=0.0
9		DO 10 J=1,20
10		RATIO=(CONCI-CONC(J))/CONC(J)
11		FLCW=0.01*VTTT*RATIO/60.
12		OFFLS=OFFLS+O.24*FLOW*(TS(J)-TROOM)
13		05FLI=0FFLI+0.24*FLOW*(70.0-TOA)
14	10	CONTINUE
15		QSOFF=3CO.*OFFLS/QIN
16		QIOFF=300.*1.3*0.7*0FFLI/QIN
17		RETURN
18		END

Subroutine FUNT4

HTRS*BOIL6A(1). FU	NT4(1)
1	.,	SUBROUTINE FUNT4(N,SI,TTOFF,REFTOA,REFTRM,FI,FJ)
2		T1=REFTRM-REFTOA
3		C1=1.
4		T2=REFTRM+460.
5		IF(N.E0.4) T1=0.
6		IF(N.EQ.8) C1=0.0
7		X=0.
8		FI =0.
9		FJ ≈0.
10		DX =TTOFF /500.
11		FF11=(SI+T1)**0.56*SI**C1/(SI+T2)**1.19
12		FF21=(SI+T1+100.)**0.56*(SI+100.)**C1/(SI+T2+100.)**1.19
13		D0 100 I=1.250
14		X=X+DX
15		XX=SI *EXP(-X)
16		FF12=(XX+T1)**0.56*XX**C1/(XX+T2)**1.19
17		FF22=(XX+T1+100.)**0.56*(XX+100.)**C1/(XX+T2+100.)**1.19
18		X=X+DX
19		XX=SI *EXP(-X)
20		FF13=(XX+T1)**0.56*(XX)**C1/(XX+T2)**1.19
21		FF23=(XX+T1+100.)**0.56*(XX+100.)**C1/(XX+T2+100.)**1.19
22		FI =FI +(FF11+4.*FF12+FF13)
23		FJ = FJ + (FF21+4.*FF22+FF23)
24		FF11=FF13
25	100	FF21=FF23
26	100	IF((ABS(FJ-FI)).LE.0.0000001) GO TO 110
27		FJ = (FJ - FI) / (100. * TTOFF)
28		FJ =DX *FJ /3.
29		GO TÚ 120
30	110	FJ =0.
31		F1 =F1 *DX /(3.*TTOFF)
32		RETURN
33		END

Figure C3. Input data format for FBVH

Line 1: NRUN (integer) NRUN = number of sets of test data to be analyzed. Lines 2 through 53 should be repeated NRVN times in the stored data file/element Line 2: TITLE TITLE = one to 80 alphanumeric characters describing the test conditions/data Line 3: SUBTITLE SUBTITLE = one to 80 alphanumeric characters describing the test conditions/data Line 4: IFB, INST, ICTRL, LOSOPT (all integers) IFB = 1 for furnaces = 2 for boilers = 3 for vented heaters INST = 1 for vented heating equipment installed indoors = 2 for vented heating equipment installed outdoors and floor furnaces ICTRL = 0 for single stage controls = 1 for step modulating controls = 2 for two stage controls LOSOPT = 0 for analytic determination of off-cycle stack losses (method used in References 1 and 4) = 1 for determination of off-cycle stack losses from tracer gas technique (see Reference 6) Line 5: NSYS, IFUEL, HHV, QP, PE, BE, XCO25 Line 6: TSSS, XCO2F, TFSS, TFON1, TFON2, TFOFF3, TFOFF4, TFOFF5 Line 7: TRA, QJ, SFR, DF, DS, Y Measured quantities/assigned values defined in Reference 4, evaluated at maximum firing rate Line 8: TON, TOFF, TOA

TON = 20 min TOFF = 20 min TOA = $45^{\circ}F$ For Vented Heaters

See Reference 4 for values for other types of heating equipment.

OMIT LINES 9-11 for single stage controls (ICTRL = 0)

Line 9: QINM, XCO2SM

Line 10: TSSSM, XCO2FM, TFSSM, TFON1M, TFON2M, TFOF3M, TFOF4M, TFOF5M

Line 11: TRAM, SFRM, DFM, DSM

Measured quantities/assigned values evaluated at minimum firing rate OMIT LINES 12-53 for Analytic Determination of Off-Cycle Losses (LOSOPT = 0)

Lines 12-31 · CONC, TS

CONC = measured concentration of tracer gas in sample taken from stack, PPM TS = measured stack gas temperature, °F

Twenty sets of concentration and temperature measurements for a cooldown following steady state operation at maximum fire. For more details on tracer measurements see Reference 3.

Line 32: CONCI, VTTT, TROOM

CONCI = concentration of active traver gas in the tracer gas in PPM, eg., for a carbon monoxide/nitrogen tracer gas mixture consisting of 50.8 percent carbon monoxide, CT = 508,000 PPM

VTTT = volumetric flow rate of tracer gas, cm³/sec

TROOM = test room temperature, °F Values for test at maximum firing rate.

OMIT LINES 33-53 For Single Stage Controls (ICTRL = 0)

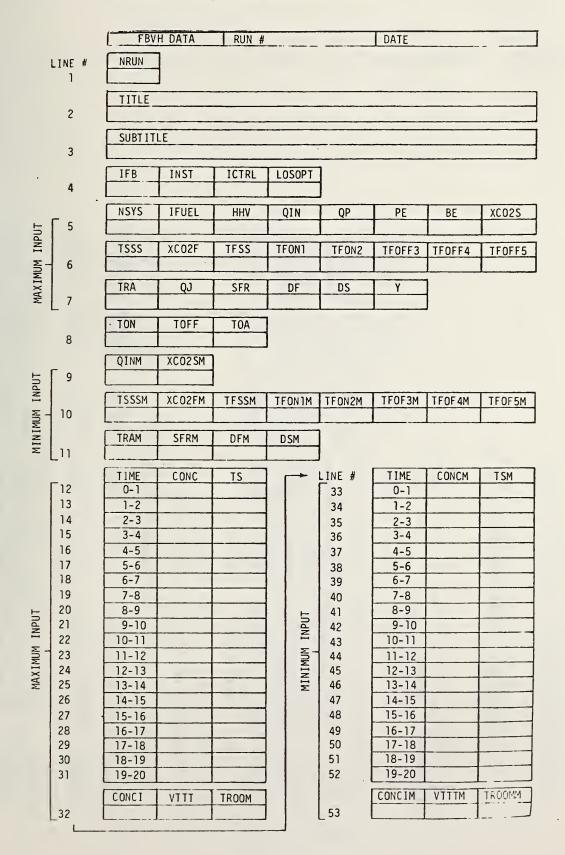
Lines 33-52: CONCM TSM

Twenty sets of concentration and temperature measurement for a cooldown following steady state operation at minimum fire.

Line 53: CONCIM, VTTTM, TROOMM

Values for test at minimum firing rate.

Figure C4. Input data form for FBVH



WXQT BUILGA.FBVH

INPUT DATA -- @ADD FILE.ELEMENT

OLID. P

MUL9BHI - MED1

REDUCED PILOT, NORMAL COOLDOWN & HIGH FIRE. Normal cooldown & Med Fire

INSTALLED INDOOR STEP MODULATED INPUT ASSIGNED VALUES FOR OFF-LOSSES VENTED HEATER

•

INPUT VALUES

8)XC02S 1.90+000	16)TF0FF5 1.08+002			
7)BE 8)XC02S 7.25-002 1.90+000	15)TFOFF4 1.54+002			
6)PE .00	9)TSSS 10)XC02F 11)TFSS 12)TF0N1 13)TF0N2 14)TF0FF3 15)TF0FF4 16)TF0FF5 2.30+002 7.36+000 6.19+002 4.69+002 5.95+002 2.84+002 1.54+002 1.08+002	22)Y 1.38+000		
5)QP 6)PE 5.85+002 .00	13)TF0N2 5.95+002	19)S/F 20)DF 21)DS 4.82+000 1.00+000		
1)NSYS 2)IFUEL 3)HHV 4)QIN 1 3 2.01+004 4.03+004	12)TF0N1 4.69+002	20)DF 1.00+000	T0A= 45.0	
3)HHV 2.01+004	11)TFSS 6.19+002	19)S/F 4.82+000	20.00	
2)IFUEL 3	10)XCO2F 7.36+000	18)QJ .00	TON= 20.00 TOFF= 20.00	
1)NSYS	9)TSSS 2.30+002	17)TRA 18)QU 7.20+001 .00	TON= 20.00	

ADDITIONAL INPUT VALUES FOR MINIMUM FIRING RATE

.

0	2 E	
8)XC02S 1.30+000	16) TFOF 1.08+00	
7) BE	15)TFOFF4 1.38+002	
6) PE	9)TSSS 10)XC02F 11)TFSS 12)TF0N1 13)TF0N2 14)TF0FF3 15)TF0FF4 16)TF0FF5 1.85+002 4.40+000 4.91+002 3.74+002 4.86+002 2.05+002 1.38+002 1.08+002	22)Y
5)QP	13)TF0N2 4.86+002	21)DS 1.00+000
4)QIN 2.50+004	12)†F0N1 3.74+002	20)DF 21)DS 1.00+000 1.00+000
3) HHV	11)TFSS 4.91+002	19)S/F 4.29+000
2)IFUEL	10)XC02F 4.40+000	18)QJ
1)NSYS	9)TSSS 1.85+002	17)TRA 7.20+001

.690

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FRACTION OF TIME IN LOW FIRE/CYCLING MODE FRACTION OF TIME IN HIGH FIRE/NON-CYCLING MODE OUTDOOR AIR TEMP FOR CYCLING MODE = 47.70 OUTDOOR AIR TEMP FOR NON-CYCLING MODE = 28.60

Program output for a heater with step-modulating control Figure C5.

PROGRAM COMPLETE

BTU

WEIGHTED AVERAGE ANNUAL FUEL EFFICIENCY = 65.47 ANNUAL FUEL ENERGY CONSUMPTION = 3.701+007 BTU ANNUAL ELECTRICAL ENERGY CONSUMPTION = 8.031+301

STEADY-STATE EFFICIENCY -- HIGH FIRE = 73.85 STEADY-STATE EFFICIENCY -- LOW FIRE = 73.37 WEIGHTED AVERAGE STEADY-STATE EFFICIENCY = 73.44

WEIGHTED AVERAGE PART-LOAD EFFICIENCY = 67.76

PART-LOAD EFFICIENCY -- HIGH FIRE = 70.09 PART-LOAD EFFICIENCY -- LOW FIRE = 66.71

38)PSISOX 4.78+001 30) EFFYSS 59)F6 2.47-005 51)PSIFI 3.60+001 7.39+001 37) PSISIX 7.47+000 58)F7 5.17-003 2.30+002 50) PSIF0 36) PSIFIX 1.58+000 3.60+001 49)ZETFO 2.34+002 57)F6 .00 28)RT 35) PSIFOX 64)EFFYU 6.56+001 2.30+002 43)CIOFF 1.25+001 48) TTOFF 3.58+000 27)CJ . 56)F5 .00 00 CALCULATED VALUES -- MINIMUM FIRING RATE 34)TAUGFF 5.59+000 63)QIOFF 2.78+000 42)CION 9.59-002 47)TTON 1.83+001 55)F4 8.02-003 9.55+000 26)QL 33)ZETF0X 2.37+002 25)A/F 1.45+001 41)CSOFF 3.38+000 62)QION 3.97+000 54)F3 3.78-001 46) TOFF 2.00+001 32) TAUON 1.09+C00 24)HHVA 2.01+004 53)PSISI 7.47+000 61)0S0FF 2.25+000 40)CSON 2.84-002 2.00+001 45)TON 1.45-002 1.06+002 2.86+001 52)PSIS0 4.78+001 1.62+001 **31)TSSS** 60)QSON 44) TOA 23) P.5 39)CS 80.

S

23)PF	24)HHVA	25)A/F	26)QL	27)CJ	28)RT	29)QSSS	30)EFFYSS
1.45-002	2.01+004	1.45+001	9.55+000	.00	2.58+000	1.71+001	7.34+001
31)TSSS	32) TAUON	33)ZETFOX	34) TAUOFF	33)ZETFOX 34)TAUOFF 35)PSIFOX 36)PSIFIX 37)PSISIX 38)PSISOX	36)PSIFIX	37)PSISIX	38)PSISOX
1.70+002	6.34-001	2.57+002	6.39+000	2.57+002 6.39+000 1.23+002 3.60+001 8.39+000 2.86+001	3.60+001	8.39+000	2.86+001
39)CS ;	40)CSON 4.57-002	41)CSOFF 5.43+000	42)CION 1.37-001	43)CIOFF 2.01+001			
44)TOA	45)TON	46)TOFF	47)TTON	48)TTOFF	49)ZETF0	49)ZETF0 50)PSIF0	51)PSIFI
4.77+031	2.00+001	2.00+001	3.15+001	3.13+000	2.54+002	2.54+002 1.23+002	3.60+001
52)PSIS0	53)PSISI	54)F3	55)F4	56)F5	57)F6	58)F7	59)F8
2.86+001	8.39+000	1.81-001	7.67-003	.00	.00	3.82-003	3.22-005
60)QSON 1.67+001	61)QSOFF 62)QION 2.48+000 3.06+000	62)QION 3.06+000	63)QIOFF 1.83+000	64)EFFYU 6.67+001			

Figure C5 (cont)

55

OXQT BOILEA.FBVH

INPUT DATA -- @ADD FILE.ELEMENT

@ADD,P MUL9BHI-MED1

REDUCED PILOT, NORMAL COOLDOWN & HIGH FIRE, NORMAL COOLDOWN & MED FIRE

VENTED HEATER INSTALLED INDOOR TWO STAGE INPUT ASSIGNED VALUES FOR OFF-LOSSES

INPUT VALUES

3)XC02S 1.90+000	16)TF0FF5 1.08+002		
7)BE 3)XC02S 7.25-002 1.90+000	15)TF0FF4 1.54+002		
6)PE	9)TS5S 10)XC02F 11)TFSS 12)TF0N1 13)TF0N2 14)TF0FF3 15)TF0FF4 16)TF0FF5	22)Y	
.00	2.30+002 7.36+000 6.19+002 4.69+002 5.95+002 2.84+002 1.54+002 1.08+002	1.38+000	
4)01N 5)0P 6)PE	13)TF0N2	21)DS 22)Y	
4.03+004 5.85+002 .00	5.95+002	1.00+000 1.38+000	
4)QIN	12)TF0N1	19)S/F 20)DF	T0A= 45.0
4.03+004	4.69÷002	4.82+000 1.00+000	
3)HHV	11)TFSS	19)S/F	TOFF= 20.00
2.01+004	6.19+002	4.82+000	
2)IFUEL	10)XC02F	18) 0J	0 TOFF=
3	7.36+000	.00	
1)NSYS	9)TS55 2.30+002	17)1RA 18)QJ 7.20+001 .00	TON= 20.00

ADDITIONAL INPUT VALUES FOR MINIMUM FIRING RATE

8)XCO2S 1.30+000	16)TF0FF5 1.08+002	
7)BE	15)TFOFF4 1.38+002	
6) PE	10)XC02F 11)TFSS 12)TF0N1 13)TF0N2 14)TF0FF3 15)TF0FF4 16)TF0FF5 4.40+000 4.91+002 3.74+002 4.86+002 2.05+002 1.38+002 1.08+002	22)Y
5)QP	13)TF0N2 4.86+002	19)S/F 20,DF 21)DS 22)Y 4.29+000 1.00+000 1.00+000
4)QIN 2.50+004	12)TF0N1 3.74+002	20,DF 1.GO+000
3) ННV	11)TFSS 4.91+002	19)S/F 4.29+000
2)IFUEL 3)HHV	10)XCO2F 4.40+000	18)01
1)NSYS	9)TSSS 1.85+002	17)TRA 18)QJ 7.20+001

FRACTION OF TIME IN LOW FIRE/CYCLING MODE = .690 FRACTION OF TIME IN HIGH FIRE/NON-CYCLING MODE = .310 OUTDOOR AIR TEMP FOR CYCLING MODE = 47.70 OUTDOOR AIR TEMP FOR NON-CYCLING MODE = 28.60

PROGRAM COMPLETE

30) EFFYSS 30)EFFYSS 38) PSISOX 37) PSISIX 38) PSISOX 2.86+001 7.39+001 4.78+001 51)PSIFI 2.47-005 7.34+001 3.60+001 59)F3 37) PSISIX 7.47+000 8.39+000 56)F7 5.17-003 1.66+001 50)PSIF0 2.30+002 1.71+001 29)QSSS 29)QSSS 36) PSIFIX 36)PSIFIX 3.60+001 1.58+000 2.58+000 3.60+001 **49) ZETFO** 2.34+002 28) 91 57)F6 28)RT 00. 35) PSIFOX 35) PSIFOX 2.30+002 48)7TOFF 3.58+000 1.23+002 43)CIOFF 64) EFFYU 43)CIOFF 1.25+001 6.56+001 2,01+001 . 56)F5 .00 27)CJ .00 27)CJ 34)TAUOFF 36.39+000 CALCULATED VALUES -- MINIMUM FIRING RATE 34)TAUCFF 42)CION 9.59-002 63)Q10FF 2.7E+000 26)QL 9.35+000 5.59+000 9.55+000 42)CION 1.37-001 8.02-003 1.83+001 47)TTON 55)F4 26)QL 33)ZETFOX 33)ZETFOX 25)A/F 1.45+001 41)CSOFF 3.38+000 62)010N 3.97+000 25)A/F 1.45+001 2.37+002 54) F3 3.78-001 2.57+002 41)CSOFF 5.43+000 2.00+001 46) TOFF 32) TAUON 6.34-001 53) PSISI 7.47+000 2.01+004 2.01+004 32) TAUON 1.09+000 61)QSOFF 2.25+000 2.84-002 4.57-002 2.00+001 24)HHVA 24)HHVA 40) C S ON 40)CSON 45)TON 1.45-002 1.86+002 52)PSIS0 1.45-002 1.70+002 4.78+001 2.86+001 1.62+001 31) I SSS 60)QSON **31)TSSS** 44)T0A 23)PF 39)CS .00 39)CS 23)PF 00.

Figure C6 (cont)

PART-LOAD EFFICIENCY -- HIGH FIRE = 65.57 PART-LOAD EFFICIENCY -- LOW FIRE = 66.71 WEIGHTED AVERAGE PART-LOAD EFFICIENCY = 66.36

3.22-005

59)F8

58)F7 3.82-003

57)F6 .00

56)F5 .00

55)F4 7.67-003

1.81-001

54)F3

53)PSISI 8.39+000

52) PSISO 2.86+001 64)EFFYU 6.67+001

1.83+000

62)QION 3.06+000

61)0S0FF 2.48+000

1.67+001

60)QSON

63)QIOFF

51)PSIFI

50) PSIF0

49)ZETFO

48) TTOFF 3.13+000

3.15+001

2.00+001

2.00+001

4.77+001

44)TOA

45) TON

46) TOFF

47) TTON

2.54+002

1.23+002

3.60+001

STEADY-STATE EFFICIENCY -- HIGH FIRE = 73.85 STEADY-STATE EFFICIENCY -- LOW FIRE = 73.37 WEIGHTED AVERAGE STEADY-STATE EFFICIENCY = 73.52 WEIGHTED AVERAGE ANNUAL FUEL EFFICIENCY = 64.16 ANNUAL FUEL ENERGY CONSUMPTION = 3.772+007 BTU ANNUAL ELECTRICAL ENERGY CONSUMPTION = 8.212+001 BTU

PAR

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11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)						
As annual operating efficiency of vented heating equipment is affected by burner fuel and combustion air modulation, it is important to differentiate between the various types of controls in determining annual energy requirements. Test procedures for evaluating annual efficiency have already been developed and implemented by the Department of Energy (DoE) for furnaces with single-stage thermostat control. A modified test procedure is necessary to account for operation with fuel modulation. A revised procedure which accommodates two types of fuel modulating controls has recently been developed. Tests are conducted at reduced and maximum firing rates, and along with typical derived values from a bin analysis of weather data, the fraction of the total hours for each operating mode is obtained to calculate a weighted annual efficiency. These test methods and calculation procedures are based on and are an extension to the current DoE test procedures for the single-stage type of thermostat control of central warm air furnaces. By using the procedures developed in the report, the energy savings impact of fuel modulating controls when combined with the use of modulated combustion air is evaluated. Energy savings from 6 percent to 20 percent were determined from the increase in efficiency with both fuel and combustion air modulation. Improved efficiency was dependent on the type of thermostat control and the minimum-to-maximum fuel input; i.e., turndown ratio.						
		italize only proper names; and set				
annual efficiency; household heaters and furnace test procedures; hydraulic thermostat control; modulating control gas-fueled; two-stage thermostat.						
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