A-2180

**FINAL REPORT** 

PROJECT A-2180

## CIRCULATING FIREPLACE COMBUSTION EFFICIENCY STUDIES

By

H.T. Ghaffari W.S. Bulpitt

Prepared for The Department of Energy July 1, 1978 to July 1, 1979

July, 1979

# **GEORGIA INSTITUTE OF TECHNOLOGY**



Engineering Experiment Station Atlanta, Georgia 30332



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#### SUMMARY

This paper represents the final report on a series of tests performed at Georgia Tech to assess the performance of circulating fireplaces. The test program was funded jointly by the Teague Brick Sales Company of Tyler, Texas and the Fossil Fuel Utilization Division of the Department of Energy.

A factory-built fireplace was installed in a well insulated calorimeter room on the Georgia Tech campus and subjected to more than thirty wood firing tests to determine the thermal efficiency and net heat output of the fireplace under varying conditions. Parameters that were investigated included variations in fuel firing rate, the use of glass doors, the use of different forms of fuel, the use of different heat exchange flow rates, and the use of circulating fans.

Results indicated that the fireplace as tested could perform with a thermal efficiency of 3% to 33% depending upon the operational configuration. The overall average of the test efficiencies was 15.7%. It was determined that having glass doors open during a well established fire resulted in significantly higher heat transfer to the room. In addition, the use of circulating features (including electric fans) were shown to offer a significant increase in fire-place efficiency.

Included in this report are a description of the test facilities and associated instrumentation, a description of the test program, a description of the analysis methods (including a computer program) for reducing the data, and a discussion of conclusions.

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## TEXT NOMENCLATURE

## SYMBOLS

| С                | Carbon   |
|------------------|--|
| CO               | Carbon monoxide                                      |
| <sup>C0</sup> 2  | Carbon dioxide                                       |
| С <sub>р</sub>   | Specific heat coefficient (Btu/1bm - <sup>O</sup> F) |
| Е                | Electricity usage (Btu/hr)                           |
| h                | Enthalpy (Btu/1bm)                                   |
| HHV              | Higher heating value (Btu/1bm)                       |
| н <sub>2</sub> 0 | Water  |
| KWH              | Kilowatt hour  |
| LHV              | Lower heating value (Rtu/lbm)                        |
| 0                | Oxygen   |
| đ                | Heat rate (Btu/min)                                  |
| Т                | Temperature ( <sup>O</sup> F)                        |
| w                | Work (Btu/min)                                       |
| GREEK LI         | ETTERS   |

## K LEITERS

| η | Efficiency                     |
|---|--------------------------------|
| ρ | Density (1bm/ft <sup>3</sup> ) |

Specific humidity ratio ω

## SUBSCRIPTS

ae Air exit

ai Air inlet

## SUBSCRIPTS (Continued)

| ai <sub>l</sub>                           | Indirect for combustion   |
|---|---|
| ai <sub>2</sub>                           | Direct for combustion   |
| am  | Air moisture  |
| С   | Combustion  |
| са  | Combustion air  |
| CO  | Carbon monoxide   |
| dfg                                       | Dry flue gas  |
| e   | Electricity   |
| •1  | Part of the fireplace being tested                                |
| e <sub>2</sub>                            | Not part of the fireplace being tested                            |
|   |   |
| f   | Fuel  |
| f<br>fm                                   | Fuel<br>Fuel moisture   |
| -   |   |
| fm  | Fuel moisture   |
| fm<br>H                                   | Fuel moisture<br>High   |
| fm<br>H<br>H <sub>2</sub>                 | Fuel moisture<br>High<br>Hydrogen                                 |
| fm<br>H<br>H <sub>2</sub><br>in           | Fuel moisture<br>High<br>Hydrogen<br>Input                        |
| fm<br>H<br>H <sub>2</sub><br>in<br>1      | Fuel moisture<br>High<br>Hydrogen<br>Input<br>Leakage             |
| fm<br>H<br>H <sub>2</sub><br>in<br>1<br>L | Fuel moisture<br>High<br>Hydrogen<br>Input<br>Leakage<br>Low, lab |

## SUPERSCRIPTS

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•: Time rate (1/min)

#### I. INTRODUCTION AND BACKGROUND

Wood as an energy source has realized renewed interest since the Arab oil embargo of 1973, and this trend shows no signs of letting up, especially when the effect on the price of home heating oil that the latest series of OPEC price increases will have is considered. Early in the history of our nation, wood supplied most of the energy for cooking and residential heating, and even today it has been estimated that 1/3 of the residences in the world are still heated with wood (1).

In terms of tons per year, most of the wood used in the U.S. today is used by the forest products industries for the production of building materials, pulp and paper, and chemicals. There is also a growing trend toward the use of wood as an industrial energy source as well as for residential heating, since there are certain advantages to burning wood. One advantage in certain installations is fuel costs, and another may be less severe environmental effects since wood contains only small amounts of sulfur. Particulate emissions from wood burning sources can create environmental problems but these can be controlled relatively easily with existing technologies. Wood is a complex fuel, however, and there is growing concern by some parties that trace elements may create environmental problems, particularly in areas where air pollution episodes have resulted from the concentrated use of residential wood heaters. The emissions of interest appear to be polycyclic organic materials (POMS) and studies have recently been started on these compounds (2). Other compounds found in wood smoke which may eventually be of interest environmentally are shown in Table 1.

Due to the recent upsurge in sales of wood heaters and fireplaces, there has been renewed interest in the real value of these appliances for providing space heating. Many new manufacturers have entered this field and some are making irresponsible claims for their products. There has been a demonstrated need for recognized testing procedures and it is in this regard that the test program described in this paper was undertaken. Many studies on the value of fireplaces have been done in the past, and the work of Konzo and Harris is one of the better known publications on total (uncontrolled) operating cycles (4). Controlled environments such as calorimeter rooms have been used for several years in the testing of HVAC devices such as

air conditioners, and more recently similar techniques have been used to test wood burners (5). Along these lines the Engineering Experiment Station at Georgia Tech was approached by a private contractor. Teague Brick Sales, to perform some basic tests on factory built fireplaces which were of interest to that company. In connection with this work a grant was awarded by the Department of Energy to perform some additional work that would be of interest to that agency. During this time frame, the Fireplace Institute, a manufacturers' organization, published a suggested method for rating fireplaces (7,8,9) and contracted with Auburn University to perform standardized rating tests on products built by member companies. The testing methods used by Georgia Tech and the methods advocated by the Fireplace Institute are similar in some respects, although the objective of this program is not to perform exhaustive tests on a wide range of wood heaters, but rather to carry out enough tests to make some basic judgments on the value of fireplaces as a heating medium. Other methods of arriving at similar conclusions for uncontrolled operating systems have recently been described by Sonderegger, et al (6), and further information on the Fireplace Institute programs for controlled steady state cycles can be found in publications by Maxwell, et al (10).

The remaining sections of this paper describe the fireplace test program performed at Georgia Tech. Descriptions of the apparatus and methods used are included, and conclusions based on the data collected are drawn.

## TABLE 1: COMPOUNDS DETECTED IN HARDWOOD SMOKE (from Reference 3)

ACIDS Formic Acetic Propionic Butyric Aconitic? Tricarballylic? Ketoglutaric? ALCOHOLS Methanol Ethanol CARBONYLS Formaldehyde Acetaldehyde Acetone Diacetyl Furfural Methyl Furfural

HYDROCARBONS 3,4-Benzpyrene 1,2,5,6-Dibenzanthracene 20-Methylcholanthrene PHENOLS Cresols Creosol Guaiacol Guaiacol derivatives 4-Ethyl 4-Propyl 6-Methyl 6-Ethyl 6-Propyl Pyrogallol ethers 1-0-Methyl 1,3-Dimethyl

l

PHENOLS(continued) 1,3-Demethyl Pyrogallol derivatives 5-Methyl 5-Ethyl 5-Propyl 1-0-Methyl-5-Methyl Pyrogallol Veratrole Xylenols OTHERS Anmonia Carbon dioxide Resins Water Waxes

#### **II. EXPERIMENTAL APPARATUS AND INSTRUMENTATION**

For this test program a well insulated fireplace calorimeter room was constructed within an existing concrete-block building on the Georgia Tech campus. The interior dimensions of the room are approximately 10 feet by 8 feet by 8 feet tall. The walls are constructed of 4 inch wood studs on 12 inch centers which are staggered alternately from the inside to the outside of 6 inch sills and plates. The insulation consists of woven fiberglass batts 4 inches thick which are woven through the studs. The inside and outside walls are gypsum wallboard and 3/4 inch thick styrofoam insulation is used between the studs and the inside layer of wallboard. One three foot access door is provided and this door is also insulated with fiberglass and styrofoam.

In the rear center portion of the room a modified circulating fireplace is installed on a poured concrete foundation. The basic design of the factory built fireplace is shown in Figure 1. The basic fireplace has been modified by the addition of a false floor allowing a three inch wide combustion air passage to be provided at the front of the combustion chamber. The combustion air is supplied by a rectangular sheet metal duct fitted to the rear of the fireplace shell. In addition, another duct has been cut through the rear of the shell to provide combustion air to the rear of the combustion chamber.

The steel fireplace was surrounded with standard masonry bricks giving a structure with dimensions of approximately 5'  $1\frac{1}{2}$ " by 2'  $10\frac{1}{2}$ " by 4' 11". Side cool air inlets and a front warm air outlet are provided as shown in Figure 1. A standard triple wall flue pipe is provided at the top of the fireplace and passes through the roof of the calorimeter room and through the roof of the building.

The cool air inlets can be left open or closed, and in addition can be operated with two small circulating fans which are rated at 34.5 watts each. The fans force room air through the double shell of the fireplace and through a pipe heat exchanger which passes through the fireplace flue. This air then exits the fireplace structure through a warm air grille, which can be left open or easily blocked off to restrict convection.

The fireplace front opening is approximately 3 feet by 2 feet and is covered by a standard accessory glass door which can be opened or closed as

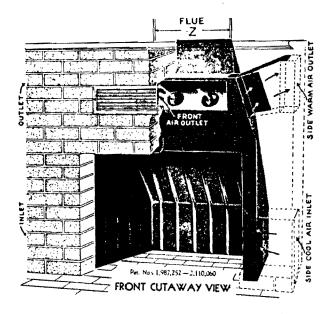


FIGURE 1. CIRCULATING FIREPLACE CONSTRUCTION (COURTESY SUPERIOR FIREPLACE COMPANY)

desired. The fireplace is also equipped with a conventional damper which can be opened or closed as necessary. The hearth area is trapezoidal in shape with widths of 35" and 31.5" at the front and rear, respectively, and the firebox is 16.5" deep.

With the above modifications the fireplace can be provided with combustion air in one of three modes. Combustion air can be provided directly through the front fireplace opening or it can be ducted as "outside combustion air" to the front or rear of the hearth. A duct of approximate dimensions of  $8^{1}2$ " by 4" is provided for the outside air and this duct is about ten feet in length. Due to the reinforced concrete construction of the building, the only available opening in the building wall for the duct to pass through was well above the hearth level, and this detail may have complicated the mechanics of the air introduction, as will be discussed later.

The overall concept of the facility is similar to the "calibrated room calorimeter" as described by the Fireplace Institute (FI) in their Standards (7,8,9). Due to the level of funding in this program and the time constraints involved in the construction (this project was started before the FI standard was published) no effort was made to duplicate the FI standard exactly.

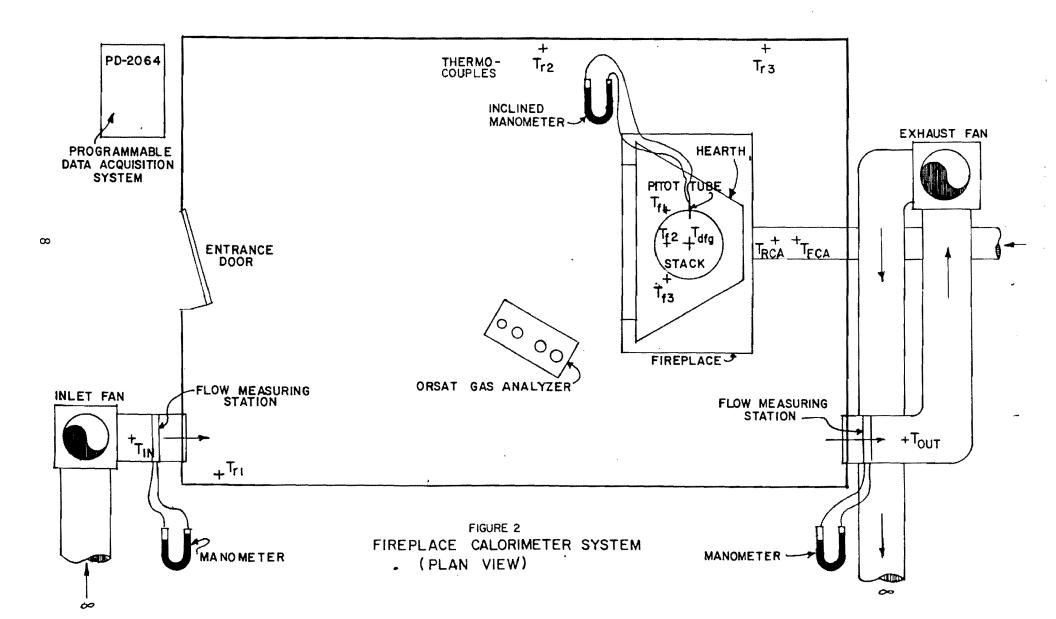
The amount of heat provided by the fireplace to the calorimeter room is determined by using the room itself as a heat exchanger. Supply and exhaust ducts and fans are provided for this purpose as shown in Figure 2. The inlet and outlet fans are identical and are powered with 3/4 horsepower motors. The inlet and outlet ducts have dimensions of 16" by 16" and the fan flow rates are controlled by adjustable dampers. Inlet and outlet flows are measured with Cambridge flow measuring stations. These are standard HVAC type devices and consist of a series of manifolded pitot tubes in a flow straightening section. Each flow measuring station is provided with its own stationary inclined manometer which is calibrated by the manufacturer. Flue gas velocity is measured with an "S-Type" pitot tube located in the stack, and velocity head is read with a portable inclined manometer. This pitot tube and manometer were calibrated at Georgia Tech using a low speed wind tunnel. An additional manometer was used to measure the pressure differential between the inside and outside of the calorimeter room (this was necessary for setting fan dampers).

Various temperature measurements were required during the tests, and these

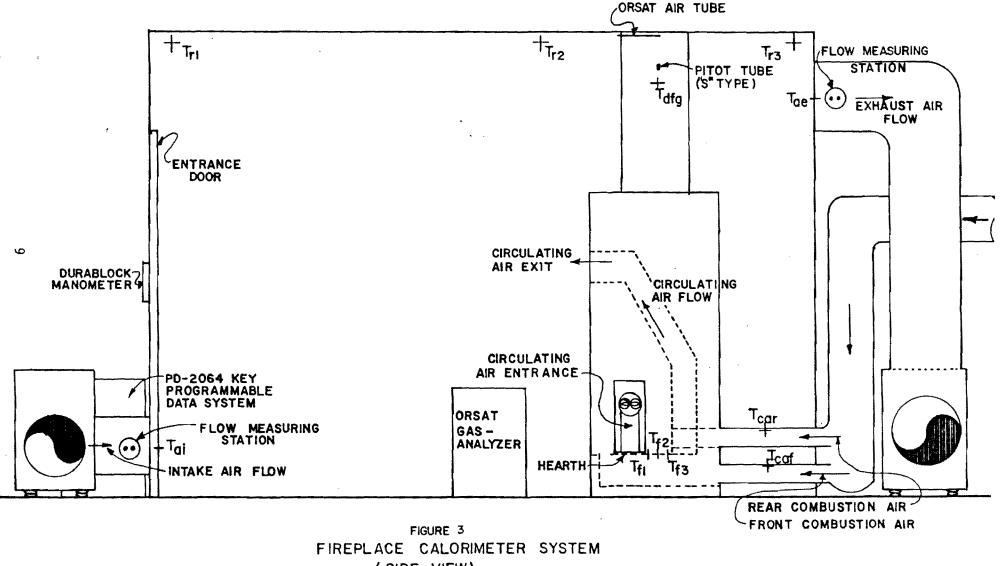
were indicated by iron/constantan J type thermocouples using glass insulation. The readings of these various sensors are recorded with a fifteen channel key programmable data acquisition system manufactured by Esterline Angus. Locations of the thermocouples of interest will be discussed more fully in the next section and these locations are shown in Figures 2 and 3.

The fuel used for the majority of the tests in this program was wood brands made from standard builder grade #3 Douglas fir (cut to 3/4" by 3/4"), as recommended by the Fireplace Institute and Under-writers Laboratories (7). An illustration of a typical brand is included in Figure 4. In some of the tests, pine and oak logs were used. Preparation of the wood included kiln drying in a laboratory oven to 0% moisture content at approximately  $220^{\circ}$ F. Measuring the amount of time necessary to obtain no further weight loss indicated that 24 hours drying time was sufficient to obtain "bone dry" wood. The weight of logs and brands was determined using a 0 to 3000 g balance. Heating values of representative wood samples were determined in the laboratory using bomb calorimeter tests.

Relative humidities of the calorimeter room and the surrounding environment were determined using a sling psychrometer. Gaseous constituents of the fireplace flue gases were determined in some of the tests using an Orsat gas analyzer, although it was quickly determined that these results were not always reliable.



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(SIDE VIEW)

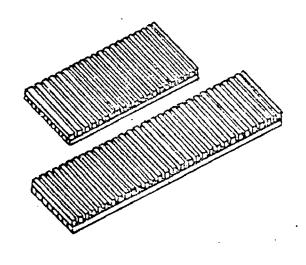


FIGURE 4. TYPICAL FIREPLACE WOOD BRANDS

### III. FIREPLACE TEST PROCEDURES

The calorimeter room air circulation system could be adjusted over a wide range of flow rates and part of the test program was devoted to the determination of the flow conditions which produced acceptable tests. A series of flow rate tests yielded the following data:

|     | CONDITION          | INLET AIR FLOW                      | OUTLET AIR FLOW                     |  |  |  |
|-----|--------------------|-------------------------------------|-------------------------------------|--|--|--|
| I   | (Dampers 1/4 Open) | 900 CFM<br>(Approx. 67.5 lbm/min)   | 600 CFM<br>(Approx. 43.2 lbm/min)   |  |  |  |
| II  | (Dampers 1/2 Open) | 1400 CFM<br>(Approx. 105 lbm/min)   | 1300 CFM<br>(Approx. 93.6 lbm/min)  |  |  |  |
| III | (Dampers 3/4 Open) | 1900 CFM<br>(Approx. 142.5 lbm/min) | 1800 CFM<br>(Approx. 129.6 lbm/min) |  |  |  |

These air flows remain quite stable during the testing period and are not appreciably affected by the temperature rise of the calorimeter room. A series of tests were run at each air flow setting and it was determined that Condition II was the optimum configuration. Condition I resulted in test conditions that were uncomfortable for the test personnel and Condition III resulted in excessive turbulence in the room. Since a constant comfortable temperature range could not be maintained in the room with the equipment available, it was found that the inside room temperature could rise to as high as 130°F during the course of a test, which caused discomfort to test personnel, particularly when a fire showed any tendency to generate smoke. The lower flow rates did not allow enough fresh air to enter the room to permit the tester to remain reasonably comfortable by remaining near the inlet duct. On the other hand, the higher flow rates seemed to produce too much turbulence in the room even though deflector baffles were always placed between the inlet air and the fireplace. Under this condition, it was sometimes difficult to maintain a stable fire. For these reaons, Condition II was used most often for testing.

The pressure differential between the inside of the calorimeter and the surrounding building could be readily changed by varying the control settings for the inlet and outlet fans. It was attempted to maintain a

slightly negative pressure  $(-0.015" \text{ H}_2^0)$  in the calorimeter room to simulate a typical house, but sometimes this pressure setting had to be changed slightly to alleviate a smoking condition.

A typical test required several hours to complete, in addition to several hours of preparation which were devoted mostly to the making of brands and instrument calibration. Before test data was actually taken, the fireplace was "warmed up" using wood scraps or ordinary logs to maintain a fire. The door was kept closed as much as possible during this time in an attempt to achieve a steady state condition. During the warmup period, manometers were calibrated, test brands were removed from the oven, weighed, and placed in the calorimeter, and velocity measurement equipment was checked. This step included the cleaning of soot deposits from the pitot tube used to measure flue gas velocities. Temperature readouts were checked and if false readings were obtained, thermocouples were replaced. New thermocouples were checked for correct readings on the data acquisition system using an ice water bath.

Attempts were made early in the test program to measure the flow rates of the fireplace when an outside air source was used, but these efforts were not entirely successful due to the low duct velocities. A standard pitot tube was used at first, but was not sensitive enough for the low flows. It appears that a hot wire anemometer or laminar flow elements might have produced more acceptable data, but the purchase of this equipment was not within the budget. Further test programs may result in improvements for this area of the instrumentation.

The thermocouples used for monitoring temperatures during the tests included three in the calorimeter room, three within the hearth of the fireplace, one in each of the air flow measuring stations for the inlet and outlet air supply, one in the center of the flue pipe, two in the surrounding building, one in each of the combustion air supply ducts, and an additional thermocouple to determine outside air temperature. Radiation shields were provided for the thermocouples located over the hearth. Temperatures were recorded during the course of a test at seven minute intervals.

Leakage of heat from the calorimeter room was estimated using electric heaters. The heaters were placed inside the calorimeter room (with no fire present), the various inlet and outlet ducts were sealed off (and the fire-place damper was closed) and the electrical input was monitored for two hours using a kilowatt-hour meter. This energy usage was converted to Btu's and divided by temperature difference and time to obtain a heat leakage factor having the units of Btu/<sup>o</sup>F-minute.

Three different sizes of brands were made for the majority of the tests, giving weight differentials of about 3%. The weights for each brand category were 1.32 lb, 1.68 lb, and 2.10 lb. The burning of three sets of brand sizes during a test provided an indication of efficiency differences with firing rates. As mentioned, all brands were kiln dried to constant weight for at least 24 hours to provide a more consistent, repeatable fuel supply.

Relative humidity recordings were made during tests inside the calorimeter room, in the surrounding building, and outside the building.

During the course of most of the fireplace tests, flue gas samples were analyzed with an Orsat gas analyzer. Gas samples were withdrawn from the flue with a hand pump and analyzed for carbon dioxide  $(CO_2)$ , carbon monoxide (CO), and oxygen  $(O_2)$ . This analysis was normally performed at least once during the burning of each weight category of brands. Results of Orsat analyses were not always consistent due to grab samples being taken at random points during the "firing cycle" of a given brand, and these results indicated the need for continuous monitoring instruments if more detailed gas analysis is to be done in the future.

To review the procedure for a typical fireplace test, the following sequence of events normally occurred:

- 1. Warmup period logs and scrap wood (1 to 2 hours)
- 2. Setting of air handling equipment, entry of personnel to calorimeter, closing of door
- Commencement of test one brand added every six minutes. Temperature data recorded every seven minutes, Orsat analysis carried out during different size category series.

## 4. Completion of test

Most tests consumed 21 brands, 7 each in each of the weight categories. A new brand was introduced to the hearth every six minutes, and thus a total test duration of approximately 126 minutes resulted. Due to space limitations in the calorimeter room, most tests were performed by one person. Acquisition of temperature data was automatic, and the tester's primary responsibilities included firetending and recording of velocity measurements and Orsat data, and the timing of events. An entire test from start to finish including warmup and shutdown usually required approximately four hours.

### IV. ANALYSIS

The overall object of this test program is to determine the thermal efficiency of circulating fireplaces under a variety of steady state controlled test conditions. The thermal efficiency could be defined as the percentage of useful heat obtained from the burning of wood in the fireplace. This efficiency can be measured by several methods, as can be done with other heat generating devices such as steam boilers. This evaluation can be done by considering the ratio of the heat gained by the calorimeter room to the heat input to the room, or by considering a comparison of heat input with known heat losses. These methods will be considered in greater detail below.

If we consider a control volume containing the calorimeter room and its associated hardware, the energy input consists of the energy of the wood fuel plus any other form of energy (e.g. electricity) introduced into the control volume. The energy released by wood is evaluated by multiplying the mass rate of wood addition to the fire,  $\dot{m}_{f}$ , by the higher heating value (HHV)<sup>1</sup> of the wood:

$$q_f = (\dot{m}_f) (HHV) Btu/min$$
(1)

Electrical energy input to the control volume (e.g. lights and circulating fans) is represented by  $E_{in}$  in kilowatts (KW) and converted to Btu/min by the proper conversion factor:

$$q_e = (56.9)(\Sigma E_{in}) Btu/min$$
 (2)

The total energy input to the system can thus be represented by  $\boldsymbol{q}_{\mathrm{H}}$  as in the following:

$$q_{\mu} = q_{f} + q_{\rho} Btu/min \qquad (3)$$

 $<sup>^{1}\</sup>mbox{An}$  expanded discussion of heating value convections will be included in Section V.

Let us now consider a control volume as shown in Figure 5.

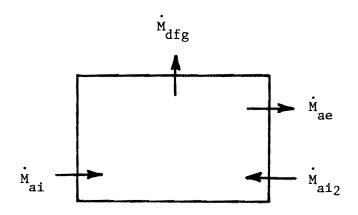


FIGURE 5. CONTROL VOLUME

The mass balance for this control volume will be as follows:

 $\Sigma \dot{m} = 0$   $\Sigma \dot{m}_{e} - \Sigma \dot{m}_{i} = 0 \qquad (4)$ 

$$(\dot{m}_{ae} + \dot{m}_{dfg}) - (\dot{m}_{ai} + \dot{m}_{ai_2}) = 0$$
 (5)

where

 $\dot{m}_{ae}$  = mass flow of air exiting control volume through duct system  $\dot{m}_{dfg}$  = mass flow of flue gas leaving stack  $\dot{m}_{ai}$  = mass flow of air entering control volume through duct system  $\dot{m}_{ai_2}$  = mass flow of air to fire through combustion air system (if used) An energy balance can now be made on the control volume as follows:

$$q + w = \Sigma \dot{m}_{e}h_{e} - \Sigma \dot{m}_{i}h_{i}$$
 (6)

OR

$$q + w = q_{\rm H} - q_{\rm L} \tag{7}$$

where

$$q_{H}$$
 = energy input to the system  
 $q_{L}$  = heat losses from the system

Then

$$q_{\rm H} - q_{\rm L} = (\dot{m}_{\rm ae}h_{\rm ae} + \dot{m}_{\rm dfg}h_{\rm dfg}) - (\dot{m}_{\rm ai}h_{\rm ai} + \dot{m}_{\rm ai}h_{\rm ai})$$
(8)

Where the h values represent the fluid enthalpies for the flow rates of interest.

Then

$$q_{\rm H} - q_{\rm L} = (q_{\rm f} + q_{\rm e_1} + q_{\rm e_2}) - (q_{\rm H_2} + q_{\rm co} + q_{\rm am} + q_{\rm fm} + q_{\rm uc} + q_{\rm \ell})$$
(9)

where

q<sub>co</sub> = heat loss due to incomplete burning of carbon
q<sub>am</sub> = heat loss due to moisture in air
q<sub>fm</sub> = heat loss due to moisture in fuel
q<sub>uc</sub> = heat loss due to uncombusted material in ash
q<sub>k</sub> = heat loss due to leakage through calorimeter walls

OR

$$q_{H} - q_{L} = (\dot{m}_{ae}C_{P} T_{ae} + \dot{m}_{dfg}C_{P} T_{dfg} - (\dot{m}_{ai}C_{P} T_{ai} + \dot{m}_{ai}C_{P} T_{ai}^{T} )$$

$$+ (-\dot{m}_{ae} - \dot{m}_{dfg} + \dot{m}_{ai} + \dot{m}_{ai}^{2}) C_{P}T_{r}$$
(10)

Where the last term represents zero, and the various  $C_p$ 's designate specific heats, while the T's represent corresponding temperatures.

Manipulating the last term above and neglecting minor changes in specific heats, yields the following

$$q_{H} - q_{L} = \dot{m}_{ae} C_{P_{ae}} T_{ae} + \dot{m}_{dfg} C_{P_{dfg}} (T_{dfg} - T_{r}) - (\dot{m}_{ae} + \dot{m}_{ai} - \dot{m}_{ae}) C_{P_{ai}} T_{ai}$$

$$- \dot{m}_{ai_{2}} C_{P_{ai_{2}}} (T_{ai_{2}} - T_{r}) + (-\dot{m}_{ae} + \dot{m}_{ai}) C_{P} T_{r}$$

$$= \dot{m}_{ae} C_{P_{ae}} (T_{ae} - T_{ai}) + \dot{m}_{dfg} C_{P_{dfg}} (T_{dfg} - T_{r})$$

$$- (\dot{m}_{ai} - \dot{m}_{ae}) C_{P_{ai}} (T_{ai} - T_{r}) - \dot{m}_{ae} C_{P_{ai_{2}}} (T_{ai_{2}} - T_{r})$$
(11)

If we define  $(\dot{m}_{ai} - \dot{m}_{ae})$  to be  $\dot{m}_{ai}$ , the combustion air supplied by the inlet fan, then

$$q_{\rm H} - q_{\rm L} = q_{\rm ae} + q_{\rm dfg} - q_{\rm ai_1} - q_{\rm ai_2}$$
 (12)

Equating the above with an earlier definition gives

$$(q_{f} + q_{e_{1}} + q_{e_{2}}) - (q_{H_{2}} + q_{co} + q_{am} + q_{fm} + q_{uc} + q_{l}) = q_{ae} + q_{dfg}$$

$$- q_{ai_{1}} - q_{ai_{2}}$$
(13)

If we consider the  ${\rm q}_{\rm dfg}$  to be a loss (heat carried out by the flue gas) we can arrange the equation as follows

$$q_{f} - (q_{H_{2}} + q_{co} + q_{am} + q_{fm} + q_{uc}) - q_{dfg} =$$

$$q_{ae} + q_{\ell} + q_{ai_{1}} - q_{ai_{2}} - q_{e_{1}} - q_{e_{2}}$$
(14)

In this equation,  $q_{\ell}$  is considered an unavoidable loss due to the construction of the calorimeter and thus is separated from the combustion losses.

We can then define  $q_{\rm NH}$  to be the net heat generated by the system. This value is equal to the heat contained in the fuel minus the heat losses OR

$$q_{\rm NH} = q_{\rm f} - (q_{\rm H_2} + q_{\rm co} + q_{\rm am} + q_{\rm fm} + q_{\rm uc}) - q_{\rm dfg}$$
 (15)

but we have seen from (14) above that this is also equal to

$$q_{\rm NH} = q_{\rm ae} + q_{\rm l} - q_{\rm ai_1} - q_{\rm ai_2} - q_{\rm e_1} - q_{\rm e_2}$$
 (16)

This gives two independent solutions for the net heat generated by the fireplace. Equation (16) above can be called the direct method and is analogous to determining the heat content of the steam produced by a boiler

minus the heat contained in the feedwater. The thermal efficiency of the system can then be defined by

$$\eta = \frac{q_{\rm NH}}{q_{\rm f}} = \frac{q_{\rm ae} + q_{\rm g} - q_{\rm ai_1} - q_{\rm ai_2} - q_{\rm e_1} - q_{\rm e_2}}{q_{\rm f}}$$
(17)

Equation (15) above can be called the indirect or direct method or heat loss method and provides a check on the first method when continuous gas monitoring equipment is available.

Let us consider equation (16) again

. . . . . . . .

$$q_{\rm NH} = q_{\rm ae} + q_{\rm l} - q_{\rm ai_1} - q_{\rm ai_2} - q_{\rm e_1} - q_{\rm e_2}$$

The terms of this equation can be considered in more detail

$$q_{ae} = \dot{m}_{ae}C_{p}(T_{ae} - T_{ai})$$
(18)

which represents the heat gained by the duct heat exchanging system

$$q_{\ell} = (\frac{2.0}{20}) (\frac{3413}{120}) (T_r - T_L) Btu/min$$

This equation was determined by investigating the calorimeter room heat loss with electric heaters, by maintaining a  $20^{\circ}F$  temperature difference between the average temperature in the room  $(T_r)$ , and the temperature in the laboratory surrounding the calorimeter  $(T_r)$ , for a period of two hours.

$$q_{ai_1} = (\dot{m}_{ai} - \dot{m}_{ae}) C_P (T_{ai} - T_r)$$
 (19)

This expression represents the indirect combustion heat flow

$$q_{ai_2} = \dot{m}_{ai_2} C_P (T_c - T_r)$$
 (20)

Where  $T_c$  = measured temperature of combustion air. This results in the more complete equation

$$q_{\rm NH} = \dot{m}_{ae} C_{\rm p} (T_{ae} - T_{ai}) - (\frac{2.0}{20}) (\frac{3413}{120}) (T_{\rm r} - T_{\rm L}) - (\dot{m}_{ai_1} - \dot{m}_{ae}) C_{\rm p} (T_{ai_1} - T_{\rm r}) - \dot{m}_{ai_2} C_{\rm p} (T_{\rm c} - T_{\rm r}) - q_{e_1} - q_{e_2}$$
(21)

Where  $q_{e_1}$  and  $q_{e_2}$  vary depending upon the input electrical loads of the fire-place lab and its appliances.

Let us now look more closely at equation (15) again

$$q_{\rm NH} = q_{\rm f} - (q_{\rm H_2} + q_{\rm co} + q_{\rm am} + q_{\rm fm} + q_{\rm uc}) - q_{\rm dfg}$$

The terms in this equation can now be considered in greater detail. The heat loss due to the combustion of hydrogen can be defined as follows (8)

$$q_{H_2} = 8.933 \ \dot{m}_{H_2} (1090.7 - T_f + 0.455 \ T_{dfg})$$
 (22)

where

$$\dot{m}_{H_2}$$
 = mass rate of burning of hydrogen in fuel  
 $T_{dfg}$  = temperature of dry flue gas  
 $T_f$  = temperature of fuel

Moisture in the air used for combustion causes another heat loss which may be defined as follows

$$q_{am} = 0.444 \ \dot{m}_{ca} \ \omega \ (T_{dfg} - T_r)$$
 (23)

where

 $\dot{m}_{ca}$  = mass flow rate of air being used for combustion  $\omega$  = specific humidity ratio

The effect of heat absorption by incomplete burning of carbon and the production of carbon monoxide would be

$$q_{co} = \left[ \frac{(10160) (\% CO)_{dfg} (\% C)_{f}}{(\% CO_{2})_{dfg} + (\% CO)_{dfg}} \right] \left[ 1 - (\% H_{2}^{0})_{f} \right]_{\dot{m}f}$$
(24)

The percentages of the flue gas constituents are measured with gas analysis equipment such as Orsats.

The higher heating value of the uncombusted materials (ash and unburned carbon) can be evaluated directly by the bomb calorimeter methods, and multiplied by the mass rate of production of uncombustible materials to obtain the heat loss due to uncombustibles

$$q_{uc} = (HHV)_{uc} \dot{m}_{uc}$$
(25)

The moisture content of the fuel would have an adverse effect on the useful heat produced

$$q_{fm} = \dot{m}_f (%H_2 0)_f (1090.7 - T_f + 0.455 T_{dfg})/100$$
 (26)

The effect of wood moisture is not pertinent to this test program since all of the fuel was kiln dried before each test.

Finally, the heat lost to the flue gas can be evaluated by

$$q_{dfg} = \dot{m}_{dfg} C_{P_{dfg}} (T_{dfg} - T_r)$$
(27)

Substituting the foregoing equations into equation (15) will yield the basic expression for the heat loss method.

Equation (16) for analysis of the direct method was used most extensively during this test program since the terms in the equation could be measured more readily with the instruments available. The terms in the heat loss equation (15) could only be estimated at best, largely due to the fact that continuous monitoring gas sampling equipment was not available for hydrogen content (although this percentage could be estimated from the literature without introducing a large error). The amount of uncombustibles was also impossible to determine for every test, since the scope of the program did not allow for analysis of ash samples for each test. Weighing of the total ash collected would also be a difficult matter. There is some question as to the validity of an indirect heat method due to the normal levels of excess air found in a typical fireplace. If continuous monitoring instruments had been available to maintain records of the levels of  $CO_1$ ,  $CO_2$ , and  $O_2$  in the stack and gas chromatographs had been used to measure the other smoke constituents, this questions could have been answered more completely.

A computer program was written to analyze the test data collected. A flow chart and listing of this program are included in Appendix A. While the program shows the analysis of efficiency utilizing both the direct method and the heat loss method, the results reported in the next section are based upon the direct methods since the data for the heat loss method were impossible to collect for all tests.

#### V. TEST PLAN AND TEST RESULTS

A comprehensive test plan was drawn up at the beginning of the program to ensure that the performance of a circulating fireplace could be adequately determined and that the effects of hardware changes and operational changes could be assessed. The results of thirty-two (32) of these controlled steady state tests are presented in Table 2. A careful examination of this table will reveal the parameters of interest which were carried through the test program.

The first column identifies the test by number. All tests are not in numerical order, but are placed in a logical sequence to group the data by test categories. Those test numbers that are missing were normally used for equipment checkout and the test numbers followed by "A" normally indicate a repeat of a previous test which yielded incomplete data.

The second column indicates the test setup airflow setting, an equipment variable which has already been discussed. The third column indicates the source of the combustion air used for the fire. "Room" indicates that the air was drawn from the room itself, through the open glass door (if the door was open) or through the vents provided by the door manufacturer around the glass doors (if the door was closed). These could be manually opened and closed, and sealing in the closed position was not completely positive. The amount of possible leakage through the glass doors was impossible to determine. "Front" air indicates combustion air was allowed to enter the fireplace from outside the calorimeter room and this air was introduced at the front of the hearth. "Rear" air indicates that combustion air entered the fireplace at the rear of the hearth. In some of the tests, the glass doors remained open and combustion air was supplied both from the room itself and through the auxiliary ducts. Due to the lack of sensitive instrumentation for the measurement of outside air velocities, exact estimates of the percentages of combustion air provided from the outside source could not be determined.

The "Glass Door" column is self-explanatory. The "Circulation" column indicates whether the fireplace convective passages were open or closed. When the passages were open, air could be drawn in from the room and circulated through the flue gas heat exchanger (under free or forced convection)

| Test | Airflow<br>Setting | Combustior<br>Air Supply |        | Cir. | Fans | $\frac{(\text{Btu/hr})}{\frac{Q_{f_1}}{Q_{Nil_1}}}$ | Effl | $\frac{(\text{Btu/hr})}{\frac{Q_{f2}}{Q_{NH2}}}$ | Eff2 | $(Btu/hr) = \frac{Q_{f3}}{Q_{NH3}} Eff_3$ | (Btu/hr)<br>Q <sub>fAvg</sub><br>Q <sub>NHAvg</sub> | Eff <sub>Avg</sub> | Comments                  |
|------|--------------------|--------------------------|--------|------|------|---|------|--|------|---|---|--------------------|---------------------------|
| 13   | I                  | Room                     | OPEN   | OPEN | NONE | 107,018   | 0.29 | 139,659<br>48,191                                | 0.35 | 175,964 0.34<br>59,620                    | 140,880<br>46,402                                   | 0.33               | T                         |
| 9A   | I                  | Rear                     | OPEN   | OPEN | NONE | 107,545<br>29,477                                   | 0.27 | 140,555<br>42,918                                | 0.31 | 175,938 0.31<br>54,878                    | 141,346<br>42,424                                   | 0.30               |                           |
| 11   | I                  | Front                    | OPEN   | OPEN | NONE | 108,600<br>16,581                                   | 0.15 | 142,533<br>36,918                                | 0.26 | 177,388 0.26<br>46,785                    | 142,840<br>33,428                                   | 0.23               | LOW FLOW<br>FREE CONV.    |
| 14   | Í                  | Room                     | CLOSED | OPEN | NONE | 108,363<br>26,493                                   | 0.24 | 140,371<br>36,846                                | 0.26 | 174,040 0.25<br>43,636                    | 140,924<br>35,658                                   | 0.25               |                           |
| 10   | Ι                  | Rear                     | CLOSED | OPEN | NONE | 109,681<br>10,374                                   | 0.09 | 142,032<br>18,923                                | 0.13 | 178,759 0.15<br>27,439                    | 143,491<br>18,912                                   | 0.13               |                           |
| 12   | I                  | Front                    | CLOSED | OPEN | NONE | 111,922<br>8,598                                    | 0.08 | 145,512<br>24,186                                | 0.17 | 181,316 0.20<br>35,375                    | 146,250<br>22,720                                   | 0.15               | Ţ                         |
| 4A   | II                 | Room                     | OPEN   | OPEN | NONE | 111,421<br>12,546                                   | 0.11 | 142,295<br>29,089                                | 0.20 | 176,966 0.21<br>37,337                    | 143,561<br>26,324                                   | 0.18               | Ŧ                         |
| 6    | II                 | Rear                     | OPEN   | OPEN | NONE | 109,787<br>21,366                                   | 0.19 | 141,953<br>28,248                                | 0.20 | 176,202 0.20<br>35,750                    | 142,647<br>28,455                                   | 0.20               |                           |
| 7    | II                 | Front                    | OPEN   | OPEN | NONE | 110,841<br>16,389                                   | 0.15 | 143,086<br>25,518                                | 0.18 | 179,392 0.19<br>33,424                    | 144,440<br>25,110                                   | 0.17               | NORMAL FLOW<br>FREE CONV. |
| 15   | II                 | Room                     | CLOSED | OPEN | NONE | 108,099<br>12,434                                   | 0.12 | 141,003<br>19,195                                | 0,14 | 173,512 0.14<br>24,324                    | 140,872<br>18,651                                   | 0.13               |                           |
| 5    | II                 | Rear                     | CLOSED | OPEN | NONE | 109,496<br>11,462                                   | 0.10 | 143,113<br>18,747                                | 0.13 | 179,629 0.15<br>27,059                    | 144,079<br>19,089                                   | 0.13               |                           |
| 8    | II                 | Front                    | CLOSED | OPEN | NONE | 110,077<br>9,804                                    | 0.09 | 141,874<br>17,529                                | 0.12 | 176,544 0.14<br>25,051                    | 142,831<br>17,462                                   | 0.12               | <b></b>                   |

### TABLE 2: FIREPLACE TEST DATA SUMMARY

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| Test | Airflow<br>Setting | Combustio<br>Air Suppl |        | cir.   | Fans | $\frac{(\text{Btu/hr})}{\frac{Q_{f_1}}{Q_{NH_1}}}$ | Eff <sub>1</sub> | $\frac{Q_{f2}}{Q_{NH2}}$ | Eff2 | $(Btu/hr) = \frac{Q_{f3}}{Q_{NH3}} Eff_3$ | (Btu/hr)<br>QfAvg<br>Q <sub>NHAvg</sub> | Eff <sub>Avg</sub> | Comments                |
|------|--------------------|------------------------|--------|--------|------|--|------------------|--------------------------|------|---|---|--------------------|-------------------------|
| 20   | III                | Room                   | OPEN   | OPEN   | NONE | 108,547<br>15,334                                  | 0.14             | 140,450<br>20,246        | 0.14 | 177,599 0.15<br>25,763                    | 142,199<br>20,447                       | 0.14               | Ŧ                       |
| 16   | III                | Rear                   | OPEN   | OPEN   | NONE | 110,736<br>9,478                                   | 0.09             | 144,299<br>20,344        | 0.14 | 180,499 0.16<br>29,287                    | 145,178<br>19,703                       | 0.13               |                         |
| 18   | III                | Front                  | OPEN   | OPEN   | NONE | 108,785<br>11,326                                  | 0.10             | 142,559<br>18,201        | 0.13 | 180,341 0.12<br>21,842                    | 143,895<br>17,123                       | 0.12               | HIGH FLOW<br>FREE CONV. |
| 21   | III                | Room                   | CLOSED | OPEN   | NONE | 108,706<br>10,175                                  | 0.09             | 138,762<br>10,728        | 0.08 | 175,701 0.08<br>14,231                    | 141,056<br>11,711                       | 0.08               |                         |
| 17   | III                | Rear                   | CLOSED | OPEN   | NONE | 111,632<br>4,730                                   | 0.04             | 141,452<br>9,655         | 0.07 | 177,203 0.08<br>13,668                    | 143,429<br>9,351                        | 0.06               |                         |
| 22   | III                | Front                  | CLOSED | OPEN   | NONE | 110,367<br>4,698                                   | 0.04             | 144,510<br>7,905         | 0.05 | 184,243 0.05<br>8,775                     | 146,373<br>7,126                        | 0.05               | L                       |
| 29   | II                 | Room                   | OPEN   | CLOSED | NONE | 107,493<br>21,207                                  | 0.20             | 140,239<br>29,474        | 0.21 | 172,985 0.22<br>38,467                    | 140,239<br>29,716                       | 0.21               | Ŧ                       |
| 31   | II                 | Rear                   | OPEN   | CLOSED | NONE | 108,363<br>19,500                                  | 0.18             | 142,348<br>31,837        | 0.22 | 177,388 0.23<br>40,899                    | 142,700<br>30,745                       | 0.21               |                         |
| 33   | II                 | Front                  | OPEN   | CLOSED | NONE | 108,706<br>18,566                                  | 0.17             | 139,896<br>27,011        | 0.19 | 177,072 0.21<br>38,010                    | 141,891<br>27,862                       | 0.19               | NORMAL FLOW<br>NO CONV. |
| 30   | II                 | Room                   | CLOSED | CLOSED | NONE | 109,101<br>. 3,640                                 | 0.03             | 140,898<br>3,323         | 0.02 | 178,021 0.03<br>5,921                     | 142,673<br>42,945                       | 0.03               |                         |
| 32   | II                 | Rear                   | CLOSED | CLOSED | NONE | 108,020<br>7,154                                   | 0.07             | 140,582<br>8,399         | 0.06 | 175,648 0.06<br>10,525                    | 141,416<br>8,693                        | 0.06               |                         |
| 34   | II                 | Front                  | CLOSED | CLOSED | NONE | 107,704<br>4,859                                   | 0.05             | 138,446<br>6,857         | 0.05 | 172,748 0.06<br>9,917                     | 139,632<br>7,211                        | 0.05               | T                       |
| 29A  | II                 | Room                   | OPEN   | CLOSED | NONE | 114,998<br>17,493                                  | 0.15             | 106,021<br>18,493        | 0.17 | 106,388 0.18<br>19,418                    | 109,135<br>18,468                       | 0.17               | PINE FUEL               |
| 29B  | II                 | Room                   | OPEN   | CLOSED | NÔNE | 134,452<br>18,342                                  | 0.14             | 144,277<br>21,172        | 0.15 | 163,744 0.18<br>29,299                    | 147,491<br>22,938                       | 0.15               | OAK FUEL                |

#### TABLE 2: FIREPLACE TEST DATA SUMMARY (Cont'd)

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|      |                    |                        |        |      |      |                            | (Cont'           | d)                                  |      |   |        |  |        |                             |
|------|--------------------|------------------------|--------|------|------|----------------------------|------------------|-------------------------------------|------|---|--------|--|--------|-----------------------------|
| Test | Airflow<br>Setting | Combustic<br>Air Suppl |        | Cir. | Fans | $\frac{Q_{f_1}}{Q_{NH_1}}$ | Eff <sub>1</sub> | (Btu/hr)<br>Qf2<br>Q <sub>NH2</sub> | Eff2 | $\frac{(Btu/hr)}{\frac{Q_{f3}}{Q_{NH3}}} E$ |        | Btu/hr)<br>Q <sub>fAvg</sub><br>Q <sub>NHAvg</sub> | EffAvg | Comments                    |
| 23A  | II                 | Room                   | OPEN   | OPEN | TWO  | 110,498<br>16,531          | 0.15             | 143,113<br>34,596                   | 0.24 | 177,575 0<br>42,246                         | .24 14 | 43,789<br>31,124                                   | 0.21   | Ŧ                           |
| 25A  | II                 | Rear                   | OPEN   | OPEN | TWO  | 108,310<br>23,863          | 0.22             | 139,817<br>35,056                   | 0.25 | 175,041 0<br>44,493                         |        | 41,056<br>34,471                                   | 0.24   |                             |
| 27   | IĻ                 | Front                  | OPEN   | OPEN | TWO  | 108,890<br>16,464          | 0.15             | 142,058<br>27,829                   | 0.20 | 178,733 O<br>34,192                         |        | 43,2 <b>2</b> 7<br>26,162                          | 0.18   |                             |
| 24   | II                 | Room                   | CLOSED | OPEN | TWO  | 108,969<br>12,774          | 0.12             | 143,376<br>20,147                   | 0.14 | 179,049 0<br>25,240                         |        | 43,798<br>19,387                                   | 0.13   | NORMAL FLOW<br>FORCED CONV. |
| 26   | II                 | Rear                   | CLOSED | OPEN | TWO  | i09,180<br>12,259          | 0.11             | 140,160<br>21,415                   | 0.15 | 176,149 0<br>26,976                         |        | 41,830<br>20,216                                   | 0.14   |                             |
| 28   | II                 | Front                  | CLOSED | OPEN | TWO  | 110,314<br>16,375          | 0.15             | 141,953<br>23,891                   | 0,17 | 175,516 0<br>30,351                         |        | 42,594<br>23,539                                   | 0.16   | Ţ                           |

TABLE 2: FIREPLACE TEST DATA SUMMARY (Cont'd)

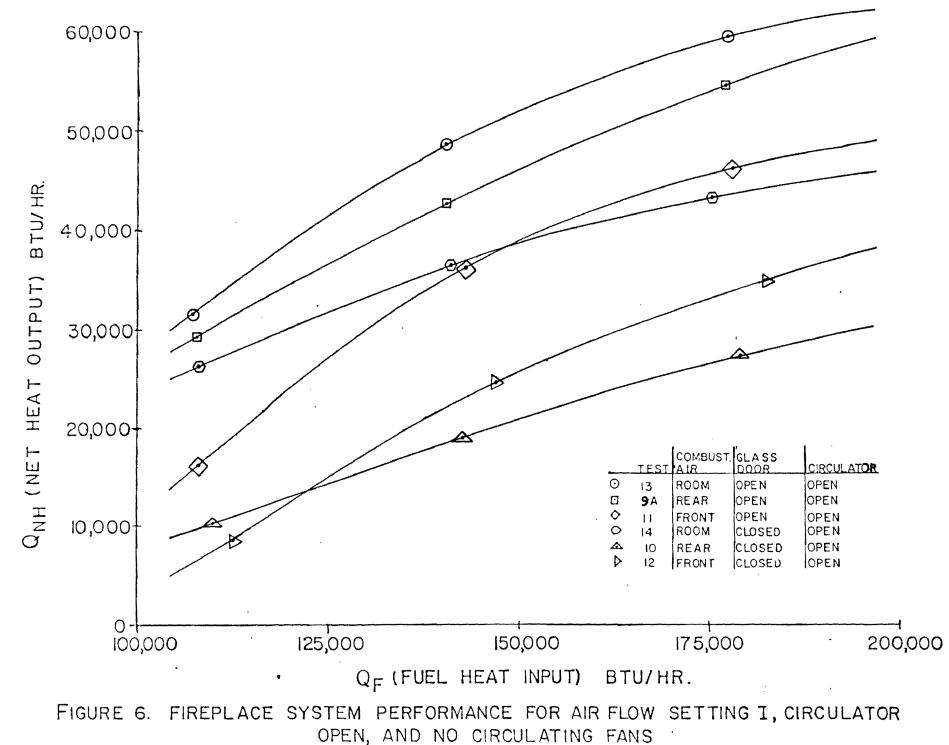
and allowed to escape through the warm air grille over the hearth. When the circulation features were closed, the side inlets and warm air outlet were all sealed with sheet metal covers and duct tape to prevent convective heating. The "Fans" column indicates whether or not the forced draft fans were in operation.

The next eight columns summarize the overall results of the tests. These columns were compiled from the raw data presented in the computer printouts included in Appendix B.  $Q_{f_1}$  and  $Q_{NH_1}$  indicate the average heat content of the fuel added to the fireplace (during the portion of the test using the lightest brands) and the average net heat delivered to the room by the fireplace. Eff<sub>1</sub> indicates the average thermal efficiency of the fireplace during this portion of the test.  $Q_{f_2}$  and  $Q_{NH_2}$  give corresponding values for the portion of the test during which intermediate weight brands were burned, and Eff<sub>2</sub> gives the average thermal efficiency for this portion of the test.  $Q_{f_3}$ ,  $Q_{NH_3}$ , and Eff<sub>3</sub> give the same results for the last portion of the test burning the heavier brands and  $Q_{fAvg}$ ,  $Q_{NHAvg}$ , and Eff<sub>Avg</sub> give the same range thermal efficiency is summary average values for the entire test. The comments column is self-explanatory.

As can be seen from the table, the first six tests (in the order presented) are concerned with data collected under conditions of low air flow with free convection. The next six tests present data collected under normal airflow (Condition II) with free convection which was the airflow setup used for most of the testing. The next six tests were performed using high airflow with free convection, and the following six tests were carried out with normal airflow and the convection passages sealed off. After these tests, two tests were run with alternate fuel (actual logs) and the last six tests shown were run with normal airflow and forced convection using the auxiliary fans.

The data presented in Table 2 can now be analyzed more fully through the use of data plots.

Figure 6 shows a series of curves generated from the data collected during the low calorimeter airflow (Setting I) tests. For this series of tests, the sides to the calorimeter heat exchanger were left open and air was allowed to pass through the heat exchanger through natural convection.



No circulation fans were used for these tests. The horizontal scale on the graph indicates the heat input to the fireplace resulting from the wood combustion and the vertical scale indicates the useful heat transferred to the room. It is readily apparent that in most instances, the tests with the glass door open result in significantly higher net heat transfer to the room (indicating a high thermal efficiency). Also, it should be noted that the net heat transfer and efficiencies for greater firing rates as indicated from the three columns of points corresponding to the three series of progressively heavier brands.

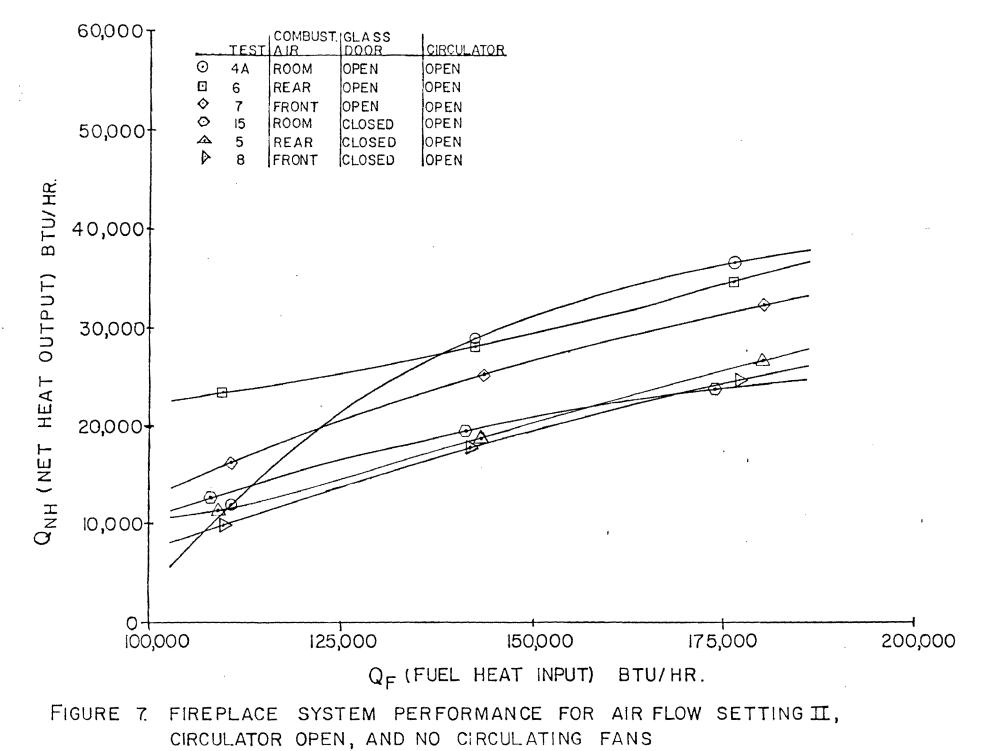
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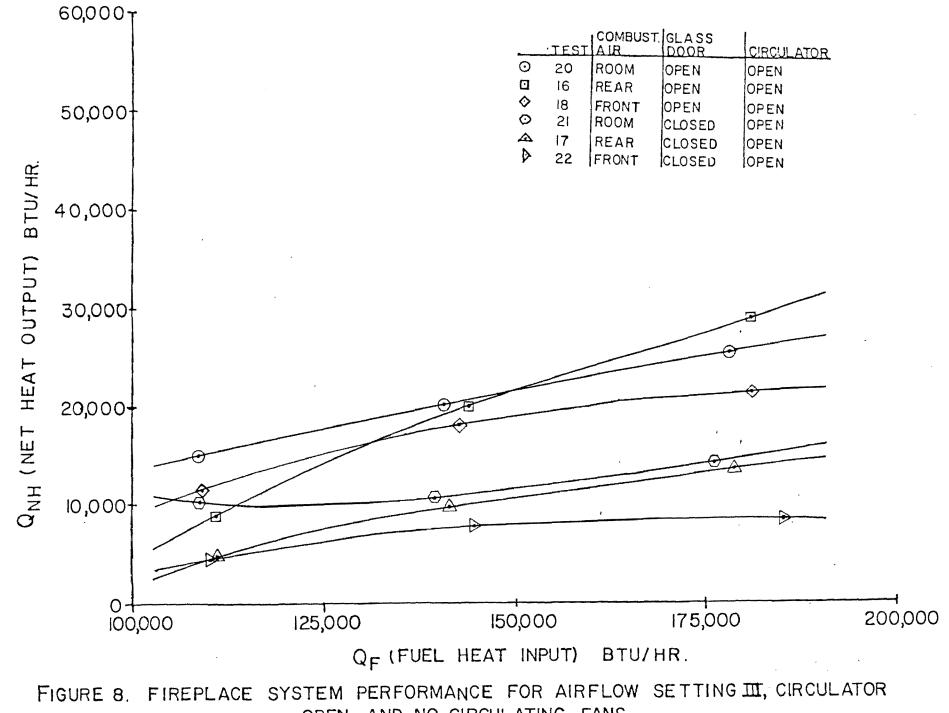
For this series of tests, the highest apparent net heat transfers result from the test run with the glass door open and combustion air coming directly from the room. With combustion air coming from the rear of the hearth, the efficiency is slightly lower, and with the combustion air supplied to the front of the hearth, the efficiency is lower still. These results were not expected.

Figure 7 presents a series of curves similar to those in Figure 6 for the tests run with the fireplace circulator running under natural convection and the calorimeter airflow settings at Setting II. Again, the highest net heat transfer was obtained with the glass door open and the combustion air coming directly from the room. Net heat transfers with the glass doors closed were significantly lower. The low point for the lower fuel feed rate for test 4A is probably due to the warmup effects of the calorimeter. This tendency will also be apparent in other graphs.

Figure 8 gives similar trends to the two previous graphs for airflow setup III although the highest net heat output for these tests occurred during a test when the combustion air was being supplied from the rear of the hearth. Again, the differences in heat output with the glass doors opened and closed are apparent.

Figure 9 shows a set of curves from the data collected with airflow setup II and the side inlets and front outlet to the circulator closed allowing no heat transfer to the room by convection. Again, in this case the rear combustion air shows a trend toward higher efficiency than the room combustion air case. With no circulating effects, the difference between the heat transferred by the fireplace with the door opened and the door closed is even more dramatic. This effect can be seen by comparing this graph with Figure 7.





OPEN, AND NO CIRCULATING FANS

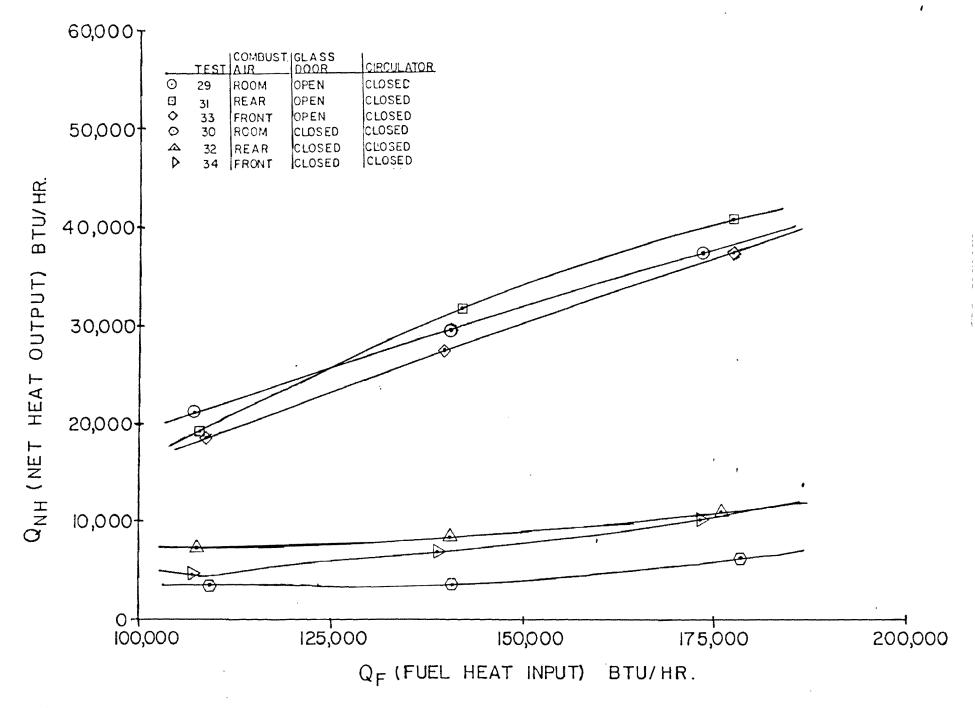


FIGURE 9. FIREPLACE SYSTEM PERFORMANCE FOR AIR FLOW SETTING I, WITH CIRCULATOR CLOSED

မ ပ Figure 10 shows some difference in steady state performance of the fireplace using different fuels. In these tests, the baseline used was the Douglas fir brands with airflow setting II, room combustion air, the glass door open and the circulating features of the fireplace closed. The oak and pine samples used were actual logs, so there was some difficulty assessing the actual heat content of the fuel, although the logs were dried in the oven and weighed. The graph shows lower net heat transfer for the other fuels, but the results cannot be considered conclusive. In order to obtain results with better correlation, the tests should be repeated with kiln dried pine and oak brands.

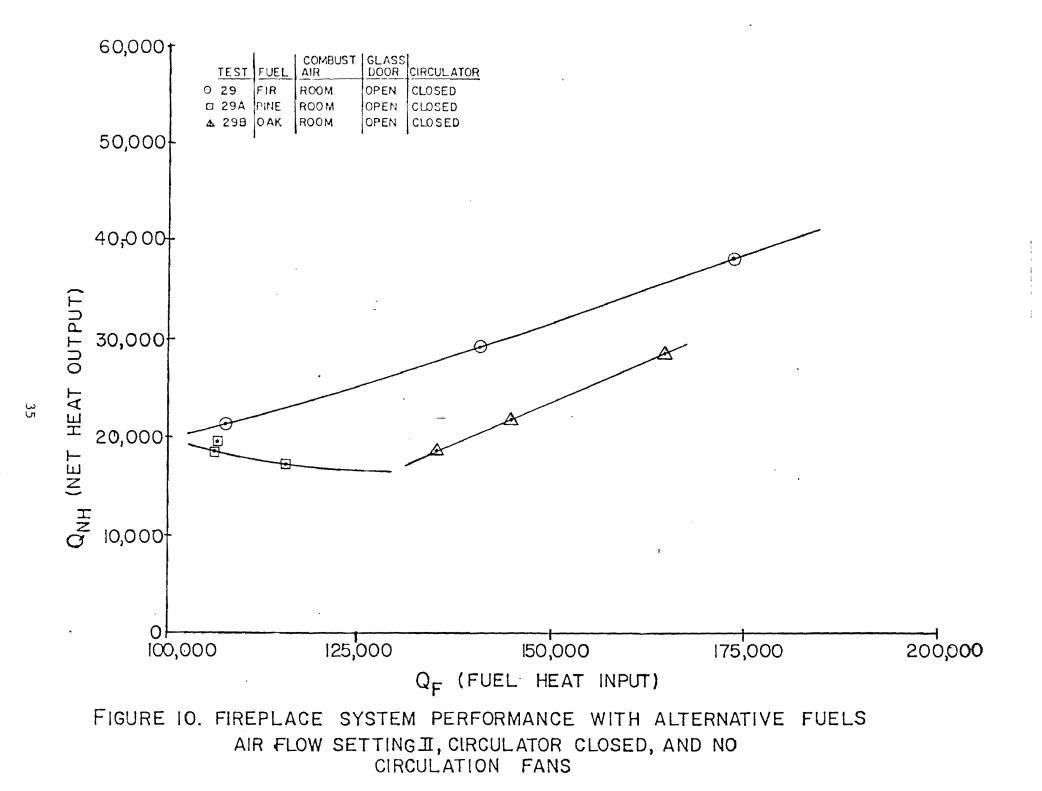
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Figure 11 shows a set of curves resulting from a series of tests using airflow setting II with the fireplace circulator open and the two electric circulation fans in use. Again, the test with combustion air from the rear exhibits the highest net heat output. Comparing this graph with Figure 9 shows a trend to higher fireplace output with the circulating fans under all conditions.

Figure 12 shows the effect of changing the airflow setup on the net heat output. It appears that higher efficiencies are possible with lesser airflow through the calorimeter, but as mentioned previously, test conditions became intolerable for the operators at the lower airflow conditions. Since the change in the airflow setup affects the use of the calorimeter room as a heat exchanger, it is probably not accurate to compare this effect with the effects of air infiltration in an actual house since airflow setting I represents approximately one air change of the calorimeter volume per minute, airflow setting II represents approximately two air changes, and airflow setting III represents approximately three air changes. This is a much higher rate of change than would be expected in a normal house (one to two air changes per hour) but may show that a tighter house with less infiltration results in a higher output for the fireplace. This possible conclusion would have to be investigated further to find the definite answer.

Figure 13 presents some plots of data for airflow setting II, with the thermal efficiency of the fireplace plotted versus the heat input, with combustion air supplied from the room. Again, the adverse affects of test warmup efficiencies are shown for test 4A and test 23A. As might

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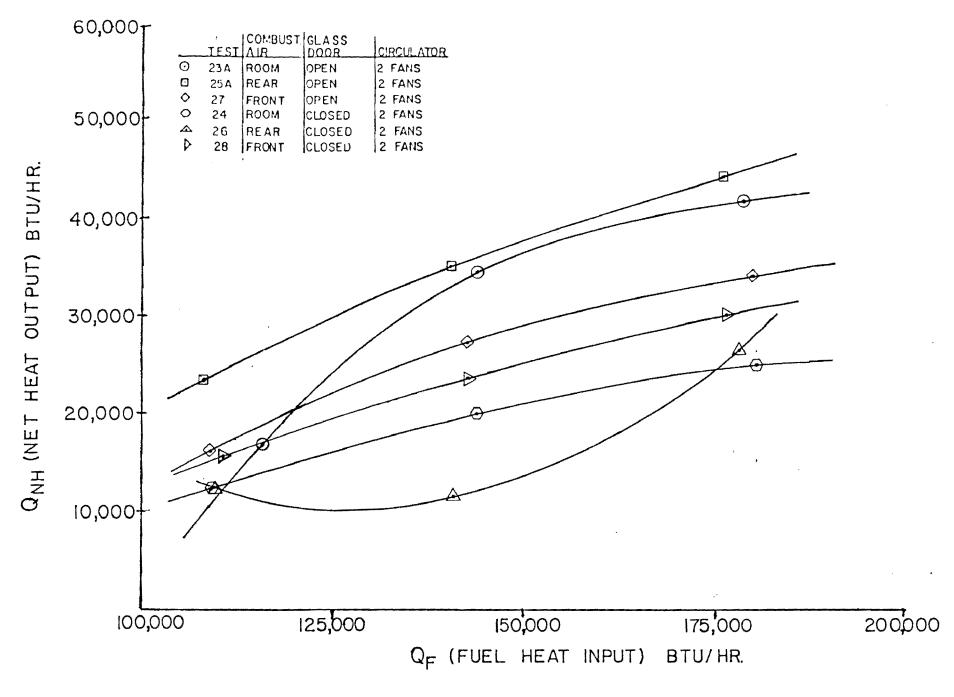
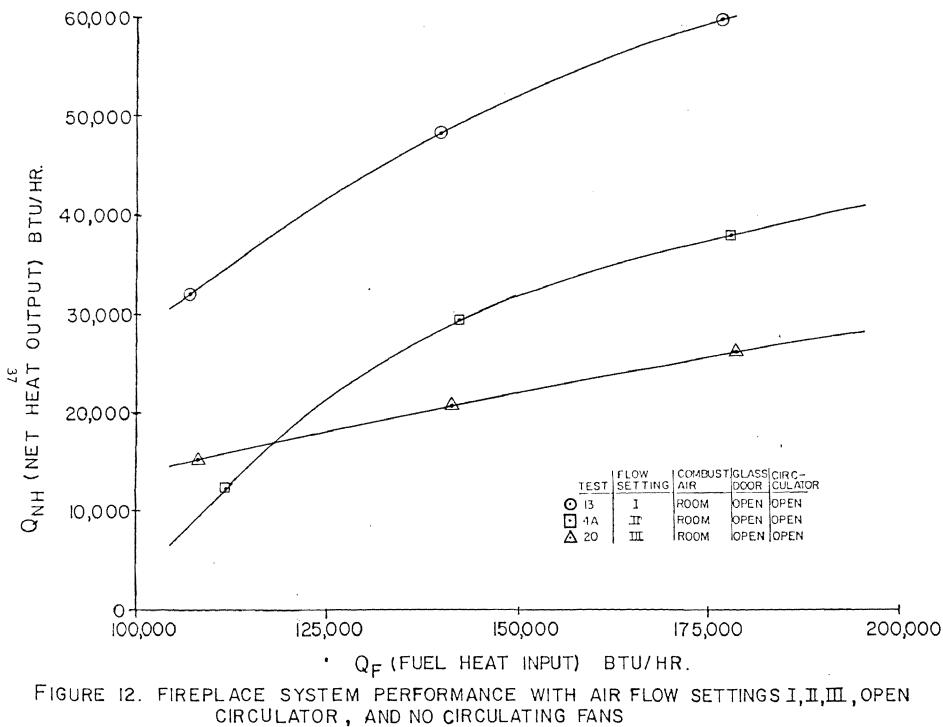
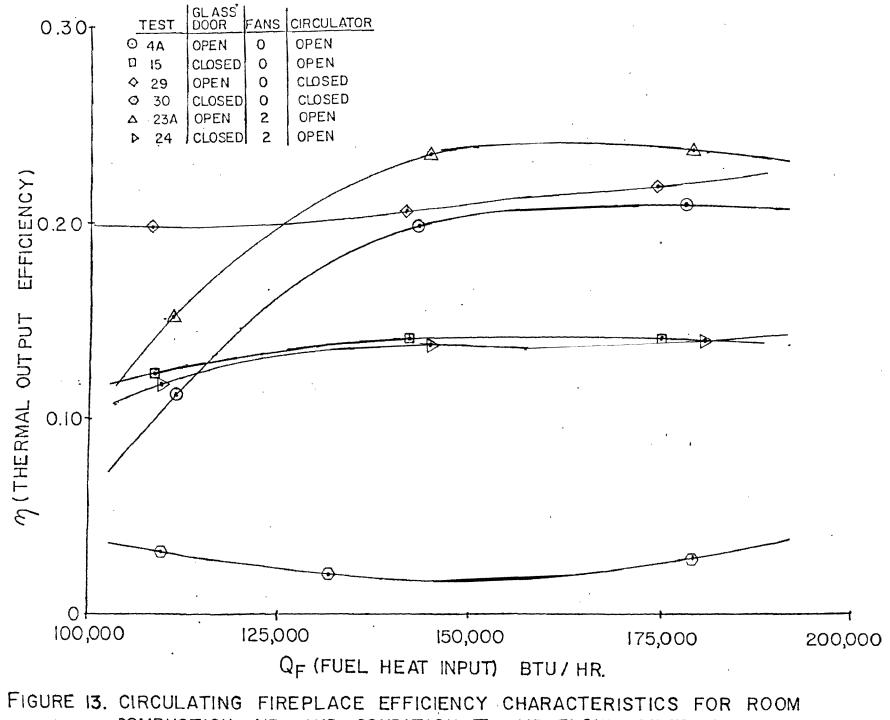


FIGURE II. FIREPLACE SYSTEM WITH AIR FLOW SETTING II, CIRCULATOR OPEN, AND TWO CIRCULATING FANS.





COMBUSTION AIR, AND CONDITION IL AIR FLOW SETTING

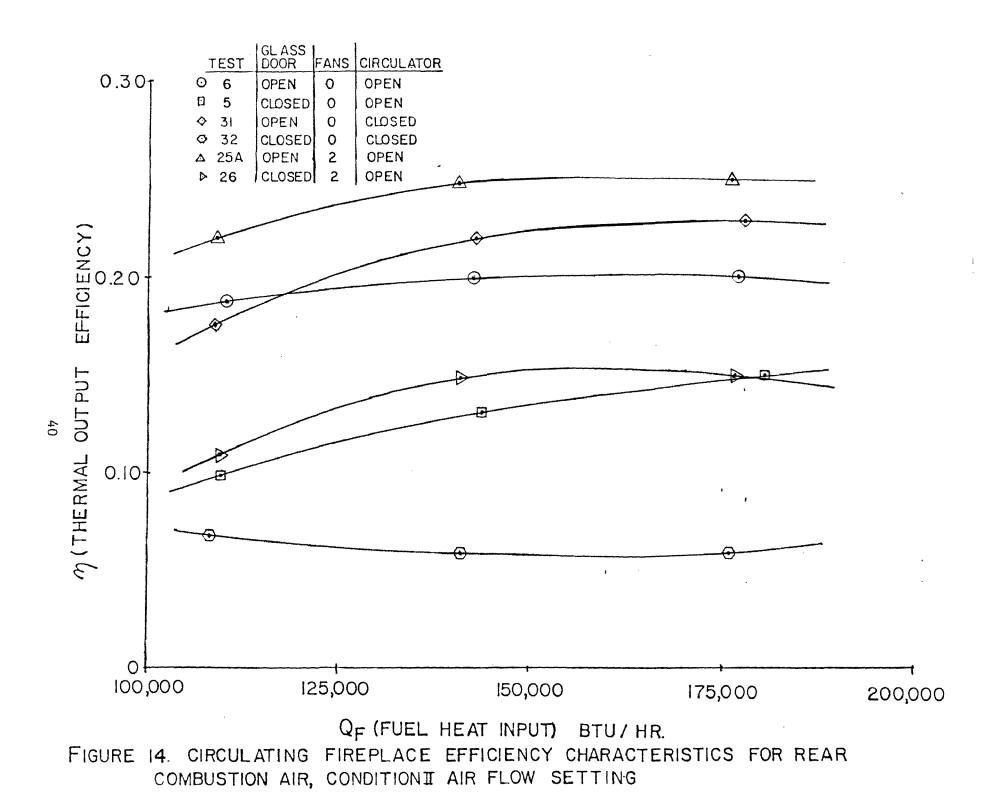
be expected, the trend to highest efficiencies is shown by test 23A, with the glass door open and two fans operating. The lowest efficiencies were exhibited in test 30, with both the glass doors closed and the circulator closed. Indeed, under these conditions the fireplace supplies very little heat to the room. In contrast to test 30, test 24 with the door closed but with the addition of the two circulating fans shows a marked improvement in overall efficiency. Some surprising results are shown by the curve of test 29, since it would be expected that the results of test 4A would show a higher overall efficiency with the circulator open. If time had permitted, one of these tests could have been repeated to verify this difference. This set of curves shows that the thermal efficiencies tend to remain quite constant with variations in fuel feed rate, while the heat net output show sharper rises as fuel feed rates are increased.

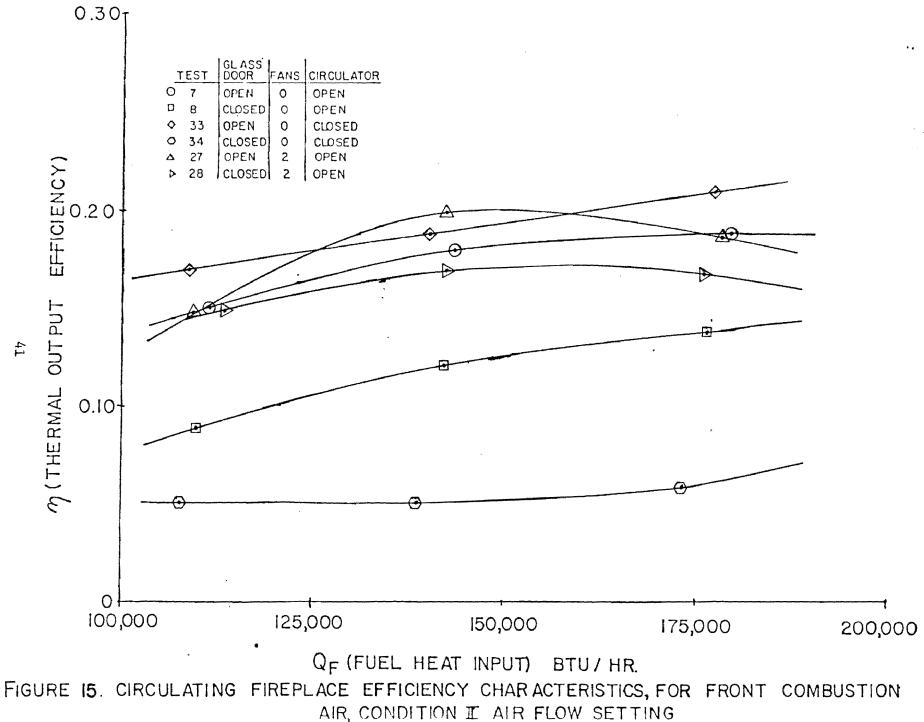
Figure 14 shows a set of curves similar to those shown in Figure 13, but this time the combustion air was provided from the rear of the hearth. Again, the highest efficiency is exhibited with the glass doors open and the fans running, while the lowest efficiencies resulted with the doors closed and the circulator closed.

Figure 15 shows curves similar to the previous two plots for combustion air supplied from the front. Again, the fireplace performance with the door open and the circulator closed is remarkably high. In this case, the doors closed condition with the two fans in operation approaches the performance of the door open cases.

Overall Figures 13, 14, and 15 serve to illustrate the order of magnitude effects the circulating feature and the use of the glass doors have on fireplace performance. It should be noted that the glass doors used in this test program contained "Temper Pyrex" glass manufactured by the Corning Glass Works in Corning, New York.

The heating values for representative samples of the wood used in this test program were determined using a bomb calorimeter and the "high heating values" (HHV) was thus calculated and used as an input to the computer program. This heating value was determined to be 8379 Btu/lb and was used because it is generally the accepted practice in the United States to assign heating values based on HHV. In Europe, the "lower heating value" (LHV) is often used, and this heating value is approximately 8% lower or





about 7720 Btu/lb for Douglas fir. Using this heating value in the calculations results in a slightly higher net heat output for the fireplace and a slightly higher thermal efficiency. For comparison, a test case (test number 4A) was run using the two heating values. Test 4A (see Table 2) was run using room combustion air, the glass door open, the circulator open, and no circulating fans. The computer printouts for this revised case are included at the end of Appendix B. Comparative values using the two heating values are shown in Table 3.

| Toot | Heating       | $(Btu/hr)  Q_{f_{1}}  Q_{NH_{1}} $ | Eff,     | $\frac{(\text{Btu/hr})}{\frac{Q_{f_2}}{Q_{NH_2}}}$ | Eff <sub>2</sub> | (Btu/hr)<br>Qf3<br>QNH3 | Eff  | (Btu/hr)<br>Q <sub>f</sub> Avg<br>Q <sub>NH</sub> Avg | Eff <sub>Avg</sub> |
|------|---------------|------------------------------------|----------|--|------------------|-------------------------|------|---|--------------------|
| Test | Value         | <u>1</u>                           | <u> </u> |  |                  | 3                       |      | Avg   | Avg                |
| 4A   | HHV<br>(8379) | 111,421<br>12,546                  | 0.11     | 142,295<br>29,089                                  | 0.20             | 176,966<br>37,337       | 0.21 | 143,561<br>26,324                                     | 0.18               |
| 4A   | LHV<br>(7720) | 102,653<br>12,782                  | 0.12     | 131,097<br>29,325                                  | 0.22             | 163,304<br>37,572       | 0.23 | 132,263<br>26,560                                     | 0.19               |

TABLE 3: HEATING VALUE COMPARISON

#### VI. CONCLUSIONS AND RECOMMENDATIONS

The overall results of this test program have been interesting and, in some respects, surprising. Unanswered questions still remain, and due to the limited scope of the program, there was not sufficient time or funding to repeat all tests several times to obtain statistically significant data. General trends were apparent, however, and the more important of these will be discussed here. The purpose of these studies overall has been to show these general characteristics and not the absolute efficiencies.

Results of the thirty-two tests discussed in this report indicated fireplace thermal efficiencies from a low of 3% to a high of 33%. The arithmetical average of all the steady state controlled tests performed was 15.7%. Table 4 gives a brief summary of some of the data trends.

For each series of tests, a higher average thermal efficiency was found with the glass doors open. This difference amounted to a low of 5.6% and a high of 15.6%, with an average of 9.2%. This is to be expected since the transmittance of infrafred radiation (thermal radiation with wavelengths greater than  $3\mu$ ) through glass is poor (12). The major conclusion to be drawn from this result is that when a moderate to intense fire is burning in the fireplace, the glass doors should be left open to produce the maximum heating effect on the room and its occupants. The glass doors can be effective in limiting air outflow through the chimney when a fire is dying, but in normal operation, should remain open.

Table 4 also shows the overall value of a fireplace circulating device. As can be seen from the data, the use of circulating fans can add approximately 2.7% to the fireplace efficiency with the glass doors open and 1.6% with the glass doors closed. The tests with the circulating feature blocked off completely showed an efficiency almost as great as with the fans with the glass doors open, while with the doors closed, the efficiency was almost 10% less. The high efficiency with the doors open and the circulator closed is thus open to suspicion, and these tests should be repeated to obtain more conclusive results.

Table 5 illustrates the relative merits of the methods for introducing combustion air to the fire. Considering the tests performed under the same

## TABLE 4 : FIREPLACE TEST SUMMARIES

| Test         | Condition          | Glass Doors | Average Efficiency |
|--------------|--------------------|-------------|--------------------|
| Airflow I,   | Circulator Open,   | Open        | 28.7%              |
|              | No fans            | Closed      | 17.7%              |
| Airflow II,  | Circulator Open,   | Open        | 18.3%              |
|              | No fans            | Closed      | 12.7%              |
| Airflow III, | Circulator Open,   | Open        | 13.0%              |
|              | No fans            | Closed      | 6.0%               |
| Airflow II,  | Circulator Closed, | Open        | 20.3%              |
|              | No fans            | Closed      | 4.7%               |
| Airflow II,  | Circulator Open    | Open        | 21.0%              |
|              | 2 fans             | Closed      | 14.3%              |

### TABLE 5: COMBUSTION AIR TEST SUMMARIES

| Test Condition       | Glass Doors | Efficiencies | Average |
|----------------------|-------------|--------------|---------|
| Airflow II           | Open        | 18, 21, 21   | 20.0    |
| Room Combustion Air  | Closed      | 13, 3, 13    | 9.7     |
| Airflow II           | Open        | 20, 21, 24   | 21.6    |
| Rear Combustion Air  | Closed      | 13, 6, 14    | 11.0    |
| Airflow II           | Open        | 17, 19, 18   | 18.0    |
| Front Combustion Air | Closed      | 12, 5, 16    | 11.0    |
|                      |             |              |         |

airflow conditions, the averages were computed and presented in the table. The differences in efficiencies for any of the air supplies is not dramatic, and thus the commonly held conclusion that outside combustion air has a significant positive effect on fireplace efficiency is not borne out by these results. However, it should be noted that a satisfactory device for measuring flow rates of outside combustion air was not available during the test program and there is some question as the effectiveness of the method for outside air introduction. Examination of Figure 3 will show that in some respects the outside air ducts are arranged more like chimneys, and it may be that combustion air could be forced out of the calorimeter room rather than in, when the room balance was off even a small amount. Thus, more conclusive results could be obtained by routing the combustion air flow from an elevation significantly lower than the hearth and by accurately measuring air flow (and direction).

A closer look at Figure 10 reveals that the use of actual logs rather than carefully constructed firebrands results in a slight drop in heat output. Thus it is probable that the test efficiencies obtained in this program are somewhat higher than a person could expect to achieve at home with ordinary firewood. There were not enough tests performed to statistically evaluate fir as opposed to oak or pine, but other factors must be considered besides total heat release, and these include creosote buildup and the possibility of chimney fires when burning softwood.

The major question which results for the testing of a fireplace in a calorimeter room is whether or not these tests approximate what happens in a real house. The answer to this question is that the overall effect on the house as a system cannot be evaluated with this apparatus. Combustion air for the fireplace is normally drawn up the chimney from the conditioned air space and this air demand may indeed result in a higher heat demand on other systems (such as a gas furnace, etc.) which may be heating the house. With this test setup, there is no basis for estimation of these effects.

The conduct of this test program has pointed out some shortcomings in the calorimeter room as it exists, and several improvements could be made including provisions for the more accurate measurement of combustion air flows and for the continuous monitoring of flue gas constituents (CO,  $O_2$ ,  $CO_2$ ) with electronic instruments to better utilize the heat loss efficiency calculation method.

With the calorimeter room as a tool, other tests on wood burning apparatus could be performed including the evaluation of fireplace inserts and wood stove to fireplace retrofits. In addition, other methods for hot air circulation could be evaluated as well as water heating devices. The existing laboratory could also be used for further analysis of smoke constituents of interest, possibly using gas chromatography.

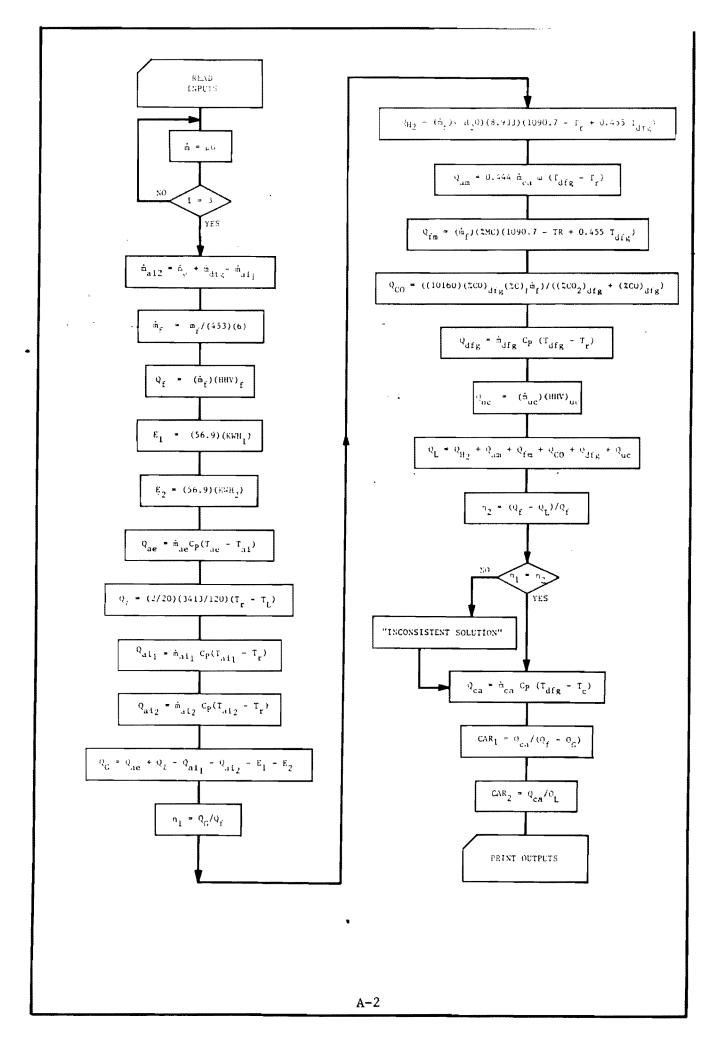
In summary, the overall test program showed a steady state arithmetical average thermal efficiency for the fireplace of 15.7%. This efficiency is, of course, significantly less than is available with an airtight wood stove. The tests have shown that a more intense fire results in a slightly higher net heat output than a quiet fire. The results also show that open glass doors allow a higher net heat transfer to the surroundings when a well established fire is burning and that circulating features incorporatin electric fans can add several percent to a fireplace's overall efficiency.

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## APPENDIX A

COMPUTER ANALYSIS FLOW CHART COMPUTER PROGRAM LISTING COMPUTER ANALYSIS NOMENCLATURE



```
PROGRAM FPR(INPUT,OUTPUT,TAPES=INPUT,TAPEC-UUTPUT, TAPES
     @TAPE8=ANS, DAT, TAPE9=DAT)
00110 DIMENSION Q(12),T(14),G(3),AD(5),PC(6),PH(3),AH(10),
     QEF(2), RA(2)
00115 REAL HHV, KWH
00121 READ(9,*) (G(N),N=1,2),(AD(N),N=1,4),(FC(N),N=1,3),(FH(N),N=1,3)
00172 TAEF=0
00174 TAQF=0
00176 TAQNH=0
00183 DO 1000 L=1,3
   81 READ(9,*) G(3)
00184 TEF=0
00185 TMF=0
00186 DO 900 M=1,7
   71 READ(9,*) FM, (T(N), N=1,14)
00190 DO 155 I=1,3
  155 AM(I)=AD(I)*G(I)
00222 AM(8)=AM(1)-AM(2)
00224 AM(6)=FM/(454*6)
00226 AM(5)=15,96*AM(6)
00227 AM(4)=AM(2)+AM(3)+AM(5)-AM(1)
00228 HHV=8379
00230 QF=AM(6)*HHV
00240 KWH=.04*2+.0345*2
C
      WHEN THE CIRCULATING FANS ARE RUNNING, ADD (.0345*2) TO THE KWH.
00245 E1=KWH*56.9
00250 E2=((3/4)*42+4)*2
      WE HAVE TWO 3/4 HP FUMPS WHICH CIRCULATE AIR INTO THE CALORIMETER.
С
С
      THESE ARE CONSIDERED AS THE ELECTRICITY USEAGES E2(CF. THE TEXT),
C
      WHICH ARE NOT PART OF THE FIREPLACE SYSTEM.
00255 TF=(T(5)+T(6)+T(7))/3
00260 TR=((T(9)+T(10)+T(11))/3+T(1))/2
00262 TL = (T(12) + T(13))/2
   31 TC=TR
00266 W=PH(3)/20
00268 CP=+24
00270 PC(4)=+56
00272 PC(5)=0.07
00274 PC(6)=0.0
00280 Q(12)=AM(5)*CP*(T(8)-TR)
С
      EFFICIENCY ANALYSIS : METHOD I
00300 Q(1)=AM(2)*CP*(T(2)-T(1))
00305 Q(2)=(2,/20,)*(3413,/120,)*(TR-TL)
00310 Q(3)=AM(8)*CP*(T(1)-TR)
00315 Q(4) = AM(4) * CF * (TC - TR)
00320 Q(5)=E1+E2
00325 \ QG=Q(1)+Q(2)-Q(3)-Q(4)-Q(5)
00330 EF(1)=QG/QF
00335 RA(1)=Q(12)/(QF-QG)
      GO TO 550
£.
      EFFICIENCY ANALYSIS : METHOD II
00400 Q(6)=AM(6)*.063*8.933*(1090.7-TR+.455*T(8))
C 405 Q(7)=AM(7)*HHVA
00410 \ Q(8) = .444 \times AM(5) \times W \times (T(8) - TR)
00415 Q(9)=AM(6)*PC(6)*(1090.7-TR+.455*T(8))
00420 Q(10)=(10160*PC(2)*.523)*AM(6)/(PC(1)+PC(2))
00425 Q(11)=AM(3)*CF*(T(8)-TR)
00430 Q(12)=AM(5)*CP*(T(8)-TR)
00435 Q(7)=QF-(Q(6)+Q(8)+Q(9)+Q(10)+Q(11)+Q(12))-QG
00440 \ RL = R(6) + R(7) + R(8) + R(9) + R(10) + R(11) + R(12)
00445 EF(2)=(QF-QL)/QF
```

```
00450 RA(2)=Q(12)/QL
00500 IF((EF(1)-EF(2)).LE..05) GO TO 550
00510 PRINT(8,515)
00515 FORMAT(* *,T10,*SOLUTION IS NOT CONSISTENT*)
00550 IF(M.GT.1) GD TO 600
      PRINT (8,*) (* *)
   91 FRINT(8,461) L
  461 FORMAT(* *,T10,*TEST NUMBER : -*,111,T50,*DATE : *)
  196 FRINT (8,*) (* *)
      PRINT (8,198)
  198 FORMAT(* *,T2,78(*=*))
      FRINT (8;*) (* *)
      FRINT (8,201)
  201 FORMAT(* *,T25,*FIREPLACE SIMULATION STUDIES*)
      PRINT (8+*) (* *)
      PRINT (8,202)
  202 FORMAT(* *,T20, "CHARACTERISTICS AND EFFICIENCY ANALYSIS")
      PRINT (8,*) (* *)
      PRINT (8,203)
  203 FORMAT(* *,T2,78(*=*))
      PRINT (8,*) (* *)
   41 PRINT(8,21)
   21 FORMAT(* *,T10, "COMBUSTION AIR : *,T50, "GLASS DOOR : *)
  204 FRINT (8,*) (* *)
      PRINT (8,205)
  205 FORMAT(* *,T10,*CIRCULATION FANS : *,
     @T50, "FUEL MATERIAL : ")
      PRINT (8,*) (* *)
      PRINT (8,206) HHV
  206 FORMAT(* *,T10,*FUEL TYPE : *,T50,*HEATING VALUE =*,
     @F7.2,T71,*(BTU/LB)*)
      PRINT (8,*) (" ")
      PRINT (8,207)
  207 FORMÁT(* *,T2,78(*=*))
      PRINT (8,*) (* *)
      PRINT (8,208) (AM(I),I=1,2)
  208 FORMAT(* *,T10, "MASS AIR IN ==*,F6,2,,*(LB/MIN)",T50, *MASS AIR *,
     @"OUT =",F6.2,,"(LB/MIN)")
      PRINT (8,*) (* *)
      PRINT (8,209) AM(3),AM(5)
  209 FORMAT(* *,T10,*MASS DRY FLUE GAS =*,F5,2,,*(LB/MIN)*,
     @T50, "MASS COMB AIR = ",F5.2,, "(LB/MIN)")
      FRINT (8,*) (* *)
      PRINT (8,210)
  210 FORMAT(* *,T2,78(*=*))
      PRINT (8,*) (" ")
      PRINT (8,211) (PC(I),I=1,3)
  211 FORMAT(* *,T10,*%CO2 =*,F5,3,T30,*%CO =*,F5,3,T50,*%O2 =*,
     @F5.3)
      PRINT (8,*) (* *)
      PRINT(8,212) (PC(J), J=4,6)
  212 FORMAT(* *,T10,"%C =",F5.3,T30,"%H =*,F5.3,T50,"%MC =*,
     @F5.3)
      PRINT (8,*) (* *)
      PRINT (8,213) (PH(I),I=1,3)
  213 FORMAT(" ",T10,"(R.H.)LAB ==",F5.3,T30,"(R.H.)OUT ==",F5.3,
     @T50,"(R.H.)ROOM =",F5.3)
      PRINT (8,*) (" ")
      PRINT (8,214)
  214 FORMAT(* *,T2,78(*=*))
      PRINT (8,*) (* *)
      PRINT (8,215)
                                   A-4
```

```
215 FORMAT(* *,T8,*FUEL*,T71,*COMB AIR/*)
      PRINT (8,216)
  216 FORMAT(* *,T2,*TIME*,T7,*WEIGHT*,T32,*TEMPERATURE(F)*,
     @T67, "EFF", T71, "TOT LOSS")
  ----FRINT (8,217)
  217 FORMAT(* *,T2,78(*-*))
      FRINT (8,218)
  218 FORMAT(* *,T3,*MIN*,T7,*LB/MIN*,T16,*IN*,T22,*OUT*,T28,
     @*STACK*,T35,*COMB*,T41,*FIRE*,T48,*CALR*,T54,*LAB*,T60,
     @"ENV",T68,"%",T74,"%")
      PRINT (8,219)
  219 FORMAT(* *,T2,78("-*))
  600 PRINT (8,620) M-1,AM(6),T(1),T(2),T(8),TC,TF,TR,TL,T(14),
     QEF(1), RA(1)
  620 FORMAT(* *,T4,111,T7,F5.4,T15,F4.1,T21,F5.1,T28,F5.1,T34,
     @F5.1,T40,F6.1,T47,F5.1,T53,F5.1,T59,F5.1,T66,F4.2,T72,F4.2)
       TOTAL MASS OF FUEL AND THE EFFICIENCY ARE EVALUATED,
C
С
      FOR THE AVERAGE EFFICIENCY CALCULATIONS.
       TMF = TMF + AM(6)
       TEF = TEF + EF(1)
  900 CONTINUE
      PRINT (8,*) (" ")
      PRINT (8,221)
  221 FORMAT(* *,T2,78(*=*))
00630 AEF=TEF/(M-1)
00635 AMF=TMF/(M-1)
00640 AQF=AMF*HHV*60
00645 AQNH=AEF*AQF
00650 FRINT(8,910) AEF, AQF, AQNH
00910 FORMAT(* *,T3;*AEF=*,F4.2,T22;*AQF=*,E11.6;*(BTU/HR)*,T54;
     @*AQNH=*,E10.5,*(BTU/HR)*)
00655 PRINT(8,915)
00915 FORMAT(* *,T2,78(*=*))
00660 TAEF=TAEF+AEF
00665 TAQF=TAQF+AQF
00670 TARNH=TARNH+ARNH
 1000 CONTINUE
00675 AEFT=TAEF/(L-1)
00680 AQFT=TAQF/(L-1)
00685 AQNHT=TAQNH/(L-1)
      PRINT(8,*) (" ")
00690 FRINT(8,930) AEFT, AQFT, AQNHT
00930 FORMAT(* *,T3,*AEFT=*,F4.2,T22,*AQFT=*,E11.6,*(BTU/HR)*,T54,
     @*AQNHT=*;E10.5;*(BTU/HR)*)
      FRINT(8,*) (* *)
00695 PRINT(8,940)
00940 FORMAT(* ",T2,78(*=*))
00700 STOP
00800 END
```

#### NOMENCLATURE

# SYMBOLS AD: Air density (1bm/ft<sup>3</sup>) AF: Air fuel ratio AM: Air mass (1bm/min) C: Carbon CA: Combustion air CALR: Calorimeter CAR: Combustion air ratio CO: Carbon monoxide CO<sub>2</sub>: Carbon dioxide $C_{p}, CP$ : Specific heat coefficient (Btu/lbm- $^{O}F$ ) Electricity usage (Btu/hr), E1: part of the fireplace being tested, E : $E_2$ : not part of the fireplace being tested. EF: Efficiency G: Volumetric flow rate (ft<sup>3</sup>/min) H<sub>2</sub>: Hydrogen HHV: Higher heating value (Btu/1bm) KWH: Kilowatt hour M,m: Mass (1bm) MC: Moisture content (wet basis) MF: Mass of fuel 0: Oxygen PC: Percentage PH: Relative humidity Q,q: Heat rate (Btu/min) RA: Ratio of heat loss by combustion to the total heat loss R.H.: Relative humidity T: Temperature (°F)

W: Specific humidity

#### GREEK LETTERS

```
η: Efficiency
```

- $\rho$ : Density (lbm/ft<sup>3</sup>)
- $\omega$ : Specific humidity

#### SUBSCRIPTS

- A: Average, Ash
- ae: Air exit
- ai: Air inlet,  $ai_1$ : indirect for combustion,  $ai_2$ : direct for combustion
- am: Air moisture
- C,c: Combustion
- ca: Combustion air
- CO: Carbon monoxide
- dfg: Dry flue gas
  - e: Electricity
- F,f: Fuel
  - G: Gained
- H<sub>2</sub>: Hydrogen
- l: Leakage
- L: Losses, lab
- NH: Net heat output
- R: Calorimeter room
- T: Total
- uc: Uncombustibles

#### SUPERSCRIPTS

- -: Average
- ·: Time rate (1/min)

APPENDIX B

COMPUTER ANALYSIS DATA SHEETS

|                         | TEST NUMBER : 13-1     |                    |                               |                          |             |  |                              |                    | DATE : 1/22/79 |                     |   |  |  |
|-------------------------|------------------------|--------------------|-------------------------------|--------------------------|-------------|--|------------------------------|--------------------|----------------|---------------------|---|--|--|
|                         | : uz. ez ez an. uz.    |                    | FI                            | REPLACE                  | SIMUL       | ATION S  | TUDIES                       | ;                  |                |                     | 22 Mir, 201 Mir Mir Mir Mir Mir Mir Mir |  |  |
|                         |                        |                    |                               |                          |             | EFFICIE  |                              |                    |                |                     |   |  |  |
| the the sea are and the |                        | USTION             |                               |                          |             | - 140 PW - 140 - 140 - 144 - 144 - 144 - 144 - 144 - 144 - 144 - 144 - 144 - 144 - 144 - 144 - 144 - 144 - 144 |                              |                    | DR : OPI       |                     |   |  |  |
|                         | CIRC                   | ULATION            | FANS                          | : NONE                   |             |  | FUE                          | L MATE             | RIAL :         | woon                |   |  |  |
|                         | FUEL                   | TYPE :             | DOUGL                         | AS FIR                   |             |  | HEA                          | TING V             | ALUE =         | 3379.(              | )(BTU/LB)                               |  |  |
|                         |                        | an an an a an an a |                               |                          |             |  |                              |                    |                |                     |   |  |  |
|                         | MASS                   | AIR IN             | = 75.                         | 00(LB/M                  | IN)         |  | MAS                          | S AIR              | OUT = 4        | 43.20               | (LB/MIN)                                |  |  |
|                         | MASS                   | DRY FL             | UE GAS                        | =11.45                   | (LB/MI      | N)   | MAS                          | S COMB             | AIR =          | 3.39                | (LB/MIN)                                |  |  |
|                         | 1994 and 2004 and 7000 |                    |                               |                          | = = = = = = |  | ne 22 te 27 /2 /2            |                    |                | II 104 04 03 15 1   | 9 22 32 101 22 22 22 22 22 22           |  |  |
|                         | %02                    | ≕ <b>,</b> 030     |                               | %00                      | = .040      | •  | <b>%</b> 02                  | <b>≕</b> .01       | 0              |                     |   |  |  |
|                         | %C =                   | •560               |                               | %Η =                     | .070        |  | <b>%M</b> C                  | = <b>0</b> .00     | 0              |                     |   |  |  |
|                         | (R.H                   | •)LAB =            | .500                          | (R.H                     | •) OUT      | - •800   | (R.                          | H.)R00             | IM = ₊4(       | 00                  |   |  |  |
|                         | (*) <b>(*) (*)</b> (*) |                    | <b>ur au 115 m in 116 s</b> a | 114 82 82 82 82 98 96 49 |             |  | 121 <b>25 21 12 12</b> 24 24 | an na da ini mi bi |                | 19 JUL 13 JUL 18 AN |   |  |  |
| F<br>TIME WE            | UEL<br>IGHT            |                    |                               | TE                       | MPERAT      | URE(F)   |                              |                    |                | EFF                 | COMB AIR/<br>TOT LOSS                   |  |  |
| MIN LB                  | /MIN                   | או                 | out                           | STACK                    | СОМВ        | FIRE   | CALR                         | LAB                | ENV            | %                   | %                                       |  |  |
|                         |                        | 33.6<br>34.0       |                               | 106.6<br>262.8           |             | 449.7<br>525.3   | 49.7<br>51.5                 | 67.6<br>68.4       |                | •15<br>•22          | .03<br>.12                              |  |  |
|                         |                        | 35.7               |                               | 360.9                    |             |  |                              | 67.6               |                | •28                 | .19                                     |  |  |
|                         |                        |                    |                               | 347.4                    |             |  |                              |                    |                | .31                 | •19                                     |  |  |
|                         |                        | 34.5               |                               |                          |             | 606.8  |                              |                    |                | •36                 | + 22                                    |  |  |
|                         |                        | 35.8<br>36.1       | 82+2<br>85+6                  | 359.1<br>229.3           | 59.8        | 596.8<br>569.6   |                              |                    |                | •35<br>•37          | •21<br>•12                              |  |  |
| AEF= .                  | 29                     |                    | AQF=.                         | 107018E                  | +06(BT      | U/HR)  |                              | AQNH=              | •31161E        | E+05(B              | TU/HR)                                  |  |  |

|                          | TESI                           | NUMBE                      | ER : 13-                         | -2                     |                                 | DATE : 1/22/79  |                               |  |                              |  |                                    |  |
|--------------------------|--------------------------------|----------------------------|----------------------------------|------------------------|---------------------------------|---|-------------------------------|--|------------------------------|--|------------------------------------|--|
| <b>14 au 16 19</b>       | un an air an an an an an a     | u an 20 97 211 an 12       |                                  |                        |                                 | _ATION S  |                               |  | 12 12 11: <i>11</i> 11 11 12 | NI II 95 M II II 95  | 72 121 <b>75</b> 26 20 10 02 02 02 |  |
|                          |                                |                            | CHARACT                          | ERISTIC                | CS AND                          | EFFICIE   | ENCY AN                       | ALYSI                                  | 3                            |  |                                    |  |
| 197 228 248 247 j        | 10 11 11 11 11 11 11 11 11 11  |                            | : 118 alls (117 112 alls 112 all | : 22 22 33 42 70 38 3  | 2 000 001 001 004 001 00        |   | a ma tet est tet tet te       | 4 <del>- 2</del> 111 71 71 71 71 71 71 | n 200 (10 00 100 100 000 000 |  | an ini ini fin dia 22 me any 55    |  |
|                          | COME                           | USTION                     | I AIR :                          | ROOM                   |                                 |   | GLA                           | ASS DO(                                | DR : OP                      | EN   |                                    |  |
|                          | CIRC                           | ULATIC                     | N FANS                           | : NONE                 |                                 |   | FUEL MATERIAL : WOOD          |  |                              |  |                                    |  |
|                          | FUEL                           | . TYPE                     | : DOUGL                          | AS FIR                 |                                 |   | HEATING VALUE =8379.0(BTU/LB) |  |                              |  |                                    |  |
|                          |                                |                            |                                  |                        |                                 | 1 <b>111</b> an 111 he at 11 h                                      | <b></b>                       | 2 83 121 72 72 83 6                    |                              | anna ann gaga ann ang ana ang .<br>gga na Sant Sant agus ag g cago |                                    |  |
|                          | MASS                           | AIR I                      | N = 75.                          | 00(LB/M                | (NI                             |   | MAS                           | S AIR                                  | OUT =                        | 43+20()  | LB/MIN)                            |  |
|                          | MASS                           | DRY F                      | LUE GAS                          | =12.82                 | CLB/MI                          | (N)   | MAS                           | S COME                                 | AIR =                        | 4+45()   | LB/MIN)                            |  |
| an 110 55 AP 1           | 17 ka 22 25 76 23 16 16 5      | na an 18 ke ng ta          |                                  |                        | , <b>200 ANT 111 T</b> E 117 TE |   |                               | t dat soo par ake kar at               |                              | in 12 27 21 21 21 27 31  | en hat all ten all tet an het an   |  |
|                          | %002                           | ≕ .03                      | 0                                | %C0                    | = .040                          | )   | <b>%</b> 02                   | 2                                      | .0                           |  |                                    |  |
|                          | %C =                           | .560                       |                                  | <b>%H = .070</b>       |                                 |   |                               | ZMC =0.000                             |                              |  |                                    |  |
|                          | (R+H                           | .)LAB                      | = .500                           | (R+H                   | I.)OUT                          | = .800  | (R.                           | (R.H.)ROOM = .400                      |                              |  |                                    |  |
| <b>112 115 111</b> 111 ( | ala and and and and and and an | ten ber ster site eite ken |                                  | 111 7# 121 12 #: 12 13 |                                 | <b>1 (12 )</b> (1 <b>)</b> (1 )(1 )(1 )(1 )(1 )(1 )(1 )(1 )(1 )(1 ) | i ant and the air and in      | , 190 and 192 (all 193 and 19          |                              |  | ur 12 vir 12 12; up 26 10; 25      |  |
| TIME                     | FUEL<br>WEIGHT                 |                            |                                  |                        |                                 | URE(F)  |                               |  |                              | EFF  | COMB AIR/<br>FOT LOSS              |  |
| MIN                      | LB/MIN                         |                            |                                  |                        |                                 |   |                               |  |                              | •  |                                    |  |
| 0<br>1                   | •2790<br>•2786                 | 36.1<br>36.2               | 85.6<br>87.3                     | 229.3<br>195.2         | 59.8<br>60.9                    | 569.3   | 59.8<br>60.9                  | 68.2<br>67.1                           | 36.1<br>36.2                 | •28<br>•31   | • <b>1</b> 1<br>•09                |  |
| 2                        | .2805                          | 36.6                       | 91.2                             | 415.6                  | 62.6                            | 665.2   | 62+6                          | 67.7                                   | 36.6                         | .32  | .24                                |  |
| 3                        | .2808                          |                            | 96.3                             | 429.7                  | 64.6                            | 670.7   | 64.6                          | 67.9                                   | 37.3                         | • 34   | •25                                |  |
| 4                        | .2735                          |                            | 102.6                            | 389.3                  |                                 | 693.3   | 66.4                          | 68.0                                   | 66.4                         | •38  | .24                                |  |
| 5<br>6                   | •2761<br>•2761                 | 37.2<br>38.0               | 104.0                            | 265.7<br>247.2         | 67.2<br>67.9                    | 749.6<br>695.0  | 67.2<br>67.9                  | 68.3<br>68.4                           | 37.2<br>38.0                 | •39<br>•38   | .15<br>.13                         |  |
| AEF                      | 34                             |                            | AQF=.                            | 139659E                | +06(BT                          | U/HR)   |                               | AQNH=                                  | .479556                      | E+05(B)  | (U/HR)                             |  |

| TEST NUMBER : 13-3   |  |                               |                        |                |                                 |                           |                               |                     | DATE : 1/22/79 |              |                               |  |  |  |
|--|--|-------------------------------|------------------------|----------------|---------------------------------|---------------------------|-------------------------------|---------------------|----------------|--------------|-------------------------------|--|--|--|
|  | na ngu data suna suis vuus suks an     | 4 MBF 2100 2400 4410 4610 461 |                        |                |                                 | ATION S                   |                               |                     |                |              |                               |  |  |  |
|  | <b>1</b> 1887 1887 1884 1984 1984 1984 |                               | CHARACI                | ERISTIC        | S AND                           | EFFICIE                   | NCY AN                        | ALYSI!              | 5              |              |                               |  |  |  |
|  | COME                                   | USTION                        | AIR :                  | ROOM           |                                 |                           | GLA                           | SS DO               | DR : OP        | EN           |                               |  |  |  |
|  | CIRC                                   | ULATIC                        | IN FANS                | : NONE         |                                 |                           | FUE                           | L MATE              | ERIAL :        | woop         |                               |  |  |  |
|  | FUEL                                   | TYPE                          | : DOUGL                | AS FIR.        |                                 |                           | HEA                           | TING V              | VALUE =        | 8379.0       | (BTU/LB                       |  |  |  |
|  | MASS                                   |                               | :=======<br>:N = 75.   |                |                                 | : 52 22 12 33 24 24 39 24 |                               |                     |                |              | LB/MIN)                       |  |  |  |
| ش عمارة المحالية موادية والأند   |  |                               | LUE GAS                |                |                                 |                           |                               |                     |                |              | LB/MIN)                       |  |  |  |
|  |  | = .03                         |                        |                | %CO = .040 %O2                  |                           |                               |                     |                |              | dia am an cai ani ani ila ita |  |  |  |
|  | %C ==                                  | .560                          |                        | %H =           | %MC                             | %MC =0.000                |                               |                     |                |              |                               |  |  |  |
|  | (R.H                                   | ,)LAB                         | = .500                 | (R.H           | I.) OUT                         | - •800                    | (R.                           | H.)ROC              | )M = .40       | 00           |                               |  |  |  |
|  | FUEL<br>WEIGHT                         | 812 02 04 10 02 04            | • 72 EN 16 12 12 15 17 | TE             | MPERAT                          | URE(F)                    | nin vil ja vil in til pri til | 1 20 20 20 70 20 70 |                |              | COMB AI                       |  |  |  |
|  | LE/MIN                                 | IN                            | OUT                    |                | . Anda anan waan waan waan waan |                           | CALR                          | LAB                 | ENV            |              |                               |  |  |  |
| 0  | .3543                                  | 38.0                          | 102.1                  | 247.2          | 67.9                            | 695.0                     | 67.9                          | 68.4                | 38.0           | .30          | .12                           |  |  |  |
|  | .3517                                  | 38.2                          | 105.0                  |                |                                 |                           |                               |                     |                | .31          | .23                           |  |  |  |
|  | .3517                                  | 38.4                          | 108.2                  |                |                                 | 697.4                     |                               |                     |                | • 33         | +31                           |  |  |  |
|  | .3506<br>.3488                         | 37+7<br>30.4                  | 110.1                  | コリア+1<br>オクウーブ | 72+0<br>77. A                   | 685+7<br>714.3            | /2+6<br>77 A                  | 07.1<br>47 5        | 37+7<br>70-7   | • 33<br>• 36 | .30<br>.25                    |  |  |  |
| 4 .3488 38.4 113.3 422.7 73.4 714.3 73.4 67.5 38.4<br>5 .3480 38.2 113.6 294.0 73.1 806.5 73.1 65.6 38.2 |  |                               |                        |                |                                 |                           | 38.2                          | • 30<br>• 36        | .16            |              |                               |  |  |  |
|  | .3451                                  | 39.1                          | 112.8                  | 259.7          | 74.9                            | 829.0                     | 74.9                          | 66.0                | 39.1           | +36          | .13                           |  |  |  |
| \EF≔   | .34                                    |                               | AQF=.                  | 175964E        | +06(BT                          | U/HR)                     |                               | AQNH=               | • 59385E       | E+05(B       | TU/HR)                        |  |  |  |
|  | 32                                     | in: 111 112 21 112 ME         |                        |                |                                 | TU/HR)                    |                               |                     |                |              |                               |  |  |  |

B-4

|                       | TES                                      | T NUMBEI                     | R : 9A-                         | -1                            |                            | DATE : 12/11/78                         |   |                            |                                 |                                |  |
|-----------------------|--|------------------------------|---------------------------------|-------------------------------|----------------------------|---|---|----------------------------|---------------------------------|--------------------------------|--|
|                       | <b>120 121 122 122 123 123</b> 124 124   | au 141 64 64 64 64 84 64 5   |                                 |                               | • = = = = = = =            | = == =;                                 | 1 <b>31 12 32 23 1</b> 2 1                                      |                            |                                 |                                |  |
|                       |  |                              | FI                              | REPLACE                       | E SIMUL                    | ATION S                                 | STUDIES   | 3                          |                                 |                                |  |
|                       |  | ι                            | CHARACT                         | ERISTIC                       | S AND                      | EFFICIE                                 | ENCY AN   | ALYSIS                     | 3                               |                                | ·                                      |
| CZ 27 (JZ 22 )        | tant telle state state state state state | ten for an the tes the state | <b></b>                         |                               | 4 20 XE EE EE IX A         |   | 1   | : 73: 33: 35: 23: 33: 4    | 2 12 TH IN 12 12 18 18          | 42 52 <u>36</u> 34 5           |  |
|                       | COM                                      | BUSTION                      | AIR :                           | REAR                          |                            |   | GLf   | SS DOG                     | DR : OP                         | EN                             |  |
|                       | CIR                                      | CULATIO                      | FANS                            | : NONE                        |                            |   | FUE   | L MATE                     | ERIAL :                         | woon                           |  |
|                       | FUE                                      | L TYPE                       | DOUGL                           | AS FIR                        |                            |   | HEATING VALUE =8379.0(BTU/LB)                                   |                            |                                 |                                | (BTU/LB)                               |
|                       | <b></b>                                  | ad 189 Mit 194 Mit 187 Ant 4 | ta anal sum avai sum ann ann in | - 7.4 122 111 572 112 584 584 | i di ini ini ini ini ini i | <b></b>                                 | , 22 JH 28 28 28 28   |                            |                                 |                                | : 12 55 55 55 55 58 <u>58 56 56</u> 56 |
|                       | MAS                                      | S AIR IN                     | 1 = 75.                         | OO (LBZM                      | IIN)                       |   | MAS   | S AIR                      | 0UT = 4                         | 43,200                         | LB/MIN)                                |
|                       | MAS                                      | S DRY FL                     | UE GAS                          | =11+45                        | ICLB/MI                    | (N)                                     | MASS COMB AIR = 3.46(LB/MIN)                                    |                            |                                 |                                | LB/MIN)                                |
| :::: ::: ::: ::: ::   | <b>11 (15 15) (18 15)</b> (18 15)        |                              | <b></b>                         |                               |                            | 1 <u>22 117</u> ha 314 <u>22</u> / 83 H | . 60 65 69 65 65 66 68  | i 111, 112 115 116 116 116 | i site vies and one had site is | <b>27 177 175 18</b> 7 181 183 | . met fan its gis ter teg om and sy    |
|                       | %002                                     | 2 = •030                     | )                               | 200                           | = .010                     | )                                       | 202   | ! = .10                    | 0                               |                                |  |
|                       | %C =                                     | - ,560                       |                                 | %H =                          | •070                       |   | % MC  | =0.00                      | 0                               |                                |  |
|                       | (R+1                                     | H.)LAB =                     | ,450                            | (R•H                          | I.)OUT                     | 650                                     | (R.   | H.)ROC                     | IM = •4(                        | 00                             |  |
| ::: 20 35 35 <b>3</b> | <b>n ni 1</b> 07 <b>an</b> 112 93 93 9   |                              | . 201 1117 THE 100 ICC 110      | ng 141 100 ga an an an an     |                            |   | . <b></b>   |                            |                                 | na tai ist ku sa aa            | - 214 115 111 111 111 111 215 115 216  |
| TIME                  | FUEL<br>WEIGHT                           |                              |                                 | TE                            | MPERAT                     | URE(F)                                  |   |                            |                                 |                                | COMB AIR/<br>TOT LOSS                  |
| MIN                   | LB/MIN                                   | IN                           | OUT                             | STACK                         | СОМВ                       | FIRE                                    | CALR  | LAB                        | ENV                             | 7                              | %                                      |
| 0                     | .2166                                    | 40.7                         | 55.7                            | 127.7                         | 51.9                       | 574.9                                   | 60.1  | 70.0                       | 38.3                            | •13                            | +04                                    |
| 1                     | .2148                                    | 41.5                         | 71.4                            | 169.5                         | 50.4                       | 668.7                                   | 57.2  | 70.0                       | 38.2                            | •20                            | • 06                                   |
| 2                     | .2159                                    | 43.9                         | 75.1                            | 333+7                         | 56,4                       | 679.9                                   | 66.0  | 70.2                       | 38.7                            | .24                            | •16                                    |
| 3                     | .2137                                    | 43.7                         | 96.5                            | 344+4                         | 58.2                       | 834.0                                   | 69.1  | 69.9                       | 38.9                            | •38                            | .20                                    |
| 4                     | .2122                                    | 42+9                         | 82.1                            | 306.3                         | 58.3                       | 881.5                                   | 69.2  | 70.3                       | 39+1                            | • 31                           | •16                                    |
| 5                     | .2115                                    | 45.6                         | 85.7                            | 220.8                         |                            | 864.2                                   | 71.1  | 69+3                       | 37.9                            | • 31                           | +10                                    |
| 6                     | <b>,</b> 2129                            | 44.9                         | 87.9                            | 194+8                         | 58.2                       | 819.8                                   | 70.7  | 69+2                       | 40.1                            | •33                            | •08                                    |
|                       | • • 27                                   | 0 at 10 m an 10 ta 14        |                                 | <br>107545E                   |                            |   | NYNG ANNE MINN AANT LANN ANNE<br>Arber Minn Ynwy geni Linge men |                            | <br>•29241E                     |                                | TU/HR)                                 |
|                       |  |                              |                                 |                               |                            |   |   |                            |                                 |                                |  |

|                              | TEST              | NUMBE                                  | R : 9A-                 | 2                                   |  | DATE : 12/11/78                  |                               |  |                                       |                       |  |
|------------------------------|-------------------|--|-------------------------|-------------------------------------|--|----------------------------------|-------------------------------|--|---------------------------------------|-----------------------|--|
|                              |                   | 92 88 35 86 69 a                       |                         |                                     | • = = = = = = =  | 1 <b>22 an 22 an 26 22</b> 2     |                               | - 222 222 222 222 222 22               |                                       |                       |  |
|                              |                   |  | FI                      | REPLACE                             | SIMUL  | ATION S                          | TUDIES                        | :                                      |                                       |                       |  |
|                              |                   |  | CHARACT                 | ERISTIC                             | S AND  | EFFICIE                          | NCY AN                        | ALYSIS                                 | \$                                    |                       |  |
| <b>12 (2 47 12 1</b> 5) 12 3 | <b>.</b>          |  | : AN 12 1A 12 M AN 12 M |                                     | : 111 HB 127 227 135 35  |                                  | : == == == == == ==           |  |                                       | = = = = = =           |  |
|                              | COMB              | USTION                                 | AIR :                   | REAR                                |  |                                  | GLA                           | ss poc                                 | DR : OPI                              | EN                    |  |
|                              | CIRC              | ULATIO                                 | N FANS                  | : NONE                              |  |                                  | FUEL MATERIAL : WOOD          |  |                                       |                       |  |
|                              | FUEL              | TYPE                                   | : DOUGL                 | AS FIR                              |  |                                  | HEA                           | TING V                                 | ALUE =                                | 3379.0                | O(BTU/LB)                              |
| <b>10 de 61 (11 de 1</b> 2 d |                   |  |                         |                                     |  | 1 mil 271 mil 271 mil die 72     |                               | ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, |                                       | n ar 22 <b>m</b> ar 1 |  |
|                              | MASS              | AIR I                                  | N = 75.                 | 00(LB/M                             | IN)  |                                  | MAS                           | S AIR                                  | 0UT = 4                               | 43.20                 | (LB/MIN)                               |
|                              | MASS              | DRY F                                  | LUE GAS                 | =12.82                              | CLB/MI   | N)                               | MAS                           | S COME                                 | AIR =                                 | 4.50                  | (LB/MIN)                               |
|                              | a ma na: 22 22 23 | nn 20 az 27 az 52                      | an an an 199 an 199 an  | <b>12 12 05 05 12 11 1</b> 2        | -  |                                  | rati anna aith mair inn dan   | - abart they been black and abart to   |                                       |                       |  |
|                              | %C02              | = .03                                  | 0                       | <b>%</b> C0                         | 010  | )                                | <b>%0</b> 2                   | <b>.</b> . 10                          | 0                                     |                       |  |
|                              | %C =              | • 560                                  |                         | %H ==                               | .070   |                                  | %MC                           | % The =0.000                           |                                       |                       |  |
|                              | (R•H              | .)LAB                                  | = .450                  | (R.H                                | H.)OUT = .650 (R.H.)ROO  |                                  |                               |  | )M = .400                             |                       |  |
|                              |                   | :::::::::::::::::::::::::::::::::::::: |                         | after bild aver start free star and | . semil array sina pera bilis stor<br>1999 decis Jaw ends Sure cos | tere case and any this gave con- | ande when some store arms and |  | verse preme bildin book upple some of |                       | ;; ;;; ;;; ;;; ;;; ;;; ;;; ;;; ;;; ;;; |
| F                            | FUEL              |  |                         |                                     |  |                                  |                               |  |                                       |                       | COMB AIR/                              |
| TIME WE                      |                   |  |                         | TE                                  | MPERAT   | URE(F)                           |                               |  |                                       | EFF                   | TOT LOSS                               |
| MIN LE                       | B/MIN             | IN                                     | OUT                     | STACK                               | COMB   | FIRE                             | CALR                          | LAB                                    | ENV                                   | %                     | 72                                     |
| 0.2                          | 2819              | 44.9                                   | 87.9                    | 194.8                               | 58.2   | 819.8                            | 70.7                          | 69,4                                   | 40.1                                  | •25                   | .08                                    |
|                              |                   |  | 88.0                    | 389.8                               |  | 792.3                            | 72.8                          | 70.2                                   | 40.0                                  | +26                   | .20                                    |
|                              |                   |  |                         | 421.2                               |  | 769.0                            | 74.3                          |  |                                       | .30                   | .23                                    |
|                              |                   |  |                         | 436.7                               |  | 810,8                            |                               |  |                                       | •33                   | +24                                    |
|                              |                   |  | 107.4                   |                                     |  |                                  |                               |  |                                       | •34                   | .19                                    |
|                              |                   |  | 99+4                    |                                     |  | 612+4                            | 77.7                          |  |                                       | • 32                  | •13                                    |
| 6.2                          | 2768              | 46+4                                   | 101.0                   | 238.5                               | 62,7   | 570.6                            | //.1                          | 70+4                                   | 40.6                                  | •33                   | +11                                    |
|                              |                   | <b>=</b> == == == ==                   |                         |                                     |  |                                  |                               |  |                                       |                       |  |
| AEF= +                       |                   |  |                         | 140555E                             |  |                                  |                               |  | <b>,</b> 42682E                       |                       |  |
|                              | <b></b>           | 11 HE 27 PH 10 HE                      |                         |                                     |  | 100 100 100 100 100 100 100      |                               | 111 HE 111 114 117 116                 |                                       | 2 W AN IN IN 18       |  |

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|                     | TEST                            | г лимве                  | ER : 9A-                   | -3                    | ПА                  | DATE : 12/11/78                      |            |                               |                           |                     |                              |
|---------------------|---------------------------------|--------------------------|----------------------------|-----------------------|---------------------|--------------------------------------|------------|-------------------------------|---------------------------|---------------------|------------------------------|
| 22 13 15 <u>1</u> 2 |                                 | 2 NB 32 96 82 92 9       |                            |                       |                     | ATION 9                              |            |                               | 12 135 MA NO NO NO 135 CO | 25 33 15 16 26 CÖ 2 | z an 62 al 12 in 15 UN 18 18 |
|                     |                                 |                          | CHARACI                    | FRISTI                | S AND               | EFFICIE                              | ENCY AN    | ALYSI                         | 6                         |                     |                              |
|                     |                                 |                          |                            |                       | -                   |                                      |            |                               |                           |                     |                              |
|                     | COME                            | USTION                   | AIR :                      | REAR                  |                     |                                      | GLA        | 495 DOL                       | DR : OF                   | EN                  |                              |
|                     | CIRC                            | ULATIO                   | IN FANS                    | : NONE                |                     |                                      | FUE        | L MATE                        | ERIAL :                   | WOOD                |                              |
|                     | FUEL                            | TYPE                     | : DOUGL                    | AS FIR                |                     |                                      | HE         | HEATING VALUE =8379.0(BTU/LB) |                           |                     |                              |
| 42 JT 53 24 :       |                                 |                          | N = 75.                    |                       |                     | 2 20:1 222 223 223 225 225 225 225   |            |                               |                           |                     | LB/MIN)                      |
|                     | MASS                            | NRY F                    |                            | =13.29                | 3(1 R/MT            | 'N)                                  | МФС        | S COMI                        | 4 ATR =                   | 5.457               | LB/MIN)                      |
|                     |                                 |                          |                            | 10120                 | / 1 4 - 4 / / / / 1 | ,                                    |            | 0.0011                        |                           | 0.00                |                              |
| 22 GB 22 GB 33 S    | 64 135 46 138 88 73 38 68       | * *** *** *** *** ***    | 2 89 412 121 84 127 128 23 | 13                    | , 14 ol 14 co 20 co | 1 <b>231 883 885 873 875 885 8</b> 2 |            |                               | (11 62 62)                | an na 22 22 22 22 m | ,                            |
|                     | %02                             | - • 03                   | 50                         | %00                   | )                   | 202                                  | %02 = .100 |                               |                           |                     |                              |
|                     | %C =                            | .560                     |                            | %H =                  | •070                |                                      | %мс        | =0.00                         | 00                        |                     |                              |
|                     | (R.H                            | .)LAB                    | = .450                     | (R.F                  | (R.                 | H.)ROC                               | M = .40    | 00                            |                           |                     |                              |
|                     |                                 |                          |                            |                       |                     |                                      |            |                               |                           |                     |                              |
|                     |                                 |                          |                            |                       |                     |                                      |            |                               |                           |                     |                              |
| TIME                | FUEL<br>WEIGHT                  |                          |                            | TE                    | MPERAT              | URE(F)                               |            |                               |                           |                     | COMB AIR/<br>TOT LOSS        |
| MIN                 | LB/MIN                          | IN                       | OUT                        | STACK                 | COMB                | FIRE                                 | CALR       | LAB                           | ENV                       | 7.                  | %                            |
|                     | .3543                           | 46.4                     |                            |                       |                     | 570.6                                |            |                               |                           | .26                 | .10                          |
|                     |                                 | 45.5                     |                            |                       |                     | 631.3                                |            |                               |                           | •32                 | •27                          |
|                     | •3488<br>•3484                  |                          | 110.7<br>107.4             |                       |                     |                                      |            |                               |                           | •31<br>•30          | •26<br>•25                   |
|                     | •3464                           |                          | 117.6                      |                       |                     |                                      |            |                               | 42.6                      |                     | •24                          |
|                     | .3495                           |                          | 115.5                      |                       |                     |                                      |            |                               |                           |                     | •17                          |
| 6                   | •3499                           | 47.8                     | 112.3                      | 266.5                 | 65.9                | 652.8                                | 84.1       | 68.7                          | 42.3                      | •32                 | .12                          |
|                     |                                 | 112 LUT: 212 112 112 113 |                            |                       |                     |                                      |            |                               |                           |                     |                              |
|                     | = .31<br>=======                |                          |                            |                       |                     | U/HR)                                |            |                               | ••54642i                  |                     | (TU/HR)                      |
| AEFT                | r= .30                          |                          | AQFT=                      | .141346               | E+06(B              | TU/HR)                               |            | AQNHT                         | -42189                    | 9E+05(              | BTU/HR)                      |
| <i></i>             | 3 117 <b>6</b> 8 84 85 82 92 55 | an an an an 12 an        |                            | N3 111 80 60 40 Hz 80 |                     | 112 137 22 23 82 82 82 88            |            |                               |                           |                     |                              |

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| TEST NUMBER : 11-1 DATE : 1/12/79   |  |  |   |                                      |  |   |  |  |  |  |
|---|--|--|---|--------------------------------------|--|---|--|--|--|--|
|   |  |  |   |                                      | una adda dhiar yang yang anga<br>nan adda dalar yang yang anga |   |  |  |  |  |
|   | FIREPLAC   | E SIMULATION   | STUDIES   |                                      |  |   |  |  |  |  |
|   | CHARACTERISTI  | CS AND EFFICI  | ENCY ANALYSI  | S                                    |  |   |  |  |  |  |
| <b>25 25 25 27 25 25 25 25 25 25 25 25 25 25</b> 26 25 26 27 25 26 27 25 26 27 25 26 27 25 26 26 26 26 26 26 26 26 26 26 26 26 26 |  |  |   | ting will used sing they find have a |  |   |  |  |  |  |
| COMBUSTI  | ON AIR : FRONT   |  | GLASS DO  | OR : OPI                             | EN   |   |  |  |  |  |
| CIRCULAT  | ION FANS : NONE  |  | FUEL MAT  | ERIAL :                              | woop   |   |  |  |  |  |
| FUEL TYP  | E : DOUGLAS FIR  |  | HEATING VALUE =8379.0(BTU/LB)   |                                      |  |   |  |  |  |  |
|   |  |  |   |                                      | tar form finne skar mår fort                                   |   |  |  |  |  |
| MASS AIR  | IN = 60.00(LB/   | MIN)   | MASS AIR  | 0UT = 4                              | 43.20(   | LB/MIN)                                       |  |  |  |  |
| MASS DRY  | FLUE GAS =12.5   | 9(LB/MIN)  | MASS COM  | BAIR =                               | 3,52(  | LB/MIN)                                       |  |  |  |  |
|   |  |  |   | 100 100 000 000 000 100 100 0        |  |   |  |  |  |  |
| %c02 = .:   | 110 %CO  | = .010   | %02 = .0  | 70                                   |  |   |  |  |  |  |
| %C = .560   | o <b>%</b> H÷  | 070  | %MC =0.00   | 00                                   |  |   |  |  |  |  |
| (R.H.)LA  | 8 = .980 (R.I  | H.)OUT = .480  | (R.H.)RO(   | OM = .40                             | 00   |   |  |  |  |  |
|   |  |  |   | <b>II 10 6</b> 1 11 12 12 13 13      | 1. 160 ptc 110 ptp 110 p                                       |   |  |  |  |  |
| FUEL<br>TIME WEIGHT   | TE   | EMPERATURE(F)  |   |                                      |  | COMB AIR/<br>TOT LOSS                         |  |  |  |  |
| MIN LB/MIN IN   | OUT STACK  | COMB FIRE  | CALR LAB  | ENV                                  | 7.   | 1/2   |  |  |  |  |
| 0 .2203 36.8<br>1 .2173 36.9<br>2 .2173 36.8<br>3 .2052 36.8<br>4 .2184 36.9<br>5 .2166 37.3<br>6 .2170 37.1                      | 9       54.2       408.7         3       51.5       151.4         3       60.1       160.1         9       62.2       160.3         3       72.6       375.3 | 45.7       402.6         47.2       609.5         47.8       472.1         48.5       414.0         49.3       517.3 | 51.9       66.8         53.7       66.7         55.2       67.3         56.6       67.1         58.8       67.3 | 41.0<br>42.1<br>51.3                 | .07<br>.10<br>.10<br>.16<br>.17<br>.23<br>.23                  | .09<br>.18<br>.05<br>.06<br>.06<br>.19<br>.09 |  |  |  |  |
| AEF= .15  | AQF=.108600E   | E+06(BTU/HR)   | AQNH=   | .16345E                              | +05(B)   | (U/HR)  |  |  |  |  |

|                       | TEST                                   | NUMBER       | : : 11-                         | ·2                              |                           | DATE : 1/12/79              |                               |                                 |                      |                          |   |
|-----------------------|--|--------------|---------------------------------|---------------------------------|---------------------------|-----------------------------|-------------------------------|---------------------------------|----------------------|--------------------------|---|
|                       | <b>na ak ku ku ku ku ku</b> k <b>u</b> |              | FI                              |                                 |                           | ATION S                     |                               |                                 |                      |                          | <b>an in in an an an an an an an an</b> |
|                       |  | C            | HARACT                          | ERISTIC                         | S AND                     | EFFICIE                     | NCY AN                        | ALYSIS                          | 3<br>                |                          |   |
|                       | СОМВ                                   | USTION       | AIR :                           | FRONT                           |                           |                             | GLA                           | ISS DOC                         | DR : OP              | EN                       |   |
|                       | CIRC                                   | ULATION      | FANS                            | : NONE                          |                           |                             | FUEL MATERIAL : WOOD          |                                 |                      |                          |   |
|                       | FUEL                                   | TYPE :       | DOUGL                           | AS FIR                          |                           |                             | HEATING VALUE =8379.0(BTU/LB) |                                 |                      |                          | O(BTU/LB)                               |
|                       | a 10 au 10 an - 1 ar 1                 |              | NATE and the case sing you      |                                 |                           | 0 134 112 123 124 123 124 1 | <b>:</b>                      |                                 |                      |                          |   |
| v 100                 | MASS                                   | AIR IN       | = 60.                           | 00(LB/M                         | (או)                      |                             | MAS                           | S AIR                           | OUT = -              | 43.20                    | (LB/MIN)                                |
|                       | MASS                                   | DRY FL       | UE GAS                          | =13,28                          | (LE/MI                    | (N)                         | MAS                           | S COME                          | 3 AIR =              | 4.58                     | (LE/MIN)                                |
| <b>12 12 14 1</b> 2 1 |  |              |                                 |                                 | = .010                    |                             |                               | ×02 = .090                      |                      |                          |   |
|                       | <b>%C</b> ==                           | .560         |                                 | %H =                            |                           | %MC =0.000                  |                               |                                 |                      |                          |   |
|                       | (R+H                                   | •)LAB =      | •980                            | (R.H                            | I.)OUT                    | 480                         | (R.H.)ROOM = .400             |                                 |                      |                          |   |
|                       | FUEL                                   |              | 571 (72 (75 (15 <u>15</u> 75 75 | 112 /st ()2 25 22 22 23         | . 112 122 123 127 127 128 | :                           |                               | 111 in <del>111</del> ch 115 in | :                    | m no 112 20 20 7         | COMB AIR/                               |
| TIME                  | WEIGHT                                 |              |                                 | TE                              | MPERAT                    | URE(F)                      |                               |                                 |                      | EFF                      | TOT LOSS                                |
| MIN                   | LE/MIN                                 | IN           | OUT                             | STACK                           | Сомв                      | FIRE                        | CALR                          | LAB                             | ENV                  | 7                        | %                                       |
| 0                     | .2871                                  | 37.1         | 70.9                            | 210.2                           |                           | 457.6                       |                               |                                 |                      | .17                      | +08                                     |
| 1                     | .2819                                  | 36.9         | 75.5                            | 389.0                           | 50.9                      | 497.5                       |                               |                                 | 47.5                 | • 20                     | •19                                     |
| 2                     | +2827                                  | 37.6         | 94.2                            | 418.6                           | 51.8                      | 505.5                       | 63.0                          |                                 |                      | •28                      | •23                                     |
| 3                     |  | 37.5         | 88.9                            | 438.7                           | 53.0                      | 593.1                       |                               | 67.5                            |                      | + 27                     | •23                                     |
| 4<br>5                |  | 37.5<br>38.1 | 94.4                            | 405.6                           | 53+3                      | 577.6                       |                               |                                 |                      | +29                      | +22                                     |
| 6                     | +2883                                  | 37,8         | 98 <b>.1</b><br>90.7            | 329.3<br>238.2                  | 54.1<br>54.2              | 549.2<br>492.5              | 67.1                          | 69.6<br>69.4                    | 43.9<br>44.1         | •30<br>•28               | •17<br>•11                              |
| <b>4</b>              |  |              | <b>17 18 19 16 14 1</b> 7 17    | /=                              |                           |                             |                               |                                 |                      | ,                        |   |
|                       | • .26                                  |              |                                 | 142533E                         |                           |                             |                               |                                 | +36683E              |                          |   |
|                       | 1 MAR CAR SAN CAR SAN SAN SAN S        |              | 11 11 15 in se m                | <b>35 32 52 86 86 5</b> 2 52 52 | TR 88 60 68 68 68         | No 231 227 228 229 227 228  | an in na m ni ni ni           | c:; =: =: #: #: #2 12           | ne 10 12 12 12 18 19 | <b>2 ML //2 111 ML</b> 1 |   |

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| TEST NUMBER : 11-3 |   |                           |  |                                  |                                 |                              |                               | DATE : 1/12/79               |              |            |                       |  |  |
|--------------------|---|---------------------------|--|----------------------------------|---------------------------------|------------------------------|-------------------------------|------------------------------|--------------|------------|-----------------------|--|--|
|                    | <b>12 12 12 1</b> 2 12 12 13 1              | R 400 (27) 200 (28 (44 )) |  | 2 C/7 E2 C/7 52 110 110 111 1    |                                 | 2 = 17 17 12 14 14 12 2      | : <b></b>                     |                              |              |            |                       |  |  |
|                    |   |                           | F]   | REPLACE                          | E SIMUL                         | ATION S                      | STUDIES                       | 3                            |              |            |                       |  |  |
|                    |   |                           | CHARACT  | ERISTIC                          | CS AND                          | EFFICIE                      | ENCY AN                       | ALYSIS                       | 3            |            |                       |  |  |
|                    | <b>n:</b> 20 <b>20 00</b> 00 20 00 <u>2</u> | : 22 72: 22 73: 27 23     | ני אה כו שו כז או הי הו או   | : 177 IV. IV. 32 AV. 22 A        | # 172 199 <b>89</b> 89 197 27 2 |                              |                               | a para ang ang ang ang ang a |              |            |                       |  |  |
|                    | COME  | USTION                    | AIR :  | FRONT                            |                                 |                              | GLA                           | NSS DOC                      | )R : OP      | EN         |                       |  |  |
|                    | CIRC  | ULATIC                    | N FANS   | : NONE                           |                                 |                              | FUE                           | L MATE                       | ERIAL :      | WOOD       |                       |  |  |
|                    | FUEL  | . TYPE                    | : DOUGL  | AS FIR                           |                                 |                              | HEATING VALUE =8379.0(BTU/LB) |                              |              |            |                       |  |  |
|                    |   | = = = = = =               | id brad Juga stats Hadd Jaars Make afg<br>a Tunin rinds cade Gada dave adam da | : 111 112 112 112 112 112 112 11 | 1 112 au 117 ao 118 b           | - 199 17 200 199 199 199 199 | : na 12 22 111 12 12          | <b>; in</b> in 24 mi in      |              |            |                       |  |  |
|                    | MASS  | AIR I                     | N = 60.  | 00(LB/N                          | (NIN)                           |                              | MAS                           | S AIR                        | 0UT =        | 43+20(     | (LB/MIN)              |  |  |
|                    | MASS  | DRY F                     | LUE GAS  | =13.73                           | (N)                             | MAS                          | S COME                        | AIR =                        | 5.64(        | (LB/MIN)   |                       |  |  |
|                    | <b>e en en en en 1</b> 0 en 14.             |                           | <b>1 100 100 100 122 100 100 10</b>  |                                  | r 24 al 28 al 12 1              |                              |                               |                              |              |            |                       |  |  |
|                    | <b>%CO</b> 2                                | . = .11                   | .0   | %0%                              | 010                             | )                            | %02                           | ! = ₊05                      | °0           |            |                       |  |  |
|                    | %C ==                                       | .560                      |  | <b>%H</b> = .070                 |                                 |                              |                               | %MC =0.000                   |              |            |                       |  |  |
|                    | (R.H  | +)LAB                     | - ,980   | (R++                             | (R.                             | (R.H.)RODM = .400            |                               |                              |              |            |                       |  |  |
| 17 IX IX IX I      |   | <b></b>                   | , 200 <b>311 325 322</b> 425 325 33  | : #1 55 <b>58 18 18</b> 18 18 5  |                                 | :                            |                               | : 12 m 12 m 12 m             |              |            |                       |  |  |
| TIME               | FUEL<br>WEIGHT                              |                           |  | TE                               | MPERAT                          | URE(F)                       |                               |                              |              | EFF        | COMB AIR/<br>TOT LOSS |  |  |
| MIN                | LB/MIN                                      | IN                        | OUT  | STACK                            | СОМВ                            | FIRE                         | CALR                          | LAB                          | ENV          | 7.         | %                     |  |  |
| 0                  | •3532                                       | 37.8                      | 90.7   | 238.2                            | 54.2                            | 492.5                        | 67.1                          | 69.4                         | 44.1         | •22        | •10                   |  |  |
| 1<br>2             | .3561<br>.3532                              |                           | 84+2<br>97+9   | 211.6                            |                                 |                              | 67.6<br>69.9                  | 69.4<br>69.4                 | 47.3<br>48.8 | •20<br>•25 | •08<br>•27            |  |  |
|                    | .3561                                       |                           |  | 519.3                            |                                 |                              | 71.8                          | 70.1                         | 44.7         | •20<br>•30 | +29                   |  |  |
|                    | .3480                                       |                           |  |                                  | 57.0                            |                              |                               |                              | 48.3         | .31        | .22                   |  |  |
|                    | .3480                                       |                           |  |                                  |                                 | 711.8                        |                               |                              |              |            |                       |  |  |
| 6                  | •3554                                       | 37.4                      | 100.5  | 259.1                            | 57.2                            | 630.1                        | 72.8                          | 69.4                         | 47.1         | + 27       | •12                   |  |  |
| AEF=               | • .26                                       |                           | AQF≃.  | 177388E                          | +06 (BT                         | U/HR)                        |                               | AQNH=                        | +46549       | E+05(E     |                       |  |  |
|                    | r= <b>.</b> 22                              |                           |  |                                  |                                 |                              |                               |                              |              |            | BTU/HR)               |  |  |

| TEST NUMBER :  | TEST NUMBER : 14-1  |                              |                                   |                           |   |                                    | DATE : 1/29/79                  |   |  |  |  |  |
|--|---|------------------------------|-----------------------------------|---------------------------|---|------------------------------------|---------------------------------|---|--|--|--|--|
| 制的复数非常可以是正常是是可以是是是是是是是是  |   | 1 221 118 221 221 221        |                                   | 100 km 22 02 02 0         | ngo dalat panja julia sina aliat di                               |                                    |                                 |   |  |  |  |  |
|  | FIREPLACE   | SIMUL                        | ATION S                           | TUDIE                     | 3   |                                    |                                 |   |  |  |  |  |
| СНА  | RACTERISTICS  | AND                          | EFFICIE                           | NCY A                     | NALYSIS   | 6                                  |                                 |   |  |  |  |  |
| <b>112 cm 111 cm 015 cm cm 115 cm</b> 115 cm 115 | 1 274 1711 218 214 772 183 714 185 EF LIV 182 877 68  | 1 121 124 123 <u>225</u> 125 | 22 No 85 65 411 25 27             |                           | n 41 ar 22 al 83 a  | a in de in 29 de in                |                                 |   |  |  |  |  |
| COMBUSTION AI  | R : ROOM  |                              |                                   | GLA                       | ASS DOC   | DR : CL                            | OSED                            |   |  |  |  |  |
| CIRCULATION F  | CIRCULATION FANS : NONE FUEL MATERIAL : WOOD<br>FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB) |                              |                                   |                           |   |                                    |                                 |   |  |  |  |  |
| FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BT   |   |                              |                                   |                           |   |                                    | O(BTU/LB)                       |   |  |  |  |  |
|  |   | -                            |                                   |                           | ar stêl inne helf ern som bede st<br>1 mile same witt same bede f | ne ange erne stel lege bitt omer t | that soat anne atti trav        |   |  |  |  |  |
| MASS AIR IN =  | MAS   | MASS AIR DUT = 43.20(LB/MIN) |                                   |                           |   |                                    |                                 |   |  |  |  |  |
| MASS DRY FLUE  | MAS   | MASS COMB AIR = 3.40(LB/MIN) |                                   |                           |   |                                    |                                 |   |  |  |  |  |
|  |   | State State State state many | nat juga star star and some natur | 00 03 02 <b>2</b> 2 02 2  | 1 av 12 14 15 16 16   |                                    | 1) Ja (2: hr: 11: 1             | tat gata bata andi mala anti anti anti anti |  |  |  |  |
| %02 = .030   | <b>%CO</b> ==   | .010                         |                                   | %02                       | 2 = +12   | 20                                 |                                 |   |  |  |  |  |
| %C = .560  | %C = .560 %H = .070   |                              |                                   |                           | %MC =0.000  |                                    |                                 |   |  |  |  |  |
| (R.H.)LAB = .  | (R.H.)LAB = .490 (R.H.)OUT = .800   |                              |                                   |                           |   |                                    | (R.H.)ROOM = .400               |   |  |  |  |  |
|  |   |                              |                                   |                           | : ## 1# 1# 23 ## #  | the we pay his had the a           | 21 (22) (22: 23 <b>1</b> (22: 3 | R an 13: To 20 an 15: To 12: 10             |  |  |  |  |
| FUEL<br>TIME WEIGHT  |   |                              |                                   | EFF                       | COMB AIR/<br>TOT LOSS   |                                    |                                 |   |  |  |  |  |
| MIN LE/MIN IN O  | UT STACK  | COMB                         | FIRE                              | CALR                      | LAB   | ENV                                | 7.                              | %   |  |  |  |  |
|  |   | 51.8                         | 726.7                             |                           | 66.4<br>66.1  |                                    | •12<br>•21                      | .04   |  |  |  |  |
|  |   | 53.1                         | 803.1                             | 53.1                      |   |                                    |                                 | .19   |  |  |  |  |
|  |   | 54.1<br>55.0                 | 779.5                             | 54.1                      | 60+0<br>66+3  | 41+8                               | •24<br>•26                      | +21<br>+22                                  |  |  |  |  |
|  |   | 55.8                         | 720.4<br>700.3                    |                           | 66+3  |                                    | •∡o<br>•28                      | • 22<br>• 22                                |  |  |  |  |
|  | 3.3 326.4   |                              | 679.3                             |                           | 65.5  |                                    | •29                             | •17   |  |  |  |  |
|  |   | 57.5                         | 708.4                             | 57.5                      |   | 43.4                               | • 27<br>• 30                    | •13   |  |  |  |  |
|  |   |                              |                                   |                           |   |                                    |                                 |   |  |  |  |  |
| AEF= .24   | QF=.108363E+  |                              |                                   | <b>17 18 21 36 56 1</b> 5 |   | •26257E                            |                                 |   |  |  |  |  |

TEST NUMBER : 14-2 DATE : 1/29/79 FIREFLACE SIMULATION STUDIES CHARACTERISTICS AND EFFICIENCY ANALYSIS GLASS DOOR : CLOSED COMBUSTION AIR : ROOM **CIRCULATION FANS : NONE** FUEL MATERIAL : WOOD FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB) MASS AIR IN = 60.00(LB/MIN)MASS AIR OUT = 43.20(LB/MIN)MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 4.46(LB/MIN) %02 = .030 %CO = .010X02 = .120% C = .560% 2H = .070%MC =0.000 (R,H,)LAB = .490 (R,H,)OUT = .800 (R,H,)ROOM = .400

| FIME          | FUEL<br>WEIGHT |      | TEMPERATURE(F) |         |                          |   |      |       | EFF     | COMB AIR/<br>TOT LOSS |          |
|---------------|----------------|------|----------------|---------|--------------------------|---|------|-------|---------|-----------------------|----------|
| MIN           | LB/MIN         | IN   | OUT            | STACK   | COMB                     | FIRE                                      | CALR | LAB   | ENV     | %                     | ".<br>". |
| 0             | •2797          | 37.2 | 84.5           | 256.2   | 57.5                     | 708.4                                     | 57.5 | 66.3  | 44.4    | .23                   | .12      |
| 1             | .2757          | 37.0 | 85.8           | 450.5   | 58,3                     | 751.0                                     | 58.3 | 66.3  | 42+6    | +24                   | +24      |
| 2             | ·2827          | 36.9 | 89,9           | 473.3   | 59.1                     | 748.9                                     | 59.1 | 66.1  | 45.2    | .26                   | •26      |
| 3             | .2808          | 37.5 | 90.8           | 440.8   | 60.4                     | 731.0                                     | 60.4 | 66.9  | 45.0    | +26                   | .24      |
| 4             | .2790          | 38.0 | 93.4           | 394.2   | 61.4                     | 727.5                                     | 61.4 | 66.4  | 45.4    | +28                   | .21      |
| 5             | .2805          | 38.2 | 91.6           | 473.1   | 61.6                     | 751.6                                     | 61.6 | 66.5  | 45.3    | .27                   | .26      |
| 6             | •2761          | 37,5 | 95.1           | 268.4   | 61.7                     | 720.8                                     | 61+7 | 66.9  | 44.1    | • 29                  | .13      |
| e 22 11 co co |                |      |                |         | an an an <b>an an</b> an | teris unte tiut ciur dina atte dina teris |      |       |         | n an: 119 Ju: 117 (13 |          |
| AEF=          | • • 26         |      | AQF=.          | 140371E | +06(BT                   | U/HR)                                     |      | AQNH= | .366118 | E+05(B                | TUZHR)   |

|                           | TEST                              | г мимве                  | ER : 14-                        | -3                       |   | DAT                               | DATE : 1/29/79            |  |                               |                           |   |  |  |  |
|---------------------------|-----------------------------------|--------------------------|---------------------------------|--------------------------|---|-----------------------------------|---------------------------|--|-------------------------------|---------------------------|---|--|--|--|
|                           |                                   | i 10 al 12 di 12 i       |                                 | 2 44 un nu an an an an n |   | 11 ill 157 ill 157 ill 12 il      | t att att att dis car it  | n 199 Ann an Ann Ann A   |                               |                           | anno anno latto chia anno litor anto litor anto litor |  |  |  |
|                           |                                   |                          | F]                              | REPLACE                  | SIMUL   | _ATION S                          | TUDIES                    | ò  |                               |                           |   |  |  |  |
|                           |                                   |                          |                                 |                          |   | بر وی چنز بن بندر در م            |                           |  | •                             |                           |   |  |  |  |
|                           |                                   |                          | CHARACT                         | ERISTIC                  | 25 ANU  | EFFICIE                           | NCY AN                    | ALYS15   | Ċ                             |                           |   |  |  |  |
|                           |                                   | 1 ANG 1950 CAT AND THE S | 3 <b>33 52 15 16 16</b> 35 35 3 |                          |   |                                   |                           | n 1999 (197 1979 1979 1999 1996 19   | a ini ini ini ini ini ini ini | <b>111</b> 112 113 113    | 117 <b>28</b> 18 28 28 28 28 28 18 18 18              |  |  |  |
|                           | COME                              | NUSTION                  | AIR :                           | ROOM                     |   |                                   | GLA                       | ASS DOC  | DR : CL                       | OSED                      |   |  |  |  |
|                           | CIRC                              | ULATIO                   | N FANS                          | : NONE                   |   |                                   | FUE                       | L MATE   | ERIAL :                       | WOOD                      |   |  |  |  |
|                           | FUEL                              | TYPE                     | : DOUGL                         | AS FIR                   | HEA   | ATING V                           | VALUE =                   | 8379.  | O(BTU/LB)                     |                           |   |  |  |  |
|                           |                                   |                          |                                 |                          |   |                                   |                           |  |                               |                           |   |  |  |  |
|                           |                                   |                          |                                 |                          |   |                                   |                           | עם זהו את המו שב שה את אה את או את של את |                               |                           |   |  |  |  |
|                           | MASS                              | AIR I                    | IN = 60.                        | 00(LB/M                  | IIN)  |                                   | MAS                       | S AIR  | OUT =                         | 43.20                     | (LB/MIN)  |  |  |  |
|                           | MASS DRY FLUE GAS =13.28(LB/MIN)  |                          |                                 |                          |   |                                   |                           |  | 8 AIR =                       | 5.57                      | (LB/MIN)  |  |  |  |
| 10 m m m                  | <b>12 12 12 10 10 10</b> 10 11 11 |                          | . 03 pa 48 48 48 48 55 56       | . 12 88 28 18 19 19 19   | 1 <b>12 12 2</b> 9 12 22 13   | 1) 100 F20 (11) (25 (11) VII) 101 |                           | :  | n FID 27: HIL 21: III 22: I   | <b></b>                   | til blan dale blan det jele der bas vin sige          |  |  |  |
|                           | ፖድቡን                              |                          | KO I                            | %00                      | 200   | 2 = .12                           | 20                        |  |                               |                           |   |  |  |  |
|                           |                                   |                          |                                 |                          |   | /                                 |                           |  |                               |                           |   |  |  |  |
|                           | %C =                              | +530                     |                                 | %H =                     | •070  |                                   | <b>%</b> MC               | : ∞0.00  | 0                             |                           |   |  |  |  |
|                           | (R.H                              | I.)LAB                   | = <b>.</b> 490                  | (R.H                     | 1.)OUT  | - • 800                           | (R+                       | H.)ROC   | )M = .4                       | 00                        |   |  |  |  |
| antas kanan daran julim s | <b>10 100 110 120</b> 121 201 201 |                          |                                 |                          | , jaan taan jalan sebat arali tali<br>1974 maan adat sebat ratis tali | 9 MA 201 102 002 00 00 MI         | alan Mer and file case of |  | 9 20 21° 82 32 45 28 :        | 1977 NAM 1977 1989 1997 1 |   |  |  |  |
|                           | FUEL                              |                          |                                 |                          |   |                                   |                           |  |                               |                           | COMB AIR/   |  |  |  |
| TIME                      | WEIGHT                            |                          |                                 | TE                       | MPERAT  | URE(F)                            |                           |  |                               | EFF                       | TOT LOSS  |  |  |  |
| MIN                       | LB/MIN                            | IN                       | OUT                             | STACK                    | COMB  | FIRE                              | CALR                      | LAB  | ENV                           | %                         | 7.  |  |  |  |
| 0                         | .3488                             | 37.5                     | 95.1                            | 268.4                    | 61.7  | 720.8                             | 61.7                      | 66.9   | 44.1                          | .23                       | .12   |  |  |  |
| 1                         | .3469                             | 37.6                     | 95.3                            | 505.2                    | 62.7  | 762.7                             | 62.7                      | 66.7   | 45.2                          | .23                       | .26   |  |  |  |
| 2                         | • 3488                            | 38.4                     | 98.0                            | 524+8                    | 63.9  | 856.6                             | 63.9                      | 66.1   | 44+6                          | •24                       | •28   |  |  |  |
| 3                         | +3436                             | 39.0                     | 98.7                            | 528.1                    | 64.8  | 825.6                             | 64.8                      | 66.3   | 46.1                          | +25                       | +28   |  |  |  |
| 4                         | •3451                             | 38.3                     | 101.4                           | 479.1                    | 65.1  | 800.2                             | 65.1                      | 67.0   | 44.4                          | •26                       | + 26  |  |  |  |
| 5                         | +3488                             | 38.4                     | 103.6                           | 340+6                    | 66.0  | 879.9                             | 66.0                      | 66.3   | 47.5                          | +27                       | • <b>1</b> 7  |  |  |  |

| 0             | • • • • • • • • • | 0041 | * * • • • * •  | 010+0   | $\omega \omega \neq \omega$  |  |      |                              | 17 4 64                           | • • • •                      | * <b></b> .                         |              |
|---------------|-------------------|------|--|---|--|--|------|------------------------------|-----------------------------------|------------------------------|-------------------------------------|--------------|
| 6             | •3414             | 40.1 | 104.4  | 319.3   | 67.3   | 869.7  | 67.3 | 67.1                         | 47.1                              | +27                          | .16                                 |              |
|               |                   |      |  |   |  |  |      |                              |                                   |                              |                                     |              |
|               |                   |      |  |   |  |  |      |                              | 92 00 00 00 00 00 <del>00</del> 0 |                              |                                     | <b>H</b> 333 |
| AEF           | 25                |      | AQF≕.  | 174040E   | +06(BT   | U/HR)  |      | ิ่AQNH≕                      | .43400E                           | E+05(B1                      | FU/HR)                              |              |
| 20 20 55 22 2 |                   |      |  | , tirk some døre bese boder medd søre<br>- tige døne døgt state søre tide fom | r akter samt voor synt iver samt<br>Tale anter voor samt samt samt s | wert some stil ones with rows with<br>the sense with some some fore call |      | hine per jobe tret eres trit | na an 22 22 33 an 1               | <b>3 (12 12) 12) 12) 12)</b> | te 1999 2000 7112 2127 1017 7000 11 |              |
| ACC1          | r= .25            |      | <u>م من المناطقة من مناطقة المناطقة المناطقة من مناطقة من مناطقة المناطقة من من من من من من م</u> | 1 4000 4  | m10270   | Y1171055   |      | A (53111)**                  |                                   | 15125521                     | 5771171315 N                        |              |
| HEF           |                   |      | HUT I  | .140924   | ETVOLD   | IU/ MK/  |      | HUNDI                        | ∽ ಕರ್ಷಿಕಷ್ಟ                       | DETUQUE                      | (TU/HR)                             |              |

B-13

|                  |  | NUMBER  |                              |  |                               | DATE : 12/18/78  |                                  |  |                                   |                       |                                       |  |  |
|------------------|--|---|------------------------------|--|-------------------------------|--|----------------------------------|--|-----------------------------------|-----------------------|---------------------------------------|--|--|
| میں ناے بنار اور | ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, |   | FI                           | REPLACE  | E SIMUL                       | ATION S  | STUDIES                          | 3  |                                   |                       | <b>- IN 10 1</b> 11 12 IN 17 IN 17 IN |  |  |
|                  |  |   |                              |  |                               |  |                                  |  |                                   |                       |                                       |  |  |
|                  | COMB                                   | USTION  | AIR :                        | REAR   |                               |  | GLA                              | SS DOC   | DR : CL                           | OSED                  |                                       |  |  |
|                  | CIRC                                   | ULATION   | FANS                         | : NONE   | FUE                           | L MATE   | ERIAL :                          | woon   |                                   |                       |                                       |  |  |
|                  | FUEL                                   | TYPE :  | DOUGL                        | AS FIR   | HEA                           | TING V   | VALUE =                          | 8379.(   | O(BTU/LB)                         |                       |                                       |  |  |
| 22 42 62 22 :    |  | anna ang kom anna ake shan ya<br>Bi'ni anna kan ake ing ing shan ak | a <b>22 22 23 23 23 28 2</b> | 771 77 <b>7 777 777 777 777 777</b> 777 777 777                          | 1 dia am 221 am 242 am        | ם מזו שה הה של או או עם בת שב את או או או או או את אה או |                                  |  |                                   |                       |                                       |  |  |
|                  | MASS                                   | AIR IN  | 1 = 67.                      | 50(LB/M  | MAS                           | MASS AIR OUT = 43.20(LB/MIN)   |                                  |  |                                   |                       |                                       |  |  |
|                  | MASS                                   | DRY FL  | UE GAS                       | =11.45   | ICLB/MI                       | (N)  | MAS                              | MASS COMB AIR = 3.49(LB/MIN)                                       |                                   |                       |                                       |  |  |
| == == == == :    | 18 000 100 001 000 000 000 <u>000</u>  |   |                              | 119 14: 22 21: <del>112</del> 22 23                                      | ) <u></u>                     |  | , and <b>and the log</b> and the | : Mar 1997 (Mar 1992 (Mar 199                                      |                                   |                       | 2 10 m 10 10 10 m 11 m 11             |  |  |
|                  | %02                                    | - • 030   | >                            | %C0  | = .010                        | )  | <b>%</b> 02                      | <b>X02</b> = .100  |                                   |                       |                                       |  |  |
|                  | %C =                                   | •560  |                              | %H =   | +070                          |  | ZMC                              | = <b>0.0</b> 0   | 00                                |                       |                                       |  |  |
|                  | (R.H                                   | .)LAB =   | • 450                        | (R.H   | .)OUT                         | = +680   | (R.                              | H.)RO0   | )M = .4                           | 20                    |                                       |  |  |
|                  |  |   |                              | neng berg same bene bina ante sone<br>Pen- nen anne bene crut gene state | i dana dini biri ana like pap | N side dill com mer side prim side<br>In side dist text and side (the boy)                   | 1947 - The Alas Mar (1947 - 1949 | - Main Malad arns anna balan Alba<br>Tara 1996 arns Abab Brat Mala | n atau kana sigi pana kana anar a | nin 100 /01 (** 145 1 | D de 23 En qu'au au un da un          |  |  |
| TIME             | FUEL<br>WEIGHT                         |   |                              | TE   | MPERAT                        | URE(F)   |                                  |  |                                   | EFF                   | COMB AIR/<br>TOT LOSS                 |  |  |
| MIN              | LB/MIN                                 | IИ  | OUT                          | STACK  | COMB                          | FIRE   | CALR                             | LAB  | ENV                               | 7,                    | ",                                    |  |  |
|                  | •2184<br>•2184                         |   |                              |  |                               |  |                                  |  |                                   |                       |                                       |  |  |

47.0 596.2

47.6 611.8

49.4 657.7

640.1

48.7

AQF=.109681E+06(BTU/HR)

58.2 68.2

59.9 68.0

61.0 68.6

62.4 67.2

64.3 68.7

42+4 +08

AQNH=,10138E+05(BTU/HR)

43.5

44.5

44.8

46.4

+09

.11

.12

.12

.08

.15

.17

+15

.15

43.9 55.8 211.8 44.7 457.9

383.2

355.6

347.5

56.7 363.8

61.8

63.4

64.7

2

3

4

5

6

+2203

.2184

.2184

+2166

.2166

AEF= .09

44.5

45.2

45.8

47.2

| FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
|---|--------------------|--|--|--|--|--|--|--|--|--|--|--|--|
|   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| COMBUSTION AIR : REAR GLASS DOOR : CLOSED   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| CIRCULATION FANS : NONE FUEL MATERIAL : WOOD  |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/  | .B)                |  |  |  |  |  |  |  |  |  |  |  |  |
|   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| MASS AIR IN = 67.50(LB/MIN) MASS AIR DUT = 43.20(LB/MIN)  |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| MASS DRY FLUE GAS =12.82(LB/MIN) MASS COMB AIR = 4.46(LB/MI)  | • •                |  |  |  |  |  |  |  |  |  |  |  |  |
|   | 712 397 <b>588</b> |  |  |  |  |  |  |  |  |  |  |  |  |
| 202 = .030 $202 = .100$ $202 = .100$  |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| 2C = .560 2H = .070 2MC =0.000  |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| (R.H.)LAB = .450 (R.H.)OUT = .680 (R.H.)ROOM = .420   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
|   | 11; en 70          |  |  |  |  |  |  |  |  |  |  |  |  |
| FUELCOMB (TIME WEIGHTTEMPERATURE(F)EFF TOT LO   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| MIN LB/MIN IN OUT STACK COMB FIRE CALR LAB ENV % %  |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| 0 .2794 47.2 64.7 347.5 49.4 558.0 64.3 68.7 46.4 .10 .14   | ĺ                  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 .2794 47.2 74.0 260.8 47.9 650.9 65.2 68.4 46.8 .14 .10   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 .2830 47.4 69.5 365.8 49.2 601.0 66.0 70.5 47.3 .12 .16   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 .2849 47.0 66.6 268.1 49.3 611.9 66.5 71.1 46.7 .11 .10   |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| 4       •2852       47.2       70.1       377.9       48.2       604.2       67.2       70.8       46.6       •13       •16         5       •2801       47.1       73.3       440.5       49.1       802.0       67.6       68.4       46.4       •15       •20 |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$  |                    |  |  |  |  |  |  |  |  |  |  |  |  |
| AEF= .13 AQF=.142032E+06(BTU/HR) AQNH=.18687E+05(BTU/HR)  |                    |  |  |  |  |  |  |  |  |  |  |  |  |

|          | TEST   | NUMBEI                               | R : 10-   | -3  | DATE : 12/18/78                                     |                              |   |                                    |                                |  |  |  |  |  |
|----------|--|--------------------------------------|---|---|---|------------------------------|---|------------------------------------|--------------------------------|--|--|--|--|--|
|          |  | ; 221 122 227 22 122 122 1           |   | , 12 17 29 29 29 29 70 27   | 8 23 88 25 68 88 28 29                              | -                            | 1 IF III III 20 III II  | <b>a 1717 has 1811 hit fin t</b> a | <b>e na na ze ve</b> na na     |  |  |  |  |  |
|          |  |                                      | FI  | REPLACE   | E SIMUL   | ATION S                      | STUDIES   | 3                                  |                                |  |  |  |  |  |
|          |  | (                                    | CHARACT   | FERISTIC  | S AND   | EFFICIE                      | ENCY AN   | ALYSIE                             | 3                              |  |  |  |  |  |
|          | <b>12 - 14 117 116 116 116 116 116</b>                   |                                      |   |   | a az az az az az z                                  |                              | 5 11 12 13 15 15 15 1   | 2 22 32 az 25 az 2                 |                                | <b></b>                                      | 111 111 111 111 111 111 111 111 111          |  |  |  |
|          | COMB   | USTION                               | AIR :   | REAR  | GL4   | 488 DOC                      | DR : CL   | OSED                               |                                |  |  |  |  |  |
|          | CIRC   | ULATIO                               | N FANS  | : NONE  | FUE   | EL MATE                      | ERIAL :   | woon                               |                                |  |  |  |  |  |
|          | FUEL   | TYPE :                               |   | AS FIR  | HEA   | TING V                       | ALUE =  | 8379.(                             | O(BTU/LB)                      |  |  |  |  |  |
|          | = = = = = = = = = =                                      | ***                                  |   |   |   | 2 102 22 27 27 27 28 28      | :   |                                    | an 198 an na an an an an an an |  |  |  |  |  |
|          | MASS AIR IN = 67.50(LB/MIN) MASS AIR DUT = 43.20(LB/MIN) |                                      |   |   |   |                              |   |                                    |                                |  |  |  |  |  |
|          | MASS   | DRY FL                               | LUE GAS   | =13.28  | MAS   | MASS COMB AIR = 5,72(LB/MIN) |   |                                    |                                |  |  |  |  |  |
|          | <b>4 32 00 64 64 65 55 55</b> 55                         |                                      | and more that tare over more take<br>an take stat bills along that take | adda Shine saor sada ukur a at vert<br>anta ange stor sada ukur pjan ther | . 22 88 28 28 28 18                                 |                              | a name been unte bese pres bij  | t tott stat stat plat sine byr     |                                | an in an an an an i                          | 19 JUL 19 JUL 20 III III III III III III III |  |  |  |
|          | <b>%C</b> 02   | = .030                               | )   | <b>%C</b> 0   | = .010  | )                            | %02   | 202 = .100                         |                                |  |  |  |  |  |
|          | %C =   | +560                                 |   | %H =  | • • 070   |                              | ZMC =0.000  |                                    |                                |  |  |  |  |  |
|          | (R.H   | .)LAB =                              | = ,450  | (R.H  | 1.)OUT  | - • 680                      | (R.H.)ROOM = .420   |                                    |                                |  |  |  |  |  |
| <u> </u> |  |                                      | aj 201 170 000 122 722 000 1  |   |   | ; cm cm cm cm tex (c) (c)    | : 20 20 10 10 10 10   | . 27 25 25 25 25 47 47             | : ## 2:: :# == ## :# :# :      | 57 25 42 42 42 42 42 42 42 42 42 42 42 42 42 |  |  |  |  |
| TIME     | FUEL<br>WEIGHT   |                                      |   | TE  | MPERAT  | URE(F)                       | 11 - 5744 - 1247) 1999 - 1244 - 1464 - 1466   |                                    |                                | EFF  | COMB AIR/<br>Tot loss                        |  |  |  |
| MIN      | LB/MIN   | IN                                   | OUT   | STACK   | COMB  |                              |   |                                    |                                | %  | 7.   |  |  |  |
| 0<br>1   | •3583<br>•3561   | 46.0                                 | 76,7<br>78,6  | 499+6<br>535+6  | 48.7<br>50.1  | 736.4<br>743.0               | 67.6<br>69.7  | 68.6<br>70.8                       | 45.6<br>47.4                   | .14<br>.14                                   | .23<br>.25                                   |  |  |  |
| 2        | .3561  | 46.7                                 | 70.0<br>71.9  | 408.6   | 49.7  | 801.4                        | 70.2  | 69.3                               | 45.8                           | •12  | • 18   |  |  |  |
| 3        | .3561  | 46.8                                 | 84.9  | 308.7   | 47.2  | 827+2                        | 70.2  | 69.9                               | 45.5                           | •12  | +10  |  |  |  |
| 4        | .3557  | 47.3                                 | 24+7<br>76+5  | 288.9   | 807.3   | 72.1                         | 20+8  | 46+0                               | •14                            | +13  |  |  |  |  |
| 5        | .3543  | 47.4                                 | 89.9  | 477.2   | 49.7<br>49.4  | 868.0                        | 72.1  | 68.5                               | 46.3                           | •14  | • 23   |  |  |  |
| 6        | •3524  | 47.6                                 | 86.3  | 260.1   | 48.4  | 762+8                        | 72.4  | 69.8                               | 46+3                           | •17  | .10  |  |  |  |
|          |  |                                      |   |   | a and the second subject but it and a second second |                              | הת היה היה את היה היה היה היה היה היה את היה את היה היה יום את היה היה היה היה היה היה היה היה היה את את היה הי |                                    |                                |  |  |  |  |  |
| AEF=     | 15   |                                      | AQF=.1  | 178759E   | +06 (BT   | U/HR)                        |   | AQNH=                              | •27203E                        | E+05(E                                       | STUZHR)                                      |  |  |  |
|          |  | and these takes saves which have and | a mit bes the car and bes h   |   |   | and the off the star and the |   | The same man and sale and and      |                                |  | 17 mm esti och avs (ht ett avs avs att       |  |  |  |

AEFT= .13 AQFT=.143491E+06(BTU/HR) AQNHT=.18676E+05(BTU/HR)

| TES                                      | T NUMBER   | R : 12-                              | DATE : 1/17/79 |                                     |                              |  |                           |  |  |  |  |
|--|--|--------------------------------------|----------------|-------------------------------------|------------------------------|--|---------------------------|--|--|--|--|
| <b>12 15 68 18 12 12 12 13 1</b> 2 12 1  | ie 12 21 12 13 13 13 13  |                                      |                |                                     |                              | : <b>111 112 112 112</b> 113 111                           |                           |  |  | 19 01: 11: <u>01:</u> 01: 11: 11: 11: 11:  |  |
|  |  | FI                                   | REPLACE        | SIMUL                               | ATION S                      | TUDIES   |                           |  |  |  |  |
|  | C  | CHARACT                              | ERISTIC        | S AND                               | EFFICIE                      | NCY AN   | ALYSIS                    | 6  |  |  |  |
|  |  | # <b># 1</b> 2 <b>#</b> # <b>#</b> # |                |                                     |                              |  |                           |  |  |  |  |
| COM                                      | BUSTION  | AIR :                                | FRONT          |                                     |                              | GLASS DOOR : CLOSED  |                           |  |  |  |  |
| CIR                                      | CULATION   | N FANS                               | : NONE         |                                     |                              | FUE  | L MATE                    | RIAL :   | woop   |  |  |
| FUE                                      | L TYPE :   | : DOUGL                              | AS FIR         |                                     |                              | HEA  | TING V                    | ALUE =   | 8379.0   | (BTU/LB)   |  |
|  |  |                                      |                |                                     |                              |  |                           |  |  |  |  |
| MAS                                      | S AIR IN   | 4 = 63.                              | 75(LB/M        | MAS                                 | S AIR                        | out = -  | 43.20                     | (LB/MIN)   |  |  |  |
| MAS                                      | S DRY FL   | UE GAS                               | = 8.70         | (N)                                 | MASS COMB AIR = 3.62(LB/MIN) |  |                           |  |  |  |  |
| <b>172 EE 62 AN 22 EE 63 AN</b> 22 EE 23 | u  |                                      |                | - Maan ahte Mare Sone Anna Anna Ann |                              | anna firm arar mer ara afar<br>alat lare arat arts der ber | rine can be and the train | (;;; ;;; <b>;;;</b> ;;;; ;;;; ;;;; ;;;; ;;;;         | tin sata atan isar ting is<br>198 sent pak star tam is | e all die 2014 112 113 114 115 117   |  |
| 200                                      | 2 = .06(   | )                                    | 200            | ≔ <b>.</b> 020                      | •                            | <b>XO2</b> = .120  |                           |  |  |  |  |
| %C                                       | 560  |                                      | %H =           | .070                                |                              | % =0.000   |                           |  |  |  |  |
| (R+)                                     | H.)LAB =   | • • 450                              | (R.H           | •)OUT                               |                              | (R.H.)ROOM = .380  |                           |  |  |  |  |
|  |  | n 177 ann ann Ann Ann Ive            |                |                                     |                              |  |                           |  | to the same title size in                              | m braz dear saire sam adm yrm dafa daar sam<br>a sam ber wer ywe gan dan gan ber are i'r m |  |
| FUEL<br>TIME WEIGHT                      |  |                                      | TE             | MPERAT                              | URE(F)                       |  |                           |  | EFF  | COMB AIR/<br>Tot Loss  |  |
| MIN LB/MIN                               | IN   | OUT                                  | STACK          | COMB                                | FIRE                         | CALR   | LAB                       | ENV  | %  | " <u>"</u>   |  |
| 2 .2232<br>3 .2239<br>4 .2206            | 1       .2232       57.7       62.6       347.7       52.5       2         2       .2232       58.7       65.6       376.3       53.1       5         3       .2239       59.2       82.7       393.2       53.6       4         4       .2206       58.8       70.0       402.2       54.0       4         5       .2203       59.1       75.1       399.0       54.4       4 |                                      |                |                                     |                              |  |                           | 56.9<br>57.7<br>58.7<br>59.2<br>58.8<br>59.1<br>59.5 | .01<br>.03<br>.13<br>.06<br>.09<br>.19                 | .01<br>.13<br>.15<br>.17<br>.16<br>.17<br>.10  |  |
| AEF= .07                                 |  | AQF=.                                | 111922E        | +06(BT                              | U/HR)                        |  | AQNH=                     | •83 <b>62</b> 68                                     | E+04(B   | TU/HR)   |  |

| TEST NUMBER : 12-2 DATE : 1/17/79               |   |                                      |  |   |   |  |   |  |                                   |                                 |           |  |  |  |
|---|---|--------------------------------------|--|---|---|--|---|--|-----------------------------------|---------------------------------|-----------|--|--|--|
|   | FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS |                                      |  |   |   |  |   |  |                                   |                                 |           |  |  |  |
| <b>10 az no az no</b> :                         |   | an an 111 mar an                     |  |   |   |  |   |  |                                   | 11 <b>47 111 1</b> 17 111 1     |           |  |  |  |
|   | COMBUSTION AIR : FRONT GLASS DOOR : CLOSED                              |                                      |  |   |   |  |   |  |                                   |                                 |           |  |  |  |
|   | CIRC  | ULATIO                               | N FANS                                 | FUE                                       | L MATE                                    | RIAL :   | WOOD  |  |                                   |                                 |           |  |  |  |
| FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(B |   |                                      |  |   |   |  |   |  |                                   |                                 |           |  |  |  |
|   |   |                                      |  |   |   |  |   |  |                                   |                                 |           |  |  |  |
|   |   |                                      |  |   |   |  |   |  |                                   |                                 |           |  |  |  |
|   |   |                                      |  |   |   |  |   |  |                                   |                                 |           |  |  |  |
|   | MASS  | DRY F                                | LUE GAS                                | =12.82                                    | (LB/MI                                    | (N)  | MASS COMB AIR = $4.54(LB/MIN)$              |  |                                   |                                 |           |  |  |  |
| 10 M 10 CC 10 H2 1                              | 10 970 770 770 957 570  | 40 JE 10 JE 10 JE 12                 | 131 63 111 53 65 111 (3)               | 197 92 92 93 92 au 81                     | nene beit tett biss an                    | . 201 (CV 1/1 107 1/7 107 107  | e ar na |  |                                   |                                 |           |  |  |  |
|   | <b>%C</b> 02  | = .06                                | 0                                      | %00%                                      | = .020                                    |  | % 202 = .120                                |  |                                   |                                 |           |  |  |  |
|   | %C ==   | .560                                 |  | %H =                                      | .070                                      |  | %MC =0.000                                  |  |                                   |                                 |           |  |  |  |
|   | (R.H  | .)LAB                                | - • 450                                | (R+H                                      | .)OUT                                     | 440  | (R.H.)ROOM = .380                           |  |                                   |                                 |           |  |  |  |
|   |   |                                      | un 1a 2a an an <b>= 1</b> a an         | nn ine ne ne ne en tet es                 |   |  |   |  | erer sites soll beer sees been at | a :::: :::: :::: ::::           | . 112     |  |  |  |
| F   | FUEL  |                                      |  |   |   |  |   |  |                                   |                                 | COMB AIR/ |  |  |  |
| TIME WE   | EIGHT   |                                      |  | TE  | MPERAT                                    | URE(F)   |   |  |                                   | EFF                             | TOT LOSS  |  |  |  |
| MIN LI  | B/MIN   |                                      |  |   |   | FIRE   |   |  |                                   |                                 | %         |  |  |  |
| 1 .1<br>2 .1<br>3 .1<br>4 .1<br>5 .1            | 2882<br>2919<br>2919<br>2845<br>2845                                    | 59.7<br>60.6<br>59.8<br>60.1<br>60.2 | 82.1<br>78.9<br>88.5<br>102.0<br>107.4 | 273.0<br>609.8<br>485.6<br>425.2<br>367.0 | 392.6<br>393.5<br>478.4<br>476.1<br>447.6 | 0       71.5       72.0       59.5       .16       .09         6       72.5       71.6       59.7       .11       .10         5       73.4       71.9       60.6       .10       .27         4       74.8       72.2       59.8       .15       .22         1       77.1       72.2       60.1       .21       .20         6       77.4       72.1       60.2       .23       .17         6       78.2       71.9       60.5       .20       .16 |   |  |                                   | .10<br>.27<br>.22<br>.20<br>.17 |           |  |  |  |
| AEF=  | AEF= .16 AQF=.145512E+06(BTU/HR) AQNH=.23950E+05(BTU/HR)                |                                      |  |   |   |  |   |  |                                   |                                 |           |  |  |  |

| TEST NUMBER : 12-3   |   | DATE : 1/17/79   |  |  |  |  |  |  |  |  |  |  |
|--|---|--|--|--|--|--|--|--|--|--|--|--|
|  |   |  |  |  |  |  |  |  |  |  |  |  |
| FIRE   | PLACE SIMULATION STU  | DIES   |  |  |  |  |  |  |  |  |  |  |
| CHARACTER  | ISTICS AND EFFICIENC  | Y ANALYSIS   |  |  |  |  |  |  |  |  |  |  |
|  |   | י און גע און אין אין אין אין אין אין אין אין אין אי      |  |  |  |  |  |  |  |  |  |  |
| COMBUSTION AIR : FRONT GLASS DOOR : CLOSED   |   |  |  |  |  |  |  |  |  |  |  |  |
| CIRCULATION FANS :   | NONE  | FUEL MATERIAL : WOOD                                     |  |  |  |  |  |  |  |  |  |  |
| FUEL TYPE : DOUGLAS  | FIR   | HEATING VALUE =8379.0(BTU/LB)                            |  |  |  |  |  |  |  |  |  |  |
|  |   |  |  |  |  |  |  |  |  |  |  |  |
| MASS AIR IN = $63.75$  | (LB/MIN)  | MASS AIR OUT = 43.20(LB/MIN)                             |  |  |  |  |  |  |  |  |  |  |
| MASS DRY FLUE GAS =  | 13.28(LB/MIN)   | MASS COMB AIR = 5.57(LB/MIN)                             |  |  |  |  |  |  |  |  |  |  |
| אס אלו אנו עש את אם אלו אנו שנו שני שב אלו זים שש אנה שב אנו אל את אנו לא אני או אל אין או אלי אין איז איז איז<br>און אלו אנו או איז איז אין איז | 171 272 273 273 274 274 275 276 277 277 277 277 277 277 277 277 277 | na an an maran da an |  |  |  |  |  |  |  |  |  |  |
| %02 = .060   | 200 = .020  | <b>%02</b> = .120  |  |  |  |  |  |  |  |  |  |  |
| %C = .560  | %H = .070   | %MC =0.000   |  |  |  |  |  |  |  |  |  |  |
| (R.H.)LAB = .450   | (R.H.)OUT = .440  | (R.H.)ROOM = .380  |  |  |  |  |  |  |  |  |  |  |

| TIME          | FUEL<br>WEIGHT                      |                           |                                 | TE                           | MPERAT | URE(F) |                       |                   |                   | EFF                           | COMB AIR/<br>TOT LOSS       |
|---------------|-------------------------------------|---------------------------|---------------------------------|------------------------------|--------|--------|-----------------------|-------------------|-------------------|-------------------------------|-----------------------------|
| MIN           | LB/MIN                              | IN                        | OUT                             | STACK                        | СОМВ   | FIRE   | CALR                  | LAB               | ENV               | %                             | 1/1                         |
| 0             | •3488                               | 60.5                      | 99.2                            | 355.5                        | 56.1   | 526.6  | 78.2                  | 71.9              | 60.5              | •17                           | +15                         |
| 1             | .3678                               | 60.1                      | 104.2                           | 518.1                        | 55.9   | 580.2  | 79.1                  | 72.7              | 60.1              | •18                           | .24                         |
| 2             | •3671                               | 60.6                      | 94.0                            | 532.8                        | 56.1   | 552.3  | 80.1                  | 71.8              | 60.6              | .15                           | .24                         |
| 3             | .3616                               | 60.5                      | 110.8                           | 562.3                        | 56.3   | 653.8  | 81.5                  | 72.5              | 60.5              | •21                           | •28                         |
| 4             | .3671                               | 61.1                      | 108.7                           | 521.0                        | 56.5   | 622+3  | 82.7                  | 72.1              | 61.1              | .20                           | .25                         |
| 5             | .3488                               | 60.4                      | 113.2                           | 391.2                        | 56.0   | 563.7  | 82.8                  | 71.3              | 60.4              | .23                           | .18                         |
| 6             | +3634                               | 60.4                      | 114.6                           | 336+2                        | 56.1   | 605.9  | 82.9                  | 71.6              | 60+4              | +23                           | .15                         |
| AEF=          |                                     |                           | AQF=.                           | 181316E                      | +06(BT | U/HR)  |                       | AQNH=             | .351391           | E+05(E                        | TU/HR)                      |
| AEFI          | Γ= <b>.</b> 14                      |                           | AQFT=                           | <b>.</b> 146250              | E+06(B | TUZHR) |                       | AQNHT             | °≕ <b>,</b> 2248/ | 4E+05(                        | (BTU/HR)                    |
| 22 KB KB 72 B | <b>1 11</b> 117 117 117 117 117 117 | 10 1 <b>2</b> 12 12 22 23 | <b>(11) THE ALL SEA ALL SEA</b> | nii: 20) 200 200 700 700 200 |        |        | 111 CO 1 <b>12 FB</b> | 11 12 11 20 14 UT |                   | <b>01 102 -00 003 107 1</b> 2 | , an an an an an an an an a |

|                   |  | NUMBER                          |                                       |                |                                 |                                |  | E : 6/       |                       |                            |   |  |
|-------------------|--|---------------------------------|---------------------------------------|----------------|---------------------------------|--------------------------------|--|--------------|-----------------------|----------------------------|---|--|
| <u> </u>          |  |                                 |                                       |                |                                 | ATION S                        |  |              |                       | anna sinn dhad door anda a | a 20 mil 20 10 10 mil 20 10 mil 20      |  |
|                   |  |                                 |                                       |                |                                 | EFFICIE                        |  |              |                       |                            |   |  |
|                   |  | USTION                          |                                       |                |                                 |                                |  |              | )R : OPI              |                            | a an 15 mil 16 an 26 mil 18 an 18       |  |
|                   | CIRC                                   | ULATION                         | I FANS                                | : NONE         | FUE                             | L MATE                         | RIAL :   | WOOD         |                       |                            |   |  |
|                   | FUEL                                   | TYPE :                          | DOUGL                                 | AS FIR         | HEA                             | TING V                         | ALUE =   | 8379.(       | (BTU/LB)              |                            |   |  |
| <b>a </b> = = = = | = == == == == == ==                    |                                 | <b>.</b>                              |                |                                 |                                |  |              |                       |                            |   |  |
|                   | MASS                                   | 87,84                           | (LB/MIN)                              |                |                                 |                                |  |              |                       |                            |   |  |
|                   | MASS                                   | DRY FL                          | UE GAS                                | MAS            | MASS COMB AIR = 3.52(LB/MIN)    |                                |  |              |                       |                            |   |  |
| 112 121 712 av :  | ב. זינו אם זינו פא שנו צא בי           |                                 | 1 121: 1712 <b>1111 1713 1311</b> 131 |                | - 22 14: 17: 14: 19 <b>:</b> 22 | i ma 125 mi na 60 ma <b>12</b> | אני עם שני זה זה או שי אני אין אני או או או אני או |              |                       |                            |   |  |
|                   | <b>%CO</b> 2                           | = .030                          | •                                     | 200            | = .010                          | )                              | 202 = .100   |              |                       |                            |   |  |
|                   | %C =                                   | .560                            |                                       | %H =           | .070                            |                                | ZMC =0.000   |              |                       |                            |   |  |
|                   | (R+H                                   | .)LAB =                         | • 500                                 | (R.H           | •)OUT                           | = ,590                         | (R.H.)ROOM = .420  |              |                       |                            |   |  |
| 35 22 13 13 18 I  | ula 1:20 ligit tils hatt tilt (180 cf) | 772 teo 112 112 114 114 114 114 |                                       |                | <u>in 12 12 12 12 1</u>         |                                |  |              | : na sa 22 az 28 az 2 |                            | a the div star the stal and the sit the |  |
| TIME              | FUEL<br>WEIGHT                         |                                 |                                       | TE             | MPERAT                          | URE(F)                         |  |              |                       | EFF                        | COMB AIR/<br>TOT LOSS                   |  |
| MIN               | LB/MIN                                 | IN                              | оит                                   | STACK          | Сомв                            | FIRE                           | CALR   | LAB          | ENV                   | 74                         | %                                       |  |
| 0                 | .2203                                  | 74.4                            | 78.5                                  | 100.0          | 77.9                            | 273.0                          | 77.9   | 75.4         | 86.8                  | .05                        | .01                                     |  |
| 1                 | +2214                                  | 74.2                            | 80.2                                  | 231,9          | 78.0                            | 319.6                          | 78.0   | 75.2         | 88.7                  | • 07                       | •08                                     |  |
| 2                 | •2221                                  | 75.0                            | 84+2                                  | 404.9          | 346.5                           | 79.5                           | 75.1   | 89.6         | .11                   | +17                        |   |  |
| 3                 | .2203                                  | 75.5                            | 88.2                                  | 375.4          | 80.5                            | 367.3                          | 80.5   | 75.7         | 88.2                  | +15                        | .16                                     |  |
| 4                 | •2250                                  | 74+6                            | 86.6                                  | 198.7          | 80.3                            | 361.9                          | 80.3   | 75.5         | 86.8                  | •14                        | •06                                     |  |
| 5<br>6            | •2221<br>•2203                         | 76.4<br>75.0                    | 84.0<br>88.7                          | 406.3<br>403.3 | 79.7<br>79.7                    | 411.2<br>446.3                 | 79•7<br>79•7   | 74.7<br>74.9 | 81.5<br>80.8          | •09<br>•16                 | •16<br>•18                              |  |
|                   |  |                                 |                                       | 111421E        |                                 |                                | <b>141 cm 112 cm 1</b> 11 cm   |              | .12546                |                            |   |  |
|                   |  |                                 |                                       |                |                                 |                                |  |              |                       |                            |   |  |

n

TEST NUMBER : 4A-2 DATE : 6/27/79 FIREPLACE SIMULATION STUDIES CHARACTERISTICS AND EFFICIENCY ANALYSIS COMBUSTION AIR : ROOM GLASS DOOR : OPEN CIRCULATION FANS : NONE FUEL MATERIAL : WOOD HEATING VALUE =8379.0(BTU/LB) FUEL TYPE : DOUGLAS FIR MASS AIR OUT = 87.84(LB/MIN) MASS AIR IN = 96,75(LB/MIN) MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 4.52(LB/MIN) $\chi_{CO2} = .030$   $\chi_{CO} = .010$   $\chi_{O2} = .100$ %C = .560 %H = .070 ZMC =0,000 (R,H,)LAB = .500 (R,H,)OUT = .590 (R,H,)ROOM = .420

| TIME    | FUEL<br>WEIGHT    |        |       |         | COMB A<br>EFF TOT LO |       |      |       |         |        |                         |
|---------|-------------------|--------|-------|---------|----------------------|-------|------|-------|---------|--------|-------------------------|
| MIN     | LB/MIN            | <br>IN | OUT   | STACK   | СОМВ                 | FIRE  | CALR | LAB   | ENV     | ×      | %                       |
| 0       | ·2830             | 75.0   | 88.7  | 403.3   | 79.7                 | 446.3 | 79.7 | 74.9  | 80.8    | •13    | •17                     |
| 1       | +2823             | 74.8   | 93.6  | 413+6   | 80.6                 | 473.6 | 80.6 | 75.1  | 83.0    | .18    | •18                     |
| 2       | ·2852             | 74.2   | 105.1 | 439.0   | 83.7                 | 511.9 | 83.7 | 75.4  | 80.3    | .29    | .23                     |
| 3       | +2827             | 75.5   | 97.5  | 434.5   | 83.8                 | 515.2 | 83.8 | 75.2  | 82.1    | .21    | .20                     |
| 4       | .2838             | 76.3   | 100.5 | 422.4   | 85.5                 | 562.9 | 85.5 | 76.3  | 81.5    | .23    | .20                     |
| 5       | ·2834             | 77.4   | 96.9  | 331.3   | 86.1                 | 564.1 | 86.1 | 75.8  | 81.9    | .19    | .14                     |
| 6       | <b>,28</b> 08     | 76.4   | 97,8  | 285.0   | 86.2                 | 552.9 | 86.2 | 75.9  | 82.3    | +21    | •11                     |
| <b></b> | = = = = = = = = = |        |       |         |                      |       |      |       |         | -      | 12 72 71 76 18 18 77 AN |
| AEF=    | = ,20             |        | AQF=. | 142295E | +06(BT               | U/HR) |      | AQNH= | ·290898 | E+05(B | TU/HR)                  |

|                           | TEST                                | NUMBE                        | ER : 4A-                             | DAT                     | DATE : 6/27/79         |                       |                         |                               |                               |                           |   |  |  |  |
|---------------------------|-------------------------------------|------------------------------|--------------------------------------|-------------------------|------------------------|-----------------------|-------------------------|-------------------------------|-------------------------------|---------------------------|---|--|--|--|
|                           | 3 MK 20 70 05 06 06 72 3            | ; 212 (25 AB) AB) AB) AB) 4  |                                      |                         |                        | ATION S               |                         |                               | in an de se ka <b>in in a</b> | ning anay sing bars the s | 40 AF 44 AC 22 AF 67 AC 23 L  |  |  |  |
|                           |                                     |                              |                                      |                         |                        |                       |                         |                               |                               |                           |   |  |  |  |
|                           |                                     |                              | CHARACI                              | ERISTIC                 | S ANL                  | EFFICIE               | NCY AN                  | ALYSIS                        | 5                             |                           |   |  |  |  |
|                           |                                     | :                            |                                      |                         |                        | , AP AN <b></b>       |                         | - 22 10 10 77 10 1            |                               | = 1# 35 == ce :           | ini na 111 an 22 ao amin' ao amin' ao amin' amin' ao amin' amin' amin' amin' amin' amin' amin' amin' amin' amin |  |  |  |
|                           | COME                                | USTION                       | AIR :                                | ROOM                    |                        |                       | GLA                     | SS DOC                        | DR : OF                       | EN                        |   |  |  |  |
|                           | CIRC                                | ULATIC                       | N FANS                               | : NONE                  |                        |                       | FUE                     | L MATE                        | ERIAL :                       | woon                      |   |  |  |  |
|                           | FUEL                                | TYPE                         | : DOUGL                              | AS FIR                  |                        |                       | HEA                     | TING V                        | ALUE =                        | 8379.0                    | O(BTU/LB)   |  |  |  |
| <b></b>                   |                                     |                              |                                      |                         |                        | • 22 da 62 da az 32 a |                         |                               |                               |                           |   |  |  |  |
|                           | MASS                                | AIR I                        | N = 96.                              | 75(LB/N                 | (NI                    |                       | MAS                     | S AIR                         | OUT = 1                       | 87.84                     | (LB/MIN)  |  |  |  |
|                           | MASS                                | DRY F                        | LUE GAS                              | 8 ≔12,13                | CLB/MI                 | (N)                   | MAS                     | S COME                        | 8 AIR =                       | 5.62                      | (LB/MIN)  |  |  |  |
| gener mins tarm bier been |                                     |                              |                                      |                         |                        |                       |                         |                               |                               |                           |   |  |  |  |
|                           | %02                                 |                              | 50                                   | <b>%</b> CO             | = .010                 | )                     | <b>%</b> 02             | = .10                         | 0                             |                           |   |  |  |  |
|                           | "/ ( <sup>2</sup> )                 | ,560                         |                                      | ۰<br>ایا -              | • 070                  |                       | * <b>*</b> *            | %MC =0,000                    |                               |                           |   |  |  |  |
|                           |                                     |                              |                                      |                         |                        |                       |                         |                               |                               |                           |   |  |  |  |
|                           | (R•H                                | .)LAB                        | = ,500                               | (R++                    | 1,)OUT                 | = .590                | (R.                     | H+)ROC                        | M = +42                       | 20                        |   |  |  |  |
|                           | <b>. All an ais ine die kin</b> ne. | inte sing frei eine site der | : (17 (12 (17 <b>19)</b> 19) (17 (17 |                         | . 40 131 57 121 133 13 |                       |                         | <u>111</u> 707 708 807 612 20 |                               | 11 F.S. 200 BYZ 190 L     | ** *** 127 117 117 117 117 117 117 117  |  |  |  |
| TIME                      | FUEL<br>WEIGHT                      |                              |                                      | те                      | MPERAT                 | URE(F)                |                         |                               |                               | EFF                       | COMB AIR/<br>TOT LOSS   |  |  |  |
| MIN                       | LB/MIN                              | IN                           | оит                                  | STACK                   | COMB                   | FIRE                  | CALR                    | LAB                           | ENV                           | %                         | 7.  |  |  |  |
|                           |                                     |                              |                                      | 285.0                   |                        | 552.9                 |                         | 75.9                          |                               | •17                       | • 1 1   |  |  |  |
|                           |                                     |                              | 97.7                                 |                         |                        |                       |                         |                               | 82.5                          |                           | .13   |  |  |  |
|                           |                                     |                              | 106.3                                |                         |                        | 599.4                 |                         |                               |                               |                           | •26   |  |  |  |
|                           |                                     |                              | 104.7<br>109.3                       |                         |                        | 642+3                 |                         |                               |                               |                           | •26<br>•28  |  |  |  |
| 5                         |                                     |                              | 108.7                                |                         |                        |                       |                         |                               |                               |                           |   |  |  |  |
|                           |                                     |                              | 106.9                                |                         |                        | 619.4                 |                         |                               |                               | ,23                       | .15   |  |  |  |
|                           |                                     |                              |                                      |                         |                        |                       |                         |                               |                               |                           |   |  |  |  |
| AEF=                      |                                     | 112 112 211 211 CG 112       |                                      |                         |                        | U/HR)                 |                         |                               | • 37337E                      |                           | 31U/HR)<br>===========  |  |  |  |
| AEFT                      | <b>•</b> 18                         |                              | AQFT=                                | 143561                  | E+06(B                 | TU/HR)                |                         | AQNHT                         | =+26324                       | 4E+05(                    | (BTU/HR)  |  |  |  |
| 55 ER 56 (* 121)          | 188 AN AN AN AN AN AN               |                              | 11. 13. <b>23. 3</b> 3. 14. 14. 17.  | TL 117 PT 67( 12) IN 18 | 110 ANI 111 UK ANI DU  |                       | 111 III III III III III | <b></b>                       |                               | it oft the job tilt of    |   |  |  |  |

| TEST NUMBER : 6-   | 1  | DATE : 11/20/78                                    |  |  |  |                                |   |
|--|--|--|--|--|--|--------------------------------|---|
|  | IREPLACE SIMU  | LATION S   | TUDIES                                       | ALYSIS                                       | 3  |                                |   |
| COMBUSTION AIR :   | REAR   |  | GLA  | ss DOC                                       | DR : OP                                      | EN                             |   |
| CIRCULATION FANS   | : NONE   |  | FUE  | L MATE                                       | ERIAL :                                      | WOOD                           |   |
| FUEL TYPE : DOUG   | LAS FIR  | HEA  | TING V                                       | ALUE =                                       | 8379.(                                       | O(BTU/LB)                      |   |
| <b>2</b>   |  |  |  |  |  |                                |   |
| MASS AIR IN =105   | .00(LB/MIN)  |  | MAS  | S AIR  | 0UT = 1                                      | 93.60                          | (LB/MIN)                                      |
| MASS DRY FLUE GA   | S =14.89(LB/M  | IN)  | MAS  | S COME                                       | AIR =  | 3.50                           | (LE/MIN)                                      |
|  |  |  | IN 15 12 23 12 12                            | III //I //I //I //I (J                       |  | <b>11</b> 7 118 118 118 118 11 | 2 an 62 m 14 m 15 12 m 12                     |
| %002 = .030  | %CO = .010   | )  | %02  | = .10  | 00   |                                |   |
| %C = .560  | %H = .070  |  | <b>%M</b> C                                  | =0.00  | 00   |                                |   |
| (R.H.)LAB = .750   | (R.H.)OUT  | = .580   | <pre>(R.H.)ROOM = .500</pre>                 |  |  |                                |   |
| FUEL<br>FUEL<br>TIME WEIGHT  | TEMPERA  |  |  |  |  |                                | COMB AIR/<br>TOT LOSS                         |
| MIN LB/MIN IN OUT  | STACK COMB   | FIRE   | CALR   | LAB  | ENV  | 7.                             | */  |
| 1.215555.970.72.218457.271.23.218456.373.04.218457.173.65.218457.674.06.220355.473.5 | 359.5 67.9<br>303.2 68.6<br>227.0 66.9<br>212.8 66.8 | 612.5<br>660.6<br>649.8<br>679.3<br>665.6<br>707.1 | 63.9<br>65.5<br>66.1<br>68.4<br>69.1<br>68.5 | 68.1<br>68.0<br>68.3<br>68.1<br>68.8<br>69.5 | 52.9<br>54.4<br>54.4<br>55.4<br>54.2<br>53.4 |                                | .03<br>.14<br>.15<br>.17<br>.14<br>.09<br>.09 |
| AEF= .19 AQF=  | .109787E+06(B1                                       | U/HR)  |  | AQNH=  | •21366E                                      | E+05(E                         | TUZHR)  |

|                        | TEST  | NUMBER       | : : 6-2             | •                    |                |                | DAT                                   | E : 11   | ./20/78                       |                           |   |  |
|------------------------|---|--------------|---------------------|----------------------|----------------|----------------|---------------------------------------|--|-------------------------------|---------------------------|---|--|
|                        | = = = = = = = =   | ======       | : == == == == == == | <b></b>              |                |                |                                       |  |                               | <b>12</b> al al 16 16 al  |   |  |
|                        |   |              | FI                  | REPLACE              | SIMUL          | ATION S        | TUDIES                                | 3  |                               |                           |   |  |
|                        |   | C            | HARACT              | ERISTIC              | S AND          | EFFICIE        | NCY AN                                | ALYSIS   | 3                             |                           |   |  |
| <b>19 22 27 28 2</b> 2 |   |              |                     |                      | I              |                |                                       | - ::: 10 52 52 53 53   |                               | etti cel phy teli tel etg | a and data state part and data and sind and |  |
|                        | COMB  | USTION       | AIR :               | REAR                 |                |                | GLF                                   | 45 <b>5</b> DOC  | )R : OF                       | EN                        |   |  |
|                        | CIRC  | ULATION      | FANS                | : NONE               |                |                | FUE                                   | L MATE   | RIAL :                        | WOOD                      |   |  |
|                        | FUEL  | TYPE :       | ກຕມດ                | AS ETE               |                |                | HEA                                   |  |                               | 9770.A                    |   |  |
|                        | FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)         |              |                     |                      |                |                |                                       |  |                               |                           |   |  |
|                        |   |              |                     |                      |                |                |                                       |  |                               |                           |   |  |
|                        | MASS  | AIR IN       | =105.               | 00(LB/M              | IN)            |                | MAS                                   | S AIR  | 0UT = 1                       | 93.60(                    | LE/MIN)                                     |  |
|                        | MASS DRY FLUE GAS =16.61(LB/MIN) MASS COMB AIR = 4.52(LB/MIN) |              |                     |                      |                |                |                                       |  |                               |                           |   |  |
|                        |   |              | ======              |                      |                |                |                                       |  | <b>. #:</b> := = = := := := : |                           | The same time true and the same star and    |  |
|                        | %02   | = .030       |                     | %0                   | = .010         | •              | <b>%0</b> 2                           | . = .10  | 0                             |                           |   |  |
|                        | %C =  | .560         |                     | %H =                 | .070           |                | %MC                                   | % The second sec |                               |                           |   |  |
|                        | (R.H  | .)LAB =      | .750                | (R.H                 | •)OUT          | = .580         | (R.                                   | H.)ROO   | M = .5                        | 00                        |   |  |
| *****                  |   |              |                     | 100 m 110 m ni av 20 |                |                |                                       | . 1919 1923 1923 1923 1933 1933  |                               |                           | 171 175 275 121 726 388 131 146 588         |  |
|                        | FUEL  |              |                     |                      |                |                |                                       |  |                               |                           | COMB AIR/                                   |  |
| TIME                   | WEIGHT  |              |                     | TE                   | MPERAT         | URE(F)         |                                       | بنيد فبند بينو فلطة ببب يريد   |                               | EFF                       | TOT LOSS                                    |  |
| MIN                    | LB/MIN  | IN           | оит                 | STACK                | COMB           | FIRE           | CALR                                  | LAR  | ENV                           | 7.                        | <b>7</b> 2                                  |  |
|                        | .2830   |              |                     | 143.7                |                | 622+9          |                                       |  |                               | •18                       | +04   |  |
|                        |   |              |                     | 318.6                |                | 631.5          |                                       |  |                               | +14                       | •13   |  |
|                        | •2823   | 57.3         | 76.4                | 247.7                | 68.2           | 628.0          | 69.7                                  | 68+4   | 55.3                          | +20                       | •10   |  |
|                        | .2823   | 59.1         | 78+8                | 420.0                | 71.5           | 668.8          | 71.8                                  | 68+4   | 55,9                          | +20                       | •20   |  |
|                        | .2808   | 58.2         | /7+8                | 302+1                | /1+2<br>'9+ '9 | 694.7          | /3+1                                  | 68+8   | 55+0                          | +23                       | •14   |  |
|                        | •2827<br>•2819  | 60.6<br>59.1 | 81+4<br>79+4        | 244•4<br>227•8       | 71+3<br>71+2   | 690.5<br>706.4 | 75+0<br>74+4                          | 68+6<br>68+4   |                               | •22<br>•22                | •10<br>•09                                  |  |
|                        |   |              |                     |                      |                |                |                                       | 1456 1510 2000 MMS -14 2 6466  |                               |                           |   |  |
| AEF=                   |   |              |                     |                      |                | U/HR)          |                                       |  |                               |                           |   |  |
|                        | ie wa we za we we we  |              |                     |                      | **             |                | <b>201</b> 300 <b>201 100</b> 201 201 | ()) HE CH CO DA 100  | na en 25 en 2                 |                           |   |  |

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| TEST NUMBER : 6-3  | 3  |  | DAT                | E : 11                      | ./20/78                        |                          |                       |  |  |  |
|--|--|--|--------------------|-----------------------------|--------------------------------|--------------------------|-----------------------|--|--|--|
| د هم به ی هر و و و و و د مر مر و و و و و و و و و و                 |  |  | 11 JZ 111 NO DZ 11 | : <b></b>                   |                                |                          |                       |  |  |  |
| F  | REPLACE SIMU   | LATION S                               | TUDIES             | ;                           |                                |                          |                       |  |  |  |
| CHARAC   | FERISTICS AND  | EFFICIE                                | NCY AN             | ALYSIS                      | 5                              |                          |                       |  |  |  |
|  | E 127 DE 188 EU 22 EU 23 EU 23 EU 25 EU 25 EU 26               |  |                    | : 13 82 <i>82 5</i> 2 52 53 | t ar 62 42 42 62 42 4          | <b>11 12 a</b> . 72 a. 1 |                       |  |  |  |
| COMBUSTION AIR : REAR GLASS DOOR : OPEN                            |  |  |                    |                             |                                |                          |                       |  |  |  |
| CIRCULATION FANS   | FUE  | L MATE                                 | RIAL :             | WOOD                        |                                |                          |                       |  |  |  |
| FUEL TYPE : DOUGL  | AS FIR   | HEA                                    | TING V             | ALUE =                      | 8379.                          | O(BTU/LB)                |                       |  |  |  |
| 72 111 127 128 128 128 128 129 129 129 129 129 129 129 129 129 129 |  |  | n: 10 10 10 10 10  | : <u></u>                   |                                |                          |                       |  |  |  |
| MASS AIR IN =105   | OO(LB/MIN)   |  | MAS                | S AIR                       | OUT = 1                        | 93.60                    | (LB/MIN)              |  |  |  |
| MASS DRY FLUE GAS  | G =16.72(LB/M)   | EN)                                    | MAS                | S COME                      | AIR =                          | 5.62                     | (LB/MIN)              |  |  |  |
| <b>72 do in 10                                  </b>               |  |  | 12 m: 12 m 11 c    |                             | - 1121 Hin 111 111 111 111 111 |                          |                       |  |  |  |
| %CO2 = .030  | %CO = .010   | )                                      | <b>%</b> 02        | = .10                       | 0                              |                          |                       |  |  |  |
| %C = .560  | %H = ₊070  |  | %МС                | %MC =0.000                  |                                |                          |                       |  |  |  |
| (R.H.)LAB = .750   | (R.H.)OUT  | = .580                                 | (R•                | (R.H.)ROOM = .500           |                                |                          |                       |  |  |  |
|  |  |  |                    |                             |                                |                          |                       |  |  |  |
|  | a prod sada sada bada mane prod sama siya mad naka naka pad na | all sees at i alad blad book good of a |                    |                             |                                |                          |                       |  |  |  |
| FUEL<br>TIME WEIGHT  | TEMPERAT   | TURE(F)                                |                    |                             |                                | EFF                      | COMB AIR/<br>TOT LOSS |  |  |  |
| MIN LB/MIN IN OUT  | STACK COMB   | FIRE                                   | CALR               | LAB                         | ENV                            | %                        | %                     |  |  |  |
| 0.3521 60.8 78.1   | 153.9 69.3   | 562+2                                  | 73.9               |                             | 57.3                           | .15                      | .04                   |  |  |  |
| 1 .3499 59.7 80.1  | 460+1 72+1   | 587.3                                  | 73.3               | 68.1                        | 55.4                           | •17                      | .21                   |  |  |  |
| 2 .3517 60.9 83.0  | 438.4 75.0   | 713.7                                  | 77.4               |                             | 55.7                           | +19                      | • 20                  |  |  |  |
|  |  | 796.0                                  | 77.3               |                             | 57.2                           | .22                      | +22                   |  |  |  |
| 4 .3495 61.0 86.0  | 443.7 78.0   | 811.9                                  | 80.6               |                             | 59.0                           | •22                      | .21                   |  |  |  |
| 5 • 3499 61 • 9 92 • 2   | 391.2 77.6   |  | 82.0               |                             | 56.6                           | •27                      | •19                   |  |  |  |
| 6 .3517 64.6 85.8  | 257.8 76.5   | 845.2                                  | 84.1               | 69.1                        | 58.4                           | •20                      | .10                   |  |  |  |
|  |  | : := # !!! # :                         |                    | us est as as sa m           | na 21: 71: Az 10: 10: 2        |                          |                       |  |  |  |
| AEF= .20 AQF=.   | 176202E+06(BT  | U/HR)                                  |                    | AQNH=                       | •35750E                        | E+05(1                   | 3TU/HR)               |  |  |  |

AEFT= .20 AQFT=.142647E+06(BTU/HR) AQNHT=.28455E+05(BTU/HR)

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| TEST NUMBER : 7-1  |  | DATE : 11/27/78  |                         |
|--|--|--|-------------------------|
|  |  | ا که هو بین  |                         |
| FIR  | EPLACE SIMULATION STU                          | JDIES  |                         |
| CHARACTEI  | RISTICS AND EFFICIENC                          | Y ANALYSIS   |                         |
|  |  |  |                         |
| COMBUSTION AIR : FI  | RONT   | GLASS DOOR : OPEN  | ·                       |
| CIRCULATION FANS :   | NONE   | FUEL MATERIAL : WOO  | D                       |
| FUEL TYPE : DOUGLAS  | 5 FIR  | HEATING VALUE =8379  | •O(BTU/LB)              |
| و هم ها                | # 0# 0# 0# 0# 0# 0# 0# 0# 0# 0# 0# 0# 0#       | ו הנוג אנו אנה עם און שון אנו אנו אנו אנו אנו אני או אני און   |                         |
| MASS AIR IN =105.00  | )(LB/MIN)                                      | MASS AIR DUT = 93.6  | O(LB/MIN)               |
| MASS DRY FLUE GAS =  | =14.88(LB/MIN)                                 | MASS COMB AIR = 3.5  | 2(LB/MIN)               |
|  |  | י<br>ז הבי של היה הנו זיה הוו הם שה שם עם בנו עם את היה את היה או או או<br>היה היה היה היה היה היה היה היה היה שה שה שה היה הי |                         |
| %CO2 = .030  | %CO = .010                                     | 202 = .100   |                         |
| %C = .560  | %H = .070                                      | ZMC =0.000   |                         |
| (R.H.)LAB = .690   | (R.H.)OUT = .850                               | (R.H.)ROOM = .500  |                         |
| و ها اله جو بال کار کر | د هد ها من |  |                         |
| FUEL<br>TIME WEIGHT  | TEMPERATURE(F)                                 | EFF  | COMB AIR/<br>F TOT LOSS |

| MIN         | LB/MIN | IN   | OUT                                 | STACK   | COMB   | FIRE                               | CALR   | LAB                     | ENV     | %       | %      |
|-------------|--------|------|-------------------------------------|---------|--------|------------------------------------|--|-------------------------|---------|---------|--------|
| 0           | •2203  | 55.3 | 62.0                                | 115.4   | 63.8   | 447.8                              | 60.4   | 67.1                    | 53.6    | •07     | •03    |
| 1           | +2203  | 55.2 | 62.9                                | 363.0   | 61.2   | 511.7                              | 61.6   | 67.6                    | 53.8    | .09     | .15    |
| 2           | +2206  | 55.1 | 66.0                                | 336.3   | 62.0   | 561.3                              | 63.3   | 67.0                    | 54.0    | .14     | • 1.4  |
| 3           | .2203  | 55.0 | 66.1                                | 367.6   | 62.8   | 600.0                              | 64.7   | 67.1                    | 54.1    | .14     | •16    |
| 4           | .2214  | 54.5 | 68.6                                | 275.9   | 62.8   | 615.2                              | 64.8   | 67.9                    | 54.4    | •18     | .12    |
| 5           | .2203  | 54.4 | 71.5                                | 211.3   | 63.4   | 621.7                              | 65.8   | 67.0                    | 53.5    | •22     | • 09   |
| 6           | +2203  | 54.9 | 68.7                                | 182.6   | 63.7   | 630.4                              | 66.6   | 67.4                    | 52.7    | •18     | .07    |
| 22 cz w w z |        |      | <b>u and inte late</b> som blat för |         |        | alas 1000 Mall bidd igar stas alar | antan fanis tean tahin anisi inna<br>ang ang ang ang ang | 192 202 202 101 101 000 |         |         |        |
| AEF=        | 15<br> |      | AQF=.                               | 110841E | +06(BT | U/HR)<br>======                    |  | AQNH=                   | •163898 | E+05(B1 | FU/HR) |

|                       | TEST                     | NUMBER                        | R : 7-2      | /<br>-                                     |                     |                              | DAT                                  | DATE : 11/27/78       |  |                        |  |  |
|-----------------------|--------------------------|-------------------------------|--------------|--|---------------------|------------------------------|--------------------------------------|-----------------------|--|------------------------|--|--|
|                       | <b>= = = = = = = =</b> = | . == == == == == =            |              | 00 AL AL 42 AL AL AL                       | * == == == == == == |                              | ; #2 12 88 82 12 22                  |                       | * #2 32 32 22 22 23 33                 |                        | - 122 122 127 127 128 127 128 128 128    |  |
|                       |                          |                               | FI           | REPLACE                                    | SIMUL               | ATION S                      | TUDIES                               | •                     |  |                        |  |  |
|                       |                          |                               |              |  |                     | EFFICIE                      |                                      |                       |  |                        |  |  |
| 82 <u>25 27</u> 13 1  |                          | USTION                        |              |  | : 22 22 22 22 22 22 | 5 MB 62 AB 66 46 46 A        |                                      |                       | )R : 0P1                               |                        | י איז איז איז איז איז איז איז איז איז אי |  |
|                       | CIRC                     | ULATION                       | V FANS       | FUE  | L MATE              | ERIAL :                      | woon                                 |                       |  |                        |  |  |
|                       | FUEL                     | TYPE :                        | DOUGL        | AS FIR                                     | HEA                 | TING V                       | ALUE =                               | 8379.0                | (BTU/LB)                               |                        |  |  |
| 22 25 25 <b>25</b> 2  |                          |                               |              |  |                     |                              |                                      |                       |  |                        |  |  |
|                       | MASS                     | AIR IN                        | √ =105.      | 00(LB/M                                    | IIN)                |                              | MAS                                  | S AIR                 | OUT = 9                                | 93.60(                 | LB/MIN)                                  |  |
|                       | MASS                     | DRY FL                        | LUE GAS      | =15.11                                     | MAS                 | MASS COMB AIR = 4.58(LB/MIN) |                                      |                       |  |                        |  |  |
| 11 <b>15 12 12 1</b>  |                          |                               |              | nate best sold beer star date met          |                     |                              | 1 83 62 82 62 83 82                  | AL 81 15 M 68 68      |  | 123 616 52 761 611 753 | , NE ANI DI INI INI INI DI INI ANI       |  |
|                       | %CO2                     | - • 030                       | )            | %CO  | = .010              | )                            | 702                                  | • • 10                | 0                                      |                        |  |  |
|                       | %C =                     | •560                          |              | %H =                                       | .070                |                              | %MC                                  | =0.00                 | 0                                      |                        |  |  |
|                       | (R+H                     | •)LAB =                       | ± .690       | (R.H                                       | TUO ( +             | = .850                       | (R.H.)ROOM = .500                    |                       |  |                        |  |  |
| 12 <b>82 3</b> 2 12 1 | FUEL                     | )17 ani ka 280 196 196 196 19 | -            | benne sinde under Sonik sinde State Bereit | - 22 22 22 22 22 22 | :                            | ; (27 22 22 23 57 22                 | 22 III 83 85 15 16 EP | : 200 (12 20 20 20 20 20 1             |                        | COMB AIR/                                |  |
| TIME                  | WEIGHT                   |                               | da 648846    | TE   | MPERAT              | URE(F)                       | 9 armap blådd ganst sakad varm bleve |                       | s value AMMA andre +7 es parts burns a |                        | TOT LOSS                                 |  |
| MIN                   | LB/MIN                   | IN                            | 0UT          | STACK                                      | COMB                | FIRE                         | CALR                                 | LAB                   | ENV                                    | %                      | %  |  |
| 0<br>1                | •2867<br>•2845           | 54.9<br>57.4                  | 68.7<br>69.0 |  |                     | 630.4<br>617.6               |                                      |                       | 52.7<br>52.6                           | +14<br>+13             | .06<br>.16                               |  |
| 2                     | .2838                    |                               |              | 393.6                                      |                     | 690.1                        |                                      | 67.0                  |  | •13                    | •18                                      |  |
| 3                     | • 2838                   |                               |              |  |                     | 665.4                        |                                      |                       |  | •18                    | •19                                      |  |
| 4                     | •2882                    |                               | 72.1         |  | 660.8               |                              |                                      |                       | • 19                                   | •15                    |  |  |
| 5                     | .2834                    |                               |              |  |                     | 663.1                        |                                      |                       |  | •18                    | • 09                                     |  |
| 6                     | .2830                    | 55.4                          | 74.0         |  |                     | 695.9                        |                                      |                       | 53.7                                   | .20                    | .08                                      |  |
|                       |                          |                               |              | 143086E                                    |                     |                              |                                      |                       | .255188                                |                        | TU/HR)                                   |  |
|                       | • = = = = = = = :        |                               |              |  |                     |                              |                                      | an an ta an ta an     | ne :::: :=: :=: ::: ::: ::             | * ** ** ** ** **       |  |  |

|                 | TES                           | T NUMBE      | R : 7-3              | 5   |                      |                                   | ΓA      | TE : 1:               | 1/27/78                        |                             |  |  |
|-----------------|-------------------------------|--------------|----------------------|---|----------------------|-----------------------------------|---------|-----------------------|--------------------------------|-----------------------------|--|--|
|                 | <b>14 15 26 27 25 15 26 2</b> |              |                      |   |                      | ATION S                           |         |                       |                                | 12 III II III III /II       |  |  |
|                 |                               |              | CHARACT              | ERISTIC   | S AND                | EFFICIE                           | ENCY AN | ALYSIS                | 6                              |                             |  |  |
|                 |                               |              | AIR :                |   | 6 HE 13 22 23 III 0  | n ang ini kin kin ang ini U       |         |                       | )R : OF                        |                             |  |  |
|                 | CIRC                          | CULATIO      | N FANS               | : NONE  |                      |                                   | FUE     | L MATE                | ERIAL :                        | woop                        |  |  |
|                 |                               |              |                      |   |                      |                                   |         |                       |                                | 8379.0                      | O(BTU/LB)  |  |
|                 |                               |              |                      |   |                      |                                   |         |                       |                                |                             |  |  |
|                 | MASS                          | S AIR I      | N =105.              | 00(LB/M   | IIN)                 |                                   | MAS     | S AIR                 | OUT = '                        | 93.60                       | (LB/MIN)   |  |
| -               |                               |              |                      |   |                      |                                   |         |                       |                                |                             | (LB/MIN)   |  |
|                 |                               | 2 = .03      |                      |   | = .010               |                                   |         | . = .10               |                                | 428 2000, 4980 4063 Addi u  |  |  |
|                 | %C =                          | • • 560      |                      | %H =  | .070                 |                                   | %MC     | : =0.00               | 00                             |                             |  |  |
|                 | (8+1                          | I.)LAB =     | 690                  | (R.H  | 1.)OUT               | = .850                            | (R.     | (R.H.)ROOM = .500     |                                |                             |  |  |
| 15 III (ji 65 j | a in 12 52 52 53 52 5         |              | di 20 00 00 00 10 10 | 07 112 00 00 00 00 00   | . AL UN VE (7 11 III | : 121 22 22 22 22 23 22 23        |         |                       | * 200 511 225 711 211 22 1     | m ne 12 2e av 1             |  |  |
| TIME            | FUEL<br>WEIGHT                |              |                      | TE  | MPERAT               | URE(F)                            |         |                       |                                | EFF                         | COMB AIR/<br>Tot loss  |  |
| MIN             | LB/MIN                        | IN           | OUT                  | STACK   | COMB                 | FIRE                              | CALR    | LAB                   | ENV                            | 72                          | n oran and some some and |  |
| 1               | .3568                         | 55.3         | 71.9                 | 405.6   | 66.8                 | 695.9<br>674.8                    | 73.1    | 66.8                  | 54.0                           | •16<br>•15                  | .07<br>.18   |  |
|                 | +3561                         |              |                      |   |                      | 722.9                             |         |                       |                                |                             | .21  |  |
| 3               | .3543                         | 55.4         |                      |   |                      | 711.0                             |         |                       |                                |                             | .23  |  |
| 4<br>5          | •3568<br>•3532                | 00+4<br>55.A | 73+6                 | 410+3<br>277-1  | 68+8<br>69-3         | 734.7                             | 77.6    | 67+4                  | 04+4<br>54.1                   | •1/                         | .18<br>.12   |  |
| 6               | .3598                         | 55.7         | 77.3                 | 235.1   | 69.4                 | 678.5                             |         |                       | 54.4                           | .20                         | .09  |  |
| AEF=            | = .19                         |              | AQF=.                | 179 <b>3</b> 92E  | +06 ( BT             | U/HR)                             |         | AQNH=                 | •33424E                        | E+05(E                      | STU/HR)  |  |
|                 |                               |              |                      |   |                      |                                   |         |                       |                                |                             | BTU/HR)  |  |
| == == == == =   |                               |              |                      | anna a'fur saan nada anna mara mara<br>Lane a'fur saan nada anna mara | MI ER 62 33 68 68    | and, find were bras late find man |         | 117 III 117 IV 117 IV | 17 38 <del>39</del> 49 86 87 8 | 1 22 23 <b>25 6</b> 7 67 62 | . 7711 2017 2014 2018 <b>2019 201</b> 5 2019 2019            |  |

| TEST NUMBER :   | 15-1  |  | DATE : 2/5/79      |                                    |                         |  |  |  |  |  |  |
|---|---|--|--------------------|------------------------------------|-------------------------|--|--|--|--|--|--|
|   |   |  |                    | n na 20 fer 112 m 12 fe            |                         |  |  |  |  |  |  |
|   | FIREFLACE SIMU                                      | ATION STU                                | IES                |                                    |                         |  |  |  |  |  |  |
|   | RACTERISTICS AND                                    |  |                    |                                    |                         |  |  |  |  |  |  |
| COMBUSTION AI   |   |  | GLASS DOOF         |                                    |                         | :::::::::::::::::::::::::::::::::::::: |  |  |  |  |  |
| CIRCULATION F   | ANS : NONE  |  | FUEL MATER         | RIAL : W                           | 1000                    |  |  |  |  |  |  |
| FUEL TYPE : DO  | DUGLAS FIR  |  | HEATING VA         | ALUE =83                           | 879.0                   | (BTU/LB)                               |  |  |  |  |  |
|   |   |  |                    |                                    |                         |  |  |  |  |  |  |
| MASS AIR IN =101.25(LB/MIN) MASS AIR OUT = 91.44(LB/MIN)      |   |  |                    |                                    |                         |  |  |  |  |  |  |
| MASS DRY FLUE GAS =10.99(LB/MIN) MASS COMB AIR = 3.41(LB/MIN) |   |  |                    |                                    |                         |  |  |  |  |  |  |
|   |   |  |                    |                                    |                         |  |  |  |  |  |  |
| %02 = .030  | %CO = .010  | )  | %02 = .100         | )                                  |                         |  |  |  |  |  |  |
| %C = .560   | %H = .070   |  | %MC =0.000         | )                                  |                         |  |  |  |  |  |  |
| (R.H.)LAB = .4  | 400 (R.H.)OUT                                       | = .700                                   | (R.H.)ROOM         | 1 = .380                           | )                       |  |  |  |  |  |  |
|   |   | R 92 000 101 000 000 110 000 000 000 100 |                    |                                    | , sint cast star that t | 10 /10 10 10 10 10 10 10 10 10         |  |  |  |  |  |
| FUEL<br>TIME WEIGHT   | TEMPERAT  | (URE(F)                                  |                    |                                    |                         | COMB AIR/<br>FOT LOSS                  |  |  |  |  |  |
| MIN LB/MIN IN OU  | JT STACK COMB                                       | FIRE CA                                  | LR LAB             | ENV                                | %                       | %                                      |  |  |  |  |  |
|   | 3.8 107.3 47.0                                      |  | ·•0 66+8           | 45.8                               | • 09                    | +03                                    |  |  |  |  |  |
|   | 3.5 278.6 47.8                                      |  | .8 67.3            | 46+0                               | •07                     | .11                                    |  |  |  |  |  |
|   | 5.2 367.6 49.2                                      |  | -2 67.4            | 45.9                               | • 11                    | +16                                    |  |  |  |  |  |
|   | 7.1 382.8 50.2                                      |  | ·2 68·0            | 47.8                               | •12                     | •17                                    |  |  |  |  |  |
|   | 7.7     400.4     52.0       9.1     302.1     52.6 |  | -0 67-5<br>-6 67-9 |                                    | •13<br>•15              | •18<br>•13                             |  |  |  |  |  |
|   | 7.4 251.9 53.8                                      |  | •8 68•0            |                                    | •13                     | •13                                    |  |  |  |  |  |
|   |   | -  |                    |                                    |                         |  |  |  |  |  |  |
|   | RF=.108099E+06(BT                                   |  |                    | 12434E+                            |                         |  |  |  |  |  |  |
|   |   |  |                    | : //# <b>#0</b> 101 110 00 111 117 | 100 AZ IN IN 7          | בה מה שנו או או או או או או או         |  |  |  |  |  |

|                  | TEST   | NUMBER  | R : 15-                             | 2                      |                            |  | DAT                                   | DATE : 2/5/79                  |                           |                         |  |  |
|------------------|--|---|-------------------------------------|------------------------|----------------------------|--|---------------------------------------|--------------------------------|---------------------------|-------------------------|--|--|
|                  | ): 14 86 86 85 18 92 83                                  | ======  |                                     |                        | a wa an ini na wa <b>n</b> | z == == == == == == == == == == == == == |                                       | n daar ette taar ette biet bie | n 119 119 119 117 118 118 | <b>10</b> 63 36 16 16 1 |  |  |
|                  |  |   | f" <b>T</b>                         |                        | - CTMU                     |  | · · · · · · · · · · · · · · · · · · · |                                |                           |                         |  |  |
|                  |  |   | нт<br>Н                             | KEFLAUE                | . SIMUL                    | LATION S                                 | JUDIES                                | j -                            |                           |                         |  |  |
|                  |  | (   | CHARACT                             | ERISTIC                | S AND                      | EFFICIE                                  | NCY AN                                | ALYSIS                         | 3                         |                         |  |  |
| ar er ar ar i    | n es so an as us us us                                   |   |                                     | : 32 := 22 := 12 :2 :2 |                            | z  | : <u>111 III III III II</u> 11        | : (.:. <u>28 83 83 85</u> )3   |                           |                         |  |  |
|                  | COMB   | USTION  | AIR :                               | ROOM                   | GLA                        | SS DOC                                   | DR : CL                               | OSED                           |                           |                         |  |  |
|                  | CIRC   | ULATIO  | N FANS                              | : NONE                 |                            |  | FUE                                   | L MATE                         | ERIAL :                   | WOOD                    |  |  |
|                  | FUEL   | TYPE  | : DOUGL                             | AS FIR                 | HEA                        | TING V                                   | ALUE =                                | 8379.0                         | O(BTU/LB)                 |                         |  |  |
| 22 25 25 cm 2    |  |   |                                     |                        |                            |  |                                       |                                |                           |                         |  |  |
|                  | MASS AIR IN =101.25(LB/MIN) MASS AIR OUT = 91.44(LB/MIN) |   |                                     |                        |                            |  |                                       |                                |                           |                         |  |  |
|                  | MASS   | DRY FL  | UE GAS                              | =11,67                 | MAS                        | MASS COMB AIR = 4.44(LB/MIN)             |                                       |                                |                           |                         |  |  |
| PR 144 199 199 1 |  |   | * == == == == ==                    |                        | : == == == == == ==        | * == == == == == ==                      | -227 -227 -222 -222 -222 -222 -222    | 123 mi (12 12 13) m            |                           |                         | 12 123 135 135 136 138 138 138 139 147 147 |  |
|                  | %CO2   | = .030  | )                                   | %CO                    | = .010                     | )  | %02                                   | 2 = +10                        | 00                        |                         |  |  |
|                  | %C =   | .560  |                                     | %H =                   | •070                       |  | %MC                                   | =0.00                          | 0                         |                         |  |  |
|                  | (R.H   | ·)LAB =   | - +400                              | (R+H                   | I.) OUT                    | = .700                                   | (R.                                   | (R.H.)ROOM = .380              |                           |                         |  |  |
|                  | ======   | tions likes some syde vite bits on<br>The likes were bits the time to | <b></b> .                           | ****                   | : 223 223 223 234 235 23   | •  |                                       |                                |                           |                         |  |  |
| TIME             | FUEL<br>WEIGHT   |   |                                     | TE                     | MPERAT                     | URE(F)                                   |                                       |                                |                           | EFF                     | COMB AIR/<br>TOT LOSS                      |  |
|                  |  |   |                                     |                        | ,                          |  |                                       |                                | ·                         |                         |  |  |
|                  | LB/MIN   | 1N<br>  |                                     | 51AUN                  | CUMB                       |  | CALK                                  | LAB<br>                        | E.NV                      | / <b>.</b>              | 7.   |  |
| 0                | •2779  | 36+7  | 47.4                                | 251.9                  | 53.8                       | 575.6                                    | 53.8                                  | 68+0                           | 46.3                      | •10                     | .10  |  |
| 1                | .2790  | 36.5  | 49.2                                | 343.8                  | 53.1                       | 647.2                                    | 53.1                                  | 68.3                           | 44.9                      | .12                     | .15  |  |
| 2                | +2849  | 37.2  | 50.1                                | 375.0                  | 55.3                       | 649.7                                    | 55.3                                  | 68.2                           | 43.4                      | +12                     | •17  |  |
| 3                | +2801  | 37.1  | 50.6                                | 463.2                  | 55.6                       | 640.0                                    | 55+6                                  | 68.1                           | 47.9                      | •13                     | .21  |  |
| 4                | +2753  | 37.3  | 53.1                                | 443.9                  | 56.5                       | 705.5                                    | 56.5                                  | 69.0                           | 48.4                      | .15                     | • 21                                       |  |
| 5                | •2838  | 36.8  |                                     | 356.5                  | 57.9                       |  | 57.9                                  | 67.8                           | 47.4                      | +14                     | •16  |  |
| 6                | +2823  | 36+8  | 57.2                                | 304.1                  | 57.9                       | 631.9                                    | 57.9                                  | 68.5                           | 46.7                      | •20                     | •14  |  |
|                  |  | 181 181 193 2-3 32 88 av  | : 222 222 222 222 222 222 222 222 2 |                        |                            |  |                                       | == == == == == == == ==        |                           | = == == == == ==        |  |  |

 AEF= .14
 ARF=.141003E+06(BTU/HR)
 ARNH=.19195E+05(BTU/HR)

| TEST NUMBER  |  |  |   | DATE : 2/5/79                        |                                      |                                      |                          |  |  |
|--|--|--|---|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------|--|--|
| (  | FIREPLA<br>CHARACTERIST  |  |   |                                      |                                      | }                                    |                          |  |  |
| COMBUSTION   | AIR : ROOM   |  |   | GLA                                  | ISS 100                              | OR : CL                              | DSED                     |  |  |
| CIRCULATION  | FANS : NON   | **   |   | FUE                                  | L MATE                               | RIAL :                               | uoon                     |  |  |
| FUEL TYPE  | DOUGLAS FI   |  | HEA                                       | TING V                               | ALUE =                               | 8379.0                               | (BTU/LB)                 |  |  |
|  | V =101.25(LB.  |  | [N)                                       |                                      |                                      |                                      |                          | LB/MIN)<br>LB/MIN)                                   |  |
|  |  |  |   |                                      |                                      |                                      |                          |  |  |
| %02 = .030   | > %C   | ) = .01(                                     | )   | <b>%02</b> = .100                    |                                      |                                      |                          |  |  |
| <b>%C</b> = .560   | <b>%</b> H   | = .070                                       |   | %MC                                  | %MC =0.000                           |                                      |                          |  |  |
| (R.H.)LAB =  | = •400 (R  | н.)оит                                       | = .700                                    | (R.H.)ROOM = .380                    |                                      |                                      |                          |  |  |
| FUEL<br>TIME WEIGHT  |  | EMPERAT                                      |   |                                      | NI IN 12 28 28 28 R.                 | :                                    |                          | COMB AIR/<br>TOT LOSS                                |  |
| MIN LB/MIN IN  | OUT STACI  | с сомв                                       | FIRE                                      | CALR                                 | LAB                                  | ENV                                  | 7.                       | "  |  |
| 1 .3521 36.6<br>2 .3414 36.3<br>3 .3436 36.1<br>4 .3429 36.3 | 57.2 304.:<br>53.0 394.5<br>50.4 472.2<br>54.0 511.0<br>52.8 508.6<br>55.5 442.0<br>53.8 341.0 | 5 58.7<br>2 59.3<br>59.5<br>3 60.6<br>5 61.7 | 712.7<br>715.9<br>697.7<br>696.5<br>806.3 | 58.7<br>59.3<br>59.5<br>60.6<br>61.7 | 68.0<br>68.5<br>68.3<br>68.4<br>68.7 | 46.6<br>45.8<br>45.0<br>46.7<br>45.9 | •13<br>•12<br>•15<br>•14 | .13<br>.18<br>.21<br>.24<br>.24<br>.24<br>.21<br>.15 |  |
| AEF= .14   | AQF=.173512  | 2E+06(BT                                     | U/HR)                                     |                                      | АΩ№Н≕                                | • 24324E                             | E+05(B                   | TU/HR)   |  |
| AEFT= .13  | AQFT=.14087  |  |   |                                      |                                      |                                      |                          |  |  |

| TEST NUMBER : 5-1   |                      | DATE : 11/13/79  |
|---|----------------------|--|
|   | PLACE SIMULATION STU | NIES   |
|   |                      | עם את את את את את את את את הכי היה או את                                   |
| COMBUSTION AIR : RE   | AR                   | GLASS DOOR : CLOSED  |
| CIRCULATION FANS :  | NONE                 | FUEL MATERIAL : WOOD   |
| FUEL TYPE : DOUGLAS   | FIR                  | HEATING VALUE =8379.0(BTU/LB)  |
| ۲۰۰ ۲۰۰ ۲۰۰ ۲۰۰ ۲۰۰ ۲۰۰ ۲۰۰ ۲۰۰ ۲۰۰ ۲۰۰                                   |                      |  |
| MASS AIR IN =105.00   | (LB/MIN)             | MASS AIR OUT = 93.60(LB/MIN)   |
| MASS DRY FLUE GAS =   | 13.74(LB/MIN)        | MASS COMB AIR = 3.47(LB/MIN)   |
| עוד אה עיר אנן עוד אני אני אני אני או |                      | שם עם היה עם הה בה בה זה וה וה וה הו של ה הם הם או זה אה שו עם את שנו את הם בה או מא אה הה או אל היה או אל היה |
| % 202 = .030  | %00 = .010           | %02 = .100   |
| %C = .560   | %H = .070            | ZMC =0.000   |
| (R.H.)LAB = .780  | (R.H.)OUT = .580     | (R.H.)ROOM = .450  |
|   |                      | שנו את הוו אם ענו ענו זהו הזו זה היו זה או או אינו אי או או דע היו או אי או א |
| FUEL  |                      | COMB AIR/  |

| TIME | WEIGHT                     |                      |                      | TE      | MPERAT            | URE(F)                          |      |                             |        | EFF                              | TOT LOSS |
|------|----------------------------|----------------------|----------------------|---------|-------------------|---------------------------------|------|-----------------------------|--------|----------------------------------|----------|
| MIN  | LB/MIN                     | IN                   | OUT                  | STACK   | COMB              | FIRE                            | CALR | LAB                         | ENV    | %                                | %        |
| 0    | ,2173                      | 69,9                 | 77,6                 | 118,9   | 72.6              | 638,7                           | 72.2 | 75.7                        | 67.5   | .09                              | .02      |
| 1    | .2184                      | 68.1                 | 74.3                 | 371.4   | 72.9              | 739.1                           | 71.1 | 76.2                        | 66.7   | •07                              | .15      |
| 2    | .2195                      | 70.0                 | 77.1                 | 372.6   | 75.1              | 822.2                           | 72.1 | 75.5                        | 66.7   | •08                              | .15      |
| 3    | ,2166                      | 69,7                 | 78.5                 | 365.0   | 74.4              | 883.4                           | 72.3 | 75.1                        | 67.2   | .10                              | +15      |
| 4    | .2184                      | 71.2                 | 80.5                 | 379.9   | 75.0              | 895.3                           | 73.3 | 76.4                        | 67.3   | .11                              | .16      |
| 5    | .2170                      | 70.2                 | 81.2                 | 360.5   | 74.0              | 862.0                           | 73.2 | 76.0                        | 66.9   | .13                              | +15      |
| 6    | •2173                      | 72.0                 | 84.1                 | 282.9   | 75.1              | 776.1                           | 74.5 | 75.8                        | 69.2   | .15                              | .11      |
|      | 12 05 05 06 06 12 12 15 15 | na na 25 25 25 25 25 | n na 113 25 25 77 97 |         | uu 37 92 22 14 14 | tind the bren web this with any |      | 100 Mar 1717 1227 1247 1868 | -      | <b></b>                          |          |
| AEF  | = .10                      |                      | AQF=.                | 109496E | +06(BT            | U/HR)                           |      | AQNH=                       | •11462 | E+05(B)                          | TU/HR)   |
|      |                            |                      | *** ********         |         |                   |                                 |      |                             |        | 01 172 1721 176 272 <b>176</b> 2 |          |

|                  | TEST                            | I NUMBE                       | R : 5-2                        | <b>DA</b> 1                  | DATE : 11/13/79               |                                    |                         |                                  |   |                           |  |
|------------------|---------------------------------|-------------------------------|--------------------------------|------------------------------|-------------------------------|------------------------------------|-------------------------|----------------------------------|---|---------------------------|--|
|                  |                                 |                               | 121 121 221 122 123 123 127 12 |                              |                               | : 27. 22 32 32 33 38 38            |                         |                                  |   |                           |  |
|                  |                                 |                               | F1                             | REPLACE                      | E SIMUL                       | ATION S                            | STUDIES                 | 6                                |   |                           |  |
|                  |                                 | ł                             | CHARACT                        | ERISTIC                      | S AND                         | EFFICIE                            | ENCY AN                 | ALYSIS                           | 6   |                           |  |
|                  | <b>AR NO DE DE 20 FE 20 F</b> E | 2 121 721 821 822 877 877 821 | II II II II II II II II II     | : 52 MI 85 MI 67 MI 8        | 3 m 13 pr 12 pr 2             |                                    |                         | <u></u>                          | un terr fand anne anne konst terr fand anne |                           |  |
|                  | COME                            | NUSTION                       | AIR :                          | REAR                         |                               |                                    | GLA                     | SS DOC                           | DR : CL                                     | OSED                      |  |
|                  | CIRC                            | ULATIO                        | N FANS                         | : NONE                       |                               |                                    | FUE                     | L MATE                           | ERIAL :                                     | WOOD                      |  |
|                  | FUEL                            | . TYPE                        | : DOUGL                        | HEA                          | TING V                        | ALUE =                             | 8379.0                  | (BTU/LB)                         |   |                           |  |
|                  |                                 |                               |                                |                              |                               | 1 12 12 15 15 <b>1</b> 2 12 12     | 8                       |                                  | a 22 ka av 142 64 64                        | 1999 and 1995 and 1995 an | = W. W. Ct: III 121 /21 125 723            |
|                  | MASS                            | AIR I                         | N =105.                        | 00(LB/M                      | (IN)                          |                                    | MAS                     | S AIR                            | 0UT =                                       | 93.60(                    | LB/MIN)                                    |
|                  | MASS                            | DRY FI                        | LUE GAS                        | =16.26                       | (N)                           | MASS COMB AIR = 4.52(LB/MIN)       |                         |                                  |   |                           |  |
| <b>=</b> ===     |                                 |                               | 10 and 201 171 112 113         | The two was not far the same |                               |                                    | - #2 (1) 20 47 45 15 17 | det 110 370 200 met 20           |   | NI 42 18 82 82 92         |  |
|                  | %02                             | = .030                        | )                              | %00                          | 010                           | )                                  | <b>%0</b> 2             | 10                               | 00  |                           |  |
|                  | %C =                            | •560                          |                                | %H =                         | .070                          |                                    | %MC                     | =0.00                            | 0   |                           |  |
|                  | (R.H                            | LAB =                         | • .780                         | (R.H                         | +)OUT                         | = .580                             | (R.                     | H.)ROC                           | )M = +4                                     | 50                        |  |
|                  | 2                               |                               |                                | #5 #5 27 25 26 28 29 7       |                               |                                    |                         | 127 - 21 127 127 127 127 127 127 | 100 02 122 123 125 1                        | <b>36 611 85 67</b> 67 68 |  |
| TIME             | FUEL<br>WEIGHT                  |                               |                                | TE                           | MPERAT                        | URE(F)                             |                         |                                  |   |                           | COMB AIR/<br>TOT LOSS                      |
| MIN              | LB/MIN                          | IN                            | OUT                            | STACK                        | COMB                          | FIRE                               | CALR                    | LAB                              | ENV   | %                         | %  |
| 0<br>1           | <br>→2834<br>→2856              | 72.0                          | 84.1<br>83.4                   | 282.9<br>358.3               | 75.1<br>74.2                  | 776.1<br>833.7                     |                         | 75.8<br>75.7                     | 69.2<br>67.9                                | •11<br>•11                | .11<br>.15                                 |
| 2                | .2845                           |                               | 85.0                           | 442.5                        |                               | 897.4                              |                         | 75.4                             |   | .12                       | •19  |
| 3                | .2845                           |                               |                                | 497.2                        |                               | 945.8                              | 76.3                    | 75.3                             |   | .16                       | •23  |
| 4                | .2856                           |                               |                                |                              |                               | 837.3                              |                         |                                  |   | .15                       | .21  |
| 5                | .2845                           |                               |                                | 329.2                        | 75.9                          | 830.5                              | 77.5                    | 76.3                             | 68,6  | .12                       | +13  |
| 6                | .2845                           | 74.6                          | 89.0                           | 280.5                        | 76.6                          | 815.6                              | 78.4                    | 75.2                             | 68.8  | •14                       | •11  |
| co 11 15 15 15 1 |                                 |                               | 1 (co 110) (co 110) (ch 110)   | AR 22 AR 22 AR 32 AR         | <b></b>                       |                                    |                         |                                  | un er == un in to :                         | z az <b>az az</b> az az   |  |
| AEF=             | = .13                           |                               | AQF=.                          | 143113E                      | +06(BT                        | U/HR)                              |                         | AQNH=                            | ·18747                                      | E+05(B                    | TU/HR)                                     |
|                  | 2 333 333 345 355 355 355 355   |                               |                                |                              | tion stat have been part when | THE MAN INT THE SECOND AND AND ADD |                         |                                  | the the two is and the set of               | 17 (hr 117 kg 117 cu      | and and the set of the star and a star and |

•

|                      | TEST   | NUMBER                           | :                            | DAT     | DATE : 11/13/79        |                               |                  |                                 |                             |                                       |   |  |
|----------------------|--|----------------------------------|------------------------------|---------|------------------------|-------------------------------|------------------|---------------------------------|-----------------------------|---------------------------------------|---|--|
|                      | =======  | =======                          |                              |         |                        | a من الله عن من الله عن من من |                  | <b>: 20 22 22 23 2</b> 8 26 3   |                             | 123 <b>11</b> 2 127 212 <b>112</b> 1  | ;   |  |
|                      |  |                                  | FI                           | TUDIES  | 5                      |                               |                  |                                 |                             |                                       |   |  |
|                      |  | C                                | CHARACT                      | ERISTIC | S AND                  | EFFICIE                       | NCY AN           | ALYSIS                          | 5                           |                                       |   |  |
|                      | 12 cz  |                                  | 1 27 <b>-</b> 11 12 12 12 13 |         |                        |                               |                  | : 122 127 22 124 125 <b>2</b> 5 | a 112 un ne 112 au 212 :    | <b>28</b> 12 12 <i>28</i> 12 0        | a ua (ni nii in: ma <b>ini nii nii</b> ma |  |
|                      | COMB   | USTION                           | AIR :                        | REAR    |                        |                               | GLA              | ss Doc                          | DR : CL                     | OSED                                  |   |  |
|                      | CIRC   | ULATION                          | FANS                         | : NONE  |                        |                               | FUE              | L MATE                          | RIAL :                      | woor                                  |   |  |
|                      | FUEL   | TYPE :                           | DOUGL                        | AS FIR  |                        |                               | HEA              | TING V                          | ALUE =                      | 8379.(                                | )(BTU/LB)                                 |  |
|                      |  |                                  | <b></b>                      |         |                        |                               |                  |                                 |                             | an an an an an a                      |   |  |
|                      | MASS   | AIR IN                           | 1 =105.                      | 00(LB/M | IN)                    |                               | MAS              | S AIR                           | OUT =                       | 93.60                                 | (LB/MIN)                                  |  |
|                      | MASS   | DRY FL                           | UE GAS                       | =17.64  | (LB/MI                 | N)                            | MAS              | MASS COMB AIR = 5.69(LB/MIN)    |                             |                                       |   |  |
| 30 22 22 <b>22</b> 2 | 12 SI SI SI 22 IS IS IS IS   | ante 1977 teme 1989 ates teta se |                              |         |                        |                               |                  | - 122 5.21 525 522 523 523      | e arr die sid ett tip ter : | 1997 - 1997 - 1997 - 1997 - 1997 - 19 |   |  |
|                      | %02  | = .030                           | )                            | %CO     | 010                    | )                             | <b>XO</b> 2      | <b>%02</b> = .100               |                             |                                       |   |  |
|                      | %C =   | .560                             |                              | %H =    | .070                   |                               | ZMC              | %MC =0.000                      |                             |                                       |   |  |
|                      | (R.H   | •)LAB =                          | • •780                       | (R.H    | .)OUT                  | = ,580                        | (R.              | H,)ROC                          | )M = .4                     | 50                                    |   |  |
|                      | R 11 III III III III III III III                                   |                                  |                              |         | ana ben ann an ben ben |                               | ai 12 ai 12 ai 2 |                                 |                             |                                       | h ao tik in 10 m in 15 55 25 m            |  |
| TIME                 | FUEL<br>WEIGHT   |                                  |                              | TE      | MPERAT                 | URE(F)                        |                  |                                 |                             | EFF                                   | COMB AIR/<br>TOT LOSS                     |  |
| MIN                  | LB/MIN   | IN                               | STACK                        | FIRE    | CALR                   | LAB                           | ENV              | 7.                              | %                           |                                       |   |  |
| 0                    | 0 .3568 74.6 89.0 280.5 76.6 81<br>1 .3590 70.7 87.2 507.4 77.8 99 |                                  |                              |         |                        |                               |                  | 75.2                            | 68.8<br>69.1                | •12<br>•13                            | •10<br>•23                                |  |
| 2                    | .3601  | 74.0                             | 91.0                         | 526.9   | 79.4                   | 970.6                         | 76.9<br>79.2     | 75.9                            | 70.2                        | •13                                   | +24                                       |  |
| 3                    | .3598  | 73.0                             | 91.4                         | 512.1   | 79.2                   | 943.2                         | 78.7             | 75.4                            | 68.7                        | •14                                   | .23                                       |  |
| 4                    | .3532  | 73.1                             | 95.8                         | 503.4   | 80.3                   | 937.0                         | 79.0<br>78.3     | 75.8                            | 68.3                        | •18                                   | •24                                       |  |
|                      | <b>5 ,3</b> 579 70.8 96.0 373.0 79.0 973.3                         |                                  |                              |         |                        |                               |                  | 75.4                            | 69.7<br>20 7                | •20                                   | .17                                       |  |
| O                    | 6 • 3543 71•1 91•4 322•4 77•5 958•9                                |                                  |                              |         |                        |                               |                  | 76+4                            | 68.3                        | •16                                   | .13                                       |  |

AEF= .15 AQF=.179629E+06(BTU/HR) AQNH=.27059E+05(BTU/HR)

AQNHT=,19089E+05(BTU/HR)

AQFT=+144079E+06(BTU/HR)

AEFT = .13

|                             | TEST                              | NUMBE                    | R : 8-1                            |                                       |                                  | DATE : 12/4/78                |                      |                               |   |                                  |   |
|-----------------------------|-----------------------------------|--------------------------|------------------------------------|---------------------------------------|----------------------------------|-------------------------------|----------------------|-------------------------------|---|----------------------------------|---|
|                             | <u>13 12 12 13 13 12 13 1</u> 2 1 |                          | na 42 52 52 52 52 52 52            | : III III III III III III III III III | 1 30 62 22 23 25 <b>2</b> 5 14 6 |                               |                      | 1 12 55 22 12 12 27 13        | NC 400 FB 971 212 (                     | an |   |
|                             |                                   |                          | FI                                 | REPLACE                               | SIMUL                            | ATION S                       | TUDIES               |                               |   |                                  |   |
|                             |                                   | I                        | CHARACT                            | ERISTIC                               | S AND                            | EFFICIE                       | NCY AN               | ALYSIS                        | 5                                       |                                  |   |
|                             |                                   | - 13 11 11 11 11 11 11   |                                    |                                       |                                  |                               |                      |                               | <b></b>                                 | ne ne na 110 pe :                |   |
|                             | COME                              | NOTION                   | AIR :                              | FRONT                                 |                                  |                               | GLA                  | ss Doc                        | DR : CL                                 | OSED                             |   |
|                             | CIRC                              | ULATIO                   | N FANS                             | : NONE                                |                                  | FUE                           | L MATE               | RIAL :                        | woon                                    |                                  |   |
|                             | FUEL                              | TYPE                     | : DOUGL                            | AS FIR                                |                                  | HEA                           | TING V               | ALUE =                        | 8379.0                                  | O(BTU/LB)                        |   |
|                             |                                   |                          | 17 UN 77 PH UN 19 DA               | - 12 24 22 22 23 23 23                |                                  | 3 160 100 100 400 100 100 100 |                      | . <del>Ma</del> NE 22 NO 22 N |   | <b></b>                          | nan digin anan salah kuni gada adah sina salah sina<br>an digin anan salah kuni gada salah salah sina |
|                             | MASS                              | AIR I                    | N =105.                            | 00(LB/M                               | (NI)                             |                               | MAS                  | S AIR                         | 0UT = 1                                 | 93.60                            | (LB/MIN)  |
|                             | MASS                              | DRY F                    | LUE GAS                            | =15.58                                | N)                               | MASS COMB AIR = 3.52(LB/MIN)  |                      |                               |   |                                  |   |
| <b>11</b> 02 <b>12</b> 12 1 |                                   |                          |                                    |                                       |                                  |                               | -                    |                               |   | <b>111 111 112 21</b> 117 1      | tera aber abur sann yann binn vigat mibb daur mabb  |
|                             | %002                              | = .03                    | 0                                  | %0                                    | = .010                           | )                             | %02                  | = .10                         | 00                                      |                                  |   |
|                             | %C =                              | • 560                    |                                    | %H =                                  | .070                             |                               | %MC                  | =0.00                         | 0                                       |                                  |   |
|                             | (R•H                              | •)LAB =                  | 650                                | (R.H                                  | .)OUT                            | = .900                        | (R.                  | H.)ROC                        | )M = .5                                 | 40                               |   |
|                             | 12 112 112 117 119 70 119 110     |                          |                                    |                                       |                                  | . 20 22 12 37 29 29 21 13     | 194 an 195 195 an ai |                               |   | 14 mi en 13 Mi e                 | ne nue des aux son per aix aix aux  |
| TIME                        | FUEL<br>WEIGHT                    |                          |                                    | ז'ד                                   | MPERAT                           | URE(F)                        |                      |                               |   | FFF                              | COMB AIR/<br>TOT LOSS   |
|                             |                                   |                          | aan talar toos webs stor sawa away |                                       |                                  |                               |                      |                               | a yaya (una <u>ara</u> ayar ciki seki u |                                  |   |
| MIN                         | LB/MIN                            | IN<br>                   | OUT                                | STACK                                 | COMB                             | FIRE                          | CALR                 | LAB                           | ENV                                     | <b>%</b>                         | <b>%</b>  |
| 0                           |                                   | 60.7                     |                                    |                                       |                                  | 429.4                         |                      |                               | 60.7                                    | •04                              | .03   |
| 1                           |                                   | 60.6                     | 67.3                               |                                       |                                  | 485.8                         |                      |                               | 60.7                                    | •07                              | +09   |
| 2                           |                                   | 61.1                     |                                    | 223.5                                 |                                  |                               |                      |                               | 59.6                                    | .08                              | +08<br>09   |
| 3<br>4                      |                                   | 63.2<br>61.4             |                                    | 228.0<br>377.0                        |                                  |                               |                      | 78.4<br>79.4                  | 61.5                                    | .07<br>.11                       | .08<br>.16  |
| 4<br>5                      |                                   | 60.3                     |                                    |                                       |                                  | 602+0                         |                      |                               |   | •14                              | •11   |
| 6                           |                                   | 63.8                     | 73.0                               |                                       |                                  | 632.6                         |                      |                               | 60.6                                    | • 11                             | .09   |
|                             |                                   | NT 22 122 122 222 22 22  |                                    |                                       |                                  | 122 22 33 56 30 <u>22</u> 22  |                      |                               | 10 10 50 10 40 10 1                     |                                  | na fran punt daga aran yeku aran masa dana ange<br>n man cana raga bury san dana ange masa raga bury  |
| AEF=                        | = .09                             |                          | AQF=.                              | 110077E                               | +06(BT                           | U/HR)                         |                      | AQNH≔                         | •98043E                                 | E+04(1                           | BTU/HR)   |
|                             | <b>1</b> 22 12 12 12 12 12 12 12  | AL 371 112 112 312 317 3 | : 111 111 111 <b>11</b> 2 115 115  | 117, 118 als dis dis sit set          | \$5 mi 100 mi 100 an             |                               |                      |                               | 112 112 112 112 112 112 1               | <b>u na ne a</b> e 12 r          | ) an an an an an an ini an an an  |

|                            | TEST           | NUMBER                     | R : 8-2                        | DAT                 | DATE : 12/4/78          |          |                       |                              |                     |                        |                       |  |  |
|----------------------------|----------------|----------------------------|--------------------------------|---------------------|-------------------------|----------|-----------------------|------------------------------|---------------------|------------------------|-----------------------|--|--|
|                            |                | , an ar 12 17 10 m i       |                                | z az az az az az az |                         |          | 1 IIK EX 10 IIK EX 10 | s 22 00 10 00 00 10          | = == ## #2 #2 #2 #2 | <b>18 18 19 18 1</b> 8 | ==============        |  |  |
|                            |                |                            | FI                             | STUDIES             | 5                       |          |                       |                              |                     |                        |                       |  |  |
|                            |                | ſ                          | HARACI                         | NCY AN              |                         | <b>x</b> |                       |                              |                     |                        |                       |  |  |
|                            |                |                            |                                |                     |                         |          |                       |                              |                     |                        |                       |  |  |
|                            |                |                            |                                |                     |                         |          |                       |                              |                     |                        |                       |  |  |
|                            | COME           | USTION                     | AIR :                          | FRUNT               |                         |          | GLA                   | 155 DUC                      | )R : CL             | USED                   |                       |  |  |
|                            | CIRC           | ULATION                    | FANS                           | : NONE              |                         |          | FUE                   | EL MATE                      | ERIAL :             | WOOD                   |                       |  |  |
|                            | FUEL           | TYPE :                     | DOUGL                          | AS FIR              |                         |          | HEA                   | TING V                       | ALUE =              | 8379.                  | O(BTU/LB)             |  |  |
|                            |                |                            | <b>. 27 63 111 111 114 1</b> 1 |                     | : UR 111 112 112 112 11 |          |                       |                              |                     |                        |                       |  |  |
|                            | 5 A 4 45 45    | . <u>A</u> and part, and a |                                |                     |                         |          | 54 A (*               |                              | Ann. 1. ( 7997      | ~~ / ~                 |                       |  |  |
|                            | MASS           | AIR IN                     | ( =105,                        | 00(LB/M             | IIN)                    |          | MAS                   | MASS AIR DUT = 93.60(LB/MIN) |                     |                        |                       |  |  |
|                            | MASS           | DRY FL                     | UE GAS                         | =17.18              | CLB/MI                  | (N)      | MAS                   | S COMB                       | AIR =               | 4+54                   | (LE/MIN)              |  |  |
| ,;;;; ;;; ;;;; ;;;; ;;;; ; | ========       |                            |                                | . 112 122           | - 20 20 40 40 40 40     |          | ( )))                 |                              | -                   | <b>15 m 15 16</b> 70 1 |                       |  |  |
|                            | 2002           | = .030                     | )                              | %C0                 | = .010                  | <b>)</b> | 202                   | ×02 = .100                   |                     |                        |                       |  |  |
|                            |                |                            |                                |                     |                         |          |                       |                              |                     |                        |                       |  |  |
| ,                          | %C =           | •560                       |                                | %H ==               | •070                    |          | %MC                   | =0.00                        | 0                   |                        |                       |  |  |
|                            | (R+H           | •)LAB =                    | •650                           | (R.H                | г.) ойт                 | - • 900  | (R.                   | H.)R00                       | )M = +5             | 40                     |                       |  |  |
|                            |                |                            |                                |                     |                         |          | -                     |                              |                     |                        |                       |  |  |
|                            | -              |                            |                                |                     |                         |          |                       |                              |                     |                        |                       |  |  |
| TIME                       | FUEL<br>WEIGHT |                            |                                | TE                  | MPERAT                  | URE(F)   |                       |                              |                     | EFF                    | COMB AIR/<br>TOT LOSS |  |  |
|                            | LB/MIN         |                            |                                |                     |                         |          |                       |                              |                     |                        |                       |  |  |
|                            | •2845          | 63.8                       | 73.0                           | 245.9               | 64.2                    | 632.6    | 70.6                  | 79.2                         | 60.6                | .09                    |                       |  |  |
| 1                          |                | 60.5                       | 71.5                           | 422.6               | 64.6                    | 611.8    | 69.6                  | 76.7                         | 60.9                | .11                    | •18<br>•20            |  |  |
| 2                          | •2775          | 60.7                       | 72.4                           | 452.8               | 65+4                    | 629.5    | 70.4                  | 79.5                         | 60.2                | .12                    | .20                   |  |  |
| 3                          | •2838          |                            |                                |                     |                         |          |                       |                              |                     |                        |                       |  |  |
| 4                          | •2834          | 60.2                       | 73.4                           | 398.5               | 64.2                    | 642+8    | 71.9                  | 78.4                         | 60.2                | •14                    | •17                   |  |  |

74.3 297.8 64.2 667.3 72.2 77.3 60.3

AEF= .12 AQF=.141874E+06(BTU/HR) AQNH=.17529E+05(BTU/HR)

680.5 72.6 79.5 59.8

72.6 275.9 64.3

.12

.11

.15

.13

5

6

.2823

.2808

60.2

60.3

| TEST NUMBER : 8-3     |                |         |                                  |                                  |                          |                         |                               | DATE : 12/4/78                             |  |                              |                                    |  |
|-----------------------|----------------|---------|----------------------------------|----------------------------------|--------------------------|-------------------------|-------------------------------|--|--|------------------------------|------------------------------------|--|
| <b>20</b> 25 32 32 30 |                |         |                                  | 1 AM (127 AM (128 AM (127 AM (12 |                          |                         | <b>2 86 98 92 22 35 38</b> 53 |  |  |                              |                                    |  |
|                       |                |         | FI                               | REFLACE                          | SIMUL                    | ATION S                 | TUDIES                        |  |  |                              |                                    |  |
|                       |                | (       | CHARACT                          | ERISTIC                          | S AND                    | EFFICIE                 | INCY AN                       | ALYSIS                                     | 6                                      |                              |                                    |  |
|                       |                |         | = = = = = = = =                  |                                  | n 202 (de 100 (CC 100 12 |                         |                               |  | ng nyapi bala inga pina dan dan tasa   |                              |                                    |  |
|                       | COME           | NOTION  | AIR :                            | FRONT                            |                          |                         | GLA                           | ss Doc                                     | DR : CL                                | OSED                         |                                    |  |
|                       | CIRC           | ULATIO  | N FANS                           | : NONE                           |                          |                         | FUE                           | L MATE                                     | ERIAL :                                | WOOD                         |                                    |  |
|                       | FUEL           | TYPE :  | DOUGL                            | AS FIR                           |                          |                         | HEA                           | TING V                                     | VALUE =                                | 8379.0                       | (BTU/LB)                           |  |
| 12 (4 12 12 12 12     |                |         |                                  |                                  |                          |                         |                               |  |  |                              | LB/MIN)                            |  |
|                       |                |         |                                  |                                  |                          | N)                      |                               |  |  |                              |                                    |  |
|                       |                |         |                                  |                                  |                          |                         |                               |  |  |                              |                                    |  |
|                       |                | = .03(  |                                  |                                  | = .010                   |                         |                               | = .10                                      |  |                              |                                    |  |
|                       |                |         | ,                                |                                  |                          |                         |                               |  |  |                              |                                    |  |
|                       | %C =           | • 560   |                                  | %H =                             | • 070                    |                         | <b>%</b> MC                   | =0.00                                      | 0                                      |                              |                                    |  |
|                       | (R+H           | ·)LAB = | • • 650                          | (R.H                             | I.)OUT                   | = .900                  | (R.                           | H.)ROC                                     | )M = .54                               | 40                           |                                    |  |
| ======                |                | ***     | 0 <b>668</b> 135 220 481 375 138 |                                  |                          |                         |                               |  | id enne stade stade bedet enne derer t | 11 111 112 111 112 112<br>11 |                                    |  |
| TIME I                | FUEL<br>WEIGHT |         |                                  | TE                               | MPERAT                   | URE(F)                  |                               |  |  |                              | COMB AIR/<br>TOT LOSS              |  |
| MIN                   | LB/MIN         | IN      | 0UT                              | STACK                            | СОМВ                     | FIRE                    | CALR                          | LAB  | ENV                                    | %                            | %                                  |  |
|                       |                | 60.3    |                                  | 275.9                            |                          | 680.5                   | 72.6                          | 79.5                                       |  | .10                          | .10                                |  |
|                       | .3506          |         |                                  |                                  |                          | 687.6                   |                               | 77.6                                       |  | +13                          | .21                                |  |
|                       |                |         |                                  |                                  |                          | 680+4                   |                               |  |  | .15                          | •23                                |  |
|                       |                |         |                                  |                                  |                          | 699.2                   |                               |  |  | .15                          | • 23                               |  |
|                       |                |         |                                  |                                  |                          | 719.4                   |                               |  |  | .15                          | • 23                               |  |
|                       |                |         |                                  |                                  |                          | 734.1                   |                               |  |  |                              | •14                                |  |
| 6                     | •3506          | 38./    | /0+0                             | 302+1                            | 00+0                     | 681.8                   | 75.2                          | 78.3                                       | 60.3                                   | •15                          | .12                                |  |
| AEF=                  | •14            |         | AQF=.                            | 176544E                          | +06 (BT                  | U/HR)                   |                               | AQNH=                                      | .250516                                | E+05(B                       | TU/HR)                             |  |
| AEFT                  | = .12          |         | AQFT≕                            | .142831                          | E+06(B                   | TU/HR)                  |                               | AQNHT                                      | =+17462                                | 2E <b>+05</b> ()             | BTU/HR)                            |  |
|                       | <b></b>        |         | <b></b>                          | 23 12 12 12 12 12 12 12 12       |                          | NE NE NE 44 45 11 11 EE | 112 113 III III III III       | <b>na an</b> i <b>an</b> i <b>an</b> i 811 | -22 117 24 22 22 23 2                  | a the care dat the same i    | 11 III III III III III III III III |  |

|  | TEST                 | NUMBEI          | R : 20-                        | 1                                       |   |                           | DATE : 3/5/79             |  |                  |  |            |  |
|--|----------------------|-----------------|--------------------------------|---|---|---------------------------|---------------------------|--|------------------|--|------------|--|
|  | <b></b>              | . = = = = = = : |                                |   |   |                           | <b></b>                   |  |                  |  |            |  |
|  |                      |                 | FI                             | REPLACE                                 | E SIMUL   | ATION S                   | STUDIES                   | 1  |                  |  |            |  |
|  |                      | ,               | CHARACT                        | FRISTIC                                 | S ANTI  | FFFICIE                   | ENCY ANALYSIS             |  |                  |  |            |  |
|  |                      |                 |                                |   |   |                           |                           |  |                  |  |            |  |
|  |                      |                 |                                |   |   |                           |                           |  |                  |  |            |  |
|  | COMB                 | NOITZU          | AIR ;                          | KUUM                                    |   |                           | BLA                       | 155 1100                                 | )R : OP          | EN                                     |            |  |
|  | CIRC                 | ULATIO          | V FANS                         | : NONE                                  |   |                           | FUE                       | L MATE                                   | RIAL :           | WOOD                                   |            |  |
|  | FUEL                 | TYPE            | : DOUGL                        | HEA                                     | TING V  | ALUE =                    | 8379.(                    | (BTU/LB)                                 |                  |  |            |  |
|  | 11 W 12 W 12 20 11   |                 |                                | • |   |                           |                           | 14 Iola 189 Iola 199 700 200 100 100 100 |                  |  |            |  |
|  | MASS                 | AIR IN          | ۷ =165.                        | 00(LB/M                                 | (NI   |                           | MAS                       | S AIR                                    | OUT =1           | 54.80                                  | (LB/MIN)   |  |
|  | MASS                 | DRY FI          | UF GAS                         | =12.59                                  |   | 'N )                      | MAS                       | S COMP                                   | α ΔΤ <u></u> Ρ = | 3.390                                  | (LB/MIN)   |  |
|  |                      |                 |                                |   |   |                           |                           |  |                  |  |            |  |
|  | 2 22 M 60 M 51 57 25 |                 |                                | 311 ME 170 ME AN AR AR                  | . <b>20 10:</b> 24 11: 11                             |                           | : 200 750 200 100 100 100 |  |                  | 20 82 12 12 19 76 2                    |            |  |
|  | %02                  | = .030          | >                              | %CO                                     | = .01C  | )                         | 702                       | = .10                                    | 0                |  |            |  |
|  | %C =                 | •560            |                                | %H =                                    | • 070   |                           | %MC                       | =0.00                                    | 0                |  |            |  |
|  | (R+H                 | .)LAB =         | • •580                         | (R.H                                    | I.) OUT   | = .510                    | (R.                       | H.)ROO                                   | M = .4           | 00                                     |            |  |
| <b>1911 1111 1111 1117</b> 1117 11                               | <b></b>              |                 | -                              |   |   | , 72 60 27 28 18 18 28 28 |                           |  |                  |  |            |  |
|  | FUEL                 |                 |                                |   |   |                           |                           |  |                  |  | COMB AIR/  |  |
| TIME U   | JEIGHT               |                 |                                | TE                                      | MPERAT  | URE(F)                    |                           |  |                  | EFF                                    | TOT LOSS   |  |
| MIN L  | B/MIN                | IN              | OUT                            | STACK                                   | COMB  | FIRE                      | CALR                      | LAB                                      | ENV              | %                                      | %          |  |
|  | 2122                 | 53.8            | 58.3                           | 102.5                                   | 56+6  | 455.7                     |                           | 61.6                                     | 65.1             | •09                                    | +02        |  |
|  | 2166                 | 54.4            | 60.7                           | 236.9                                   |   |                           |                           | 62.8                                     |                  | .12                                    | • 09       |  |
|  | 2129                 |                 | 62.4                           | 322.1                                   |   |                           |                           | 62.6                                     |                  | •16                                    | •14        |  |
|  | 2173                 |                 | 62+1                           | 291.5<br>327.6                          | 58.8<br>50 0  | 762+1                     |                           |  | 62.1             | •14                                    | •12        |  |
|  | 2173                 |                 |                                |   |   |                           |                           | 62.5                                     |                  | •15                                    | •14        |  |
| 5 .2170 54.9 63.7 232.7 59.0 1<br>6 .2181 54.9 62.6 188.2 59.0 ( |                      |                 |                                |   |   |                           |                           |  | 62+1<br>61+6     | •18<br>•15                             | •10<br>•07 |  |
|  |                      |                 |                                | 112 III III III III III III             | idiji sute bişi sute jişa mişi<br>Seni vası sest dağı |                           |                           |  |                  |  | -          |  |
| AEF=   |                      |                 |                                |   |   | U/HR)                     |                           |  | .15334           |  |            |  |
|  |                      |                 | n 314 112 55 53 <b>4</b> 57 55 |   |   |                           |                           | ===========                              |                  | ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, |            |  |

| TEST NUMBE   | R : 20-2   |                              | DATE : 3/5/79  |                                      |                                |                                      |   |  |
|--|--|------------------------------|--|--------------------------------------|--------------------------------|--------------------------------------|---|--|
| <b>n u u u u u u u u u u u u u u u u u</b> u u u u u | FIREPLAC   |                              | STUDIES  |                                      |                                |                                      |   |  |
|  | CHARACTERISTI  |                              |  |                                      |                                |                                      |   |  |
| COMBUSTION   | AIR : ROOM   | ni 121 122 23 25 25 25       | ו ערה ערה אנגי אנג אינה אינה אינה אינה אינה אינה אינה אינה |                                      |                                | )R : OPI                             |   | # 12 12 12 12 12 12 12 13 13 13 12                   |
| CIRCULATIO   | N FANS : NONE  |                              |  | FUE                                  | L MATE                         | RIAL :                               | wood  |  |
| FUEL TYPE  | : DOUGLAS FIR  |                              | HEA  | TING V                               | ALUE =                         | B379.(                               | O(BTU/LB)                                     |  |
|  | <b>101 an 114 115 116 116 116 11</b> 7 117 117 117 117 117                                     |                              |  |                                      | :=======                       |                                      |   |  |
| MASS AIR I   | N =165.00(LB/  | MIN)                         |  | MAS                                  | S AIR                          | OUT =1                               | 54.80   | (LB/MIN)   |
| MASS DRY FI  | LUE GAS =13.20   | B(LB/MI                      | N)   | MAS                                  | S COME                         | AIR =                                | 4.55  | (LB/MIN)   |
|  |  |                              |  |                                      | 71 72 22 21 14 G               | 1 52 10 12 52 12 12 1                | 17 az 121 az 131 f                            |  |
| <b>%CO2</b> = .03                                    | 0 %00  | = .010                       | )  | <b>%</b> 02                          | = .10                          | 0                                    |   |  |
| %C = ₊560  | 2H -   | <b>• • 070</b>               |  | %MC                                  | =0.00                          | 0                                    |   |  |
| (R.H.)LAB =  | = .580 (R.H  | 4.)OUT                       | = .510   | (R.                                  | H.)ROC                         | )M = .40                             | 00  |  |
| FUEL<br>TIME WEIGHT                                  |  | MPERAT                       |  |                                      | 1997 - 200 100 100 100 100 100 |                                      |   | COMB AIR/<br>TOT LOSS                                |
| MIN LB/MIN IN  | OUT STACK  | COMB                         | FIRE   | CALR                                 | LAB                            | ENV                                  | %   | 7.   |
|  | 62.6 188.2<br>65.4 174.4<br>64.7 386.5<br>65.0 370.1<br>66.8 363.0<br>64.9 355.2<br>67.0 269.1 | 61.7<br>61.1<br>61.5<br>61.3 | 914.8<br>902.4<br>974.2                                    | 61.2<br>61.7<br>61.1<br>61.5<br>61.3 | 63,6<br>62,3<br>61,8           | 61.6<br>62.9<br>61.3<br>61.5<br>61.1 | .12<br>.12<br>.12<br>.15<br>.17<br>.15<br>.17 | .07<br>.06<br>.17<br>.17<br>.17<br>.17<br>.16<br>.11 |
| AEF= .14   | AQF=.140450E   | E+06(BT                      | U/HR)  |                                      | AQNH=                          | .202468                              | E+05(1  | STU/HR)  |

|   | TEST                                 | NUMBER                   | : 20-                | 3              |                          | DATE : 3/5/79                                 |                           |                            |  |                            |  |
|---|--------------------------------------|--------------------------|----------------------|----------------|--------------------------|---|---------------------------|----------------------------|--|----------------------------|--|
| an 35 55 50 10 10                                     | t w w := := := ::                    | 221 NZ 22 13 13 13 NJ 13 |                      | REPLACE        |                          |   |                           | 1 de su 112 en 131 su      | 12 12 IN 12 12 12  |                            |  |
|   |                                      | _                        |                      |                |                          |   |                           |                            |  |                            |  |
|   |                                      | C                        | HARACT               | ERISTIC        | S AND                    | EFFICIE                                       | ENCY AN                   | ALYSIS                     | 3  |                            |  |
| anna agus bais bhin sub an<br>suas bais agus anna sub |                                      | 112 27 20 22 27 19 19    |                      |                |                          | =   | : :# :#: :# :# :# #       | d ana 110 gata 120 gata 12 | te anni anti inte anni inte anni i   |                            |  |
|   | COMB                                 | USTION                   | AIR :                | ROOM           | •                        |   | GLA                       | ASS DOC                    | DR : OPI   | EN                         |  |
|   | CIRC                                 | ULATION                  | FANS                 | : NONE         |                          |   | FUE                       | L MATE                     | ERIAL :  | woop                       |  |
|   | FUEL                                 | TYPE :                   | DOUGL                | AS FIR         | HEA                      | TING V  | ALUE =                    | 8379.0                     | (BTU/LB)   |                            |  |
|   |                                      |                          |                      | 00(LB/M        |                          | - 88 28 22 32 39 39 65 33                     |                           |                            |  |                            | LB/MIN)  |
|   |                                      |                          |                      |                |                          | • • • •                                       |                           |                            |  |                            |  |
|   |                                      |                          |                      |                |                          |   |                           |                            |  |                            | LB/MIN)  |
| CE CP 13 15 15 15 15                                  |                                      |                          |                      |                |                          |   |                           |                            |  | 14 AZ 70 14 AZ 70          | 127 122 122 122 223 231 223 737 123                |
|   | <b>%C</b> 02                         | = .030                   |                      | 200            | 010                      | )   | 202                       | 2 = .10                    | 0  |                            |  |
|   | %C =                                 | .560                     |                      | %H =           | .070                     |   | %MC                       | =0.00                      | 0  |                            |  |
|   | (R•H                                 | .)LAB =                  | +580                 | (R.H           | •)OUT                    | = .510  | (R.                       | H.)R00                     | IM = +4(   | 00                         |  |
|   | <b>- 201 202 202 2</b> 0 - 202 202 - |                          |                      |                |                          | : ::: ::: ::: ::: ::: ::: :::                 |                           |                            | a water after gauge near dans with a<br>a gran neag tage water for state a | <b>II 62 III 72 III</b> 10 |  |
| TIME W  | FUEL<br>EIGHT                        |                          |                      | TE             | MPERAT                   | URE(F)  |                           |                            |  |                            | COMB AIR/<br>TOT LOSS                              |
|   |                                      |                          |                      | STACK          |                          |   |                           | <br>ι Δη                   | <br>ГNU  |                            |  |
|   |                                      |                          |                      |                |                          |   |                           |                            |  |                            | 1788 Aland Anda Anda and anna 4888, anna anna anna |
|   | 3532<br>3532                         | 56.2                     | 67.0                 | 269.1<br>222.6 |                          | 863.0   |                           | 62.6                       | 60.1<br>61.2   | •14<br>•14                 | •11<br>•09   |
|   | 3524                                 |                          |                      | 426.6          |                          |   |                           |                            | 01.2<br>59.8   |                            | •09  |
|   | 3539                                 |                          |                      | 446+3          |                          |   |                           |                            | 61.6   |                            | .20  |
|   | 3524                                 |                          |                      | 436.6          |                          |   |                           |                            |  |                            |  |
|   |                                      |                          |                      | 405.8          |                          |   |                           |                            |  |                            |  |
| 6.  | 3524                                 | 57.8                     | 70.4                 | 292.2          | 65.5                     | 809.5   | 65.5                      | 63.0                       | 60.7   | .17                        | .12  |
|   |                                      |                          |                      |                |                          |   | 111 CH 22 III 71 III      |                            |  |                            |  |
| AEF=  |                                      |                          |                      | 177599E        |                          |   |                           |                            | .257638  |                            | TU/HR)   |
| AEFT=   | •14                                  |                          | AQFT=                | •142199        | E+06(B                   | TU/HR)  |                           | AQNHT                      | <b>=.</b> 20447  | 7E+05()                    | BTU/HR)  |
| AZ 221 CIN 122 KZ 127                                 |                                      | ui cur un ite cu ite cu  | na 112 ne st na en f |                | <b>10 11 11 11 11</b> 11 | <b>un di</b> : 160 <del>170 372</del> 113 185 | (#1 <u>11</u> 11 11 11 11 | an an 111 Int Int Int      |  | <b># ## ## 00 00 00</b> 1  | 111 THE 201 HE III THE ROLL OF STR                 |

|                                  | TEST                                  | NUMBER                                  | २ : 16-              | 1                             |                            | DATE : 3/28/79   |              |                       |                     |                         |                                 |
|----------------------------------|---------------------------------------|---|----------------------|-------------------------------|----------------------------|--|--------------|-----------------------|---------------------|-------------------------|---------------------------------|
| # <b># #</b> = =                 |                                       |   | <b>.</b>             | : e= == 1,; == == == ==       |                            |  |              |                       |                     |                         |                                 |
|                                  |                                       |   | FI                   | REPLACE                       | ATION S                    | STUDIES  |              |                       |                     |                         |                                 |
|                                  |                                       | (                                       | CHARACT              | ERISTIC                       | S AND                      | EFFICIE  | INCY AN      | ALYSIS                | 3                   |                         |                                 |
|                                  |                                       | 782 H2 777 P-3 H2 782 C                 |                      | - 121 117 112 112 112 112 112 |                            | ین جد سالت میں اور این اور این اور |              |                       |                     |                         |                                 |
|                                  | COMB                                  | NOITSU                                  | AIR :                | REAR                          |                            |  | GLA          | ss poc                | )R : OPI            | EN                      |                                 |
|                                  | CIRC                                  | ULATION                                 | FANS                 | : NONE                        |                            | FUE  | L MATE       | RIAL :                | WOOD                |                         |                                 |
|                                  | FUEL                                  | TYPE 3                                  | DOUGL                | AS FIR                        |                            | HEA  | TING V       | ALUE =                | 8379.0              | )(BTU/LB)               |                                 |
| <b>1940 - 1940 - 1940 - 1940</b> |                                       |   | - 64 85 55 12: 55 33 | : 115 111 (°C (°C 115 11) ()  | ;                          |  |              |                       |                     |                         |                                 |
|                                  | MASS                                  | AIR IN                                  | 148.                 | 50(LB/M                       | (NI                        |  | MAS          | S AIR                 | OUT =1              | 36,80                   | (LB/MIN)                        |
|                                  | MASS                                  | DRY FL                                  | UE GAS               | =12.59                        | (N)                        | MASS COMB AIR = 3.46(LB/MIN)   |              |                       |                     |                         |                                 |
| Was your dive tool :             |                                       | 14 <u>24 15 14 55 18</u> 8              |                      | 120 121 255 122 128 129 15    |                            |  |              | , na 22 10 10 au an 1 | ca :na car ant na c |                         |                                 |
|                                  | %CO2                                  | <b>≕</b> ,030                           | )                    | %C0                           | = .010                     | )  | %02          | 10                    | 0                   |                         |                                 |
|                                  | %C =                                  | .560                                    |                      | %H =                          | •070                       |  | %MC          | =0.00                 | 0                   |                         |                                 |
|                                  | (R.H                                  | •)LAB =                                 | • 500                | (R.H                          | I.)OUT                     | = .660   | (R.          | H.)ROO                | IM = +4(            | 00                      |                                 |
| <b>12 12 12 12 1</b> 2 1         | <b>19 11 12</b> 16 12 17 <b>13 13</b> | <b>119 al: 119 119 119 11</b> 9 119 119 | n na bo in ta in lat |                               |                            |  |              |                       |                     | nan anna anna san inn a |                                 |
| TIME                             | FUEL<br>WEIGHT                        |   |                      | TE                            | MPERAT                     | URE(F)   |              |                       |                     | EFF                     | COMB AIR/<br>TOT LOSS           |
| MIN                              | LB/MIN                                | IN                                      | OUT                  | STACK                         | COMB                       | FIRE   | CALR         | LAB                   | ENV                 | 7.                      | <b>%</b>                        |
| 0                                | •2170                                 | 63.0                                    | 64.9                 | 80.7                          | 71.0                       | 435.0  | 64.9         |                       | 67.5                | .03                     | .01                             |
| 1                                | +2206                                 | 64.9                                    | 67.7                 | 151.2                         | 67.7                       | 556.6  | 67.2         | 66,8                  | 68.0                | .05                     | •04                             |
| 2                                | .2214                                 | 64.5                                    | 69.0                 | 222.9                         | 67.5                       | 563.5  | 67.8         | 66.9                  | 68.1                | •08                     | •08                             |
| 3                                | .2195                                 | 66+2                                    | 71.5                 | 328.2                         | 68.3                       | 701.3  | 69.3         | 66.7                  | 69.2                | •10                     | •13                             |
| 4                                | •2228                                 | 65.8                                    | 71.7                 | 286.9                         | 93.7                       | 782.7  | 69.8         | 66.6                  | 70.7                | .10                     | + 11                            |
| 5<br>6                           | •2206<br>•2199                        | 64+7<br>66+8                            | 72.1<br>72.1         | 270.3<br>184.4                | 67.6<br>88.8               | 743.9<br>677.2   | 69.4<br>70.7 | 66•6<br>66•6          | 68.6<br>70.8        | •14<br>•09              |                                 |
|                                  |                                       |   |                      |                               |                            |  |              |                       |                     |                         | r (12 67) 57) 18 17 52 53 88 62 |
|                                  | = .09                                 |   |                      |                               |                            | U/HR)  |              |                       | •94783E             |                         | STU/HR)                         |
| 25 22 <u>32</u> 22 :             |                                       |   |                      |                               | and the first state of the |  |              |                       |                     | a                       |                                 |

| TEST NUMBER   | : : 16-2   | D   | DATE : 3/28/79  |  |  |  |  |
|---|--|---|---|--|--|--|--|
|   |  |   |   |  |  |  |  |
|   | FIREPLACE SIMUL  | ATION STUDI   | UDIES   |  |  |  |  |
| C   | CHARACTERISTICS AND  | EFFICIENCY  | ANALYSIS  |  |  |  |  |
|   |  |   |   |  |  |  |  |
| COMBUSTION  | AIR : REAR   | G   | LASS DOOR : OP  | EN   |  |  |  |
| CIRCULATION   | FANS : NONE  | F   | UEL MATERIAL :  | WOOD   |  |  |  |
| FUEL TYPE :   | DOUGLAS FIR  | н   | EATING VALUE =  | 8379.0(BTU/LB)   |  |  |  |
|   |  |   |   |  |  |  |  |
| MACC ATE TA   | =148+50(LB/MIN)  | м   | ASS AIR OUT =1  | 74 00/1 12/MTNN  |  |  |  |
|   |  |   |   |  |  |  |  |
| MASS DRY FL   | UE GAS =13.28(LB/M)  | EN) M   | ASS COMB AIR =  | 4.57(LB/MIN)   |  |  |  |
| 42 (12 12) 42 (12 12 12 12 12 12 13 13 15 15 12 12 12 12 12 12 12 12 12 12 12 12 12             | , 122 (12 AD 50 50 AD 50 AD 50 AN 20 AN 20 AD 50 AN 50 AN 50 AN 50 AN                              | - 15 13 18 21 21 19 19 19 19 19 19 19                       | 271 227 307 722 112 771 277 377 372 888 887 187 288 288 188   |  |  |  |  |
| <b>%CO2</b> = .030  | 200 = .010   | ) %   | 02 = .100   |  |  |  |  |
| <b>%C</b> = .560  | %H = .070  | 21  | MC =0.000   |  |  |  |  |
| (R.H.)LAB =   | .500 (R.H.)OUT   | = .660 (1   | R.H.)ROOM = .4  | 00   |  |  |  |
| אם עם וווה מה שב בס שב שה כל לם אם של שי שו עם של או היו או | י שב את זות שב בינו זמן שה את שה את את היום ביבו ונון את את או |   | שנה שלו שבו אני נוין בער און אין אין אין אין אין און אין און אין אין אין אין אין אין אין אין אין אי | אה זות וננו ננו אה אה גות לכו של איז גם את או או או או או או עת                      |  |  |  |
| FUEL<br>TIME WEIGHT   | TEMPERAT   | THRE (E)  |   | COMB AIR/<br>EFF TOT LOSS  |  |  |  |
|   |  | a anal muun muun yang araw yana saga muga anan gaba dijan u |   | pante anno viver stage anne aver viver attai minis stats viver teas viver vante para |  |  |  |
| MIN LB/MIN IN   | OUT STACK COMB   | FIRE CAL  | R LAB ENV   | */* */*  |  |  |  |
| 0.2863 66.8   | 72.1 184.4 88.8  | 677.4 70.1  |   | .07 .06  |  |  |  |
| 1 .2871 65.8  | 73.1 368.9 69.0  | 674.8 71.3  |   | .11 .15  |  |  |  |
| 2 .2885 67.1  | 75.0 411.8 69.6  | 699+4 72+6  |   | .12 .18  |  |  |  |
| 3,2863 66.4   | 76.5 401.1 70.1  | 665.5 72.0  |   | .15 .18  |  |  |  |
| 4 .2863 67.7  | 78.3 355.5 71.3  | 693.2 76.0  |   | .17 .15  |  |  |  |
| 5 .2863 67.4  | 79.9 288.9 71.9  | 873.9 77.   |   | .20 .12  |  |  |  |
| 6 .2882 68.3  | 79.3 280.3 72.5  | 902.3 77.8  | 3 67.3 72.4   | .17 .11  |  |  |  |
| AEF= .14  | AQF=.144299E+06(BT   |   | AQNH=.20344E+05(BTU/HR)   |  |  |  |  |
|   | HMI+ 1   | WZ FINZ   | AUNH#+20344E+03(BIU/HR)   |  |  |  |  |

## B-42

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|               |                           |                        | R : 16-              |              |                         | DATE : 3/28/79                  |                    |                   |                            |                       |                    |  |
|---------------|---------------------------|------------------------|----------------------|--------------|-------------------------|---------------------------------|--------------------|-------------------|----------------------------|-----------------------|--------------------|--|
|               | # 26 25 86 52 88 92 82 32 | ; 82 24 25 25 25 22 22 |                      |              |                         | _ATION S                        |                    |                   | 2 33 <u>32</u> 63 42 22 82 | 12 III 12             |                    |  |
|               |                           |                        |                      |              |                         | EFFICIE                         |                    |                   |                            |                       |                    |  |
| : == == == == |                           |                        | AIR :                |              | 8 128 WA IN IN IN 12 13 | - 127 27 22 22 22 22 23         |                    |                   | DR : OP                    |                       |                    |  |
|               | CIRC                      | ULATIO                 | N FANS               | : NONE       |                         |                                 | FUE                | L MATE            | RIAL :                     | woon                  |                    |  |
|               |                           |                        | : DOUGL              |              |                         |                                 |                    |                   |                            |                       | O(BTU/LE           |  |
| 5K 101 M2 101 |                           |                        |                      | 50(LB/M      |                         | : 52 211 ita 22 iii iia iii iii |                    |                   |                            |                       | (LB/MIN)           |  |
|               |                           |                        |                      |              |                         | :N)                             |                    |                   |                            |                       | (LB/MIN)           |  |
|               |                           | - • 03                 |                      |              | 010                     |                                 |                    | . = .10           |                            | ing Dat wet one reg - |                    |  |
|               | %C =                      | .560                   |                      | <b>%</b> H = | • 070                   |                                 | <b>%M</b> C        | =0.00             | 0                          |                       |                    |  |
|               |                           |                        |                      |              |                         | - • 660                         |                    |                   |                            |                       |                    |  |
|               | FUEL<br>WEIGHT            | an at at at at a       | 12 ES 32 NE 12 ES 13 |              | MPERAT                  |                                 | an 14 m an 10 m an | 20 22 04 AT 12 13 | : 82 52 52 52 53 53 56 5   |                       | COME AI<br>TOT LOS |  |
| 1IN           | LB/MIN                    | IN                     | оит                  | STACK        | COMB                    | FIRE                            | CALR               | LAB               | ENV                        | 7.                    | <u>"</u>           |  |
| 1             | .3590                     |                        |                      | 466.3        | 73.9                    | 902.3<br>905.7                  | 80.0               | 67.7              |                            | •16                   | •11<br>•21         |  |
|               |                           |                        | 79.3                 |              |                         | 796+3                           |                    |                   |                            |                       | • 22               |  |
|               | .3616                     |                        |                      |              |                         |                                 |                    |                   |                            |                       | .20                |  |
|               | •3568<br>•3598            |                        |                      |              |                         | 771.9<br>775.8                  |                    |                   |                            |                       |                    |  |
|               | .3616                     |                        |                      |              |                         |                                 |                    |                   |                            | •16                   | .16                |  |
| λEF=          | .16                       |                        | AQF=.                | 180499E      | +06 ( BT                | UZHR)                           |                    | AQNH=             | .29287E                    | E+05(1                | BTU/HR)            |  |
| <b>ΑEFT</b>   | = .13                     |                        | AQFT=                | .145178      | E+06(B                  | TU/HR)                          |                    | AQNHT             | =.19703                    | 3E+05(                | (BTU/HR)           |  |

| FIREPLACE SIMULATION STUDIES   |                |
|--|----------------|
|  |                |
| CHARACTERZOTZCO AND ETTETOTENCY ANALVOTC   |                |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS  | berm bern unst |
|  |                |
| COMBUSTION AIR : FRONT GLASS DOOR : OPEN   |                |
| CIRCULATION FANS : NONE FUEL MATERIAL : WOOD   |                |
| FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/L  | B)             |
|  |                |
| MASS AIR IN =161.25(LB/MIN) MASS AIR OUT =144.00(LB/MIN  | >              |
| MASS DRY FLUE GAS =12.59(LB/MIN) MASS COMB AIR = 3.43(LB/MIN   | )              |
|  | 77 er 22       |
| XCO2 = .030 XCO = .010 XO2 = .100  |                |
| %C = .560 %H = .070 %MC =0.000   |                |
| (R.H.)LAB = .860 (R.H.)OUT = .960 (R.H.)ROOM = .600  |                |
|  |                |
|  | - <b>-</b> , , |
| FUEL COMB A TIME WEIGHT TEMPERATURE(F) EFF TOT LC  |                |
| MIN LB/MIN IN OUT STACK COMB FIRE CALR LAB ENV % %   |                |
| 0 ,2148 60,0 62,7 80,9 65,0 137,2 63,0 71,7 60,9 ,04 ,01   |                |
| 1 .2155 60.4 63.2 352.1 64.5 259.7 62.9 70.5 61.4 .04 .14  |                |
| 2 .2188 60.5 65.4 331.4 67.0 344.8 63.4 71.4 60.4 .08 .13  |                |
| 3 .2162 60.6 66.1 323.6 69.0 442.0 63.6 70.5 64.0 .10 .13  |                |
| 4 .2173 60.9 69.0 301.2 70.1 504.8 64.5 71.7 63.0 .15 .13  |                |
| 5 .2151 61.6 69.4 289.4 70.9 594.5 65.3 71.6 62.8 .15 .12<br>6 .2170 61.6 70.2 201.9 71.8 380.1 65.2 70.9 62.4 .16 .07 |                |
| n frank (1440) (045 molt) (140 GOAAL ODAN (047) GLAN (100 40)  |                |
| AEF= ,10 AQF=,108785E+06(BTU/HR) AQNH=,11326E+05(BTU/HR)   |                |
|  | 111 ins As     |

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|   | TEST NUMBER : 18-2                                 |  |  |  |  |  |  |  | DATE : 2/23/79                               |  |   |  |  |  |
|---|--|--|--|--|--|--|--|--|--|--|---|--|--|--|
|   |  |  |  |  |  |  |  |  |  |  |   |  |  |  |
| FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS |  |  |  |  |  |  |  |  |  |  |   |  |  |  |
| COMBUSTION AIR : FRONT GLASS DOOR : OPEN                                |  |  |  |  |  |  |  |  |  |  |   |  |  |  |
|   | CIRC   | ULATION                                      | FANS   | : NONE   | FUE  | L MATE   | RIAL :                                       | wood   |  |  |   |  |  |  |
|   | FUEL   | TYPE   | TIOUGL                                       | AS FIR   |  |  | HEA  | TING V                                       | ALUE =                                       | 8379.                                  | O(BTU/LB)                                   |  |  |  |
| FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU                       |  |  |  |  |  |  |  |  |  |  |   |  |  |  |
|   |  | AIR IN                                       |  |  | MASS AIR OUT =144.00(LB/MIN)                 |  |  |  |  |  |   |  |  |  |
|   | MASS   | DRY FL                                       | .UE GAS                                      | MAS  | MASS COMB AIR = 4.52(LB/MIN)                 |  |  |  |  |  |   |  |  |  |
|   |  |  |  |  |  |  |  |  |  |  |   |  |  |  |
|   | %002   | - • 030                                      | %C0  | 202  | ×02 = .100                                   |  |  |  |  |  |   |  |  |  |
|   | %C =   | •560   |  | %H =   | %MC  | ZMC =0.000   |  |  |  |  |   |  |  |  |
|   | (R.H   | 1.)LAB =                                     | • 860  | (R+H   | (R.  | (R.H.)ROOM = .600                                  |  |  |  |  |   |  |  |  |
| 20 27 28 18 1   |  |  |  | UN 22 10 NO 12 10 NO                               | na 10 Mi 54 Mi 45                            | : 112 MH (11: 112 MH 142 MH                        |  | 177 Nov 194 Tax 215 Ca                       | - 112 115 34 35 115 36 1                     |  | tte size son gest base son son aven son ber |  |  |  |
| TIME  | FUEL<br>(IME WEIGHT TEMPERATURE(F)                 |  |  |  |  |  |  |  |  | EFF                                    | COMB AIR/<br>TOT LOSS                       |  |  |  |
| MIN   | LB/MIN   | IN   | OUT  | STACK  | COMB   | FIRE   | CALR   | LAB  | ENV  | %                                      | %   |  |  |  |
| 0<br>1<br>2<br>3<br>4<br>5  | .2830<br>.2827<br>.2834<br>.2830<br>.2827<br>.2845 | 61.6<br>61.9<br>61.6<br>61.3<br>62.0<br>61.9 | 70.2<br>69.7<br>68.6<br>70.7<br>71.3<br>72.1 | 201.9<br>273.9<br>401.3<br>409.1<br>363.8<br>258.3 | 71.8<br>72.1<br>71.4<br>73.3<br>75.3<br>75.0 | 380.1<br>468.8<br>751.8<br>573.4<br>691.1<br>818.4 | 65.2<br>65.5<br>65.5<br>65.9<br>66.9<br>66.5 | 70.9<br>72.1<br>70.7<br>72.4<br>70.6<br>71.8 | 62.4<br>63.1<br>63.0<br>63.1<br>63.5<br>62.9 | .12<br>.11<br>.10<br>.13<br>.14<br>.15 | .07<br>.11<br>.17<br>.18<br>.16<br>.10      |  |  |  |
| 6   | •2856  | 61.8   | 71.5   | 236.6  | 75.4   | 515.6  | 66.6   | 70.1   | 63.8   | •14                                    | •09   |  |  |  |

AEF= .13 AQF=.142559E+06(BTU/HR) AQNH=.18201E+05(BTU/HR)

|   | R : 18-                          |                                  | DATE : 2/23/79               |                                 |                                  |                                 |             |                     |                              |                              |  |  |  |  |  |
|---|----------------------------------|----------------------------------|------------------------------|---------------------------------|----------------------------------|---------------------------------|-------------|---------------------|------------------------------|------------------------------|--|--|--|--|--|
| FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS |                                  |                                  |                              |                                 |                                  |                                 |             |                     |                              |                              |  |  |  |  |  |
|   | COMB                             | USTION                           | AIR :                        | FRONT                           |                                  |                                 | GLA         | GLASS DOOR : OPEN   |                              |                              |  |  |  |  |  |
|   | CIRC                             | ULATION                          | FANS                         | FUE                             | L MATE                           | RIAL :                          | woor        |                     |                              |                              |  |  |  |  |  |
|   | FUEL                             | TYPE :                           | DOUGL                        | AS FIR                          |                                  |                                 | HEA         | TING V              | ALUE =                       | 8379.0                       | (BTU/LB)   |  |  |  |  |
| <b>10 33 65 15 65 65</b> 12 5   |                                  |                                  |                              |                                 |                                  |                                 |             |                     |                              |                              |  |  |  |  |  |
|   | 1 =161.                          | MAS                              | MASS AIR OUT =144.00(LB/MIN) |                                 |                                  |                                 |             |                     |                              |                              |  |  |  |  |  |
|   | MASS DRY FLUE GAS =13.96(LB/MIN) |                                  |                              |                                 |                                  |                                 |             |                     |                              | MASS COMB AIR = 5.68(LB/MIN) |  |  |  |  |  |
|   |                                  | Same prin trag time care dian ad | r and ter has bee the set    |                                 | na ann ann 21st ath ann 2st      | : :::: :::: :::: :::: :::: :::: |             |                     |                              | 12 111 IV: 111 IV: 111       | ie alle alle blak yog syk ardt and alle and aret                     |  |  |  |  |
|   | <b>%</b> C02                     | = .030                           | )                            | %C0                             | = .010                           | ,                               | <b>X</b> 02 | ×02 = .100          |                              |                              |  |  |  |  |  |
|   | %C =                             | .560                             |                              | %H =                            | 070                              |                                 | %MC         | %MC =0.000          |                              |                              |  |  |  |  |  |
|   | (R.H                             | .)LAB =                          | .860                         | (R.)                            | 4.)OUT                           | 960                             | (R.         | (R.H.)ROOM = .600   |                              |                              |  |  |  |  |  |
|   | <b>1 100 100 10</b> 0 100 100    | de en en de be ar                | : <u>15 #2 (5) #2 72</u> 72  | 101 111 111 <b>211 111 11</b> 1 | <b>i 186 al 187 188 6</b> 77 183 | 100 00 02 02 12 05 05           |             | 122 AD 422 AZ 22 AZ | - 156 Filt 201 JET 211 XEE 2 |                              | <b>1 (11 (12 (12 (12 (13 (14 (14 (14 (14 (14 (14 (14 (14 (14 (14</b> |  |  |  |  |
| F<br>TIME WE  | UEL<br>IGHT                      |                                  |                              | TE                              | EMPERAT                          | URE(F)                          |             |                     |                              | EFF                          | COMB AIR/<br>TOT LOSS  |  |  |  |  |
| MIN LE  | MIN                              | IN                               | оит                          | STACK                           | СОМВ                             | FIRE                            | CALR        | LAB                 | ENV                          | %                            | %  |  |  |  |  |
|   |                                  | 61.8                             |                              | 236.6                           |                                  |                                 |             |                     | 63.8                         | .11                          | .09  |  |  |  |  |
|   | 605                              | 62.1                             | 72.2                         | 304.0                           | 121.0                            | 521.1                           | 66.9        | 71.5                | 63.1                         |                              | .12  |  |  |  |  |
| 2 •3<br>3 •3  | 561                              | 62.1                             | 72.3                         | 470.9                           | 137.7                            | 658,9<br>656,0                  | 68.2        | 71.4                | 63.5                         | •11                          | •21  |  |  |  |  |
| 4 • 2   | 598<br>561                       | 61+7<br>62.1                     | 74+3<br>74-9                 | 472+9                           | 148+1                            | 638.0<br>639.7                  | 68.7        | 71+1<br>70.0        | 63.1                         | •13<br>•14                   | •21<br>•21   |  |  |  |  |
|   | 568                              | 62.3                             | 73.0                         | 466.4                           | 139.3                            | 517.1                           | 68.7        | 70.2                | 63.6                         | .12                          | •21  |  |  |  |  |
|   | 656                              | 62.1                             | 74.9                         | 343.3                           | 134.8                            | 903.0                           | 68.9        | 72,8                | 64.1                         | .14                          |  |  |  |  |  |
| AEF= .  | AEF= .12 AQF=.180341E+06(BTU/HR) |                                  |                              |                                 |                                  |                                 |             |                     | AQNH=.21842E+05(BTU/HR)      |                              |  |  |  |  |  |
| AEFT=   | .12                              |                                  | AQFT=                        | .143895                         | 5E+06(B                          | TU/HR)                          |             | AQNHT               | =.17123                      | SE+05(                       | BTU/HR)  |  |  |  |  |

| TEST NUMBER : 21-1                        |                                  |  |  |   |        |                                      | DATE : 3/12/79    |                          |  |        |  |  |  |  |
|---|----------------------------------|--|--|---|--------|--------------------------------------|-------------------|--------------------------|--|--------|--|--|--|--|
|   |                                  |  |  |   |        |                                      |                   |                          |  |        |  |  |  |  |
| FIREPLACE SIMULATION STUDIES              |                                  |  |  |   |        |                                      |                   |                          |  |        |  |  |  |  |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS   |                                  |  |  |   |        |                                      |                   |                          |  |        |  |  |  |  |
|   | 7 14 18 48 18 m                  |  | -  |   |        |                                      |                   | - 212 331 355 125 316 51 |  |        | - 222 717 212 222 222 224 224 225 225              |  |  |  |
| COMBUSTION AIR : ROOM GLASS DOOR : CLOSED |                                  |  |  |   |        |                                      |                   |                          |  |        |  |  |  |  |
|   | CIRC                             | ULATION  | FANS   | FUE   | L MATE | RIAL :                               | WOOD              |                          |  |        |  |  |  |  |
|   | FUEL TYPE : DOUGLAS FIR          |  |  |   |        |                                      |                   |                          | ALUE =   | 8379.0 | (BTU/LB)   |  |  |  |
| ari ne 10 me 20 12 1                      | <b></b>                          |  | 2 22 27 27 27 27 27  |   |        | a sana mara dina jindi sana Mini san |                   |                          | - 111  |        | 1 TTI 123 TTI 123 TTI 123 TTI 123                  |  |  |  |
|   | MASS                             | AIR IN   | v =165.  | MASS AIR OUT =151.20(LB/MIN)  |        |                                      |                   |                          |  |        |  |  |  |  |
|   | MASS DRY FLUE GAS =12.36(LB/MIN) |  |  |   |        |                                      |                   |                          | MASS COMB AIR = 3.43(LB/MIN)   |        |  |  |  |  |
|   |                                  |  |  |   |        |                                      |                   |                          |  |        |  |  |  |  |
|   | <b>%CO2 = .030 %CO = .010</b>    |  |  |   |        |                                      |                   |                          | X02 = .100   |        |  |  |  |  |
|   | %C = .560 %H = .070              |  |  |   |        |                                      | %MC =0.000        |                          |  |        |  |  |  |  |
|   | (R.H                             | •)LAB =  | 450  | (R.H  | •)OUT  | = +440                               | (R.H.)ROOM = .480 |                          |  |        |  |  |  |  |
|   | <b>. III I</b> II 111 117 117    | anna dhir acda adan aran duna ada<br>anna dhir aran anna daga aran dha | na adam bayar danar aynar anna yana<br>a ganar danar danar yanar yanar annar | in in ones have been been area and<br>the ones have a set and which along state |        | unte open bury onto man dess dess    | <b></b>           | 705 101 xxx 505 104 101  | - Banti pinan artik kolar ditar vamo d<br>- Banti pinan kata liyon dinan kolar p |        | anam pros base them been your aver both parts they |  |  |  |
| F<br>TIME WE                              | UEL<br>IGHT                      |  |  | TE  | MPERAT | URE(F)                               | COMB<br>EFF TOT L |                          |  |        |  |  |  |  |
| MIN LE                                    | MIN                              | IN   | OUT  | STACK   | СОМВ   | FIRE                                 | CALR              | LAB                      | ENV  | %      | " <u>"</u>   |  |  |  |
|   | 2151                             |  |  |   |        | 482.4                                |                   |                          |  | •11    | •03  |  |  |  |
|   | 159                              |  |  | 352.3   |        |                                      |                   |                          | 67.2   | •06    | .14  |  |  |  |
|   |                                  |  |  | 267.4   |        |                                      |                   |                          | 67.2   |        | .10  |  |  |  |
|   | 181                              |  |  |   |        | 568.9                                |                   |                          |  |        | +17  |  |  |  |
|   |                                  |  |  | 368.5   |        |                                      |                   |                          |  | •09    | +15  |  |  |  |
|   | 166<br>166                       |  |  | 231.0   |        | 589.3<br>568.5                       |                   |                          | 63.5   |        | .10<br>.09   |  |  |  |
|   |                                  | ni 25 m 28 m 28 m 26   |  |   |        |                                      |                   |                          |  |        | an an an an ag an an an an                         |  |  |  |
| AEF= .                                    |                                  |  |  |   |        | U/HR)                                |                   |                          | ·10175   |        |  |  |  |  |
| 18 18 18 12 12 13 55 13                   |                                  |  |  |   |        |                                      |                   |                          |  |        |  |  |  |  |

| TES   | Т NUMBE   | R : 21  | DA          | DATE : 3/12/79               |                           |                    |                   |              |        |           |  |  |
|---|-----------|---------|-------------|------------------------------|---------------------------|--------------------|-------------------|--------------|--------|-----------|--|--|
|   |           |         |             |                              |                           |                    |                   |              |        |           |  |  |
| FIREPLACE SIMULATION STUDIES                  |           |         |             |                              |                           |                    |                   |              |        |           |  |  |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS       |           |         |             |                              |                           |                    |                   |              |        |           |  |  |
|   |           |         |             |                              |                           |                    |                   |              |        |           |  |  |
| COMBUSTION AIR : ROOM GLASS DOOR : CLOSED     |           |         |             |                              |                           |                    |                   |              |        |           |  |  |
| CIR   | CULATIO   | N FANS  | FUE         | EL MATI                      | ERIAL :                   | WOOD               |                   |              |        |           |  |  |
|   | L TYPE    |         |             |                              |                           |                    |                   |              |        | O(BTU/LB) |  |  |
| FUE   | LITTE     | + nooer | .A5 FIK     |                              |                           | HEF                | ALTING V          | HLUE =       | 0.0/7+ |           |  |  |
|   |           |         |             |                              |                           |                    |                   |              |        |           |  |  |
| MAS   | 5 AIR I   | N =165. | MAS         | MASS AIR OUT =151.20(LB/MIN) |                           |                    |                   |              |        |           |  |  |
| MAS   | 5 DRY F   | LUE GAS | MAS         | MASS COMB AIR = 4.43(LB/MIN) |                           |                    |                   |              |        |           |  |  |
| : هد ها ها<br>: |           |         |             | 8 ma 148 ma 80 ma 4          |                           | : es es et 6: es e |                   |              |        |           |  |  |
| <b>7</b> CO                                   | 2 = .03   | 0       | <b>%C</b> 0 | = .010                       | <b>`</b>                  | <b>2</b> 02        | 202 = .100        |              |        |           |  |  |
|   |           |         |             |                              | ,                         |                    |                   |              |        |           |  |  |
| <b>%</b> C ÷                                  | 560       |         | %H =        | • 070                        |                           | %МС                | %MC =0.000        |              |        |           |  |  |
| (R.)  | H.)LAB    | 450     | (R+H        | I.)OUT                       | <b>≈ .44</b> 0            | (R.                | (R.H.)ROOM = .480 |              |        |           |  |  |
|   |           |         |             |                              | a na 27 an 25 an 28 an 23 |                    |                   |              |        |           |  |  |
| FUEL  |           |         |             |                              |                           |                    |                   |              |        | COMB AIR/ |  |  |
| TIME WEIGHT                                   |           |         |             |                              |                           |                    |                   |              | EFF    | TOT LOSS  |  |  |
| MIN LB/MIN                                    | IN        | OUT     | STACK       | COMB                         |                           |                    |                   | ENV          |        | %         |  |  |
| 0 ,2775                                       | 59.6      | 65.1    | 231.0       | 62.2                         | 568.5                     | 62.2               | 72.2              | 67.4         | •08    | •08       |  |  |
| 1 .2775<br>2 .2783                            | 59.2      | 65.1    | 412.9       | 61.9                         | 577.5                     | 61.9               | 66.0              | 66.4         | • 09   | •18       |  |  |
|   |           |         | 418.6       |                              |                           |                    |                   | 65,1<br>65,4 |        | •17       |  |  |
|   | • • • • • |         |             |                              |                           | 1 mm 4m            |                   |              | + 17 / |           |  |  |

61.6 66.9 432.3 63.9 543.9 63.9 71.8 66.2

337.0 63.7 558.4 63.7

65.0 552.1

•08

•09

.09

73.3 66.3

65.9

70.7

65.0

AQF=.138762E+06(BTU/HR) AQNH=.10728E+05(BTU/HR)

.18

.14

.11

4

5

6

.2724

.2731

.2761

AEF= .08

60.7

62.6

67.1

288.3

68.4

| TEST NUM   | 2/79   |  |   |  |   |
|--|--|--|---|--|---|
|  |  | CE SIMULATION S  |   |  | , an air in an an an an an an an              |
|  |  | ICS AND EFFICIE  | NUT ANALTSIS  |  |   |
| COMBUSTI   | ON AIR : ROOM  |  | GLASS DOOR  | : CLOSED   |   |
| CIRCULAT   | ION FANS : NON   | E  | FUEL MATER  | IAL : WOOD   |   |
| FUEL TYP   | 'E : DOUGLAS FI  | R  | HEATING VA  | LUE =8379.0  | (BTU/LB)                                      |
| MASS AIR   | IN =165.00(LB  | /MIN)  |   | UT =151.20(  |   |
|  | / FLUE GAS =12.  | 36(LB/MIN)   | MASS COMB   |  |   |
| %02 = •  |  | 0 = .010   | ×02 = .100  |  |   |
| %C = .56   | о %н   | = .070   | %MC =0.000  |  |   |
| (R.H.)LA   | B = .450 (R  | .H.)OUT = .440   | (R.H.)ROOM  | = .480   |   |
| FUEL<br>TIME WEIGHT                                  |  | TEMPERATURE(F)   | nn an an an an mar in na shi ng ka ng ka sa ng ka   |  | COMB AIR/<br>TOT LOSS                         |
| MIN LE/MIN IN  | OUT STAC   | K COMB FIRE  | CALR LAB  | ENV %  | 7.  |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | 5       68.9       462.4         1       69.3       458.4         2       70.0       487.4         8       70.7       457.5         4       70.7       461.4 | 3       65.0       552.1         9       65.2       588.3         0       65.9       596.1         1       65.7       579.2         3       66.1       569.9         1       66.7       585.2         9       66.5       579.3 | 65.2       73.1         65.9       71.9         65.7       73.4         66.1       74.4         66.7       72.3 | 66.0       .07         65.8       .07         65.9       .09         66.4       .09         63.4       .09 | .11<br>.20<br>.19<br>.21<br>.20<br>.20<br>.13 |
| AEF= .08   | AQF=.17570   | 1E+06(BTU/HR)  | AQNH=.  | 14231E+05(B  | TU/HR)  |
|  |  | 56E+06(BTU/HR)   |   |  |   |

|                                 |   | NUMBER   |   |  |  | DATE : 3/19/79   |  |  |  |   |  |
|---------------------------------|---|--|---|--|--|--|--|--|--|---|--|
|                                 |   | C  | F I<br>CHARACT  | REPLACE  | SIMUL<br>S AND   | ATION S  | TUDIES   | ALYSIS   | 3  |   |  |
|                                 | COME  | USTION   | AIR :   | REAR   |  |  | GLA  | ss DOO   | R : CL   | DSED  |  |
|                                 | CIRC  | ULATION  | FANS  | : NONE   |  |  | FUE  | L MATE   | RIAL :   | WOOD  |  |
|                                 |   | TYPE   |   |  |  |  |  |  |  |   | )(BTU/LB)                                      |
| Viçin dina dina birin m         | MASS  | AIR IN   | <b>↓</b> = <b>1</b> 61.   | 25(LB/M  | N)   | MASS AIR OUT =147.60(LB/MIN)<br>MASS COMB AIR = 3.53(LB/MIN) |  |  |  |   |  |
| 611 <b>12</b> 52 52 52 5        |   | 146 127 227 122 128 127 22                           | <b>6 879</b> 705 679 578 679 145                                  | tern care one cost best has acht                           | light offer state light coal when                            |  | atte biat offer bonn ment been                               |  | anna vere dese time ante vare es                     | 72 JUN 1553 ST() 4587 J                       | ad dade sela erse ense som dess soga state mår |
|                                 | %CO2  | = .030   | )   | <b>%C</b> 0  |  |  | %02  | = .10  | 0  |   |  |
|                                 | %C =  | •560   |   | %H =   | .070   |  | %MC  | =0.00  | 0  |   |  |
|                                 | (R.H  | •)LAB =  | • • 520   | (R.H   | •)OUT  | = .680   | (R.  | H.)ROO   | M = +38  | 30  |  |
|                                 | FUEL<br>WEIGHT  |  | 1 117 128 137 138 137 138 139 139 139 139 139 139 139 139 139 139 |  |  | URE(F)   | 200 BAL 100 200 200 101                                      | 114 dit 20 dit 10 13                                 |  |   | COMB AIR/<br>TOT LOSS                          |
| MIN                             | LB/MIN  | IN   | OUT   | STACK  | COMB   | FIRE   | CALR   | LAB  | ENV  | 7.  | %  |
| 0<br>1<br>2<br>3<br>4<br>5<br>6 | .2210<br>.2181<br>.2236<br>.2232<br>.2214<br>.2258<br>.2214 | 73.2<br>75.3<br>78.0<br>76.0<br>77.9<br>78.3<br>77.2 | 74.5<br>75.8<br>79.7<br>79.6<br>80.4<br>81.3<br>80.9              | 99.0<br>232.2<br>240.4<br>266.5<br>248.6<br>242.7<br>191.1 | 73.9<br>75.5<br>77.5<br>76.8<br>77.8<br>77.8<br>78.7<br>77.9 | 210.7<br>385.9<br>430.6<br>471.2<br>499.3<br>483.1<br>404.9  | 73.9<br>75.5<br>77.5<br>76.8<br>77.8<br>77.8<br>78.7<br>77.9 | 77.0<br>76.7<br>76.7<br>77.7<br>77.4<br>77.9<br>77.7 | 79.5<br>77.5<br>78.7<br>79.8<br>78.9<br>78.0<br>78.8 | .02<br>.02<br>.03<br>.06<br>.04<br>.05<br>.07 | .01<br>.07<br>.08<br>.09<br>.09<br>.08<br>.08  |

AEF= .04 AQF=.111632E+06(BTU/HR) AQNH=.47304E+04(BTU/HR)

TEST NUMBER : 17-2 FIREPLACE SIMULATION STUDIES CHARACTERISTICS AND EFFICIENCY ANALYSIS COMBUSTION AIR : REAR GLASS DOOR : CLOSED CIRCULATION FANS : NONE FUEL MATERIAL : WOOD FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB) MASS AIR OUT =147.60(LB/MIN) MASS AIR IN =161.25(LB/MIN) MASS DRY FLUE GAS ==13.73(LB/MIN) MASS COME AIR = 4.49(LB/MIN)%02 = .030%CO = .010702 = .100%C = .560% H = .070%MC =0.000 (R.H.)LAB = .520 (R.H.)OUT = .680 (R.H.)ROOM = .380 FUEL COMB AIR/ EFF TOT LOSS TIME WEIGHT TEMPERATURE(F) MIN LB/MIN IN OUT STACK COMB FIRE CALR LAB ENV 2 2 2 .05 .2812 77.2 80.9 191.1 77.9 404.9 77.9 77.7 78.8 0 .05 1 .2794 77.6 80.8 318.0 78.3 616.9 78.3 77.6 79.4 .05 .11 75.5 80.8 262.4 77.5 .09 2 .2823 77.0 566.6 77.0 77.2 +08 77.1 •06 3 .2819 79.8 292.4 80.2 77.6 .10 83.8 80.2 635.5 Δ .2812 76.9 81.8 284.4 78.2 537.2 78.2 77.5 79.3 .10 .07 5 .2801 76.5 82.4 243.3 78.3 458.5 78.3 77.9 70.3 .09 +08 .2834 74.5 79.9 219.3 76.8 407.8 77.8 77.9 6 76.8 .08 .07 AEF = .07AQF=.141452E+06(BTU/HR) AQNH=,96549E+04(BTU/HR)

DATE : 3/19/79

|  | TEST NUMBER : 17-3 DATE : 3/19/79 |  |                      |  |                             |   |                                      |                                      |  |                          |                              |
|--|-----------------------------------|--|----------------------|--|-----------------------------|---|--------------------------------------|--------------------------------------|--|--------------------------|------------------------------|
|  |                                   |  |                      |  |                             | ATION S   |                                      |                                      | 11 14 <b>0</b> 777 427 779 279 279 279                                       |                          |                              |
|  |                                   | C  | CHARACT              | ERISTIC  | S AND                       | EFFICIE   | NCY AN                               | ALYSIS                               | 5  |                          |                              |
|  |                                   | r ande Antal Land (d) (som blad an<br>Mage antal Som tars 1976 and A   |                      | 5 312 665 672 666 <b>6</b> 07 <del>60</del> 6 70                                 | ) ar mi ru at at in a       | :   | , 222 1101 122 135 237 17            | 1 Jac and 110 AU 110 11              | (* 1999 ):10 (1999 (1998 (1997 1998)   | <b>111 117 118 11</b> 1  | rine 1991 223 2020 228 1993  |
|  | COME                              | NOTION   | AIR :                | REAR   |                             |   | GLA                                  | ss DOC                               | DR : CL  | OSED                     |                              |
|  | CIRC                              | ULATIO   | FANS                 | : NONE   |                             |   | FUE                                  | L MATE                               | RIAL :   | WOOD                     |                              |
|  | FUEL                              | TYPE :   | DOUGL                | AS FIR   |                             |   | HEA                                  | TING V                               | ALUE =   | 8379.                    | O (BTUZ                      |
| Mine other seller bidly th<br>weak about mines (Fig th | = == == == == == == == == ==      | : <u>211 (27 127 127 22 22</u> 2                                       |                      | r Vaan Cimin Annis kunis maaar ajaar ann<br>Kanan annis adan kyda kunis afka kun |                             |   |                                      |                                      |  | 189 a.11 Mar v.41 Mar :  | unt the serie fairs and date |
|  | MASS                              | AIR IN   | v =161.              | 25(LB/M  | (IN)                        |   | MAS                                  | S AIR                                | OUT =1   | 47.60                    | (LB/MI                       |
|  | MASS                              | DRY FL   | .UE GAS              | =14.88   | LB/MI                       | N)  | MAS                                  | S COME                               | AIR =  | 5.61                     | (LB/MI                       |
| <b>19</b> 101 100 117 1                                |                                   |  | r == 12 12 12 12 12  | alar and and the same and the  | a tana anan ann ann ann ann | r han vien unde dies dies dies<br>a dies vien date side dies eine | , and care and take and and          | 42 W N2 84 M N                       | un anime carte salte page dur's uname.<br>Is dama anice come city anite come |                          | 110 001 Jari 1512 7013 1518  |
|  | %CO2                              | = .03(   | >                    | %C0  | ≈ .010                      | )   | 202                                  | := +10                               | 00   |                          |                              |
|  | %C =                              | • 560  |                      | %H =   | .070                        |   | <b>%</b> MC                          | =0.00                                | 0  |                          |                              |
|  | (R+H                              | I.)LAB =   | 520                  | (R+H   | I.) OUT                     | - • 680   | (R.                                  | H.)ROC                               | )M = .3  | BÖ                       |                              |
| 27 37 <del>32</del> 22 4                               | <b># 10 10 10 10 10</b> 10 10     | . Main pada shar araw atau araw dh<br>Main paga pana araw atau araw dh | -                    | . Mark some your blas sins and sta<br>year your some and rise rule and           | <b></b>                     |   | : 111 KB (12 KB 112 BC               | - 121 - 122 - 123 - 123 - 123        | 1 DE 10 10 10 10 10 10 10  |                          | in an iii ii na ai           |
| TIME   | FUEL<br>WEIGHT                    |  |                      | TE   | MPERAT                      | URE(F)  |                                      |                                      |  | EFF                      | COMB<br>TOT                  |
| MIN  | LB/MIN                            | IN   | OUT                  | STACK  | СОМВ                        |   |                                      |                                      |  |                          |                              |
| 0<br>1<br>2<br>3<br>4                                  | •3488<br>•3465                    | 74.5<br>77.4   | 81+1<br>83+2<br>83-5 | 219.3<br>300.3<br>361.3<br>362.4<br>309.0  |                             | 407.8<br>551.9<br>687.6<br>704.4                                  | 76.8<br>77.0<br>78.8<br>78.8<br>78.8 | 77.8<br>77.9<br>77.6<br>77.8<br>78.9 | 77.7<br>78.7<br>79.4   | •03<br>•08<br>•07<br>•08 | 4                            |
| 5  | <b>3</b> 535                      | 75.0   | 82+6                 | 249.0  | 78.1                        | 530.0   | 78.1                                 | 78.8                                 | 79.7   | .09                      |                              |
| 6  | •3561                             | 76.1   | 82+8                 | 226.8  | 78.7                        | 474.7   | 78.7                                 | 78.8                                 | 79.7   | •08                      |                              |
| AEF=   | - • 08<br>- • 08                  |  | AQF≡.                | 177203E  | +06(BT                      | U/HR)   |                                      | AQNH=                                | 13668  | E+05()                   | 31                           |
| AEFT   | .06                               |  | AQFT=                | .143429  | E+06(B                      | TU/HR)  |                                      | AQNHT                                | <b>≈.9351</b> (  | )E+04)                   | (                            |

| TEST NUMBER :   | 22-1   | I  | DATE : 4/2/79   |  |  |  |
|---|--|--|---|--|--|--|
| 25 25 25 27 27 28 28 29 38 29 38 29 28 28 28 28 29 28 29 28 29 29 29 29 29 29 29 29 29 29 29 29 29  | FIREFLACE SIMUL  | ATION STUDI                              | IES   | ar na an an an air ini air an |  |  |
|   | RACTERISTICS AND   |  |   |  |  |  |
| COMBUSTION AIF  | R : FRONT  | C  | GLASS DOOR : CLO  | DSED   |  |  |
| CIRCULATION FA  | ANS : NONE   | F  | FUEL MATERIAL :   | WOOD   |  |  |
| FUEL TYPE : DO  | DUGLAS FIR   | ٢  | HEATING VALUE =8  | 3379.0(BTU/LB)   |  |  |
|   |  |  |   | a wa an an an an an wa an an an an an an an              |  |  |
| MASS AIR IN =   | 88.50(LB/MIN)  | 4  | 1ASS AIR OUT = 8  | 34.24(LB/MIN)  |  |  |
| MASS DRY FLUE   | GAS =11.67(LB/MI   | м) м                                     | ASS COMB AIR =  | 3.52(LB/MIN)   |  |  |
|   | n an inf in, inf in, ar in de in, in in in inf in in in in                 |  | n 124 an 127 an an 216 an 126 an 127 an 227 a   | u noi an             |  |  |
| <b>%CO2</b> = .030  | %CO = .010   | 7  | 402 = .100  |  |  |  |
| %C = .560   | %H = .070  | 7.                                       | % =0.000  |  |  |  |
| (R.H.)LAB = .6  | 500 (R.H.)OUT  | = .720 (                                 | (R.H.)ROOM = .660   |  |  |  |
|   | און און אין און און אין אין אין אין און און און און און און און און און או |  |   |  |  |  |
| FUEL<br>TIME WEIGHT   | TEMPERAT   | URE(F)                                   |   | COMB AIR/<br>EFF TOT LOSS                                |  |  |
| MIN LB/MIN IN OU  | JT STACK COMB  | FIRE CAL                                 | R LAB ENV   | % %  |  |  |
| 1         .2184         69.2         72           2         .2199         68.7         73           3         .2162         68.8         72           4         .2206         68.7         73           5         .2210         68.7         73 | 2.2416.072.13.1414.172.62.9399.773.2                                       | 638.571.828.971.811.771.800.272.754.472. | 7       72.5       70.0         9       72.4       69.6         2       72.7       69.7         2       72.6       69.6 | 13 ma  |  |  |
| AEF= .04 AQ   |  |  |   |  |  |  |

| TES                              | ST NUMBER : 22-2   |   | DATE : 4/2/79  |
|----------------------------------|--|---|--|
|                                  |  | و چا کا کا در الا کا در در با با کا کا کا کا در |  |
|                                  | FIRE   | PLACE SIMULATION STU  | DIES   |
|                                  | CHARACTER  | ISTICS AND EFFICIENC  | Y ANALYSIS   |
|                                  |  |   | 野胃質性發展過酸基苯基酸乙基和异物的含化和白色的白色医  |
| COM                              | BUSTION AIR : FR   | тиот  | GLASS DOOR : CLOSED  |
| CIR                              | CULATION FANS :  | NONE  | FUEL MATERIAL : WOOD   |
| FUE                              | L TYPE : DOUGLAS   | FIR   | HEATING VALUE =8379.0(BTU/LB)  |
| 23 88 67 18 18 18 28 68 68 68 58 |  |   | و به ها و به به به به به مر به به و به |
| MAS                              | S AIR IN = 88.50   | (LB/MIN)  | MASS AIR OUT = 84.24(LB/MIN)   |
| MAS                              | S DRY FLUE GAS =   | 12.13(LB/MIN)   | MASS COMB AIR = 4.62(LB/MIN)   |
|                                  | איז זער הבי היה איז איז איז היו או איז |   |  |
| %00                              | 2 = .030   | %CO = .010  | ×02 = .100   |
| %C                               | 560  | %H = .070   | %MC =0.000   |
| (R.                              | H.)LAB = .600  | (R.H.)OUT = .720  | (R.H.)ROOM = .660  |
|                                  |  |   | هم هو من من من من من شرق بين من        |

| TIME | FUEL<br>WEIGHT |      |       | TE      | MPERAT      | URE(F)  |                            |       |         | EFF    | COMB AIR/<br>Tot loss |
|------|----------------|------|-------|---------|-------------|---------|----------------------------|-------|---------|--------|-----------------------|
| MIN  | LE/MIN         | IN   | оит   | STACK   | СОМВ        | FIRE    | CALR                       | LAB   | ENV     | %      | 1/2                   |
| 0    | •2893          | 69.4 | 74.5  | 278.2   | 75.3        | 786.6   | 73.2                       | 72.4  | 70.6    | .04    | .10                   |
| 1    | ·2863          | 69.3 | 74.1  | 426.9   | 75.5        | 806.3   | 73.6                       | 72.7  | 70.0    | .04    | .17                   |
| 2    | .2882          | 69.4 | 74.7  | 459.2   | 74.5        | 938.1   | 75.6                       | 72.7  | 69.8    | .05    | .18                   |
| 3    | .2919          | 69.3 | 75.7  | 478.1   | 74.3        | 911.3   | 75.7                       | 72.7  | 69.7    | + 06   | .20                   |
| 4    | .2882          | 69.5 | 74.7  | 467.2   | 77.4        | 880.6   | 76.4                       | 72.8  | 70.1    | .05    | .19                   |
| 5    | .2863          | 69.3 | 77.7  | 327.1   | 74.4        | 893.9   | 77.6                       | 72.7  | 70.2    | •08    | .12                   |
| 6    | .2819          | 69.3 | 76.0  | 301.6   | 75.4        | 902+2   | 76.7                       | 72.7  | 69.9    | .07    | .11                   |
|      |                |      |       |         | * = = = = * | ======= |                            |       |         |        |                       |
| AEF  | 05             |      | AQF=. | 144510E | +06(BT      | U/HR)   | him form and bits vice for | AQNH= | •79055E | E+04(E | TU/HR)                |

|                     |                           | ST NUMBER : 22-3 DATE : 4/2/79 |             |  |                               |  |                                |                               |                                 |            |   |
|---------------------|---------------------------|--------------------------------|-------------|--|-------------------------------|--|--------------------------------|-------------------------------|---------------------------------|------------|---|
|                     |                           |                                | FI          | REPLACE  | E SIMUL                       | ATION S  | TUDIES                         | 5                             |                                 |            |   |
|                     |                           | USTION                         |             |  | 1 611 641 669 664 675 68      | , en 160 177 <b>20</b> 127 <b>20</b> 12  |                                |                               | )R : CL(                        |            |   |
|                     | CIRC                      | ULATIO                         | FANS        | : NONE   |                               |  | FUE                            | L MATE                        | RIAL :                          | woon       |   |
|                     |                           | TYPE :                         |             |  |                               |  |                                |                               |                                 |            | (BTU/LB)                                    |
| 12 ar ai ai in in a |                           |                                |             |  | 2 180 1911 1917 1918 1918 192 | : ::: ::: ::: ::: ::: ::: :::  | : :::: :::: :::: :::: ::::     |                               | : <u>22 23 22 22 23 33 10</u> 1 |            | : <b>112 dil 111 112 dia 211 02 112</b> 112 |
|                     | MASS                      | AIR IN                         | 4 = 88.     | 50(LB/N  | (NI)                          |  | MAS                            | S AIR                         | OUT = 1                         | B4,24(     | LB/MIN)                                     |
|                     | MASS                      | DRY FL                         | UE GAS      | =12.82   | CLB/MI                        | N)   | MAS                            | S COME                        | AIR =                           | 6.02(      | LB/MIN)                                     |
| 22 EE 22 0E 68 E    | E 188 188 255 188 257 356 | 50 55 55 55 55 55 55 55 55     |             |  |                               |  |                                |                               |                                 |            |   |
|                     | %02                       | <b>≖</b> .030                  | )           | %00  | = .010                        | •  | %02                            | = .10                         | 0                               |            |   |
|                     | %C =                      | .560                           |             | 7H =   | •070                          |  | %MC                            | =0.00                         | 0                               |            |   |
|                     | (R.H                      | .)LAB =                        | • 600       | (R.H   | I.)OUT                        | = .720   | (R.                            | H.)ROC                        | IM = •60                        | 50         |   |
|                     | 5 an 12 12 12 12 12 12    |                                |             | panna adam arapa rakas panna panna bas<br>aran bash aran panna adam mana bas |                               | vind and and blan your pare your   | And we want and some that with | THE CAR THE STATE AND AND THE |                                 |            |   |
| TIME W              | FUEL<br>JEIGHT            |                                |             | TE   | MPERAT                        | URE(F)   |                                |                               |                                 |            | COMB AIR/<br>TOT LOSS                       |
| MIN L               | B/MIN                     | IN                             | OUT         | STACK  | СОМВ                          | FIRE   | CALR                           | LAB                           | ENV                             | %          | ×.  |
|                     | 3774                      |                                |             |  |                               | 902.2  |                                |                               |                                 |            | •11   |
|                     | 3818                      | 69+0                           | /5+2        | 494.7  | /8.3                          | 870.2  | 75.6                           | /3.0                          | 69./                            | •04        | .20   |
|                     | 3726<br>3565              | 67+1<br>20 0                   | /J+8<br>7/0 | 512+0<br>570 0   | 77+U<br>70 1                  | 793.1<br>755.4   | 70+4                           | 72+0                          | 70+9<br>771 A                   | .04<br>.05 | •21<br>•22                                  |
|                     | 3598                      | 07+7<br>70.0                   | 70+7        | 544.0  | 77+1<br>70 0                  | 7 J J + 4<br>7 A 号 0   | 7347                           | 72+7                          | 71+4<br>71 0                    | .05        | • 22<br>• 22                                |
|                     | 3578                      | 48.8                           | 76.2        | 477.A  | 80.4                          | 700+7  | 70+3                           | 73+0                          | 70.2                            | .05        | .19   |
| 6.                  | 3594                      | 69.0                           | 77.7        | 366.3  | 79.3                          | 765.9<br>726.7<br>836.0  | 76+6                           | 73.0                          | 70.2                            | •05        | •19<br>•14                                  |
| AEF=                | .05                       |                                | AQF=.       | 184243E  | +06(BT                        | U/HR)  |                                | AQNH=                         | .877498                         | E+04(B     | TU/HR)                                      |
| AEFT=               | • • 05                    |                                | AQFT=       | <b>،</b> 146373  | E+06(B                        | TU/HR)   |                                | AQNHT                         | =.71261                         | LE+04(     | BTU/HR)                                     |
| ha == 12 20 11 12   |                           |                                | <b></b>     |  |                               | While righ many jour start lines ying<br>that ying many there exact lines ying |                                | au 11 Au 11 Au 11             |                                 |            |   |

| TEST NUMBER : 29                                  | -1            |                                       | DATE : 5/14/79 |                    |                                    |                        |                                    |
|---|---------------|---------------------------------------|----------------|--------------------|------------------------------------|------------------------|------------------------------------|
| <b>2 5 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 </b>   |               |                                       |                |                    |                                    | <b>in 12 12 1</b> 2 12 |                                    |
| F   | IREPLACE SIMU | LATION S                              | TUDIES         | 1                  |                                    |                        |                                    |
| CHARAC  | TERISTICS AND | EFFICIE                               | NCY AN         | ALYSIS             | 5                                  |                        |                                    |
|   |               |                                       |                | ; == == == == == = |                                    | =====                  | in sia 20 ani 22 ani 22 ani 22 ani |
| COMBUSTION AIR :                                  | RODM          |                                       | GLA            | SS DOC             | DR : OPI                           | EN                     |                                    |
| CIRCULATION FANS                                  | : SIDES CLOS  | ED                                    | FUE            | L MATE             | ERIAL :                            | WOOD                   |                                    |
| FUEL TYPE : DOUG                                  |               |                                       | HEA            | TTNG U             | JALLIE =                           | 8379.                  | O(BTU/LB)                          |
|   |               |                                       |                |                    |                                    |                        |                                    |
| MASS AIR IN =101                                  |               | and root offer pair with and and root |                |                    |                                    |                        |                                    |
|   |               |                                       |                |                    |                                    |                        | (LB/MIN)                           |
| MASS DRY FLUE GA                                  | S =12.36(LB/M | IN)                                   | MAS            | S COME             | 3 AIR =                            | 3+43                   | (LB/MIN)                           |
| <b># = = # # # # # # # # # = = = #</b> # # # #    |               |                                       |                | (17 M) 28 19 M) 28 | 4 <b>100 100 100 100 100</b> 100 1 |                        | na 123 ar 128 an 129 an 129 ar     |
| %02 = .030  | %20 = .01     | 0                                     | 702            | . ≕ <b>.</b> 18    | 30                                 |                        |                                    |
| %C = .560   | %H = .070     |                                       | ZMC            | =0.00              | 00                                 |                        |                                    |
| (R.H.)LAB = .540                                  | (R+H+)OUT     | = .580                                | (R.            | H+)ROC             | )M = .40                           | 50                     |                                    |
| و به مر بو به |               |                                       |                |                    |                                    |                        |                                    |
| FUEL  |               |                                       |                |                    |                                    |                        | COMB AIR/                          |
| TIME WEIGHT                                       | TEMPERA       | TURE(F)                               |                |                    |                                    | EFF                    | TOT LOSS                           |
| MIN LE/MIN IN OUT                                 | STACK COMB    | FIRE                                  | CALR           | LAB                | ENV                                | 7.                     | 7.                                 |
| 0.2148 65.2 73.1                                  |               |                                       | 70.3           | 72.8               | 81.7                               | .10                    | .05                                |
| 1 +2129 64-8 75-7                                 |               |                                       | 70.3           | 72.5               | 81.0                               | .14                    |                                    |
| 2 +2129 65.3 86.8                                 |               |                                       | 73.1           | 72.7               | 85.5                               | +28                    | + 22                               |
| 3 .2111 65.8 83.6<br>4 .2137 66.2 83.5            |               |                                       | 72.3<br>74.1   | 72.9<br>73.2       | 83.0<br>85.2                       | •23<br>•22             | •21<br>•17                         |
| 5 .2166 66.4 81.1                                 |               |                                       | 73.6           | 72.7               | 86.1                               | • 22                   |                                    |
| 6 .2148 66.5 84.3                                 |               |                                       | 74.2           | 73.4               |                                    | .23                    |                                    |
| a a a a a a a a a a a a a a a a a a a             |               |                                       |                |                    |                                    |                        |                                    |

AQNH=.21207E+05(BTU/HR)

AQF=.107493E+06(BTU/HR)

AEF= +20

|                     | TEST NUMBER : 29-2 DATE : 5/     |                                     |  |                                     |   |                                     |                                |                                    |   |         |                       |  |  |
|---------------------|----------------------------------|-------------------------------------|--|-------------------------------------|---|-------------------------------------|--------------------------------|------------------------------------|---|---------|-----------------------|--|--|
|                     |                                  | -                                   |  | 1 KE 12 72 KE KE EE E               | , 111 al 21 21 al 2                                     | u av an an 22 22 83 8               |                                |                                    | 1                                       |         |                       |  |  |
|                     |                                  |                                     | FI   |                                     | STMU  | ATTON S                             | STUDIES                        | 3                                  |   |         |                       |  |  |
|                     |                                  |                                     |  |                                     |   |                                     |                                |                                    | ~                                       |         |                       |  |  |
|                     |                                  | i i                                 | снакас і                                   | ERISTIC                             | S AND   | EFFICIE                             | NUT AN                         | ALTSIS                             | 5                                       |         |                       |  |  |
|                     |                                  | : == == == == == == =               | 12 <b>121 122 123 123 1</b> 23 123 123 123 |                                     | . 1996 (1996 (1996 (1996 (1996 (19                      |                                     |                                |                                    |   |         |                       |  |  |
|                     | COME                             | USTION                              | AIR :                                      | ROOM                                |   |                                     | GLA                            | ISS DOC                            | DR : OP                                 | EN      |                       |  |  |
|                     | CIRC                             | ULATIO                              | FANS                                       | : SIDES                             | CLOSE   | ED                                  | FUE                            | L MATE                             | ERIAL :                                 | WOOD    |                       |  |  |
|                     | FUEL                             | TYPE                                | : DOUGL                                    | AS FIR                              |   |                                     | HEA                            | TING V                             | ALUE =                                  | 8379.(  | )(BTU/LB)             |  |  |
|                     |                                  |                                     |  |                                     |   |                                     |                                |                                    | 1 12 dt 13 12 H H 13                    |         |                       |  |  |
|                     | MACC                             | - ATD TA                            |  | 25(LB/M                             | TAIN  |                                     | MAG                            | 0 470                              | 0UT                                     | 07 /0   | (1) Ye ( ) ( ) ( )    |  |  |
|                     | пнээ                             | HIK I                               | 4 =101+                                    | ZUILBZM                             | 1111  |                                     | MAS                            | 9 HIK                              | 001 =                                   | 73+60   | (LB/MIN)              |  |  |
|                     | MASS DRY FLUE GAS =12.82(LB/MIN) |                                     |  |                                     |   |                                     | MAS                            | S COMP                             | AIR =                                   | 4.39    | (LB/MIN)              |  |  |
| == == == <b>=</b> = |                                  | . Jahl ren, pare anto prov prov to  |  |                                     | : 201 EE ar 201 III EI                                  | n nii 911 (ki 112 jiz 117 ji        |                                | : 127 (111 (111 <b>111</b> ))) (11 | <b>.</b> 22 10 NC 12 12 12 12           |         |                       |  |  |
|                     | %02                              | = .03(                              | )  | <b>%C</b> 0                         | = .010  | )                                   | %02                            | 18                                 | 80                                      |         |                       |  |  |
|                     | %C ==                            | •560                                |  | %H ≕                                | %H = .070 %   |                                     |                                |                                    | %MC =0.000                              |         |                       |  |  |
|                     | (R.H                             | •)LAB =                             | 540  | (R.H                                | .)OUT   | = .580                              | •580 (R•H•)ROOM = •460         |                                    |   |         |                       |  |  |
|                     |                                  |                                     |  |                                     | -   | 9 9499 tápá juga 1899 jábó siku san |                                |                                    |   |         |                       |  |  |
|                     |                                  | ukrk filme angé undék dinat nyan ku | ut anna mang bire ture anna era            | - 68-1 9149 yake 1125 ways coor yan | a mana ana ing mang ang ang ang ang ang ang ang ang ang | * **** ****                         | a anna agus stad mun béan fhùi |                                    | a sound angle passe such, view of the g |         |                       |  |  |
| TIME                | FUEL<br>WEIGHT                   |                                     |  | TE                                  | MPERAT  | URE(F)                              |                                |                                    |   | EFF     | COMB AIR/<br>TOT LOSS |  |  |
| MIN                 | LE/MIN                           | IN                                  | ουτ  | STACK                               | Сомв  | FIRE                                | CALR                           | LAB                                | ENV                                     | %       | %                     |  |  |
| 0                   | •2753                            | 66.5                                | 84.3                                       | 250.1                               | 74.2  | 503.0                               | 74.2                           | 73.4                               | 89.6                                    | .18     | • 1.0                 |  |  |
|                     |                                  |                                     |  | 488+6                               |   | 476.2                               |                                |                                    | 84.1                                    |         |                       |  |  |
|                     | .2735                            |                                     |  | 509.4                               | 75.4  |                                     |                                |                                    | 81.1                                    |         |                       |  |  |
|                     | .2845                            |                                     |  |                                     |   | 592.9                               |                                |                                    | 88.8                                    | +26     | .24                   |  |  |
|                     | .2790                            |                                     |  |                                     |   | 652.4                               |                                |                                    | 85.9                                    |         |                       |  |  |
|                     | •2790                            |                                     |  |                                     |   | 630.3                               |                                |                                    |   |         |                       |  |  |
| 6                   |                                  |                                     |  |                                     |   | H. () 3                             |                                |                                    | LJ 1 1 1 1                              | • • • • |                       |  |  |
|                     | •2772                            | 67.9                                | 88+4                                       | 285.4                               | //•/  | 570.1                               | 77.7                           | / & • /                            | 82.5                                    | .21     | .12                   |  |  |

 AEF= .21
 AQF=.140239E+06(BTU/HR)
 AQNH=.29474E+05(BTU/HR)

|                        | TEST NUMBER : 29-3 DATE : 5/14/79         |                                   |                              |                                    |                              |                                |                         |                           |                                |                    |   |
|------------------------|---|-----------------------------------|------------------------------|------------------------------------|------------------------------|--------------------------------|-------------------------|---------------------------|--------------------------------|--------------------|---|
| ====                   |   | : == == == = =                    |                              |                                    |                              | ATION S                        |                         |                           | # 68 59 86 89 66 80            |                    | 47 ()F 88 38 39 38 18 18 78 18                |
|                        |   |                                   | CHARACI                      | ERISTI                             | CS AND                       | EFFICIE                        | ENCY AN                 | ALYSI                     | õ                              |                    |   |
| 92 Hi II II II I       |   |                                   | AIR :                        |                                    | 21 325 728 528 828 826 722 8 | e 28 de 12 au 12 de 18 a       |                         |                           | )R : OP                        |                    | 199 995 976 996 976 998 976 <b>998 998 99</b> |
|                        |   |                                   |                              |                                    |                              |                                |                         |                           |                                |                    |   |
|                        | CIRC                                      | ULATIC                            | IN FANS                      | : SIDES                            | 6 CLOSE                      | ED                             | FUE                     | EL MATE                   | ERIAL :                        | woon               |   |
|                        | FUEL                                      | TYPE                              | : DOUGL                      | AS FIR.                            |                              |                                | HEA                     | TING V                    | VALUE =                        | 8379.0             | (BTU/LB)                                      |
|                        |   |                                   | N =101.                      |                                    |                              | n and and 1999 Not 1999 AND 80 |                         |                           | OUT = '                        |                    | LB/MIN)                                       |
|                        | MASS                                      | DRY P                             | LUE GAS                      | =13.29                             | 3(  R/M1                     | N)                             | MDC                     | S COMP                    | 3 AIR =                        | 5,577              | BZMTNI  |
|                        |   |                                   |                              |                                    |                              |                                |                         |                           |                                |                    |   |
|                        |   |                                   |                              |                                    |                              |                                |                         |                           |                                |                    | <b>15 78 27 76 72 77 78 78 78</b>             |
|                        | %CO2                                      | •03                               | 50                           | %CO                                | = .010                       | )                              | <b>%</b> 02             | ! = .18                   | 30                             |                    |   |
|                        | %C =                                      | •560                              |                              | %H =                               | • •070                       |                                | % MC                    | =0.00                     | 0                              |                    |   |
|                        | (R+H                                      | .)LAB                             | 540                          | (R.F                               | I.)OUT                       | = .580                         | (R.                     | H.)ROC                    | )M = +4                        | 50                 |   |
|                        | ter seine besei best sons seine serr detr | read many dives debut when use    |                              |                                    | -                            |                                | and our live our ran at |                           |                                |                    |   |
|                        | FUEL                                      |                                   |                              |                                    |                              |                                |                         |                           |                                |                    |   |
| TIME                   | WEIGHT                                    |                                   |                              | TE                                 | MPERAT                       | URE(F)                         |                         |                           |                                |                    | COMB AIR/<br>TOT LOSS                         |
| MIN                    | LB/MIN                                    | <br>IN                            | оит                          | STACK                              | Сомв                         | FIRE                           | CALR                    | LAB                       | ENV                            | %                  | ~       |
|                        |   |                                   | 83+4                         |                                    |                              |                                |                         |                           |                                | •17                | .11   |
|                        | .3451                                     |                                   | 90.3                         |                                    |                              |                                |                         |                           |                                |                    | • 26  |
| 2                      | •3462<br>•3454                            | 68+1<br>69.7                      | 108.0<br>99.5                |                                    |                              |                                |                         |                           |                                | •33<br>•25         | •32<br>•27                                    |
|                        | .3434                                     | 68.8                              | 98.1                         | 443.6                              | 83.4                         | 732.7                          | 83.4                    | 73.0                      | 82.9                           | + 20               | * # /<br>• 22                                 |
|                        | .3344                                     | 68.8                              | 98+1<br>87+3                 | 364.1                              | 83.0                         | 592.0                          | 83.0                    | 73.1                      | 84.3                           | .17                | .15   |
| 6                      | .3425                                     | 68,8                              | 94.3                         | 316.3                              | 83.1                         | 596.4                          | 83.1                    | 73.2                      | 83.7                           | •22                | •14   |
|                        |   | in 17 m 17 m 18                   |                              |                                    |                              |                                |                         | 82 13 <b>86 62 8</b> 2 62 |                                | 7 in: 12 ac 12 m 1 |   |
|                        | • •22                                     | <b>na 111 111 111 111 111</b> 111 |                              |                                    |                              | U/HR)                          |                         |                           | .38467                         |                    | (U/HR)  |
|                        | ·21                                       |                                   | AQFT=                        |                                    |                              |                                |                         |                           |                                |                    |   |
| <b>38 86 12 12 1</b> 2 | = ## c# ## ## ## c= #\$ ##                | 17 ch 16 ch 64 02                 | <b>** := == := := :</b> = := | 117 114 <b>116 114 117 117</b> 118 |                              |                                | ER 10 ER 10 ER 11:      |                           | ente dans sakt kan sam bisa da |                    |   |

| TEST NUM   | BER : 31-1  |   | DATE : 5/21/79  |  |  |  |   |  |  |  |
|--|---|---|---|--|--|--|---|--|--|--|
|  |   |   | - 13 12 12 13 13 13 13 13 13  | *=======                                     |  |  |   |  |  |  |
|  | FIREPLAC  | E SIMULATIO   | ON STUDIES  | 6  |  |  |   |  |  |  |
|  | CHARACTERISTI   | CS AND EFFI   | CIENCY AN   | NALYSIS                                      | 3  |  |   |  |  |  |
|  |   |   | e ca da ve az le de da do na z  |  |  | <b>111</b> 112 112 112 112 113                     |   |  |  |  |
| COMBUSTI   | ON AIR : REAR   |   | GLA   | ASS DOC                                      | )R : OP                                      | EN   |   |  |  |  |
| CIRCULAT   | ION FANS : SIDE   | S CLOSED  | FUE   | EL MATE                                      | RIAL :                                       | WOOD   |   |  |  |  |
| FUEL TYP   | E : DOUGLAS FIR   |   | HEA   | ATING V                                      | ALUE =                                       | 8379.(   | )(BTU/LB)   |  |  |  |
|  | אם ענה הנה שה הנה היה לה לה ונע את את הה היה הנה היה א  |   |   |  |  | ann frut sens finn sens a<br>Sin frut sens finn se |   |  |  |  |
| MASS AIR   | IN =103.50(LB/  | MIN)  | MAS   | SS AIR                                       | OUT = 1                                      | 93.60  | (LB/MIN)  |  |  |  |
| MASS DRY   | FLUE GAS =10.9  | 9(LB/MIN)   | MAS   | SS COME                                      | AIR =  | 3.45   | (LB/MIN)  |  |  |  |
|  |   |   |   |  |  |  | -   |  |  |  |
| %002 = .(  | 30 %00  | 010   | 202   | 2 = .10                                      | 0  |  |   |  |  |  |
| %C = +560  | ) <b>%</b> H :  | 070   | %MC   | =0.00  | 0  |  |   |  |  |  |
| (R.H.)LAI  | 8 = <b>.</b> 620 (R.I   | H.)OUT = .8   | 80 (R.  | H.)R00                                       | M = .4                                       | 50   |   |  |  |  |
| <b> </b>   | a ana asi: asa asi ana kab gan ana uni kao ana ma ma ma ma  |   |   | : ::: ::: ::: ::: :::                        | then said blen was the said the              |  |   |  |  |  |
| FUEL<br>TIME WEIGHT  | т   | EMPERATURE (  | F)  |  |  | EFF  | COMB AIR/<br>Tot Loss                                       |  |  |  |
| MIN LE/MIN IN  | OUT STACK   | COMB FIR  | E CALR  | LAB  | ENV  | %  | %   |  |  |  |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$                             | 84.2       202.0         89.1       367.6         94.6       351.1         89.9       367.9         98.3       331.7         93.2       249.4 | 78.0       276         79.0       442         80.2       552         80.7       576         81.2       549         81.3       508 | .9       78.7         .9       80.3         .8       82.3         .8       83.0         .8       84.7         .3       84.3 | 78.6<br>78.4<br>78.7<br>78.3<br>78.3<br>78.5 | 91.2<br>91.8<br>92.9<br>88.1<br>89.1<br>91.0 | .03<br>.11<br>.18<br>.24<br>.18<br>.29<br>.23      | .01<br>.06<br>.16<br>.16<br>.16<br>.16<br>.16<br>.16<br>.10 |  |  |  |
| AEF= .18   | AQF=.108363E  |   |   |  | •19500E                                      |  |   |  |  |  |
| איז אינו אני איז איז איז איז איז און און איז |   |   |   |  |  | 19 199 20 199 27 11                                | . 20 20 14 14 14 19 19 19 19 19                             |  |  |  |

|                       |                                  |  | R : 31-               | _                         |                    |                           |                              | E:5/                      |              |                                 |                                       |
|-----------------------|----------------------------------|--|-----------------------|---------------------------|--------------------|---------------------------|------------------------------|---------------------------|--------------|---------------------------------|---------------------------------------|
|                       |                                  | - 6.29 Miles - 92.4 years when man                                     |                       | REFLACE                   | SIMUL              | ATION S                   | TUDIES                       | 3                         |              | ngga sanga riyan darja maga jan | a diy pini na ma ina na na na na na   |
|                       |                                  |  |                       |                           | -                  |                           |                              | -                         |              |                                 |                                       |
|                       | COME                             | USTION   | AIR :                 | REAR                      |                    |                           | GLA                          | SS DOC                    | OR : OP      | EN                              |                                       |
|                       | CIRC                             | ULATIO   | IN FANS               | : SIDES                   | CLOSE              | ED                        | FUE                          | L MATE                    | RIAL :       | WOOD                            |                                       |
|                       | <b>F</b>                         | TVDE   | • •                   |                           |                    |                           |                              |                           |              |                                 |                                       |
|                       | FUEL                             | . ITPE   | : DOUGL               | A2 FIK                    |                    |                           | HEF                          | HING V                    | ALUE =       | 83/9+0                          | (BTU/LB)                              |
|                       |                                  |  |                       |                           |                    |                           |                              | : :::: :::: :::: :::: ::: |              | 72 83 193 192 91 31             |                                       |
|                       | MASS                             | AIR I  | N =103.               | 50(LB/M                   | IN)                |                           | MAS                          | S AIR                     | OUT = 9      | 93.60(                          | LB/MIN)                               |
|                       | MASS                             | DRY F  | LUE GAS               | =11.45                    | (LEZM)             | N )                       | MAC                          | S COME                    | ATE =        | 4.480                           | LB/MIN)                               |
|                       |                                  | ~  | The for her her to be |                           |                    | ,                         |                              |                           |              | 14 103                          |                                       |
| 13 17 Hit 14 5        | ng bid tin the los are the the t | , Jean dada data tan nani mati pan<br>Jan Jan Jan ni Jan da San da San |                       |                           |                    | : #5 112 36 111 112 66 11 | in mid ting and this odd for |                           |              |                                 | 2 00 02 00 70 70 71 77 00 <b>78</b> 2 |
|                       | %CO2                             | = .03  | 0                     | %00                       | = .010             | )                         | <b>XO</b> 2                  | 2 = .10                   | 0            |                                 |                                       |
|                       | %C =                             | .560   |                       | ZH =                      | .070               |                           | <b>%M</b> C                  | =0.00                     | 0            |                                 |                                       |
|                       | (R.H                             | ·)LAB  | - • 620               | (R.H                      | •)OUT              | 680                       | (R.                          | H.)ROO                    | M = •4       | 50                              |                                       |
| <b>10 kz 2</b> 3 uz 2 |                                  | ante seus tete tete gang page<br>seus seus tete tete dass page         |                       | UR 121 121 82 92 92 92 92 | 112 AT 22 CH CL 23 | i ne 12 in 15 in 12 ke n  | : 22 22 52 62 82 23          |                           |              |                                 | : 114 HA CO 116 HA CA 116 HE I        |
| TIME                  | FUEL<br>WEIGHT                   |  |                       | TE                        | MFERAT             | URE(F)                    |                              |                           |              | EFF                             | COMB AIR/<br>TOT LOSS                 |
|                       | LB/MIN                           | IN   |                       | STACK                     |                    |                           | CALR                         |                           |              | %                               | %                                     |
| 0                     | .2808                            | 76.4   | 93.2                  | 249.4                     | 81.3               | 508.4                     | 84.3                         | 78.5                      | 91.0         | .18                             | +09                                   |
| 1                     | •2863<br>•2860<br>•2720          | 76.9   | 97.3                  | 466.0                     | 82.5               | 695.4                     | 86.1                         | 78.6                      | 91.0         | •21                             |                                       |
| 2                     | .2860                            | 77.6   | 97.4                  | 456.7                     | 82.9               | 567.9                     | 86,5                         | 78.9                      | 85.7         | •20                             |                                       |
| 3                     | •2720                            | 78.1   | 106.0                 | 569.9                     | 84.3               | 585.3                     | 89.2                         | 79.2                      | 94.5         | • 30                            | • 31                                  |
| 4                     | •2867<br>•2838                   | 77+4<br>70 0   | 98.6                  | 301+3<br>707 0            | ర <b>చ</b> ు 7     | J87+0                     | 88+6<br>00 /                 | 78.7<br>70 0              | 80+2<br>07 0 | •22                             | +16                                   |
| 5<br>6                | •2838<br>•2863                   | 78.4   | 99.7                  | 285.6                     | 83.5               | 530.7                     | 87.5                         | 79.0                      | 86.3         | •24<br>•22                      | •13<br>•12                            |
|                       |                                  |  |                       |                           |                    |                           |                              |                           |              |                                 |                                       |

•

| TEST NUMBER : 31-  | ·3  | DATE : 5/21/79  | DATE : 5/21/79  |  |  |  |  |  |  |
|--|---|---|---|--|--|--|--|--|--|
| <b>2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 -</b>           | . In the set of the set |   | 2 12 12 12 12 12 12 12 12 13 12 12 12 12 12 12 12 12 12 12 12 |  |  |  |  |  |  |
| FI   | REPLACE SIMULATION ST   | UDIES   |   |  |  |  |  |  |  |
| CHARACT  | ERISTICS AND EFFICIEN   | CY ANALYSIS   |   |  |  |  |  |  |  |
| H G & E S E B S S & C & S & S & S & S & S & S & S & S    |   |   |   |  |  |  |  |  |  |
| COMBUSTION AIR :   | REAR  | GLASS DOOR : OPEN   | i   |  |  |  |  |  |  |
| CIRCULATION FANS   | : SIDES CLOSED  | FUEL MATERIAL : W   | 1001  |  |  |  |  |  |  |
| FUEL TYPE : DOUGL  | AS FIR  | HEATING VALUE =83   | 79.0(BTU/LB)  |  |  |  |  |  |  |
|  |   | ע אנו אל אני אל אני אין אין אני אני אני אני אל אל אל אני אני אני אני או |   |  |  |  |  |  |  |
| MASS AIR IN =103.50(LB/MIN) MASS AIR DUT = 93.60(LB/MIN  |   |   |   |  |  |  |  |  |  |
| MASS DRY FLUE GAS  | =12.25(LB/MIN)  | MASS COMB AIR = 5   | 1.64(LB/MIN)  |  |  |  |  |  |  |
| 22 02 02 02 06 02 09 00 00 00 00 00 00 00 00 00 00 00 00 |   |   | : 20 20 30 30 30 20 40 20 20 40 30 40                         |  |  |  |  |  |  |
| %02 = .030   | %CO = .010  | 202 = .100  |   |  |  |  |  |  |  |
| %C = .560  | <b>%H</b> = .070  | %MC =0.000  |   |  |  |  |  |  |  |
| (R.H.)LAB = .620   | (R.H.)OUT = .680  | (R.H.)ROOM = .450   | ,   |  |  |  |  |  |  |
|  |   | יש אוז עם אנו או  |   |  |  |  |  |  |  |
| FUEL<br>TIME WEIGHT                                      | TEMPERATURE(F)  |   | COMB AIR/<br>EFF TOT LOSS                                     |  |  |  |  |  |  |
| MIN LB/MIN IN OUT  | STACK COMB FIRE   | CALR LAB ENV  | % %   |  |  |  |  |  |  |
| 0.3535 78.4 99.7   | 285.6 83.5 530.7  | 87.5 79.0 86.3  | .18 .11   |  |  |  |  |  |  |

AEFT= .21

.3524

.3524

.3561

.3495

.3517

.3543

AEF= .23

1

2

3

4

5

6

79.3

79.3

78.5

78.5

78,9

112.7

106.6

108.1

107.9

102.4

78.9 102.7

AQFT=+142700E+06(BTU/HR)

509.5 86.1

447.9

357.0

320.9

516.2 86.0 584.3

515.4 87.0 589.5

86.7

87.2

AQF=.177388E+06(BTU/HR)

AQNHT=.30745E+05(BTU/HR)

AQNH=,40899E+05(BTU/HR)

+28

.21

.23

.25

.25

.21

.27

.24

.25

.22

.16

.13

79.0

79.2

79.3

79.5

79.6

79.3 86.0

86.8

91.0

84.4

86.1

84.4

92.0

93.8

93.0

94.7

93.8

568.4 92.3

664.4

644.4

86.8 591.1

| TEST NUMBER : 33-1                             |   |   |                                |                             |                               |                   |                               | DATE : 5/24/79                     |                                    |                       |            |  |
|--|---|---|--------------------------------|-----------------------------|-------------------------------|-------------------|-------------------------------|------------------------------------|------------------------------------|-----------------------|------------|--|
| <b># = = = = = = = = = = = = = = = = = = =</b> |   |   |                                |                             |                               |                   |                               |                                    |                                    |                       |            |  |
|  | FIREPLACE SIMULATION STUDIES            |   |                                |                             |                               |                   |                               |                                    |                                    |                       |            |  |
|  | CHARACTERISTICS AND EFFICIENCY ANALYSIS |   |                                |                             |                               |                   |                               |                                    |                                    |                       |            |  |
|  |   | Ł   | HARAUI                         | ERISTIC                     | S AND                         | EFFICIE           | NUY AN                        | ALISIS                             | j.                                 |                       |            |  |
|  |   |   | : == 12 <u>12 12 1</u> 2 12 12 |                             |                               |                   | = = = = = = =                 |                                    |                                    | <b>ne na se</b> se is |            |  |
|  | СОМВ                                    | USTION                                    | AIR :                          | FRONT                       |                               |                   | GLA                           | ss Doc                             | )R : OP                            | EN                    |            |  |
|  | CIRC                                    | ULATION                                   | FANS                           | : SIDES                     | CLOSE                         | D                 | FUE                           | L MATE                             | RIAL :                             | ωοου                  |            |  |
| FUEL TYPE : DOUGLAS FIR                        |   |   |                                |                             |                               |                   |                               | TING V                             | ALUE =                             | 8379.0                | (BTU/LB)   |  |
|  | ======                                  |   | : 02 02 02 02 02 02            |                             |                               | : = = = = = = = = | ======                        |                                    | :                                  | 18 MR 65 55 55 55     |            |  |
|  | MASS                                    | AIR IN                                    | =103.                          | 50(LB/M                     | IN)                           |                   | MAS                           | S AIR                              | OUT = 1                            | 93.60(                | LB/MIN)    |  |
| MASS DRY FLUE GAS =10.53(LB/MIN)               |   |   |                                |                             |                               |                   |                               | S COME                             | AIR =                              | 3.41(                 | LR/MTN)    |  |
|  |   |   |                                |                             |                               |                   |                               |                                    |                                    |                       |            |  |
|  |   |   |                                |                             |                               |                   |                               |                                    |                                    |                       |            |  |
|  | 7002                                    | = .030                                    | I                              | %CU                         | = .010                        | •                 | 7.02                          | 202 = .100                         |                                    |                       |            |  |
|  | %C =                                    | .560                                      |                                | %H =                        | .070                          |                   | ZMC =0.000                    |                                    |                                    |                       |            |  |
|  | (R.H                                    | .)LAB =                                   | .600                           | (R.H                        | •)0UT                         | - 660             | (R.H.)ROOM = .440             |                                    |                                    |                       |            |  |
| 47 <b>25 26 16 16</b> 10 25                    |   | iner filt and gast film ber ber           |                                | 727 737 148 318 882 787 782 |                               |                   | and the star the provided the | 7444 4000 2000 2000 4000 4000 4000 |                                    |                       |            |  |
|  | FUEL                                    |   |                                |                             |                               |                   |                               |                                    |                                    |                       | COMB AIR/  |  |
| TIME W   | EIGHT                                   |   |                                | TE                          | MPERAT                        | URE(F)            |                               |                                    |                                    | EFF                   | TOT LOSS   |  |
| MIN L  | B/MIN                                   | IN  | OUT                            | STACK                       | COMB                          | FIRE              | CALR                          | LAB                                | ENV                                | ".                    | %          |  |
| 0.   | 2137                                    | 71.9                                      | 79.2                           | 143.2                       | 75.6                          | 377.0             |                               | 77.1                               | 78.9                               | •09                   | .03        |  |
|  | 2137                                    |   | 81.2                           | 216.1                       |                               | 436.6             |                               | 77.1                               |                                    | .12                   | .07        |  |
|  | 2195                                    |   | 83.4                           | 371.3                       |                               | 525.4             |                               | 76.8                               |                                    | •15                   | .16        |  |
|  | 2195                                    |   |                                | 419.7                       |                               | 531.2             |                               | 76.9                               |                                    | •20                   | •19        |  |
|  | 2166                                    |   |                                | 357.4                       |                               | 674.0             |                               | 76.7                               |                                    | +19                   | • 16       |  |
|  |   |   |                                | 294.0<br>261.4              |                               | 544.7<br>558.2    |                               |                                    |                                    | •22<br>•22            | .13<br>.11 |  |
|  |   |   |                                |                             |                               |                   |                               |                                    |                                    |                       |            |  |
| AEF=   |   | ngang papat punga dinda takan pikan gitar |                                | 108706E                     |                               |                   | ang olk and des new its       |                                    | •185668                            |                       |            |  |
| 70 WE DE 12 77 W                               |   |   |                                |                             | talla tint tall tall tall the |                   |                               |                                    | 772 <del>27</del> 27 27 27 27 27 2 |                       |            |  |

| TEST NUMBER : 33-2 DATE : 5/24/79  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|
|  | n an                      |  |  |  |  |  |  |  |  |  |
| FIREPLACE SIMULATION STUDIES   |  |  |  |  |  |  |  |  |  |  |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS  |  |  |  |  |  |  |  |  |  |  |
|  | e om vo ne ne lub av og bly de ne far de sin de sin de si        |  |  |  |  |  |  |  |  |  |
| COMBUSTION AIR : FRONT GLASS DOOR : OF   | PEN  |  |  |  |  |  |  |  |  |  |
| CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL  | WOOD   |  |  |  |  |  |  |  |  |  |
| FUEL TYPE : DOUGLAS FIR HEATING VALUE =  | =8379.0(BTU/LB)  |  |  |  |  |  |  |  |  |  |
|  | n der alle auf die jum die Teil 755 Teil der Bei auf die der Bei |  |  |  |  |  |  |  |  |  |
| MASS AIR IN =103.50(LB/MIN) MASS AIR OUT =   | 93.60(LB/MIN)  |  |  |  |  |  |  |  |  |  |
| MASS DRY FLUE GAS =10.87(LB/MIN) MASS COMB AIR = 4.39  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| %CO2 = .030 %CO = .010 %O2 = .100  |  |  |  |  |  |  |  |  |  |  |
| %C = .560 %H = .070 %MC =0.000   |  |  |  |  |  |  |  |  |  |  |
| (R.H.)LAB = .600 (R.H.)OUT = .660 (R.H.)ROOM = .4  | 140  |  |  |  |  |  |  |  |  |  |
|  | a an                         |  |  |  |  |  |  |  |  |  |
| FUEL<br>TIME WEIGHT TEMPERATURE(F)   | COMB AIR/<br>EFF TOT LOSS  |  |  |  |  |  |  |  |  |  |
| MIN LB/MIN IN OUT STACK COMB FIRE CALR LAB ENV   | 7. 7.  |  |  |  |  |  |  |  |  |  |
| 0 .2753 72.3 89.0 261.4 77.1 558.2 79.0 77.1 77.5  | .17 .10  |  |  |  |  |  |  |  |  |  |
| 1 .2775 72.3 92.6 415.5 77.8 623.4 80.3 76.9 79.0  | •21 •19  |  |  |  |  |  |  |  |  |  |
| 2 .2797 73.3 93.1 472.0 78.2 568.1 80.5 77.1 78.9  | •20 •22  |  |  |  |  |  |  |  |  |  |
| 3 .2783 73.6 89.9 446.0 78.9 631.5 81.3 77.1 77.9  | •17 •20  |  |  |  |  |  |  |  |  |  |
| 4 .2790 73.8 96.7 453.6 79.3 608.8 81.9 77.3 77.9<br>5 .2783 74.0 91.6 345.8 79.7 572.3 82.2 77.5 78.1 | •23 •22  |  |  |  |  |  |  |  |  |  |
| 5 .2783 74.0 91.6 345.8 79.7 572.3 82.2 77.5 78.1<br>6 .2797 73.8 91.5 288.6 80.3 546.7 83.2 77.4 78.3 | .18 .15<br>.19 .12   |  |  |  |  |  |  |  |  |  |
|  | : 200 000 100 100 000 000 000 000 000 000                        |  |  |  |  |  |  |  |  |  |
| AEF= .19 AQF=.139896E+06(BTU/HR) AQNH=.27011   | E+05(BTU/HR)   |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

|  | TEST NUMBER : 33-3   |        |                           |         |                         |                               |                              |   | /24/79                                    |  |                       |  |
|--|--|--------|---------------------------|---------|-------------------------|-------------------------------|------------------------------|---|---|--|-----------------------|--|
|  | 7 80 12 87 87 89 99<br>7 80 13 88 88 89 99   |        |                           | REPLACE | SIMUL                   | ATION S                       | STUDIES                      |   |   | 207 03 03 04 04 04 04 04               |                       |  |
|  | Сомв   | USTION | AIR :                     | FRONT   |                         |                               | GLA                          | SS DOC  | )R : OP                                   | EN                                     |                       |  |
|  | CIRC   | ULATIO | N FANS                    | : SIDES | 6 CLOSE                 | D                             | FUE                          | L MATE  | RIAL :                                    | WOOD                                   |                       |  |
|  | FUEL TYPE : DOUGLAS FIR  |        |                           |         |                         |                               |                              |   |   |  | (BTU/LB)              |  |
|  |  |        | N =103.                   |         |                         | : 110 MJ (12 12 12 12 12 12   |                              |   |   |  | LB/MIN)               |  |
|  | MASS DRY FLUE GAS =11.10(LB/MIN)   |        |                           |         |                         |                               |                              |   |   |  |                       |  |
|  | 2CO2 = .030  |        |                           |         |                         |                               |                              | <b>X02</b> = .100   |   |  |                       |  |
|  | %C =   | .560   |                           | %H =    | • 070                   |                               | %MC                          | %MC =0.000  |   |  |                       |  |
|  | (R.H   | .)LAB  | - • 600                   | (R.H    | I.)OUT                  | - • 660                       | (R.H.)ROOM = .440            |   |   |  |                       |  |
|  | UEL  |        | en de las 22 25 25 25 15  |         |                         | URE(F)                        |                              | ar II is fe ar Ni   | : (III (III 2II III III III III III III I | (                                      | COMB AIR/<br>TOT LOSS |  |
| MIN LB                                       | /MIN   | IN     | оит                       | STACK   | Сомв                    | FIRE                          | CALR                         | LAB   | ENV                                       | %                                      | %                     |  |
| 1 .3<br>2 .3<br>3 .3<br>4 .3<br>5 .3<br>6 .3 | 1.349173.696.1503.380.8678.32.356173.395.2521.181.6849.63.351773.1101.9546.082.0753.84.352472.6105.9538.082.7717.15.352169.694.1382.081.7775.8 |        |                           |         |                         |                               |                              | 77.6<br>77.6<br>77.6<br>77.2<br>77.6<br>77.1              | 76.2<br>75.8<br>73.5<br>70.9              | .19<br>.18<br>.24<br>.28<br>.21<br>.26 | .15                   |  |
| AEF= .                                       |  |        |                           |         |                         | U/HR)                         |                              |   | .38010                                    |  | TU/HR)                |  |
| AEFT=  | .19  |        | AQFT=                     | .141891 | E+06(B                  | TUZHR)                        |                              | AQNHT   | =.27862                                   | 2E+05(1                                | STU/HR)               |  |
| the sub per the test stat                    | 1978 1997 1912 1913 1918 19  |        | 20 25 38 53 53 53 88 fm : |         | <b>m</b> m: == == == == | 1911 202 2011 202 202 202 202 | 1998 BAR 1972 BAR 2012 BAR 1 | air 1944 gins i'lle var brid<br>an an art art and the tar |   |  |                       |  |

| TEST NUMBER : 30-1   |  |  |                 |              |                |         |   | DATE : 6/13/79                                       |  |   |   |  |
|--|--|--|-----------------|--------------|----------------|---------|---|--|--|---|---|--|
|  |  | C  | F I<br>CHARAC T | REPLACE      | SIMUL<br>S AND | ATION S | STUDIES   | )<br>IALYSIS   | 3  |   |   |  |
| COMBUSTION AIR : ROOM GLASS DOOR : CLOSED<br>CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD<br>FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/L |  |  |                 |              |                |         |   |  |  |   |   |  |
| MASS AIR IN = 97.50(LB/MIN)<br>MASS DRY FLUE GAS =10.30(LB/MIN)  |  |  |                 |              |                |         | MAS<br>MAS  | S AIR  | OUT = 1<br>AIR =                                     | 87.84)<br>3.51(                               | (LB/MIN)<br>(LB/MIN)                          |  |
| ,<br>10 11 10 07 07 07   | %C =<br>(R.H   |  | • 500           | 2H =<br>(R+H |                | = .460  | <pre>% 202 = .100<br/>% MC =0.000<br/>(R.H.)ROOM = .400</pre> |  |  |   |   |  |
| TIME U   |  | <b>M</b> ark Said Said Said Said Said Said |                 |              |                | URE(F)  |   |  | 1  |   | COMB AIR/<br>TOT LOSS                         |  |
| 0<br>1<br>2<br>3<br>4<br>5<br>6  | 1       .2173       75.7       78.0       367.6       78.6       628.8         2       .2166       75.5       77.9       490.9       78.4       686.3         3       .2166       76.0       78.2       492.9       78.8       787.5         4       .2170       75.9       78.4       476.1       78.8       816.7         5       .2159       76.4       78.9       383.7       79.2       900.3 |  |                 |              |                |         | 78.6<br>78.6<br>78.4<br>78.8<br>78.8<br>79.2<br>79.0          | 76.7<br>76.1<br>75.8<br>76.0<br>76.3<br>76.8<br>77.6 | 94.0<br>91.5<br>94.8<br>95.6<br>95.0<br>92.2<br>96.0 | .04<br>.03<br>.03<br>.03<br>.03<br>.03<br>.03 | .03<br>.14<br>.20<br>.20<br>.19<br>.14<br>.12 |  |
| AEF=   | AEF= .03 AQF=.109101E+06(BTU/HR) AQNH=.36395E+04(BTU/HR)   |  |                 |              |                |         |   |  |  |   |   |  |

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| TEST                                    | NUMBER                              | R : 30-                              | 2                        |        | DAT            | DATE : 6/13/79                    |              |              |                              |            |
|---|-------------------------------------|--------------------------------------|--------------------------|--------|----------------|-----------------------------------|--------------|--------------|------------------------------|------------|
|   |                                     |                                      |                          |        |                |                                   |              |              |                              |            |
| FIREPLACE SIMULATION STUDIES            |                                     |                                      |                          |        |                |                                   |              |              |                              |            |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS |                                     |                                      |                          |        |                |                                   |              |              |                              |            |
| UNHKAUJEKISJIUS AND EFFICIENUT ANALISIS |                                     |                                      |                          |        |                |                                   |              |              |                              |            |
|   |                                     |                                      | - 111 TZ AZ IZI IZ AZ AZ |        |                | . 270 1 <b>00 104 104 105</b> 100 |              |              | 122 <b>122 122 122 122</b> 1 |            |
| COMB                                    | USTION                              | AIR :                                | ROOM                     |        |                | GLA                               | SS DOC       | R : CL       | OSED                         |            |
| CIRC                                    | ULATION                             | I FANS                               | : SIDES                  | CLOSE  | D              | FUE                               | L MATE       | RIAL ;       | woon                         |            |
| FUEL TYPE : DOUGLAS FIR HEATING VAL     |                                     |                                      |                          |        |                |                                   |              | ALUE =       | B379.                        | O(BTU/LB)  |
| <b></b>                                 |                                     | <b>: 22 32 63 48 32 4</b> 8          |                          |        |                | ting and the sent with our        |              |              |                              |            |
| MASS                                    | AIR IN                              | 1 = 97.                              | 50(LB/M                  | IN)    |                | MAS                               | S AIR        | OUT = 1      | 87.84                        | (LB/MIN)   |
| HACC                                    | MAG                                 | e cour                               |                          |        | (1 Y) (MT ))   |                                   |              |              |                              |            |
| MASS DRY FLUE GAS =10.76(LB/MIN)        |                                     |                                      |                          |        |                |                                   | S CUMB       | MIK =        | 4+40                         | (LE/MIN)   |
|   |                                     |                                      |                          |        |                |                                   |              |              |                              |            |
| %02                                     | = .030                              | )                                    | %CO                      | 010    | ,              | 702                               | <b>≕</b> .10 | 0            |                              |            |
| %C =                                    | .560                                |                                      | %H ≔                     | .070   |                | %MC =0,000                        |              |              |                              |            |
| (R.H                                    | .)LAB =                             | •500                                 | (R.H                     | •)OUT  | <b>≕ ,4</b> 60 | (R.H.)ROOM = .400                 |              |              |                              |            |
|   |                                     |                                      |                          |        |                |                                   |              |              | a: 222 226 229 729 7         |            |
| FUEL                                    |                                     |                                      |                          |        |                |                                   |              |              |                              | COMB AIR/  |
| TIME WEIGHT                             |                                     |                                      | TE                       | MPERAT | URE(F)         |                                   |              |              | EFF                          | TOT LOSS   |
| MIN LB/MIN                              | IN                                  | OUT                                  | STACK                    | COMB   | FIRE           | CALR                              | LAB          | ENV          | 7.                           | 7          |
| 0,2797                                  | 76.1                                |                                      |                          |        | 842.5          | 79.0                              |              | 96.0         | .02                          | +12        |
| 1 •2827                                 | 79.7                                |                                      |                          |        | 788.7          |                                   |              | 91.0         | +01                          | •16        |
|   | 79.2<br>79.4                        |                                      | 547.3<br>566.9           |        | 836.1<br>846.8 | 81.3<br>81.7                      | 78.1         | 95.7<br>93.3 | .02<br>.03                   | •22<br>•23 |
|   |                                     |                                      |                          |        | 977.8          |                                   |              | 92.4         |                              | • 23       |
| 5 .2808                                 |                                     |                                      |                          |        | 926.3          |                                   |              |              |                              | .21        |
| 6 .2827                                 |                                     |                                      | 494+6                    |        |                |                                   |              | 94.5         | •03                          | •19        |
|   |                                     | anne helet balle vitar junit balle i |                          |        |                |                                   |              |              |                              |            |
| AEF= ,02                                |                                     |                                      |                          |        | U/HR)          |                                   |              |              |                              | BTU/HR)    |
|   | 1979 (1989 6982 1999 6598 1992 659) |                                      |                          |        |                |                                   |              |              |                              |            |

|   |                              | NUMBER                 |                       |                                  |                       | Е <b>:</b> 6/  |                       |                         |                       |                    |                                     |
|---|------------------------------|------------------------|-----------------------|----------------------------------|-----------------------|----------------|-----------------------|-------------------------|-----------------------|--------------------|-------------------------------------|
| FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS |                              |                        |                       |                                  |                       |                |                       |                         |                       |                    |                                     |
|   |                              |                        |                       |                                  |                       |                |                       |                         |                       |                    |                                     |
|   |                              | USTION                 |                       |                                  |                       |                |                       |                         | DR : CL               |                    |                                     |
|   |                              |                        |                       |                                  |                       |                |                       |                         |                       |                    |                                     |
|   |                              |                        |                       | : SIDES                          | CLOSE                 | D              | FUE                   | L MATE                  | ERIAL :               | WOOD               |                                     |
|   |                              | TYPE :                 |                       |                                  |                       |                |                       |                         |                       |                    | O(BTU∕LB)                           |
| 25 111 121 121 121 121  |                              |                        |                       | 50(LB/M                          |                       |                |                       |                         |                       |                    | (LB/MIN)                            |
|   | MASS                         | DRY FL                 | UE GAS                | =10.90                           | (LB/MI                | N)             | MAS                   | S COME                  | AIR =                 | 5.57               | (LB/MIN)                            |
|   | an 63 12 36 <del>25</del> 49 | IN (IN 12 IN 16) 72 01 |                       |                                  |                       |                |                       |                         |                       | a == == == == == = | 20 mm ant bie sie am ain ain bie 20 |
| %CO2 = .030 %CO = .010 %O2  |                              |                        |                       |                                  |                       |                |                       | 02 = .100               |                       |                    |                                     |
|   | %C =                         | •560                   |                       | %H =                             | .070                  |                | ZMC                   | =0.00                   | 00                    |                    |                                     |
|   | (R.H                         | .)LAB =                | • 500                 | (R.H                             | .)OUT                 | = .460         | (R.H.)ROOM = .400     |                         |                       |                    |                                     |
|   | na mi mi mi ini ka           |                        |                       | iter tott jer blit titt sitt sit | tan tak ana ara ka ra |                |                       |                         | 1 AR 20 22 AR AF 12 8 |                    |                                     |
| TIME W  | FUEL<br>EIGHT                |                        |                       | TE                               | MPERAT                | URE(F)         |                       |                         |                       | EFF                | COMB AIR/<br>TOT LOSS               |
| MIN L   | B/MIN                        | IN                     | OUT                   | STACK                            | COMB                  | FIRE           | CALR                  | LAB                     | ENV                   | %                  | 7.                                  |
|   | 3488<br>3590                 |                        | 81.9<br>81.9          | 494.6                            |                       | 844.8          |                       |                         | 94.5<br>94.1          | •03<br>•03         | •19<br>•24                          |
| 2 .   | 3517                         | 82.3                   | 83.9                  | 697.1                            | 84.3                  | 850.5          | 84.3                  | 78.6                    | 90.9                  | .02                | .28                                 |
|   | 3546<br>3601                 |                        |                       |                                  |                       | 994.6<br>911.9 |                       |                         | 93.0                  | +03<br>+03         | •28<br>•28                          |
|   | 3488                         |                        | 89.4                  | 533.4                            | 86.2                  | 911+9<br>877+5 | 86.2                  | 77.0                    | 07+0<br>90₊1          |                    | + 28<br>+ 22                        |
|   | 3557                         | 80.9                   | 87.8                  | 512.5                            | 85.1                  | 855.1          | 85.1                  |                         |                       | .06                | .21                                 |
| AEF=  |                              | <b>a a</b> a a a a     |                       | 178021E                          |                       |                | IN III IN III III III |                         | .59208F               |                    |                                     |
|   |                              |                        |                       |                                  |                       |                |                       |                         |                       |                    | (U/HK)                              |
| AEFT=   | .03                          |                        | AQFT=                 | .142673                          | E+06(B                | TU/HR)         |                       | AQNHT                   | <b>≕</b> ₊42945       | 5E+04(             | BTU/HR)                             |
|   |                              |                        | 199 AR AR AR AR AR AR | NH 12 NH 14 CC 12 CC             | 123 MR 400 02 02 124  |                |                       | == == == == == == == == |                       |                    |                                     |

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| TEST NUMBER   | 32-1  | DA.  | TE : 5/29/79                        |   |  |  |  |  |  |  |
|---|---|--|-------------------------------------|---|--|--|--|--|--|--|
|   |   |  |                                     |   |  |  |  |  |  |  |
| FIREPLACE SIMULATION STUDIES                                  |   |  |                                     |   |  |  |  |  |  |  |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS                       |   |  |                                     |   |  |  |  |  |  |  |
|   |   |  |                                     |   |  |  |  |  |  |  |
| COMBUSTION AIR : REAR GLASS DOOR : CLOSED                     |   |  |                                     |   |  |  |  |  |  |  |
| CIRCULATION   | FANS : SIDES CLOS   | ED FUE   | EL MATERIAL : 4                     | JOOD  |  |  |  |  |  |  |
| FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/L           |   |  |                                     |   |  |  |  |  |  |  |
|   |   |  |                                     |   |  |  |  |  |  |  |
|   |   |  |                                     |   |  |  |  |  |  |  |
| MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 88.56(LB/MIN)      |   |  |                                     |   |  |  |  |  |  |  |
| MASS DRY FLUE GAS =10.99(LB/MIN) MASS COMB AIR = 3.43(LB/MIN) |   |  |                                     |   |  |  |  |  |  |  |
|   |   |  |                                     |   |  |  |  |  |  |  |
| %02 = .030  | %00 = .010  | o %02  | 2 = .100                            |   |  |  |  |  |  |  |
| %C = .560   | %H = .070   | %MC  | =0.000                              |   |  |  |  |  |  |  |
| (R.H.)LAB =   | .780 (R.H.)OUT  | = .900 (R.   | H.)ROOM = .500                      | )   |  |  |  |  |  |  |
|   |   |  | 1                                   |   |  |  |  |  |  |  |
| FUEL<br>TIME WEIGHT   | TEMPERAT  | TURE(F)  |                                     | COMB AIR/<br>EFF TOT LOSS   |  |  |  |  |  |  |
| MIN LB/MIN IN   | OUT STACK COMB  | FIRE CALR  | LAB ENV                             | % %   |  |  |  |  |  |  |
| 3 •2137 66•2<br>4 •2155 65•8<br>5 •2133 65•7                  | 71.2142.869.271.8309.868.971.2404.868.871.9416.669.172.5409.868.871.7439.368.771.2399.868.2 | 717.2 70.2<br>767.5 70.2<br>734.2 69.9<br>745.9 71.4 | 72.9 68.1<br>73.6 67.2<br>73.3 67.3 | .05 .03<br>.06 .12<br>.06 .16<br>.07 .17<br>.08 .17<br>.07 .18<br>.07 .16 |  |  |  |  |  |  |
| AEF= .07  | AQF=.108020E+06(B)  | (U/HR)   | AQNH=.71543E+                       | 04(BTU/HR)  |  |  |  |  |  |  |

| TEST NUMBER : 32-2                | DATE : 5/29/79  |
|-----------------------------------|---|
|                                   | ی این میں این اور این کی کار این اور این  |
| FIREPLACE SIMULATION S            | TUDIES  |
| CHARACTERISTICS AND EFFICIE       | NCY ANALYSIS  |
|                                   |   |
| COMBUSTION AIR : REAR             | GLASS DOOR : CLOSED   |
| CIRCULATION FANS : SIDES CLOSED   | FUEL MATERIAL : WOOD  |
| FUEL TYPE : DOUGLAS FIR           | HEATING VALUE =8379.0(BTU/LB)   |
|                                   |   |
| MASS AIR IN = 97.50(LB/MIN)       | MASS AIR OUT = 88.56(LB/MIN)  |
| MASS DRY FLUE GAS =11.67(LB/MIN)  | MASS COMB AIR = 4.39(LB/MIN)  |
|                                   | עם אום אום אום אום אום אום אום אום אום או   |
| %CO2 = .030 %CO = .010            | 202 = .100  |
| % = .560 % H = .070               | 2MC =0.000  |
| (R.H.)LAB = .780 (R.H.)OUT = .900 | (R.H.)ROOM = .500   |
|                                   | الا الم علي عام بالا البلا عليا عليا الله عنه الله عليه الله عليا عليا ولو علي وما عليه علي عليا الله عليا عليا عليا علي عليا علي عليا علي عليا علي |

| FI | IF | 1 |
|----|----|---|

FUEL

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COMB AIR/

| IME | WEIGHT |      |      | TE    | MPERAT | URE(F) |      |      |      | EFF 1 | TOT LOSS |
|-----|--------|------|------|-------|--------|--------|------|------|------|-------|----------|
| MIN | LB/MIN | IN   | OUT  | STACK | COMB   | FIRE   | CALR | LAB  | ENV  | %     | 7.       |
| 0   | ·2753  | 64.8 | 71.2 | 399.8 | 68.5   | 692.8  | 69.2 | 72.9 | 65.9 | •06   | •16      |
| 1   | .2819  | 65.2 | 73.4 | 392.5 | 68.3   | 679.9  | 69.7 | 72.9 | 66.4 | .07   | .16      |
| 2   | .2783  | 65.5 | 71.7 | 526.9 | 68,5   | 625.2  | 69.6 | 73.0 | 65.3 | +06   | .22      |
| 3   | .2794  | 65.4 | 72.3 | 508.7 | 68.5   | 628.7  | 69.7 | 72.9 | 66.9 | •06   | •21      |
| 4   | .2808  | 65.5 | 71.8 | 537.4 | 68.9   | 642.0  | 69.8 | 73.3 | 67.1 | • 06  | .23      |
| 5   | •2772  | 65.9 | 72.2 | 447.7 | 68.8   | 666.2  | 70.1 | 72.7 | 66.2 | .06   | .18      |
| 6   | .2845  | 65.8 | 72.5 | 374.1 | 68.8   | 654.6  | 69.9 | 73.1 | 66.4 | .06   | .15      |

|  | TEST  | NUMBER                               | R : 32-  | DAT                        | E:5/         | /29/79         |      |                   |         |                            |            |  |
|--|---|--------------------------------------|--|----------------------------|--------------|----------------|------|-------------------|---------|----------------------------|------------|--|
|  | FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS |                                      |  |                            |              |                |      |                   |         |                            |            |  |
|  | COMB  | USTION                               | AIR :  | REAR                       |              |                | GLA  | ISS DOC           | )R : CL | OSED                       |            |  |
|  | CIRC  | ULATION                              | FANS   | : SIDES                    | CLOSE        | D              | FUE  | L MATE            | RIAL :  | WOOD                       |            |  |
|  |   |                                      | DOUGL  |                            |              |                |      |                   |         |                            | )(BTU/LB)  |  |
| MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 88.56(LB/MIN) |   |                                      |  |                            |              |                |      |                   |         | LB/MIN)                    |            |  |
| MASS DRY FLUE GAS =12.36(LB/MIN)                         |   |                                      |  |                            |              |                |      |                   |         |                            |            |  |
| %CO2 = .030 %CO = .010                                   |   |                                      |  |                            |              |                |      | %02 = .100        |         |                            |            |  |
|  | %C =  | .560                                 |  | %H ==                      | .070         |                | %MC  | =0.00             | 0       |                            |            |  |
|  | (R.H  | .)LAB =                              | • 780  | (R.H                       | •)OUT        | 900            | (R.  | (R.H.)ROOM = .500 |         |                            |            |  |
|  | FUEL  | *** *** *** *** *** *** **           | <b></b> <i></i>                                      |                            |              |                |      |                   |         |                            | COMB AIR/  |  |
| 11ME   | WEIGHT  | inth state lints many 5-00 10-00 1;- | a <u>2009</u> kirka antii m <u>ree</u> antii kirat i | 1E                         | MPERAI       | URE(F)         |      |                   |         | EFF<br>                    | TOT LOSS   |  |
| MIN  | LB/MIN  | IN                                   | OUT  | STACK                      | COMB         | FIRE           | CALR | LAB               | ENV     | %                          | %          |  |
| 0  |   |                                      |  |                            |              | 654.6<br>677.9 |      |                   | 66.4    | .05<br>.06                 | •15<br>•22 |  |
| 2  | .3488   | 65.6                                 | 73.1   | 584.0                      | 68.5         | 695.8          | 70.3 | 72.9              | 65.8    | .06                        | .25        |  |
|  | .3506   | 65.4                                 | 74.3   | 599.9                      | 68.5         | 675.5          | 70.4 | 72.6              | 66+2    | •07                        |            |  |
|  | •3513<br>•3451  | 65+6                                 | 74.0   | 602+3                      | <u>68.8</u>  | 678.3<br>673.1 | 70.7 | 73.1              | 66.2    | •06                        | • 26       |  |
| · 6  | .3451   | 65.5                                 | 75.0   | 421.8                      | 68.8         | 673+1          | 71.0 | 72.9              | 66.8    |                            | •22<br>•17 |  |
|  |   |                                      |  |                            |              |                |      |                   |         |                            |            |  |
| AEF=   | • • • • • •   |                                      | AQF=.  | 175648E                    | +06(BT       | U/HR)          |      | AQNH=             | .105258 | E+05(B                     |            |  |
|  |   |                                      |  |                            |              | TUZHR)         |      |                   |         |                            | BTU/HR)    |  |
| 52 M #2 #2 #   | <b></b>   | = m n= c= m =: =                     |  | c: ::: ::: ::: ::: ::: ::: | 60 m m m m m |                |      |                   |         | II III III III III III III |            |  |

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|                 |                |                              | FJ                                      | IREPLACE   | E SIMUL                       | LATION S                  | STUDIES                       | 5                              |                          |                     |                      |  |
|-----------------|----------------|------------------------------|---|------------|-------------------------------|---------------------------|-------------------------------|--------------------------------|--------------------------|---------------------|----------------------|--|
|                 |                | C                            | HARACT                                  | TERISTIC   | S AND                         | EFFICIE                   | ENCY AN                       | IALYSIS                        | ò                        |                     |                      |  |
|                 | COMB           | USTION                       | AIR :                                   | FRONT      | / die 122 Jan 325 Jan 325     |                           | :======<br>GL (               | SS DOC                         | DR : CL                  | OSED                | 12 UK IN IN IN IN IN |  |
|                 |                |                              |   |            |                               |                           |                               |                                |                          |                     |                      |  |
|                 | CIRC           | ULATION                      | FANS                                    | : SIDES    | CLOSE                         | 10                        | FUE                           | L MATE                         | ERIAL :                  | WOOD                |                      |  |
|                 | FUEL           | TYPE :                       | DOUGL                                   | AS FIR     |                               | HEA                       | TING V                        | VALUE =                        | 8379.(                   | )(BTU/              |                      |  |
| 20 22 22 29 29  | MASS           | AIR IN                       | ======================================= | 50(LB/M    | -=====<br>1IN>                |                           | MASS AIR OUT = 87.84(LB/MI    |                                |                          |                     |                      |  |
|                 |                |                              |   | 6 =10.76   |                               |                           |                               |                                |                          |                     |                      |  |
| ## <b>#</b> ### |                |                              | isses                                   |            |                               |                           |                               |                                |                          |                     |                      |  |
|                 | <b>%</b> C02   | = .030                       | )                                       | 200 = .010 |                               |                           | %02                           | ? = .10                        | >o                       |                     |                      |  |
|                 | %C =           | •560                         |   | %H =       | •070                          |                           | <b>%M</b> C                   | ZMC =0.000                     |                          |                     |                      |  |
|                 | (R.H           | .)LAB =                      | .700                                    | (R.H       | I.)OUT                        | = .900                    | (R.                           | H.)R00                         | IM = .55                 | 50                  |                      |  |
| 53 m fil 25 41  |                | 32 23 (2 <b>4</b> 6 25 25 25 |   |            | <b>30: 32: 32: 34: 22</b> 32: | . 25 10 25 15 15 27 12 13 | : 201 112 112 112 112 112 112 | ine 193 Ain <b>196</b> Ain 193 | : NO 107 IN IN IN 128 12 | 12 12 12 12 12 13 1 |                      |  |
| TIME            | FUEL<br>WEIGHT |                              |   | TE         | MPERAT                        | URE(F)                    |                               |                                |                          | EFF                 | COMB<br>TOT L        |  |
| MIN             | LB/MIN         | IN                           | OUT                                     | STACK      | СОМВ                          | FIRE                      | CALR                          | LAB                            | ENV                      | %                   | 7.                   |  |
|                 | .2111          | 75.5                         | 78.0                                    | 128.3      | 75.9                          |                           | 77.5                          | 76.7                           | 76.4                     | .03                 | .02                  |  |
|                 | .2111          | 75.7                         | 78.3                                    | 447.9      | 76.1                          |                           | 77.5                          | 76.7                           | 76.2                     | •03                 | .18                  |  |
|                 | .2126          | 75.1                         | 79.0                                    | 259.5      | 76.0                          |                           | 77.3                          | 76.8                           | 75.5                     | • 05                | • 0 9                |  |
|                 | •2129          | 75.1                         | 79.2                                    | 457.6      | 76.0                          |                           | 77.4                          | 76.6                           | 75.6                     | +05                 | .18                  |  |
|                 | +2173          | 74.8                         | 78.8                                    | 448.2      | 76.0                          |                           | 77.2                          | 76.5                           | 75.5                     | •05                 | .18                  |  |
| 5               | •2170<br>•2177 | 74.9                         | 79.6                                    | 466.9      | 75.9<br>76.7                  |                           | 77.5<br>78.2                  | 76.5<br>76.6                   | 75.6<br>76.8             | .06<br>.05          | •19<br>•13           |  |

| TEST NUMBER                       | : 34-2   | ДА  | TE : 6/8/79                           |  |  |  |  |
|-----------------------------------|--|---|---------------------------------------|--|--|--|--|
|                                   |  |   | : = = = = = = = = = = = = = = = = = = | an a         |  |  |  |
|                                   | FIREPLACE SIMUL  | ATION STUDIE                                    | S                                     |  |  |  |  |
| CH                                | ARACTERISTICS AND  | EFFICIENCY A                                    | NALYSIS                               |  |  |  |  |
|                                   | ین کو دی می می می دو       |   |                                       |  |  |  |  |
| COMBUSTION A:                     | IR : FRONT   | GL  | ASS DOOR : CLOSE                      | E D  |  |  |  |
| CIRCULATION F                     | FANS : SIDES CLOSE   | D FU  | EL MATERIAL : WO                      | αοε  |  |  |  |
| FUEL TYPE : I                     | DOUGLAS FIR  | HE  | ATING VALUE =83                       | 79.0(BTU/LB)                                     |  |  |  |
|                                   | ne en 160 za de 150 za 150 150 150 150 150 150 150 150 150 150 | No ita an III in la ita ita ita ita ita ita ita |                                       | <b>1</b> - 20 - 10 - 10 - 10 - 10 - 10 - 10 - 10 |  |  |  |
| MASS AIR IN =                     | = 97.50(LB/MIN)  | MA  | SS AIR OUT = 87                       | 84(LB/MIN)                                       |  |  |  |
| MASS DRY FLUE                     | E_GAS =10.99(LB/MI   | N) MA   | MASS COME AIR = 4.44(LE/MIN)          |  |  |  |  |
|                                   |  |   |                                       |  |  |  |  |
| %CO2 = .030                       | %CO = .010   | 20  | 2 = .100                              |  |  |  |  |
| %C = .560                         | 2H = .070  | 2M  | C =0.000                              |  |  |  |  |
| $(R_{\bullet}H_{\bullet})LAB = .$ | .700 (R.H.)OUT   | =.900 (R  | .H.)ROOM = .550                       |  |  |  |  |
|                                   |  |   |                                       |  |  |  |  |
| FUEL<br>TIME WEIGHT               | TEMPERAT   | URE(F)  | E                                     | COMB AIR/<br>FF TOT LOSS                         |  |  |  |
| MIN LB/MIN IN C                   | DUT STACK COMB   | FIRE CALR                                       | LAB ENV                               | % %  |  |  |  |
|                                   | 79.7 348.4 76.7  | 609.0 78.2                                      |                                       | .04 .13  |  |  |  |
|                                   | 31.8 318.5 76.7  | 601.6 78.6                                      |                                       | .05 .12  |  |  |  |
|                                   | 31+7 528+5 76+9  | 594.2 79.0                                      |                                       | .05 .22  |  |  |  |
|                                   | 32.3 525.1 77.0  | 598.8 79.0                                      |                                       | .06 .22  |  |  |  |
|                                   | 32,4 525,4 77,8<br>32,7 432,5 78,3                             | 607.0 80.0<br>600.7 80.5                        |                                       | .05 .21<br>.05 .17                               |  |  |  |
|                                   | 33.4 377.9 87.5  | 647.0 80.3                                      |                                       | 05 .14   |  |  |  |
|                                   |  |   |                                       |  |  |  |  |
| AEF= .05 A                        | AQF=,138446E+06(BT)  |   | AQNH=,68574E+0                        |  |  |  |  |

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| ====                                   | TEST  |  |   |  |  |   |  | Е: 6/  | /8/79<br>  |   |   |  |
|--|---|--|---|--|--|---|--|--|--|---|---|--|
|  |   |  |   | IREPLACE   |  |   |  |  |  |   |   |  |
|  |   |  |   | FERISTIC   |  |   |  |  |  |   |   |  |
| ::: <u>::</u> ::: ::                   | =======<br>Comb   | USTION   |   |  | - 167 512 512 517 517 51   | ; #11 82 44 63 63 46 62 62  |  | •  | DR : CL  |   |   |  |
|  | CIRC  | ULATIO   | N FANS  | : SIDES  | CLOSE  | D   | FUE  | L MATE   | ERIAL :  | woon  |   |  |
|  | FUEL  | . TYPE   | : DOUGL   | AS FIR   |  |   | HEA  | TING V   | VALUE =  | 8379.0  | )(BTU/  |  |
| 22 uz uz uz z                          |   |  | a m m m m m m   | :  | 2 ao 22 ao 38 am am  |   |  | ======   | - == == == == =                                      |   |   |  |
|  | MASS  | AIR IN   | <b>√</b> = 97.  | 50(LB/M  |  | MASS AIR OUT = 87.84(LB/MIN   |  |  |  |   |   |  |
|  | MASS  | DRY FL   | _UE GAS   | 5 =11.22   | (N)  | MASS COMB AIR = 5.51(LB/MI  |  |  |  |   |   |  |
|  | ****  | =======================================                          |   | **************************************                               |  |   | = •10  |  | net and and the basis and to                         | : *** #** *** *** **  |   |  |
|  | /s L/ L/ £  | - +vuv   | ,   | /4UU   | = +V1∧   | 1   |  |  |  |   |   |  |
|  | %C =  | •560   |   | %H =   | •070   |   | %MC  | %MC =0.000   |  |   |   |  |
|  | (R.H  | •)LAB =  | 700   | (R.H   | •)OUT  | 900   | (R.  | H.)ROC   | )M = .5!   | 50  |   |  |
|  |   |  |   |  |  |   |  |  |  |   |   |  |
| <u> </u>                               | EIIF(   | <b>12 12 12 12 12 1</b> 2 12 12 12 12 12 12 12 12 12 12 12 12 12 | 12 48 55 12 12 13 14 14 14 14                                 | :  |  | : die 125 zie 36 32 22 23   | t dan part saji dan 216 ter                          |  | , and see the second second second                   | # ## ## ## ## ##  |   |  |
| TIME                                   | FUEL<br>WEIGHT  |  |   | TE   | MPERAT   | URE(F)  |  |  | n mage under frei after here dete a                  |   | COMB<br>TOT L   |  |
|  |   | <br>   | <br>OUT   | TE<br>STACK  |  | URE(F)  | CALR   | LAB  | ENV  |   |   |  |
|  | WEIGHT  | 77.6   |   | STACK<br>377.9   | COMB   | a bilingan atalam ana ana ana ana ana ana ana ana ana a             | t ente under solit dente solit enter                 | LAB<br>76.7  | -  | EFF   | TOT L   |  |
| MIN<br>O<br>1                          | WEIGHT<br>LB/MIN<br>.3451<br>.3407  | 77.6<br>76.9   | 83.4<br>84.8  | STACK<br>377.9<br>508.1  | COMB<br>78.5<br>78.0   | FIRE<br>647.0<br>658.2  | 80.3<br>80.1   | 76.7<br>76.6   | 81.9<br>79.3   | EFF<br>7<br>.05<br>.06  | TOT L<br>%  |  |
| MIN<br>0<br>1<br>2                     | WEIGHT<br>LF/MIN<br>.3451<br>.3407<br>.3370                                     | 77.6<br>76.9<br>77.2   | 83,4<br>84,8<br>83,2  | STACK<br>377.9<br>508.1<br>593.8                                     | COMB<br>78.5<br>78.0<br>78.4   | FIRE<br>647.0<br>658.2<br>645.6                                     | 80.3<br>80.1<br>80.5                                 | 76.7<br>76.6<br>76.5                                 | 81.9<br>79.3<br>79.7                                 | EFF<br>7<br>.05<br>.06<br>.05                                       | TOT L<br>7<br>.14<br>.21<br>.25                             |  |
| MIN<br>0<br>1<br>2<br>3                | WEIGHT<br>LF/MIN<br>.3451<br>.3407<br>.3370<br>.3454                            | 77.6<br>76.9<br>77.2<br>76.9                                     | 83.4<br>84.8<br>83.2<br>83.6                                  | STACK<br>377.9<br>508.1<br>593.8<br>629.1                            | COMB<br>78.5<br>78.0<br>78.4<br>78.7                                 | FIRE<br>647.0<br>658.2<br>645.6<br>651.4                            | 80.3<br>80.1<br>80.5<br>80.5                         | <br>76.7<br>76.5<br>76.3                             | 81.9<br>79.3<br>79.7<br>78.1                         | EFF<br>2<br>.05<br>.06<br>.05<br>.06                                | TOT L<br>Z<br>.14<br>.25<br>.25                             |  |
| MIN<br>0<br>1<br>2<br>3<br>4           | WEIGHT<br>LF/MIN<br>.3451<br>.3407<br>.3370<br>.3454<br>.3443                   | 77.6<br>76.9<br>77.2<br>76.9<br>77.4                             | 83.4<br>84.8<br>83.2<br>83.6<br>83.9                          | STACK<br>377.9<br>508.1<br>593.8<br>629.1<br>610.2                   | COMB<br>78.5<br>78.0<br>78.4<br>78.7<br>78.8                         | FIRE<br>647.0<br>658.2<br>645.6<br>651.4<br>660.2                   | 80.3<br>80.1<br>80.5<br>80.5<br>81.0                 | 75.7<br>76.6<br>76.5<br>76.3<br>76.6                 | 81.9<br>79.3<br>79.7<br>78.1<br>78.1                 | EFF<br>2<br>.05<br>.06<br>.05<br>.06<br>.05                         | TOT 1<br>7<br>.14<br>.25<br>.27<br>.26                      |  |
| MIN<br>0<br>1<br>2<br>3<br>4<br>5      | WEIGHT<br>LB/MIN<br>.3451<br>.3407<br>.3370<br>.3454<br>.3443<br>.3443          | 77.6<br>76.9<br>77.2<br>76.9<br>77.4<br>76.9                     | 83.4<br>84.8<br>83.2<br>83.6<br>83.9<br>84.6                  | STACK<br>377.9<br>508.1<br>593.8<br>629.1<br>610.2<br>511.3          | COMB<br>78.5<br>78.0<br>78.4<br>78.7<br>78.8<br>78.8                 | FIRE<br>647.0<br>658.2<br>645.6<br>651.4<br>660.2<br>662.8          | 80.3<br>80.1<br>80.5<br>80.5<br>81.0<br>81.1         | 76.7<br>76.6<br>76.5<br>76.3<br>76.6<br>76.8         | 81.9<br>79.3<br>79.7<br>78.1<br>78.1<br>78.1         | EFF<br>2<br>.05<br>.06<br>.05<br>.06<br>.05<br>.06                  | TOT L<br>7<br>.14<br>.21<br>.25<br>.27<br>.26<br>.21        |  |
| MIN<br>0<br>1<br>2<br>3<br>4<br>5<br>6 | WEIGHT<br>LF/MIN<br>.3451<br>.3407<br>.3370<br>.3454<br>.3443<br>.3443<br>.3484 | 77.6<br>76.9<br>77.2<br>76.9<br>77.4<br>76.9<br>76.9             | 83.4<br>84.8<br>83.2<br>83.6<br>83.9<br>84.6<br>84.9          | STACK<br>377.9<br>508.1<br>593.8<br>629.1<br>610.2<br>511.3<br>431.7 | COMB<br>78.5<br>78.0<br>78.4<br>78.7<br>78.8<br>78.8<br>78.8<br>79.0 | FIRE<br>647.0<br>658.2<br>645.6<br>651.4<br>660.2<br>662.8<br>699.3 | 80.3<br>80.1<br>80.5<br>80.5<br>81.0<br>81.1<br>81.2 | 76.7<br>76.6<br>76.5<br>76.3<br>76.6<br>76.8<br>76.8 | 81.9<br>79.3<br>79.7<br>78.1<br>78.1<br>78.1<br>78.1 | EFF<br>2<br>.05<br>.06<br>.05<br>.06<br>.05<br>.06<br>.07           | TOT L<br>7<br>.14<br>.21<br>.25<br>.27<br>.26<br>.21<br>.17 |  |
| MIN<br>0<br>1<br>2<br>3<br>4<br>5<br>6 | WEIGHT<br>LB/MIN<br>.3451<br>.3407<br>.3370<br>.3454<br>.3443<br>.3443          | 77.6<br>76.9<br>77.2<br>76.9<br>77.4<br>76.9<br>76.9             | 83.4<br>84.8<br>83.2<br>83.6<br>83.9<br>84.6<br>84.9<br>AQF=. | STACK<br>377.9<br>508.1<br>593.8<br>629.1<br>610.2<br>511.3<br>431.7 | COMB<br>78.5<br>78.0<br>78.4<br>78.7<br>78.8<br>78.8<br>78.8<br>79.0 | FIRE<br>647.0<br>658.2<br>645.6<br>651.4<br>660.2<br>662.8<br>699.3 | 80.3<br>80.1<br>80.5<br>80.5<br>81.0<br>81.1<br>81.2 | 76.7<br>76.5<br>76.5<br>76.6<br>76.6<br>76.8<br>76.6 | 81.9<br>79.3<br>79.7<br>78.1<br>78.1<br>78.1<br>77.7 | EFF<br>2<br>.05<br>.06<br>.05<br>.06<br>.05<br>.06<br>.07<br>E+04(B | TOT L<br>Z<br>.14<br>.21<br>.22<br>.22<br>.22<br>.24<br>.17 |  |

|      | TEST NUMBER : 29A-1 |         |                             |                   |        |         |        | E : 5/               | /9/79    |                    |                                 |  |
|------|---------------------|---------|-----------------------------|-------------------|--------|---------|--------|----------------------|----------|--------------------|---------------------------------|--|
| **** |                     |         | 11 - 12 - 12 - 12 - 12 - 12 | . = = = = = = = = |        |         |        |                      | ======   | <u>2</u> = = = = = |                                 |  |
|      |                     |         | FI                          | REPLACE           | SIMUL  | ATION S | TUDIES | ;                    |          |                    |                                 |  |
|      |                     | (       | CHARACT                     | ERISTIC           | S AND  | EFFICIE | NCY AN | ALYSIS               | 6        |                    |                                 |  |
|      |                     |         |                             |                   |        |         | :      | . = = = = = =        |          |                    |                                 |  |
|      | COMB                | USTION  | AIR :                       | ROOM              |        |         | GLA    | ISS DOC              | DR : OPI | EN                 |                                 |  |
|      | CIRC                | ULATIO  | FANS                        | : SIDES           | CLOSE  | D       | FUE    | FUEL MATERIAL : WOOD |          |                    |                                 |  |
|      | FUEL                | TYPE    | PINE                        |                   |        |         | HEA    | TING V               | ALUE =   | 3342.              | O(BTU/LB)                       |  |
|      |                     |         |                             |                   |        |         |        |                      |          |                    | = = = = = = = = = = = = = = = = |  |
|      | MASS                | AIR IN  | v =101.                     | 25(LB/M           | IN)    |         | MAS    | S AIR                | OUT = 9  | 73,60              | (LB/MIN)                        |  |
|      | MASS                | DRY FL  | .UE GAS                     | =10.53            | (LB/MI | N)      | MAS    | S COME               | AIR =    | 3,67               | (LB/MIN)                        |  |
|      |                     |         | I == == == == == ==         |                   |        |         |        |                      |          |                    |                                 |  |
|      | %02                 | = .030  | )                           | %C0               | = .010 | ,       | %02    | = .10                | 0        |                    |                                 |  |
|      | %C =                | .560    |                             | %H =              | .070   |         | %MC    | =0.00                | 0        |                    |                                 |  |
|      | (R•H                | .)LAB = | • .720                      | (R.H              | •)OUT  | = .820  | (8.    | H.)ROO               | M = •62  | 20                 |                                 |  |
|      |                     |         |                             |                   |        |         |        |                      |          |                    | s in as in in in in ai in in    |  |
|      | FUEL                |         |                             |                   |        |         |        |                      |          |                    | COMB AIR/                       |  |
| TIME | WEIGHT              |         |                             | TE                | MPERAT | URE(F)  |        |                      |          | EFF                | TOT LOSS                        |  |
| MIN  | LB/MIN              | IN      | Ουτ                         | STACK             | COMB   | FIRE    | CALR   | LAB                  | ENV      | %                  | %                               |  |
|      | •2298               |         |                             |                   |        |         |        |                      |          |                    |                                 |  |
| 1    | •2298               |         |                             |                   |        |         |        |                      |          |                    |                                 |  |

B--74

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.2298

.2298

,2298

.2298

.2294

AEF= .15

71.4

72.9

73.0

73.1

75.5

4

89.1

90.9

81.5

87.1

321.7

294.3

261.2

195.0

84.5 234.0

77.5

78.6

79.2

80.5

AQF=.114998E+06(BTU/HR)

78.6

904.1 77.5 74.8 73.2

78.6

79.2

80.5

75.3 75.7

74.7 76.3

73.8

75.2

75.2

75.2

830.2 78.6

765.4

753.4

730.3

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.21

.22

.11

.14

.15

AQNH=.17493E+05(BTU/HR)

.14

.13

.09

.08

| TE                                       | ST NUMBE  | R : 294                       | <del>)</del> -2              |                             |                                | DAI         | TE : 5/      | /9/79                               |                        |                               |
|--|-----------|-------------------------------|------------------------------|-----------------------------|--------------------------------|-------------|--------------|-------------------------------------|------------------------|-------------------------------|
|  |           |                               |                              |                             |                                |             |              |                                     |                        |                               |
|  |           | FI                            | REPLACE                      | SIMUL                       | ATION S                        | STUDIES     | 3            |                                     |                        |                               |
|  |           | CHARACI                       | FERISTIC                     | S AND                       | EFFICIE                        | ENCY AN     | ALYSIS       | 5                                   |                        |                               |
|  |           |                               |                              | : un 12 22 22 23 13 1       | i an 22 12 12 12 12 14 14 14   | -           |              | x #2 66 92 92 93 98 98 98           | = = = = =              | NG 28 NG 39 NG 30 NG 30 NG 28 |
| CO                                       | MBUSTION  | AIR :                         | ROOM                         |                             |                                | GLA         | ISS DOC      | DR : OPI                            | EN                     |                               |
| CI                                       | RCULATIO  | N FANS                        | : SIDES                      | CLOSE                       | E DI                           | FUE         | L MATE       | ERIAL :                             | woon                   |                               |
| FU                                       | EL TYPE   | : PINE                        |                              |                             |                                | HEA         | TING V       | ALUE =                              | 8342.                  | O(BTU/LB)                     |
|  | =======   |                               | ; == == == <b>==</b> == == = |                             |                                | <b></b>     | :            | = <b></b>                           |                        |                               |
| МА                                       | SS AIR I  | N =101.                       | 25(LB/M                      | IIN)                        |                                | MAS         | S AIR        | OUT = 9                             | 73.60                  | (LB/MIN)                      |
| MA                                       | SS DRY FI | LUE GAS                       | =10,53                       | (LB/M]                      | (N)                            | MAS         | S COME       | ) AIR =                             | 3.38                   | (LB/MIN)                      |
|  | *****     | <b>II. AN AZ IZ AN IZ I</b> Z |                              | : <b>m m </b> =  =  =  =  = | 1                              |             |              | ======                              | <b>z az ez ez ez</b> : |                               |
| %C                                       | 02 = .03  | 0                             | %CO                          | = .010                      | )                              | <b>%</b> 02 | = .10        | 0                                   |                        |                               |
| <b>%</b> C                               | = .560    |                               | %H =                         | •070                        |                                | %MC         | =0.00        | 00                                  |                        |                               |
| (R                                       | .H.)LAB   | - ,720                        | (R+H                         | •)OUT                       | = .820                         | (R.         | H.)ROC       | )M = .62                            | 20                     |                               |
| 22 42 22 4 <b>0 10</b> 42 48 48 21 22 42 |           | 12 Fra 86 Fra 112 See 61      |                              |                             | 1 Mar 122 Hill And 188 Hill An | -           |              | . <b></b>                           |                        |                               |
| FUEL<br>TIME WEIGH                       | Т         |                               | TE                           | MPERAT                      | URE(F)                         |             |              |                                     | EFF                    | COMB AIR/<br>TOT LOSS         |
| MIN LB/MI                                | N IN      | OUT                           | STACK                        | COMB                        | FIRE                           | CALR        | LAB          | ENV                                 | 7.                     | ".                            |
| 0 .2118                                  |           | 87.1                          | 195.0                        |                             | 730.3                          |             | 74.7         | 76.3                                | •16                    | •06                           |
| 1 .2118                                  |           |                               | 397.8                        | 80.9                        | 819.8                          | 80.9        | 75.1         |                                     | .17                    | +17                           |
| 2 •2118                                  |           |                               | 352.0                        |                             | 784.6                          |             | 75.4         |                                     | .17                    | .15                           |
| 3 ·2118<br>4 ·2118                       |           |                               | 335.2<br>283.9               | 82.3                        | 756.5                          |             | 75.6<br>75.8 |                                     | •21                    | .15                           |
| 4 .2118<br>5 .2118                       |           | 83./                          | 283.9<br>232.4               |                             | 701.1<br>828.7                 |             | 75+8<br>75+3 |                                     | •12<br>•20             | •11<br>•09                    |
| 6 •2118                                  |           | 87.6                          | 215.2                        | 81.1                        | 864.1                          | 81.1        | 75.3<br>75.3 |                                     | •20                    | .08                           |
|  |           |                               |                              |                             |                                |             | =====        | , saar bion word book place cher of | . 23 22 32 32 38 1     |                               |

AEF= .17 AQF=.106021E+06(BTU/HR) AQNH=.18493E+05(BTU/HR)

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|                                   | TEST NUMBER : 29A-3      |                                      |                   |                                  |                               |                       |                                  | 'E : 5/                               | /9/79                    |                            |                                       |  |  |
|-----------------------------------|--------------------------|--------------------------------------|-------------------|----------------------------------|-------------------------------|-----------------------|----------------------------------|---------------------------------------|--------------------------|----------------------------|---------------------------------------|--|--|
| 22 22 22 12 12 cz 2               |                          | a a a a a a a a                      | -                 |                                  | 2 111 52 112 112 112 112      | e pe ta un se un se c | 3 <b></b>                        | : 23 an 12 22 48 1                    |                          | in in ay 111 in 115        |                                       |  |  |
|                                   |                          |                                      | FI                | REPLACE                          | E SIMUL                       | ATION S               | STUDIES                          | 5                                     |                          |                            |                                       |  |  |
|                                   |                          | C                                    |                   | COTOTIC                          |                               | EFFICIE               |                                  |                                       | 2                        |                            |                                       |  |  |
|                                   |                          | L.                                   | AAAAAA            | CRIDII                           | 79 HIND                       |                       | NUT MP                           | HEIDIC                                | 2                        |                            |                                       |  |  |
|                                   | • = = = = =              |                                      |                   | . 112 122 123 126 126 128 128 12 |                               |                       |                                  | - 112 AN AN AN AN AN AN               | 5 00 05 00 08 08 75 05 I | 12 12 12 13 12 12 12       |                                       |  |  |
|                                   | COMB                     | USTION                               | AIR :             | ROOM                             |                               |                       | GLA                              | SS DOC                                | DR : OPI                 | EN                         |                                       |  |  |
|                                   | CIRC                     | ULATION                              | FANS              | : SIDES                          | G CLOSE                       | D                     | FUE                              | L MATE                                | ERIAL :                  | WOOD                       |                                       |  |  |
|                                   | FUEL                     | TYPE :                               | FINE              |                                  |                               |                       | HEA                              | TING V                                | ALUE =                   | 8342.0                     | (BTU/LB)                              |  |  |
| this take and two trid and to     |                          |                                      |                   |                                  | e dias 1966 term dair yan bu  | -                     | a bere nakt titte daar stijd gan | the trave with such they the          |                          |                            |                                       |  |  |
|                                   | X400                     | ATE: TSI                             | 4 / 4             | 25.25 ( ) The 2 S                |                               |                       |                                  | 0 ATE                                 | 0.1177                   |                            | • • • • • • • • • • • • • • • • • • • |  |  |
|                                   |                          | AIR IN                               | /                 |                                  |                               |                       |                                  | 5 AIR                                 | UUI = 1                  | 93.600                     | LB/MIN)                               |  |  |
|                                   | MASS                     | DRY FL                               | UE GAS            | =10.99                           | N)                            | MAS                   | MASS COME AIR = 3.39(LB/MIN)     |                                       |                          |                            |                                       |  |  |
| 52 55 55 55 55 56 5 <b>6</b> 5    | 1 20 22 28 <b>2</b> 1 27 |                                      |                   |                                  |                               |                       | =========                        |                                       |                          |                            |                                       |  |  |
|                                   | %02                      | = .030                               |                   | %0                               | <b>.</b> .010                 | )                     | 702                              | = .10                                 | 0                        |                            |                                       |  |  |
|                                   | %C =                     | .560                                 |                   | %H =                             | .070                          |                       | %MC                              | %MC =0.000                            |                          |                            |                                       |  |  |
|                                   |                          |                                      | 720               |                                  |                               | - 020                 | (R.H.)ROOM = .620                |                                       |                          |                            |                                       |  |  |
|                                   | <u> (</u> к+п            | •/LHD                                | •/20              | V IX + FI                        | • 7001                        | - +020                | <b>ΥΥ</b> +                      | $(R_{\bullet}H_{\bullet})RUUM = +820$ |                          |                            |                                       |  |  |
| 111 <b>35 25 8</b> 1 61 66 113 12 |                          |                                      | x: ## ## 25 22 23 | אל את ללי עם דה או או            | i den samt man bete ofti eren |                       | . Man tible bidf find die find   |                                       | : 22 22 23 23 28 28 2    | <b>2 61 12 12 12 12</b> 14 |                                       |  |  |
| F<br>TIME WE                      | UEL                      |                                      |                   | TE                               | NDEDAT                        | URE(F)                |                                  |                                       |                          |                            | COMB AIR/<br>TOT LOSS                 |  |  |
|                                   |                          | abbh anna ràith sinn anna gasta anna |                   |                                  |                               |                       | ann der vers som ille der        |                                       |                          | **                         |                                       |  |  |
| MIN LE                            | MIN                      | IN                                   | 0UT               | STACK                            | COMB                          | FIRE                  | CALR                             |                                       | ENV                      | <b>%</b>                   | <b>%</b>                              |  |  |
|                                   |                          | 73.2                                 |                   |                                  |                               | 864.1                 |                                  |                                       | 75.5                     |                            | +08                                   |  |  |
|                                   | 2126<br>2126             | 75.0                                 |                   |                                  |                               | 906.9<br>925.7        |                                  |                                       |                          |                            | •19<br>•17                            |  |  |
|                                   | 126                      | 76.3                                 | 89.0              |                                  |                               | 876.6                 |                                  |                                       |                          |                            | .14                                   |  |  |
| 4.2                               | 126                      | 75.0                                 | 89.0              | 289.8                            | 82.6                          | 847.4                 | 82.6                             | 75.6                                  | 76.0                     | .19                        | .12                                   |  |  |
| 5.2                               | 126                      | 75.7                                 | 89.9              | 230.0                            | 83.3                          | 769.5                 | 83.3                             | 75.8                                  | 75.3                     | .19                        | •08                                   |  |  |
| 6.2                               | 126                      | 75.3                                 | 86.1              | 205.4                            | 82.8                          | 695.6                 | 82.8                             | 75.8                                  | 75.3                     | .15                        | .07                                   |  |  |
|                                   |                          |                                      |                   |                                  |                               |                       |                                  |                                       |                          |                            |                                       |  |  |
| AEF= .                            |                          |                                      |                   |                                  |                               | U/HR)<br>======       |                                  |                                       | •19418E                  |                            | FU/HR)<br>========                    |  |  |
| AEFT=                             | •17                      |                                      | AQFT=             | .109135                          | E+06(B                        | TUZHR)                |                                  | AQNHT                                 | =•18468                  | 3E+05(1                    | BTU/HR)                               |  |  |
| 12 22 12 m na 22 00               | ne == na .=1 on a        |                                      |                   |                                  | TE CR EF ER MI NO             | 92 73 WI 75 VE 65 W   |                                  |                                       |                          | , ma en de 22 de 2         |                                       |  |  |

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|                   | TEST           |  | R : 291       | 8-1                                   |                     |                          | DAT          | E:5/         | /11/79                        |                 |  |
|-------------------|----------------|--|---------------|---------------------------------------|---------------------|--------------------------|--------------|--------------|-------------------------------|-----------------|--|
|                   |                |  |               | ======                                |                     |                          | -=====       |              |                               | *====           |  |
|                   |                |  | FI            | REPLACE                               | E SIMUL             | ATION S                  | TUDIES       | 5            |                               |                 |  |
|                   |                | t  | CHARACI       | ERISTIC                               | S AND               | EFFICIE                  | ENCY AN      | ALYSIS       | 5                             |                 |  |
|                   |                | 14 12: 21: 21: 21: 21: 21: 21: 21: 21: 21: |               |                                       |                     |                          |              |              | 1 dit im im dit 32, 32, 1     |                 | = = = = = = = = = = = = = = =            |
|                   | COME           | RUSTION                                    | AIR :         | ROOM                                  |                     |                          | GLA          | ss DOC       | DR : OPI                      | EN              |  |
|                   | CIRC           | CULATIO                                    | N FANS        | : SIDES                               | CLOSE               | ED                       | FUE          | L MATE       | RIAL :                        | WOOD            |  |
|                   | FUEL           | TYPE                                       | <b>:</b> 0AK  |                                       |                     |                          | HEA          | TING V       | ALUE =                        | B260.           | O(BTU/LB)                                |
| 100 AV7 551 111 : | <b></b>        |  | <b>1</b>      |                                       |                     | r <b>m m m m m m m</b> m |              |              | :                             | er av 30 55 av  |  |
|                   | MASS           | GAIR IN                                    | N =101.       | 25(LB/M                               | (NIN)               |                          | MAS          | S AIR        | OUT = 9                       | 93.60           | (LB/MIN)                                 |
|                   | MASS           | S DRY FL                                   | LUE GAS       | =10.53                                | (LB/M)              | (N)                      | MAS          | S COME       | AIR =                         | 4.33            | (LB/MIN)                                 |
| <u> </u>          | <b></b>        | . <u>19 19 19 19 19 19 19</u>              |               | : : : : : : : : : : : : : : : : : : : | : == == == == == == |                          |              |              | ======                        |                 |  |
|                   | %CO2           | 2 = .03(                                   | >             | %00                                   | = .010              | )                        | <b>%0</b> 2  | = .18        | 10                            |                 |  |
|                   | %C =           | • • 560                                    |               | %H =                                  | • 070               |                          | <b>%</b> MC  | =0.00        | 0                             |                 |  |
|                   | (R.H           | I.)LAB =                                   | - • 630       | (R.H                                  | I.)OUT              | = .730                   | (R.          | H.)ROC       | M = +48                       | 30              |  |
| 70 at 12 12 i     |                |  | • = = = = = = |                                       |                     |                          | ======       | ======       | - 100 100 100 100 100 100 100 |                 | 19 39 65 66 30 50 50 50 50 <b>6</b> 2 50 |
| TINE              | FUEL<br>WEIGHT |  |               | TE                                    | MPERAT              | URE(F)                   |              |              |                               | EFF             | COMB AIR/<br>TOT LOSS                    |
| MIN               | LB/MIN         | IN   | ουτ           | STACK                                 | COMB                | FIRE                     | CALR         | LAB          | ENV                           | %               | %  |
|                   | +2713          |  |               | 156.6                                 |                     |                          |              |              |                               | +07             | +04                                      |
| 1                 |                |  | 90.1          |                                       |                     |                          |              |              |                               | •13             | •17                                      |
| 2                 | .2713          | 77.9                                       |               |                                       |                     | 612.1                    |              |              |                               |                 | •16                                      |
| 3                 | •2713          | 77.8                                       | 92.6          | 349,9                                 | 83.4                | 610.9                    | 83.4         | 77.2         | 81.2                          |                 | •15                                      |
| 4                 | •2713          | 77.8                                       | 93.0          | 315.1                                 | 83.5                | 625.1                    |              |              |                               | .16             | .13                                      |
| 5<br>6            | •2713<br>•2713 | 76.8<br>76.2                               | 90.6<br>90.4  | 304.9<br>243.1                        | 82.8<br>82.1        | 510.9<br>462.7           | 82.8<br>82.1 | 77.2<br>77.1 | <b>78.4</b><br>78.6           | •15<br>•15      | •12<br>•09                               |
|                   |                |  |               |                                       |                     |                          |              |              |                               |                 |  |
| AEF=              | <b>- </b> •14  |  | AQF=+         | 134452E                               | +06(BT              | U/HR)                    |              | AQNH=        | ·18342E                       | E+05(B          | TU/HR)                                   |
| =====             | ========       | ========                                   | ======        |                                       |                     |                          |              |              |                               | : ## ## ## ## 2 |  |

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|                 | TESI                   | NUMBER   | t <b>:</b> 29E                     | 1-2               |               |                | DAT                                      | E:5/    | /11/79       |                     |                                  |
|-----------------|------------------------|----------|------------------------------------|-------------------|---------------|----------------|--|---------|--------------|---------------------|----------------------------------|
|                 | in 44 in 16 an in An i |          |                                    |                   |               | ATION S        |  |         |              | 10. 07 10, 00 00, 1 | I II II AI AI AI AI Z II II II Z |
| == = =          |                        |          |                                    |                   |               |                | : 202 202 202 202 202 202 202 202 202 20 |         |              |                     |                                  |
|                 | COME                   | USTION   | AIR :                              | ROOM              |               |                | GLA                                      | SS DOC  | R : OPI      | EN                  |                                  |
|                 | CIRC                   | ULATION  | FANG                               | : SIDES           |               | - TI           | FUE                                      | 1 MATE  | RIAL :       | ພດດກ                |                                  |
| - wears are     |                        |          |                                    | • • • • • • • •   | , 02002       | • •'           |  |         |              |                     |                                  |
|                 | FUEL                   | . TYPE : | DAK                                |                   |               |                | HEA                                      | TING V  | ALUE =       | 8260.(              | )(BTU/LB)                        |
| 200 CE (20 CE ) |                        |          | -                                  |                   |               |                | - 111 111 111 111 111 111                |         |              |                     |                                  |
|                 | MASS                   | AIR IN   | =101.                              | 25(LB/M           | IN)           |                | MAS                                      | S AIR   | OUT = 1      | 93.60               | (LB/MIN)                         |
|                 | MASS                   | DRY FL   | UE GAS                             | =10.87            | '(LB/M]       | (N)            | MAS                                      | S COME  | AIR =        | 4.65                | (LB/MIN)                         |
|                 |                        |          | i Silili, yang pada akas sama yang |                   |               |                |  |         |              |                     |                                  |
|                 | *co2                   | 2 = .030 |                                    | <b>2</b> 00       | <b>≕</b> .010 |                | <b>2</b> 02                              | . = .18 | 0            |                     |                                  |
|                 |                        |          |                                    | 200               | - +010        | ,              |  |         |              |                     |                                  |
|                 | %C =                   | •560     |                                    | %H =              | •070          |                | %MC                                      | =0.00   | 00           |                     |                                  |
|                 | (R.H                   | •)LAB =  | •630                               | (R.H              | •>0UT         | = .730         | (R.                                      | H.)ROO  | IM = .48     | 30                  |                                  |
|                 | ***                    |          |                                    |                   |               |                | =====                                    |         |              |                     |                                  |
| TIME            | FUEL<br>WEIGHT         |          |                                    | TE                | MPERAT        | URE(F)         |  |         |              | EFF                 | COMB AIR/<br>TOT LOSS            |
| MIN             | LB/MIN                 | IN       | OUT                                | STACK             | COMB          | FIRE           | CALR                                     | LAB     | ENV          | %                   | <i>%</i>                         |
| 0               | .2911                  | 76.2     | 90.4                               | 253.1             | 82.1          | 462.7          | 82.1                                     | 77.1    | 78.6         | .14                 | •09                              |
|                 | .2911                  |          |                                    |                   |               |                |  |         | 77.0         |                     | +22                              |
|                 |                        |          |                                    |                   |               | 500.3          |  |         |              |                     |                                  |
|                 |                        |          |                                    |                   |               | 484.9          |  |         | 78.8         |                     | .17                              |
|                 |                        |          |                                    |                   |               | 455.3          |  |         |              |                     | •14                              |
|                 | •2911<br>•2911         |          |                                    |                   |               | 410+8<br>536+8 |  |         | 77+2<br>79+0 |                     |                                  |
|                 | * # = = = = = =        |          |                                    | ** ** ** ** ** ** |               |                |  |         |              |                     |                                  |
|                 | = .15                  |          |                                    |                   |               |                |  |         |              |                     |                                  |
|                 |                        |          |                                    |                   |               |                |  |         |              |                     |                                  |

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|                            | TESI           |           | ER : 298            | -3      |                         |         | DAT         | E : 5/                 | /11/79        |                         |                       |  |
|----------------------------|----------------|-----------|---------------------|---------|-------------------------|---------|-------------|------------------------|---------------|-------------------------|-----------------------|--|
|                            |                |           |                     | REPLACE | ст <u>ы</u> ца          |         |             |                        |               |                         | *****                 |  |
|                            |                |           |                     |         |                         |         |             |                        |               |                         |                       |  |
|                            |                |           | CHARACT             | ERISTIC | S AND                   | EFFICIE | INCY AN     | ALYSIS                 | 6             |                         |                       |  |
|                            |                |           | = = = = = = = = = = |         | y 20. and 200 and 200 a |         |             | and the set of the set | * = = = = = : | n = = <i>= a</i> :      | ****                  |  |
|                            | COME           | USTION    | N AIR :             | ROOM    |                         |         | GLA         | SS DOC                 | DR : OPI      | EN                      |                       |  |
|                            | CIRC           | ULATIC    | DN FANS             | : SIDES | CLOSE                   | D       | FUE         | L MATE                 | RIAL :        | WOOD                    |                       |  |
|                            | FUEL           | TYPE      | : OAK               |         |                         |         | HEA         | TING V                 | ALUE =8       | 3260.0                  | O(BTU/LB)             |  |
|                            |                | 1 <b></b> |                     |         |                         |         |             | <b></b>                |               |                         |                       |  |
|                            | MASS           | AIR 1     | [N =101.            | 25(LB/r | IIN)                    |         | MAS         | S AIR                  | OUT = 9       | 73.60                   | (LB/MIN)              |  |
|                            | MASS           | DRY F     | LUE GAS             | =11.22  |                         | 'N)     | MAS         | S COME                 | AIR =         | 5.27                    | (LB/MIN)              |  |
| ainst sound bread State St |                |           |                     |         |                         |         |             |                        |               |                         |                       |  |
|                            |                | 2 = .03   |                     |         | = .010                  |         |             | = .18                  |               |                         |                       |  |
|                            |                |           |                     |         |                         | ,       |             |                        |               |                         |                       |  |
|                            |                | • 560     |                     | %H =    |                         |         | %2MC =0.000 |                        |               |                         |                       |  |
|                            | (R•H           | I.)LAB    | = .630              | (R.H    | .)OUT                   | = .730  | (R.         | H.)ROC                 | IM = ₊48      | 30                      |                       |  |
|                            |                |           | : = = = = = = =     |         |                         |         |             |                        |               | 2 112 22 <b>20</b> 22 2 |                       |  |
| TIME                       | FUEL<br>WEIGHT |           |                     | TE      | MPERAT                  | URE(F)  |             |                        |               | EFF                     | COMB AIR/<br>TOT LOSS |  |
| MIN                        | LB/MIN         | IN        | OUT                 | STACK   | COMB                    | FIRE    | CALR        | LAB                    | ENV           | %                       |                       |  |
|                            |                |           | 90.2                |         |                         |         |             |                        |               |                         |                       |  |
|                            |                |           | 101.7               |         |                         |         |             |                        |               |                         |                       |  |
|                            |                |           | 106.0               |         |                         |         |             |                        |               |                         | •25                   |  |
|                            |                |           | 100.0               |         |                         |         |             |                        |               |                         | .18                   |  |
|                            |                |           | 98.6                |         |                         |         |             |                        |               |                         |                       |  |
|                            |                |           | 97.5                |         |                         |         |             |                        |               |                         |                       |  |
| o                          | +3304          | 8V+1      | 93.7                | 307+∡   | 87.47                   |         | 87,7        | /7+Q                   | 04+1          | +13                     | •12                   |  |
|                            |                |           |                     |         |                         |         |             |                        |               |                         |                       |  |
|                            |                |           | AQF=.               |         |                         |         |             |                        |               |                         | TU/HR)                |  |
|                            |                |           | AQFT=               |         |                         |         |             |                        |               |                         |                       |  |
| alles sait and alle the    |                |           |                     |         |                         |         |             |                        |               |                         |                       |  |

| TEST NUMBER : 23A-  | 1  | DATE : 5/4/79   |  |
|---------------------|--|---|--|
|                     |  |   |  |
| FIR                 | EPLACE SIMULATION ST   | UDIES   |  |
| CHARACTE            | RISTICS AND EFFICIEN   | ICY ANALYSIS  |  |
|                     |  | =======================================   | ====================================== |
| COMBUSTION AIR : RO | MOC  | GLASS DOOR : OPEN   |  |
| CIRCULATION FANS :  | TWO  | FUEL MATERIAL : WOOD  |  |
| FUEL TYPE : DOUGLAS | 3 FIR  | HEATING VALUE =8379.0   | O(BTU/LB)                              |
|                     | 1 <b></b> 2  |   |  |
| MASS AIR IN =103.50 | O(LB/MIN)  | MASS AIR OUT = 93.60  | (LB/MIN)                               |
| MASS DRY FLUE GAS = | =10.76(LB/MIN)   | MASS COMB AIR = 3.54  | (LB/MIN)                               |
| <b></b>             | 12 AN 12 NO 12 AN 12 AN 12 AN 12 AN 12 AN 13 AN 13 AN 13 AN                | . 201 BM (201 B<br>(201 BM (201 | ==========                             |
| %02 = .030          | %CO = .010   | <b>%02</b> = .100   |  |
| <b>%C = .</b> 560   | <b>%H</b> = ₊070   | %MC =0.000  |  |
| (R.H.)LAB = .580    | (R.H.)OUT = .620   | (R.H.)ROOM = .440   |  |
|                     | #) #15 #16 #16 #16 #16 #17 #17 #17 #17 #16 #16 #16 #16 #17 #15 #16 #16 #16 |   | =                                      |
| FUEL<br>TIME WEIGHT | TEMPERATURE(F)   | EFF   | COMB AIR/<br>TOT LOSS                  |
| MIN LB/MIN IN OUT S | STACK COMB FIRE  | CALR LAB ENV %  | %                                      |

-----

.03

.06

.13

.17

.21

.25

.20

AQNH=.16531E+05(BTU/HR)

.00

•06

.17

.18

.17

.13

.09

| B-80 |
|------|
|------|

395.8 81.7

248.8 84.9

207.1

406.7

378.1

297.2

87.3 78.7 121.3

79.4

84.0

83.7

85.5

AQF=.110498E+06(BTU/HR)

464.5

640.1

659.0

687.6

653.3

586.8

78.7

79.4

81.7

84.0

83.7

85.5

84.9

75.6 82.2

75.9 83.3

76.5 85.4

76.6 85.3

76.0 81.5

83.2

80.6

76.7

76.2

77.3

77.9

79.4

80.8

78.1

78.1

77.3

Ö

1

2

3

4

5

6

.2221

.2203

.2203

+2232

.2177

.2173

AEF= .15

+2177

79.3

83.0

89.8

93.3

94.5

96.8

TEST NUMBER : 23A-3 DATE : 5/4/79 FIREPLACE SIMULATION STUDIES CHARACTERISTICS AND EFFICIENCY ANALYSIS COMBUSTION AIR : ROOM GLASS DOOR : OPEN CIRCULATION FANS : TWO FUEL MATERIAL : WOOD FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB) MASS AIR IN =103.50(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)MASS DRY FLUE GAS =12.51(LB/MIN) MASS COMB (IR = 5.67(LB/MIN)%202 = .030%CO = .010 %02 = .100% 2C = .560**%H** = .070 %MC =0.000  $(R_{1}H_{1})OUT = .620$  $(R_{1}H_{1})LAB = .580$  $(R_{+}H_{+})ROOM = .440$ COMB AIR/ FUEL TIME WEIGHT TEMPERATURE(F) EFF TOT LOSS MIN LB/MIN IN OUT STACK COMB FIRE CALR LAB ENV % Ζ Ö. .3554 80.6 106.5 274.7 94.8 738.2 94.8 77.1 83.2 +22 .11 696.5 95.9 1 .3543 80.2 101.3 519.9 95.9 77.0 82.8 .19 .24 2 .3561 81.1 108.5 534.7 100.1 989.9 100.1 77.5 82.2 .24 .26 3 .3524 79.4 528.5 100.9 969.5 100.9 .26 108.5 77.6 81.7 .26 4 .3488 79.0 457.6 98.0 918.2 77.5 81.2 .28 .23 111.1 98.0 5 78.8 382.6 101.2 841.5 101.2 77.6 81.2 .3521 106.6 .25 .17 820.5 99.7 6 .3561 79.4 105.1 324.4 99.7 77.8 82.6 +23 .13 AQF=,177757E+06(BTU/HR) AQNH=,42246E+05(BTU/HR) AEF = .24AEFT = .21AQFT=,143789E+06(BTU/HR) AONHT = .31124E+05(BTU/HR)

|               |  |         | FI     | REPLACE              | SIMUL                  | ATION S                  | TUDIES               | 5       |              |                      |                           |  |  |
|---------------|--|---------|--------|----------------------|------------------------|--------------------------|----------------------|---------|--------------|----------------------|---------------------------|--|--|
|               |  | C       | HARACT | ERISTIC              | S AND                  | EFFICIE                  | ENCY AN              | ALYSIS  | 3            |                      |                           |  |  |
| 10 10 40 10   | <br>Comb                               | USTION  |        |                      | F 12 12 45 45 17 23 2  | e in: as ii: se ne ii: a |                      |         | )R : OP      |                      | 18 JU AL 18 18 18 AF AN U |  |  |
|               | CIRC                                   | ULATION | FANS   | : TWO                |                        |                          | FUEL MATERIAL : WOOD |         |              |                      |                           |  |  |
|               | FUEL                                   | TYPE :  | DOUGL  | AS FIR               |                        |                          | HEA                  | TING V  | VALUE =      | B379.                | O(BTU/LE                  |  |  |
|               | MASS                                   |         |        | 00(LB/M              |                        |                          |                      |         |              |                      |                           |  |  |
|               |  |         |        |                      |                        | (N)                      |                      |         |              |                      | (LB/MIN)                  |  |  |
| 10 EK UR 20 1 | ************************************** | = .030  |        |                      | = .010                 |                          |                      | = .10   |              | 11 ha se 23 ga :     |                           |  |  |
|               | %C =                                   | .560    |        | %н =                 | %H = .070 %M           |                          |                      |         | %MC =0.000   |                      |                           |  |  |
|               | (R•H                                   | •)LAB = | •520   | (R.H                 | I.)OUT                 | = .820                   | (R.                  | H.)ROC  | )M = •4      | 40                   |                           |  |  |
|               | FUEL                                   |         |        | 72 AZ 20 10 14 19 19 | 927 732 489 607 922 73 |                          | : 114 IZ 32 32 IZ 12 |         |              | er ner tat aut aut : | COMB AI                   |  |  |
| TIME          | WEIGHT                                 |         |        | TE                   | MPERAT                 | URE(F)                   |                      |         |              | EFF                  | TOT LOS                   |  |  |
| MIN           | LB/MIN                                 | IN      | OUT    | STACK                | COMB                   | FIRE                     | CALR                 | LAB     | ENV          | %                    | 7.                        |  |  |
| 0             |  |         |        | 109+6                |                        | 651+4                    |                      | 78.9    | 79.9         | .10                  | .02                       |  |  |
| 1             |  |         |        | 313.5                |                        | 607.8                    |                      | 78.9    |              | •23                  | +14                       |  |  |
| 2             |  |         |        | 345.4                |                        | 569+2                    |                      | 78.9    |              | +25                  | •16                       |  |  |
| 3             |  |         |        | 357.4<br>175.1       |                        | 667+1                    |                      | 78.7    | 69.4<br>70.0 | •20<br>•24           | •16<br>•06                |  |  |
| Λ.            |  |         |        | 375.6                |                        | 766.3                    |                      |         |              | • 24                 | •08                       |  |  |
| 4<br>5        | +2166                                  | M /     |        |                      |                        |                          |                      | / U + / | U Z 4 U      | • - 0                |                           |  |  |

| TEST NUMBER : 254  | )-2   | DATE : 6/25/79  |  |  |  |  |  |  |  |  |  |  |
|--|---|---|--|--|--|--|--|--|--|--|--|--|
|  |   |   |  |  |  |  |  |  |  |  |  |  |
| FIREPLACE SIMULATION STUDIES   |   |   |  |  |  |  |  |  |  |  |  |  |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS  |   |   |  |  |  |  |  |  |  |  |  |  |
|  |   |   |  |  |  |  |  |  |  |  |  |  |
| COMBUSTION AIR :   | GLASS DOOR : OPEN   |   |  |  |  |  |  |  |  |  |  |  |
| CIRCULATION FANS   | FUEL MATERIAL : WOOD  |   |  |  |  |  |  |  |  |  |  |  |
| FUEL TYPE : DOUGL  | HEATING VALUE =8379.0(BTU/LB)   |   |  |  |  |  |  |  |  |  |  |  |
|  |   |   |  |  |  |  |  |  |  |  |  |  |
|  |   |   |  |  |  |  |  |  |  |  |  |  |
| MASS AIR IN = 99.  | MASS AIR OUT = 87.84(LB/MIN)  |   |  |  |  |  |  |  |  |  |  |  |
| MASS DRY FLUE GAS  | MASS COMB AIR = 4.45(LB/MIN)  |   |  |  |  |  |  |  |  |  |  |  |
|  |   |   |  |  |  |  |  |  |  |  |  |  |
| %CO2 = .030  | %02 = .100  |   |  |  |  |  |  |  |  |  |  |  |
| <b>%C = .</b> 560  | %H = .070   | %MC =0.000  |  |  |  |  |  |  |  |  |  |  |
| (R.H.)LAB = .520   | (R.H.)OUT =   | .820 (R.H.)ROOM = .440  |  |  |  |  |  |  |  |  |  |  |
| و و د او و و و و و و و و و و و و و و و و   |   |   |  |  |  |  |  |  |  |  |  |  |
| FUEL<br>TIME WEIGHT  | TEMPERATURE   | COMB AIR/<br>E(F) EFF TOT LOSS  |  |  |  |  |  |  |  |  |  |  |
| MIN LB/MIN IN OUT  | STACK COMB F1   | IRE CALR LAB ENV % %  |  |  |  |  |  |  |  |  |  |  |
| 1       .2772       67.1       93.7         2       .2827       67.1       89.8         3       .2753       67.1       102.5         4       .2753       67.7       94.1 | 355.2       75.5       80         429.2       76.1       75         430.9       76.8       71         410.4       76.3       78         352.1       76.7       72 | 18.5       81.6       78.9       70.2       .34       .24         30.9       80.8       79.1       68.9       .26       .20         29.2       81.2       79.0       69.0       .25       .17 |  |  |  |  |  |  |  |  |  |  |
| AEF= .25 AQF=.   | IR) AQNH=.35056E+05(BTU/HR)   |   |  |  |  |  |  |  |  |  |  |  |

1 c

|   | TEST           | NUMBER : 25A-3                 |                |       |      |                | DAT                     | DATE : 6/25/79                |                              |                           |            |  |
|---|----------------|--------------------------------|----------------|-------|------|----------------|-------------------------|-------------------------------|------------------------------|---------------------------|------------|--|
| FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS |                |                                |                |       |      |                |                         |                               |                              |                           |            |  |
|   |                |                                |                |       |      |                |                         |                               |                              |                           |            |  |
| COMBUSTION AIR : REAR   |                |                                |                |       |      | GLA            | GLASS DOOR : OPEN       |                               |                              |                           |            |  |
| CIRCULATION FANS : TWO  |                |                                |                |       |      | FUE            | FUEL MATERIAL : WOOD    |                               |                              |                           |            |  |
| FUEL TYPE : DOUGLAS FIR   |                |                                |                |       |      |                | HEA                     | HEATING VALUE =8379.0(BTU/LB) |                              |                           |            |  |
|   |                |                                |                |       |      |                |                         |                               |                              |                           |            |  |
| MASS AIR IN = 99.00(LB/MIN) MASS AIR OUT = 87.84(LB/M                   |                |                                |                |       |      |                |                         |                               |                              | (I B/MTN)                 |            |  |
|   |                |                                |                |       |      |                |                         |                               |                              |                           |            |  |
| MASS DRY FLUE GAS =13.05(LB/MIN)  |                |                                |                |       |      |                | MAS                     | MASS COMB AIR = 5.51(LB/MIN)  |                              |                           |            |  |
|   |                |                                |                |       |      |                |                         |                               |                              |                           |            |  |
|   | %CO2           | % CO2 = .030 $% CO = .010$     |                |       |      |                |                         | X02 = .100                    |                              |                           |            |  |
|   | %C =           | •560                           | .560 %H = .070 |       |      |                |                         | ZMC =0.000                    |                              |                           |            |  |
|   | (R.H           | H.)LAB = .520 (R.H.)OUT = .820 |                |       |      |                | (R.                     | (R.H.)ROOM = .440             |                              |                           |            |  |
| ====:   |                |                                |                |       |      |                | = = = = = =             | an ar an an an ar             | : 51 32 <b>53 30 30 32</b> 5 |                           |            |  |
| FUEL<br>TIME WEIGHT TEMPERATURE(F)                                      |                |                                |                |       |      |                |                         |                               | EFF                          | COMB AIR/<br>TOT LOSS     |            |  |
| MIN   | LB/MIN         | IN                             | 0UT            | STACK | Сомв | FIRE           | CALR                    | LAB                           | ENV                          | %                         | 7.         |  |
|   | .3451          |                                |                |       |      |                |                         |                               |                              |                           |            |  |
| 1   | .3480          | 66.1                           | 91.4           | 382.0 | 76.5 | 680.6          | 81.2                    | 78.9                          | 67.8                         | •20                       | .17        |  |
| 23  | .3480<br>.3499 | 66.8                           | 96.2           | 507.9 | 78.2 | 8/4+0<br>759.9 | 84.0                    | 79.3                          | 68.8                         | •29<br>•23                | •27<br>•25 |  |
| 4   | •3488          | 67.2                           | 99.8           | 505.3 | 78.4 | 757.6          | 84.2                    | 79.2                          | 67.4                         | .26                       | •26        |  |
| 5   | .3484          | 66.9                           | 96.4           | 440.8 | 79.3 | 750.7          | 86.4                    | 79.3                          | 68.2                         | .24                       | •21        |  |
| 6   | •3491          | 65.7                           | 113.9          | 335.7 | 79.5 | 756.8          | 87.5                    | 78.9                          | 67.4                         | •38                       | •18        |  |
| AEF= .25 AQF=.175041E+06(BTU/HR)  |                |                                |                |       |      |                | AQNH=+44493E+05(BTU/HR) |                               |                              |                           |            |  |
| AEFT= .24 AQFT=.141056E+06(BTU/HR) AQNHT=.34471E+05(BTU/H               |                |                                |                |       |      |                |                         |                               | BTU/HR)                      |                           |            |  |
|   |                |                                |                |       |      |                |                         |                               |                              | 1 00 <b>10 00</b> 00 01 0 |            |  |

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| TEST NUMBER : 27-1                 | DATE : 4/27/79                          |  |  |  |  |  |  |
|------------------------------------|---|--|--|--|--|--|--|
|                                    | *====================================== |  |  |  |  |  |  |
| FIREPLACE SIMULATION S             | TUDIES                                  |  |  |  |  |  |  |
| CHARACTERISTICS AND EFFICIE        | NCY ANALYSIS                            |  |  |  |  |  |  |
|                                    |   |  |  |  |  |  |  |
| COMBUSTION AIR : FRONT             | GLASS DOOR : OPEN                       |  |  |  |  |  |  |
| CIRCULATION FANS : TWO             | FUEL MATERIAL : WOOD                    |  |  |  |  |  |  |
| FUEL TYPE : DOUGLAS FIR            | HEATING VALUE =8379.0(BTU/LB)           |  |  |  |  |  |  |
|                                    |   |  |  |  |  |  |  |
| MASS AIR IN =101.25(LB/MIN)        | MASS AIR OUT = 93.60(LB/MIN)            |  |  |  |  |  |  |
| MASS DRY FLUE GAS =11.45(LB/MIN)   | MASS COMB AIR = 3.45(LB/MIN)            |  |  |  |  |  |  |
|                                    |   |  |  |  |  |  |  |
| %CO2 = .030 %CO = .010             | X02 = .100                              |  |  |  |  |  |  |
| %C = .560 %H = .070                | ZMC =0.000                              |  |  |  |  |  |  |
| (R.H.)LAB = .700 (R.H.)DUT = .750  | (R.H.)RODM = .380                       |  |  |  |  |  |  |
|                                    |   |  |  |  |  |  |  |
| FUEL<br>TIME WEIGHT TEMPERATURE(F) | COMB AIR/<br>EFF TOT LOSS               |  |  |  |  |  |  |
| MIN LB/MIN IN OUT STACK COMB FIRE  | CALR LAB ENV % %                        |  |  |  |  |  |  |

B-86

95.7 66.5 355.2 65.2

356.5 66.8 397.1 67.4

449.7 64.9

372.4 68.4

67.8

69.0

66.2 453.1 66.5

380.8

366.7

65+1

67.3

67.7

68.3

AQF=.108890E+06(BTU/HR)

70.5

70.7

70.7

70.8

70.7

70.5

70.3

70.0

68.0

70.5

69.3

70.2

76.8

72.1

AQNH=.16464E+05(BTU/HR)

.08

.10

+14

.17

.18

.20

.19

.02

.15

.15

.16

.16

.12

.10

0

1

2

3

4

5

6

.2159

+2203

.2140

.2170

.2203

.2115

.2173

AEF= .15

58.8

58.2

59.2

59.5

59.2

59.1

59.6

65.9

66.9

70.6

73.1

74.0

74.6

75.1

356.8

354.5

362.7

274.5

237.5

|   | TEST   | NUMBEI                 | R : 27-                            | -2      |         |                                       | DAT                          | DATE : 4/27/79           |                        |            |                       |  |  |
|---|--|------------------------|------------------------------------|---------|---------|---------------------------------------|------------------------------|--------------------------|------------------------|------------|-----------------------|--|--|
| ====:   |  |                        |                                    |         |         |                                       |                              | 1 and 111 and 114 bit 1  | 1 22 23 33 33 33 22 33 |            | ******                |  |  |
|   |  |                        | FI                                 | REPLACE | E SIMUL | ATION S                               | STUDIES                      | 5                        |                        |            |                       |  |  |
|   |  | (                      | CHARACT                            | ERISTIC | CS AND  | EFFICIE                               | ENCY AN                      | ALYSIS                   | 5                      |            |                       |  |  |
|   |  |                        |                                    |         |         |                                       |                              |                          |                        |            |                       |  |  |
|   | COMB   | USTION                 | AIR :                              | FRONT   |         |                                       | GLA                          | GLASS DOOR : OPEN        |                        |            |                       |  |  |
|   | CIRC   | ULATIO                 | N FANS                             | : 760   |         |                                       | FUE                          | 1 MATE                   | ERIAL :                | NOOD       |                       |  |  |
|   |  |                        |                                    |         |         |                                       |                              |                          |                        |            |                       |  |  |
|   | FUEL   | TYFE                   | : DOUGL                            | AS FIR  |         | HEA                                   | TING (                       | VALUE =                  | 8379.0                 | O(BTU/LB)  |                       |  |  |
| ati 12 19 19 19 1                               |  |                        |                                    |         |         |                                       |                              |                          |                        |            |                       |  |  |
|   | MASS   | AIR IN                 | V =101.                            | 25(LB/M | MAS     | S AIR                                 | OUT =                        | 93.60                    | (LB/MIN)               |            |                       |  |  |
|   | MASS   | DRY FL                 | LUE GAS                            | =12.82  | (N)     | MAS                                   | MASS COMB AIR = 4.48(LB/MIN) |                          |                        |            |                       |  |  |
|   |  |                        |                                    |         |         |                                       |                              |                          |                        |            |                       |  |  |
|   | %02  | = .030                 | D C                                | %00     | = .010  | )                                     | <b>%0</b> 2                  | 2 = .10                  | 0                      |            |                       |  |  |
|   | %C =   | .560                   |                                    | %H ==   | • 070   |                                       | %MC                          | %MC =0.000               |                        |            |                       |  |  |
|   | (R.H   | •)LAB =                | - •700                             | (R+H    | I.)OUT  | - ,750                                | (R.H.)ROOM = .380            |                          |                        |            |                       |  |  |
| tinni anna leve atte a<br>unit inne tan king ta |  |                        | na 1446 com com 1777 com 2023<br>- |         |         | , 212 CH 112 UC 1 <b>12 UC</b> 110 UN |                              | - 213 123 123 123 127 23 |                        |            |                       |  |  |
| TIME  | FUEL<br>WEIGHT   |                        |                                    | TE      | MPERAT  | URE(F)                                |                              |                          |                        | EFF        | COMB AIR/<br>TOT LOSS |  |  |
| MIN   | LB/MIN   | IN                     | OUT                                | STACK   | COMB    | FIRE                                  | CALR                         | LAB                      | ENV                    | %          | %                     |  |  |
| 0   | .2808  | 59.6                   | 75.1                               | 237.5   | 68.3    | 366.7                                 | 69.0                         | 70.3                     | 72.1                   | •15        | •09                   |  |  |
| 1   | •2790  | 59.0                   | 75+4                               | 400+4   | 68.5    | 391.3                                 | 69.5                         | 70.3                     | 71.0                   | •16        | .18                   |  |  |
| 2   | .2845  | 60.5                   | 77.7                               | 410.4   | 69.5    | 407.7                                 | 71.3                         | 70.5                     | 77.6                   | +17        | .19                   |  |  |
| 3   | +2863  | 60.2                   | 82.5                               | 423.2   | 70.3    | 447.2                                 | 72.3                         | 70.0                     | 73.5                   | • 22       | .21                   |  |  |
| 4   | +2790  | 59.9                   | 82.8                               | 71.0    |         | 73.7<br>73.2                          | 70.0                         | 69.9                     | + 23                   | +21        |                       |  |  |
| 5<br>6  | .2827 59.9 81.9 345.0 71.0 595.3<br>.2856 61.2 82.5 266.0 71.7 536.1 |                        |                                    |         |         |                                       |                              | 70.1<br>70.0             | 74.8<br>72.5           | •22<br>•21 | •16<br>•11            |  |  |
|   |  |                        |                                    |         |         |                                       |                              |                          |                        |            |                       |  |  |
|   | • •20<br>========  | na 121 22 22 23 2 28 2 |                                    | 142058E |         |                                       | :::: ::: ::: ::: ::: :::     |                          | •27829                 |            | TU/HR)                |  |  |
|   |  |                        |                                    |         |         |                                       |                              |                          |                        |            |                       |  |  |

| TEST NUMBER : 27-3   |   | DATE : 4/27/79   |
|--|---|--|
|  | PLACE SIMULATION STU<br>SISTICS AND EFFICIENC | DIES<br>Y ANALYSIS   |
| COMBUSTION AIR : FR<br>CIRCULATION FANS :<br>FUEL TYPE : DOUGLAS | ONT<br>TWO<br>FIR                             | GLASS DOOR : OPEN<br>FUEL MATERIAL : WOOD<br>HEATING VALUE =8379.0(BTU/LB) |
|  | (LB/MIN)<br>13.28(LB/MIN)                     | MASS AIR OUT = 93.60(LB/MIN)<br>MASS COMB AIR = 5.67(LB/MIN)               |
| %CO2 = .030<br>%C = .560   | %CO = .010<br>%H = .070<br>(R.H.)OUT = .750   | <pre>%02 = .100 %MC =0.000 (R.H.)R00M = .380</pre>                         |

FUEL

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COMB AIR/ TEMFERATURE(F) EFF TOT LOSS

| TIME      | WEIGHT                           |                       |                                    | TE                          | MPERAT                   | URE(F) |                      |                         |      | EFF                | TOT LOSS                                  |  |  |
|-----------|----------------------------------|-----------------------|------------------------------------|-----------------------------|--------------------------|--------|----------------------|-------------------------|------|--------------------|---|--|--|
| MIN       | LB/MIN                           | IN                    | OUT                                | STACK                       | COMB                     | FIRE   | CALR                 | LAB                     | ENV  | 7.                 | "   |  |  |
| 0         | .3554                            | 61.2                  | 82.5                               | 266.0                       | 71.7                     | 536.1  | 74.3                 | 70.0                    | 72.5 | •17                | • 11                                      |  |  |
| 1         | <b>.35</b> 87                    | 61.0                  | 84.9                               | 312+1                       | 72.6                     | 626.4  | 76.2                 | 70.0                    | 71.1 | .19                | +13                                       |  |  |
| 2         | .3601                            | 61.0                  | 83.4                               | 453.4                       | 73.0                     | 668.7  | 75.9                 | 70.3                    | 68.7 | .18                | .21                                       |  |  |
| 3         | .3565                            | 61.2                  | 83.0                               | 502.7                       | 74.1                     | 714.6  | 78.5                 | 70.3                    | 67.5 | .18                | .24                                       |  |  |
| 4         | .3506                            | 61.1                  | 83.1                               | 492.6                       | 75.4                     | 710.0  | 80.5                 | 70.4                    | 67.9 | .19                | .23                                       |  |  |
| 5         | .3543                            | 61.3                  | 89.0                               | 381+6                       | 76.0                     | 765.9  | 80.9                 | 70.2                    | 56.1 | .23                | .18                                       |  |  |
| 6         | .3532                            | 62.0                  | 82.6                               | 301.6                       | 76.4                     | 781.2  | 82.0                 | 70.3                    | 68.2 | •18                | .12                                       |  |  |
| AEF=      | AEF= .19 AQF=.178733E+06(BTU/HR) |                       |                                    |                             |                          |        |                      | AQNH=.34192E+05(BTU/HR) |      |                    |   |  |  |
|           | <b></b>                          | 911 02 07 07 08 08 78 | 3 62 (b) 24 (): 45 (15             | 118 100 101 100 100 101 101 | 1949 MAR AND STR MAR 473 |        | - 2X 2C -== 1== 64 X |                         |      | NE 192 20 20 53 63 | 1 2011 1011 1011 1017 1017 1012 1021 1021 |  |  |
| AEFT= .18 |                                  |                       | AQFT=.143227E+06(BTU/HR) AQNHT=.26 |                             |                          |        |                      |                         |      | 2E+05(             | BTU/HR)                                   |  |  |
|           |                                  |                       |                                    |                             |                          |        |                      |                         |      |                    |   |  |  |

|                      | TEST                                  | NUMBE                         | R : 24-  | · 1   | n apar wag name aller star says have | DATE : 6/15/79  |            |                                    |                                      |                                |   |  |
|----------------------|---------------------------------------|-------------------------------|--|---|--------------------------------------|---|------------|------------------------------------|--------------------------------------|--------------------------------|---|--|
|                      |                                       |                               | FI   | REPLACE   | SIMUL                                | ATION S   | STUDIES    | - nema jana dané kona nang ka<br>I | ng mana ang pang pang pang pang pang |                                |   |  |
|                      |                                       | i                             | CHARACT  | ERISTIC   | S AND                                | EFFICIE   | ENCY AN    | ALYSIS                             | 5                                    |                                |   |  |
| <b>10</b> ar 10 Al : |                                       | -                             |  | : 10: 10: 11: 11: 11: 11: 11: 11:   | a am 22 an an an 12                  | - Ha 112 AN AN AN AN AN AN  | -          |                                    |                                      |                                |   |  |
|                      | COMB                                  | USTION                        | AIR :  | ROOM  |                                      |   | GLA        | ss Doc                             | DR : CL                              | OSED                           |   |  |
|                      | CIRC                                  | ULATIO                        | N FANS   | : тwo   |                                      |   | FUE        | L MATE                             | RIAL :                               | woop                           |   |  |
|                      | FUEL                                  | TYPE                          | : DOUGL  | AS FIR  |                                      | HEA   | TING V     | ALUE =                             | 8379.(                               | O(BTU/LB)                      |   |  |
|                      | <b>- 11: 11: 11:</b> 11: 1,4 1.1: 11: |                               | <b>11 111 111 111 111 111</b>  |   |                                      | 1 alia 110 110 ani ani 110 ani  |            | m m m m m m m                      |                                      | riger from their come parts in |   |  |
|                      | MASS                                  | AIR I                         | N = 97.  | 50(LB/M   |                                      | MAS   | S AIR      | OUT = '                            | 90.00                                | (LB/MIN)                       |   |  |
|                      | MASS                                  | DRY FL                        | UE GAS   | =10.30  | N)                                   | MASS COMB AIR = 3.44(LB/MIN)  |            |                                    |                                      |                                |   |  |
| = = = = =            |                                       | (11) (11) (11) (11) (11) (11) | na <b>1948 non an</b> te nori stan nori<br>An <b>1948 non p</b> ita stat nori 1944 | ation party wood bars after case time   |                                      | ו מער עם אות אם היה ייצו אה אה אות אות את |            |                                    |                                      |                                |   |  |
|                      | %02                                   | = .03(                        | = .030 %CO = .010  |   |                                      |   | 202 = .100 |                                    |                                      |                                |   |  |
|                      | %C =                                  | .560                          |  | <b>%</b> H =  | .070                                 |   | %MC =0.000 |                                    |                                      |                                |   |  |
|                      | (R+H                                  | .)LAB =                       | - 560  | (R.H  | •>OUT                                | 580   | (R•        | H.)ROO                             | )M = +4:                             | 20                             |   |  |
|                      |                                       | gen 120 and 120 and 120 a     | 2 32 37 32 13 13 13  | anne chail aiter seite anne anne bhan<br>Anne chail star tha chail anne anne bhan | - Mar - Hang shet in an other anno   | and date and the stat with and  |            |                                    |                                      | and most size and and to       | 7, 77, 78, 79, 79, 79, 89, 89, 89, 89, 89 |  |
| TIME                 | FUEL<br>WEIGHT                        |                               |  | TE  | MPERAT                               | URE(F)  |            |                                    |                                      | EFF                            | COMB AIR<br>TOT LOSS                      |  |
| MIN                  | LB/MIN                                | IN                            | OUT  | STACK   | COMB                                 | FIRE  | CALR       | LAB                                | ENV                                  | %                              | 7.  |  |
|                      |                                       |                               |  |   |                                      | 347.2   |            |                                    |                                      |                                | •02                                       |  |
|                      |                                       |                               |  |   |                                      | 456.0   |            |                                    |                                      |                                | •06                                       |  |
|                      |                                       |                               |  |   |                                      | 556+6   |            |                                    |                                      |                                | •16                                       |  |
|                      |                                       |                               |  |   |                                      | 729.6   |            |                                    |                                      |                                | .18                                       |  |
|                      |                                       |                               |  |   |                                      | 767.3   |            |                                    |                                      |                                | •20                                       |  |
| 5<br>6               |                                       |                               |  | 415+1<br>432+8  |                                      | 802.5<br>833.5  |            |                                    | 79.0<br>80.2                         |                                |   |  |
|                      |                                       |                               |  |   |                                      |   |            |                                    |                                      |                                | 4 222 225 225 225 225 225 225 225 225 22  |  |
|                      | • 12                                  |                               |  |   |                                      | U/HR)   |            |                                    |                                      |                                | STU/HR)                                   |  |

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B-89

|   | TEST   | NUMBER                         | : 24-        | ·2                              |                       |  | DATE : 6/15/79      |        |                             |                        |   |  |
|---|--|--------------------------------|--------------|---------------------------------|-----------------------|--|---------------------|--------|-----------------------------|------------------------|---|--|
| 10 22 34 AZ 1   | 18 12 12 12 12 18 18 18 18   | : 750 Stat 180 Stat 552 553 19 |              |                                 |                       |  |                     |        |                             | 100 100 CV, 220 210 40 | 1 ang |  |
|   |  |                                | FI           | REPLACE                         | E SIMUL               | ATION S                                    | STUDIES             | 5      |                             |                        |   |  |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS                 |  |                                |              |                                 |                       |  |                     |        |                             |                        |   |  |
|   |  | USTION                         |              |                                 | 1 13 (2) (2) 20 77 13 | 2 72 53 99 45 55 55 5                      |                     |        | DR : CL                     |                        | . 27, 22 KB KB WI KK WI KB KB             |  |
|   | CIRC   | ULATION                        | I FANS       | FUE                             | L MATE                | ERIAL :                                    | woon                |        |                             |                        |   |  |
|   | FUEL   | TYPE :                         | DOUGL        | AS FIR                          |                       |  | HEA                 | TING   | VALUE =                     | 8379.0                 | (BTU/LB)                                  |  |
| 23 42 56 6C 5   | NA MARY DAR- DARP STOR SIZE SLAR prod<br>NA MARY DARP POST SIZE SIZE SLAR POST |                                |              |                                 |                       | - 17: 111: 111: 111: 111: <b>111: 11</b> 1 |                     |        |                             | 1991                   |   |  |
| MASS AIR IN = 97,50(LB/MIN) MASS AIR OUT = 90,00(LB/MIN |  |                                |              |                                 |                       |  |                     |        |                             |                        | LB/MIN)                                   |  |
|   | MASS   | DRY FL                         | UE GAS       | MASS COMB AIR = 4.51(LB/MIN)    |                       |  |                     |        |                             |                        |   |  |
|   |  |                                |              |                                 |                       |  |                     |        |                             |                        |   |  |
|   | %02  | = .030                         | ,            | %0                              | = .010                | )  | %02                 | = ,10  | 00                          |                        |   |  |
|   | %C =   | .560                           |              | %H =                            | •070                  |  | %MC =0.000          |        |                             |                        |   |  |
|   | (R.H   | ·)LAB =                        | •560         | (R.H                            | I.)OUT                | 580  | (R.                 | H.)ROC | )M = .42                    | 20                     |   |  |
|   | FUEL   | תה עם ביה את הם לה או          |              | 125 25 75 <b>75 15 15</b> 15 15 |                       | 12. 12. 12. 12. 12. 12. 12. 12.            | . 22 25 72 26 26 18 |        | 1 20 27 27 27 28 28 28 15 1 |                        | COMB AIR                                  |  |
| TIME  | WEIGHT   |                                |              | TE                              | MPERAT                | URE(F)                                     |                     |        |                             |                        | TOT LOSS                                  |  |
| MIN   | LB/MIN   | IN                             | OUT          | STACK                           | COMB                  | FIRE                                       | CALR                | LAB    | ENV                         | %                      | "/  |  |
|   |  |                                | 84.2         |                                 |                       | 833.6                                      | 78.2                | 76.6   |                             | ,12                    | .18                                       |  |
|   |  |                                |              |                                 |                       |  | 79.8                | 77.0   |                             | .11                    | •21                                       |  |
| 2   | +2860  |                                | 89.3         |                                 |                       | 974.6                                      |                     | 77.1   |                             |                        | +24                                       |  |
| 3   | +2863  |                                |              |                                 |                       | 1005.8                                     |                     |        | 79.1                        |                        | +23                                       |  |
| <b>4</b><br>5   | •2871<br>•2856   |                                | 89+1<br>91-2 |                                 |                       | 898.9<br>826.8                             |                     |        | 79.5<br>78.7                | •16<br>•17             | .25<br>.25                                |  |
| 6   |  |                                |              |                                 |                       | 830.9                                      |                     |        |                             | •16                    | •21                                       |  |
|   |  |                                |              |                                 |                       |  |                     |        |                             |                        |   |  |
|   | • 14   |                                |              |                                 |                       | U/HR)                                      |                     |        | •20147E                     |                        |   |  |
|   |  |                                |              |                                 |                       |  |                     |        |                             |                        |   |  |

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|                        |   | NUMBER              |                              | _                            |              | -              | DATE : 6/20/79               |                         |                                |                   |  |  |
|------------------------|---|---------------------|------------------------------|------------------------------|--------------|----------------|------------------------------|-------------------------|--------------------------------|-------------------|--|--|
|                        | FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS |                     |                              |                              |              |                |                              |                         |                                |                   |  |  |
|                        |   |                     |                              |                              |              | EFFICIE        |                              |                         | -                              | <b>-</b>          |  |  |
|                        | COME  | USTION              | AIR :                        | REAR                         |              |                | GLA                          | ISS DOC                 | OR : CL                        | DSED              |  |  |
|                        | CIRC  | ULATION             | FANS                         | FUE                          | L MATE       | RIAL :         | woop                         |                         |                                |                   |  |  |
|                        | FUEL  | TYPE :              | DOUGL                        | HEA                          | TING V       | ALUE =         | 8379.(                       | (BTU/LB)                |                                |                   |  |  |
|                        |   |                     |                              |                              |              |                |                              |                         |                                |                   |  |  |
|                        | MASS  | AIR IN              | = 97 <b>.</b>                | MAS                          | S AIR        | OUT = 1        | 39,28(                       | LB/MIN)                 |                                |                   |  |  |
|                        | MASS  | DRY FL              | UE GAS                       | MASS COMB AIR = 3.49(LB/MIN) |              |                |                              |                         |                                |                   |  |  |
| <b>28 80</b> 199 110 1 | 17 (120 774) COE COE 752 (120 753)                                      |                     | 1997 INS 1913 1977 1999 1989 | an (5 C) 72 A2 C C           |              |                | , 198, 927 (22, 232, 77) (21 | 52 AL CO AL CO C        |                                | ar 12: 22 23 AZ A | 5 XII XII XII XII XII XII XII XII XII XI |  |
|                        | %CO2  | = .030              |                              | %CO                          | 010          | •              | %02                          | °≕ '₊10                 | 0                              |                   |  |  |
|                        | %C =  | .560                |                              | %H =                         | .070         |                | %MC                          | =0.00                   | 0                              |                   |  |  |
|                        | (R.H  | •)LAB =             | +480                         | (R.H                         | •)OUT        | 760            | (R.                          | H.)ROC                  | IM = +4:                       | 20                |  |  |
|                        | E (11 14 15 15 16 16 12 15  | 77 W: 10 M 11 12 12 |                              |                              |              |                |                              |                         | : 23 m2 n2 12 12 m bn :        | ir he lin an of H |  |  |
| TIME                   | FUEL<br>WEIGHT  |                     |                              | TE                           | MPERAT       | URE(F)         |                              |                         |                                | EFF               | COMB AIR.<br>TOT LOSS                    |  |
| MIN                    | LB/MIN  | IN                  | OUT                          | STACK                        | COMB         | FIRE           | CALR                         | LAB                     | ENV                            | 7                 | %  |  |
| 0                      | •2184   | 77,4                | 81.9                         | 128.1                        | 78.9         | 658.8          | 80.9                         | 80.2                    | 79.2                           | .05               | .02                                      |  |
|                        |   | 77.1                |                              |                              | 79.2         | 678.6          | 81.1                         | 80.1                    | 79.9                           |                   |  |  |
| 2                      |   | 77.9                |                              |                              |              | 698.3          |                              |                         | 79.4                           | .10               | .16                                      |  |
| 3                      |   |                     |                              |                              |              | 710.2          |                              |                         | 78.2                           | •11               | •18                                      |  |
| 4                      | .2170   |                     |                              |                              |              | 731.5          |                              |                         | 78.3                           | .16               | .18                                      |  |
| 5<br>6                 | •2159<br>•2173  | 78+4<br>77+8        | 88.4                         | 320.0                        | 79+4<br>79+3 | 740.7<br>710.0 | 81.5<br>82.7                 | 80.4<br>79.7            | 78.2<br>77.5                   | +14<br>+13        | •16<br>•13                               |  |
| 12 III 12 12 III 13    | • • • • • • • • • •   |                     |                              |                              |              |                |                              | 100 111 110 110 111 111 | )e <b>au 111 112</b> 111 111 1 |                   |  |  |
| AEF=                   | • 11  |                     | AQF⇔.                        | 109180E                      | +06(BT       | U/HR)          |                              | AQNH≕                   | ·122598                        | E+05(B            | TU/HR)                                   |  |
| ***                    |   |                     |                              |                              |              |                |                              |                         |                                |                   |  |  |

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DATE : 6/20/79 TEST NUMBER : 26-2 FIREPLACE SIMULATION STUDIES CHARACTERISTICS AND EFFICIENCY ANALYSIS GLASS DOOR : CLOSED COMBUSTION AIR : REAR FUEL MATERIAL : WOOD CIRCULATION FANS : TWO FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB) MASS AIR IN = 97.50(LB/MIN)MASS AIR OUT = 89.28(LB/MIN)MASS DRY FLUE GAS =11.22(LB/MIN) MASS COMB AIR = 4.47(LB/MIN) %CO2 = .030 %CO = .010 702 = .100 %C = .560% H = .070%MC =0.000  $(R_{1}H_{1})LAB = .480$ (R.H.)OUT = .760 (R.H.)ROOM = .420

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ten pris and an or the the class and and

TIME WEIGHT

TEMPEDATURE(E)

COMB AIR/

| I I ME                          | WEIGHT   |  |  | ۲E  | MPERAI   | UKE(F)  |  |  |  |  |  |
|---------------------------------|--|--|--|---|--|---|--|--|--|--|--|
| MIN                             | LB/MIN   | IN   | оит  | STACK   | COMB   | FIRE  | CALR   | LAB  | ENV  | 7.   | %  |
| 0<br>1<br>2<br>3<br>4<br>5<br>6 | <pre>.2801<br/>.2790<br/>.2764<br/>.2783<br/>.2794<br/>.2794<br/>.2794<br/>.2790</pre> | 77.8<br>76.9<br>77.3<br>77.5<br>76.3<br>76.3<br>76.3<br>75.7 | 88.4<br>94.5<br>91.1<br>94.8<br>91.4<br>92.5<br>95.6 | 320.0<br>506.3<br>488.4<br>535.9<br>513.0<br>525.9<br>341.4 | 79.3<br>79.6<br>79.7<br>79.5<br>79.6<br>79.6<br>79.2<br>79.1 | 710.1<br>690.5<br>688.1<br>675.1<br>699.4<br>723.7<br>781.4 | 82.7<br>82.3<br>83.0<br>83.3<br>83.1<br>83.5<br>83.2 | 79.7<br>80.1<br>80.0<br>79.8<br>80.0<br>80.0<br>80.6 | 77.5<br>81.9<br>79.3<br>78.3<br>79.6<br>79.3<br>78.8 | <pre>.10<br/>.17<br/>.13<br/>.17<br/>.15<br/>.15<br/>.16<br/>.19</pre> | +12<br>+23<br>+21<br>+25<br>+23<br>+23<br>+24<br>+15 |
| AEF=                            | •15  |  | AQF=.  | 140160E   | +06(BT   |   |  |  | •21415E  |  | U/HR)  |

| TEST NUM   | BER : 26-3                                     | 3   |   | DATE : 6/20//9                            |                                      |                                      |                                      |                                 |   |
|--|--|---|---|---|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------|---|
|  | FI   | REPLACE                                   | SIMUL                                     | ATION S                                   | TUDIES                               |                                      | ;                                    |                                 | 4 20 40 14 90 <u>00</u> 40 14 40        |
|  | CHARACTE                                       |   |   |   |                                      |                                      |                                      |                                 |   |
| COMBUSTI   | DN AIR : F                                     |   | 200 idii 140 ang ang <u>an</u> . <u>-</u> | The Mark parts that the second second     |                                      |                                      | DR : CLO                             | OSED                            | 2 12 52 56 66 64 64 66 66 66 66 56      |
| CIRCULAT   | ION FANS :                                     | : TWO                                     |   |   | FUE                                  | L MATE                               | ERIAL :                              | woon                            |   |
| FUEL TYPE  | E : DOUGLA                                     | ∖S FIR                                    |   | HEA                                       | TING V                               | 'ALUE ={                             | 8379.(                               | O(BTU/LB)                       |   |
| MASS AIR   | IN = 97.5                                      | 50(LB/M                                   |   | MAS                                       | SAIR                                 | OUT = {                              | 89.28                                | (LB/MIN)                        |   |
|  | FLUE GAS                                       |   |   | MASS COMB AIR = 5.64(LB/MIN)              |                                      |                                      |                                      |                                 |   |
| %02 = .(   |  | %CO                                       |   |   | ? = .10                              |                                      | 40 1910 1920                         | 2 100 MI 200 MI 200             |   |
| %C = .560  | )  | %H =                                      | +070                                      |   | %MC                                  | =0.00                                | 10                                   |                                 |   |
|  | 8 = .480                                       |   |   |   |                                      |                                      |                                      |                                 |   |
| FUEL<br>TIME WEIGHT                                  |  |   |   | URE(F)                                    |                                      |                                      |                                      |                                 | COMB AIR<br>TOT LOSS                    |
| MIN LB/MIN IN  | OUT  | STACK                                     | COMB                                      | FIRE                                      | CALR                                 | LAB                                  | ENV                                  | %                               | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | 5 93.6<br>3 93.2<br>3 93.7<br>3 95.3<br>1 97.1 | 535.8<br>310.0<br>604.9<br>627.4<br>477.9 | 78.9<br>78.9<br>79.4<br>79.5<br>79.1      | 760.2<br>736.4<br>734.1<br>757.7<br>759.6 | 83,5<br>84,5<br>84,6<br>85,0<br>83,9 | 80.6<br>80.3<br>79.9<br>80.9<br>80.5 | 77.6<br>79.7<br>78.6<br>77.9<br>78.8 | •14<br>•14<br>•14<br>•16<br>•16 | .24<br>.12<br>.28<br>.29<br>.21         |
| AEF= .15   | AQF=.1   |   | +06(BT                                    |   | · 222 122 125 121 125 123 3          | AQNH=                                |                                      | =====<br>E+05(B                 | BTU/HR)                                 |
| AEFT= .14  | AQFT=.   | 141830                                    | E+08(B                                    | TU/HR)                                    |                                      | AQNHT                                | ·=•20216                             | 6E+05(                          | (BTU/HR)                                |

TEST NUMBER : 28-1

DATE : 6/21/79

|   |   |         | • •• ••••• |                                      |                               |                              |                           |                     |      |          |                      |  |
|---|---|---------|------------|--------------------------------------|-------------------------------|------------------------------|---------------------------|---------------------|------|----------|----------------------|--|
|   | FIREPLACE SIMULATION STUDIES<br>CHARACTERISTICS AND EFFICIENCY ANALYSIS |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |
|   |   |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |
|   | COMB  | NOITSU  | AIR :      | FRONT                                |                               |                              | GLASS DOOR : CLOSED       |                     |      |          |                      |  |
|   | CIRC  | ULATION | I FANS     | : TWO                                |                               | FUE                          | L MATE                    | RIAL :              | WOOD |          |                      |  |
|   | FUEL  | TYPE :  | DOUGL      | HEA                                  | TING V                        | VALUE =                      | B379.                     | O(BTU/LB)           |      |          |                      |  |
| <b>68 56 68 68 6</b> 8                                  | MASS AIR IN =102.00(LB/MIN) MASS AIR OUT = 90.00(LB/MIN)                |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |
|   |   |         |            |                                      | (N)                           | MASS COMB AIR = 3.52(LB/MIN) |                           |                     |      | (LB/MIN) |                      |  |
|   |   |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |
|   | <b>%C</b> 02  | = .030  | )          | %C <b>O</b>                          | ⇒ .010                        | )                            | 702                       | 10                  | 00   |          |                      |  |
|   | %C =  | .560    |            | <b>%</b> H ==                        | .070                          |                              | ZMC =0.000                |                     |      |          |                      |  |
|   | (R.H  | ·)LAB = | +640       | (R.H                                 | 1.)OUT                        | - • 680                      | (R.H.)ROOM = .420         |                     |      |          |                      |  |
| ninen saga tina dica biad<br>apart bila saur tivel anan |   |         |            |                                      | and the state to a state with | . 22 22 22 23 23 25 24 25    | on ha an 20 ch 10         | au 111 an 112 an 11 |      | •====    |                      |  |
| TIME  | FUEL<br>WEIGHT  |         |            | TE                                   | MPERAT                        | URE(F)                       |                           |                     |      | EFF      | COMB AIR<br>TOT LOSS |  |
| MIN   | LB/MIN  | IN      | OUT        | STACK                                | COMB                          | FIRE                         | CALR                      | LAB                 | ENV  | %        | %                    |  |
| 0   | .2203   | 75.4    | 82.7       | 148.1                                | 79.4                          | 697.0                        | 80.8                      | 80.3                | 79.6 | .09      | +03                  |  |
|   |   |         | 85.0       |                                      |                               | 727.5                        |                           |                     | 79.3 |          | .12                  |  |
|   | .2177   |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |
|   | .2203   |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |
|   | .2195   |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |
|   | •2210<br>•2203  |         |            |                                      |                               | 718.5<br>753.7               |                           |                     |      |          |                      |  |
|   |   |         |            | 1= 42 <i>0</i> 7 <b>0</b> 5 05 07 == |                               |                              | <b>75 27 18 38 32 2</b> 5 |                     |      | ,        |                      |  |
| AEF=  | AEF= .15 AQF=.110314E+06(BTU/HR) AQNH=.16375E+05(BTU/HR)                |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |
|   |   |         |            |                                      |                               |                              |                           |                     |      |          |                      |  |

| TEST NUMBER : 28-2  |                      | DATE : 6/21/79  |  |  |  |  |  |
|---|----------------------|---|--|--|--|--|--|
|   | PLACE SIMULATION STU |   |  |  |  |  |  |
|   |                      |   |  |  |  |  |  |
| COMBUSTION AIR : FR                                       | тиот                 | GLASS DOOR : CLOSED   |  |  |  |  |  |
| CIRCULATION FANS :  | тыр                  | FUEL MATERIAL : WOOD  |  |  |  |  |  |
| FUEL TYPE : DOUGLAS                                       | FIR                  | HEATING VALUE =8379.0(BTU/LB)   |  |  |  |  |  |
| ین این این این این این این این این این ا                  |                      | בים אם אני הם את היה של של על אל אל או לה לה היה של עות על אל אם של של אם אל של אם או לא אל או או אל או       |  |  |  |  |  |
| MASS AIR IN =102.00                                       | (LB/MIN)             | MASS AIR DUT = 90.00(LB/MIN)  |  |  |  |  |  |
| MASS DRY FLUE GAS =                                       | 11.22(LB/MIN)        | MASS COMB AIR = 4.46(LB/MIN)  |  |  |  |  |  |
| <b>23 21 12 20 10 10 10 10 10 10 10 10 10 10 10 10 10</b> |                      | רבי בני רים שב שב ככו מה מע ככו אה של בם כנו רע, כה שב שני שו ביו או ביו של הה הוו של שה הוו או שי שו שני שני |  |  |  |  |  |
| % CD2 = .030  | %CO = .010           | ×02 = .100  |  |  |  |  |  |
| %C = .560   | %H = .070            | %MC =0.000  |  |  |  |  |  |
| (R.H.)LAB = .640  | (R.H.)OUT = .680     | (R.H.)ROOM = ,420   |  |  |  |  |  |

| TIME | FUEL.<br>WEIGHT  |      |       | TE    | MPERAT        | URE(F) |      |      |      | EFF | COMB AIR<br>Tot Loss |
|------|--|------|-------|-------|---------------|--------|------|------|------|-----|----------------------|
| MIN  | LB/MIN   | IN   | DUT   | STACK | СОМВ          | FIRE   | CALR | LAB  | ENV  | %   | %                    |
| 0    | •2797  | 77.9 | 92.2  | 307.6 | 79.1          | 753.7  | 83.0 | 80.9 | 84.6 | •14 | .12                  |
| 1    | •2827  | 76.4 | 89.8  | 259.7 | 79.3          | 764.1  | 82.6 | 80.5 | 82.1 | .13 | •09                  |
| 2    | .2830  | 77.6 | 93.3  | 514.7 | 79.3          | 770.5  | 83.6 | 81.0 | 83.2 | •15 | •23                  |
| 3    | •2827  | 77.2 | 96+4  | 518.9 | 79.7          | 757.5  | 83.7 | 80.8 | 85.3 | •18 | •24                  |
| 4    | +2819  | 79.0 | 96.7  | 498.1 | 7 <b>9.</b> 8 | 752.3  | 85.0 | 81.3 | 81.9 | •17 | •23                  |
| 5    | .2845  | 78.3 | 95.6  | 425.5 | 79,8          | 791.1  | 84.8 | 81.0 | 83.1 | •17 | .19                  |
| 6    | •2819  | 77.4 | 101.6 | 348.9 | 80.1          | 790.8  | 85.5 | 81.3 | 85.3 | .23 | .16                  |
| AEF: | AEF= .17 AQF=.141953E+06(BTU/HR) AQNH=.23891E+05(BTU/HR) |      |       |       |               |        |      |      |      |     |                      |

TEST NUMBER : 29-3

DATE : 6/21/79

|                    |   |                               | FI  | REPLACE                        | SIMUL                     | ATION S                            | TUDIES                       |        |                       |                 |                      |
|--------------------|---|-------------------------------|---|--------------------------------|---------------------------|------------------------------------|------------------------------|--------|-----------------------|-----------------|----------------------|
|                    |   |                               | CHARACT   | ERISTIC                        | S AND                     | EFFICIE                            | NCY AN                       | ALYSIS | 6                     |                 |                      |
| : == == == :       |   |                               | n anna anna Afrik Acas anna cain ann<br>a ce a nuai Mart Anna anna anna ann |                                | : =: =: n: := == =        |                                    | : 170 CC: 121 VIII CII IV    |        | n an an an 11 an 21 : |                 |                      |
|                    | COMB  | USTION                        | AIR :   | FRONT                          |                           |                                    | GLA                          | SS DOC | R : CL                | OSED            |                      |
|                    | CIRC  | ULATIO                        | N FANS  | : TWO                          |                           |                                    | FUE                          | L MATE | RIAL :                | WOOD            |                      |
|                    | . FUEL  | TYPE                          | : DOUGL   | AS FIR                         |                           |                                    | HEA                          | TING V | VALUE =               | 8379.0          | O(BTU/LB)            |
|                    | MASS  | AIR I                         | N =102.   | 00(LB/M                        | (IN)                      |                                    | MAS                          | S AIR  |                       | =====:<br>90.00 | (LB/MIN)             |
|                    | MASS DRY FLUE GAS =11.67(LB/MIN)  |                               |   |                                |                           | MAS                                | MASS COMB AIR = 5.64(LB/MIN) |        |                       |                 |                      |
| 11 WR 199 1        | 2CO2 = .030 2CO = .010  |                               |   |                                |                           | %02 = .100                         |                              |        |                       |                 |                      |
|                    | %C =  | .560                          |   | <b>%</b> H ==                  | .070                      |                                    | ZMC =0.000                   |        |                       |                 |                      |
|                    | (R.H.)LAB = .640 (R.H.)OUT = .680   |                               |   |                                | (R.H.)ROOM = .420         |                                    |                              |        |                       |                 |                      |
| <b>10 10 17</b> 21 | n peri tem Mili den ann den dist bru<br>5 Alle -res 1948 Ann tit dist die tru | 1222 2022 2022 2028 2028 2028 | tige stat figt tale free and firt   | tern für nich und sich auf bei | , dag ant the tas and for | t sint dag wit dat het der der sin |                              |        |                       |                 |                      |
| IME                | FUEL<br>WEIGHT  |                               |   | TE                             | MPERAT                    | URE(F)                             |                              |        |                       | EFF             | COMB AIR<br>TOT LOSS |
| MIN                | LB/MIN  | IN                            | OUT   | STACK                          | СОМВ                      | FIRE                               | CALR                         | LAB    | ENV                   | %               | %                    |
| 0                  | .3532   | 77.4                          | 101.5   | 348.9                          | 80.1                      | 790.8                              | 85.5                         | 81.3   | 85.3                  | •19             | .15                  |
|                    | .3480   |                               |   |                                |                           | 785.5                              |                              |        |                       | •14             | •21                  |
|                    |   |                               |   |                                |                           | 738.1                              |                              |        |                       |                 |                      |
|                    |   |                               |   |                                |                           | 773+2<br>805+7                     |                              |        |                       |                 |                      |
|                    |   |                               |   |                                |                           | 825.1                              |                              |        |                       |                 | .24                  |
|                    |   |                               |   |                                |                           | 791.1                              |                              |        |                       | .17             |                      |
|                    | • • 17  | 121 132 222 132 122 22        |   |                                |                           | U/HR)                              |                              |        |                       |                 |                      |
|                    |   |                               |   |                                |                           |                                    |                              |        |                       |                 |                      |
|                    | ·= .16  |                               |   |                                |                           | TU/HR)                             |                              |        |                       |                 |                      |

÷

## LOW HEATING VALUE TEST

|                         | TEST NUMBER : 4A-1               |                     |                      |         |                           |  | DATE : 6/27/79        |                              |                           |                                    |  |  |
|-------------------------|----------------------------------|---------------------|----------------------|---------|---------------------------|--|-----------------------|------------------------------|---------------------------|------------------------------------|--|--|
| yaja Bita Akka oray a   | in in an an                      |                     | FI                   | REPLACE | E SIMUL                   | ATION S                                | STUDIES               | 3                            |                           | 1999 - 1994 - 1994 - 1994 - 1995 - |  |  |
|                         |                                  |                     |                      |         | d hat die die die die die | na <b>um</b> dia 114 metatra 115 metat |                       |                              |                           | <b>11</b> (11 (15 11) (73 )        | אז מס זמי זה א <b>ו או הו</b> מו אי מא או                |  |
|                         | COMB                             | USTION              | AIR :                | ROOM    |                           |  | GLA                   | NSS DOC                      | DR : OP                   | EN                                 |  |  |
|                         | CIRC                             | ULATIO              | N FANS               | : NONE  |                           |  | FUE                   | L MATE                       | ERIAL :                   | MOOD                               |  |  |
|                         | FUEL TYPE : DOUGLAS FIR          |                     |                      |         |                           |  | HEA                   | TING                         | /ALUE =                   | 7719.                              | 6(BTU/LB)  |  |
|                         | MASS AIR IN = 96.75(UB/MIN)      |                     |                      |         |                           |  |                       | MASS AIR OUT = 87.84(LB/MIN) |                           |                                    |  |  |
|                         | MASS DRY FLUE GAS +10.76(LB/MIN) |                     |                      |         |                           |  | MAS                   | MASS COMB AIR = 3.52(LB/MIN) |                           |                                    |  |  |
| anne unge offen singe t | 2002 : .030 200010               |                     |                      |         |                           | 202 = .100                             |                       |                              |                           |                                    |  |  |
|                         | <b>%</b> C ==                    | +560                |                      | %H =    | • • 070                   |  | <b>%</b> MC           | =0.00                        | )0                        |                                    |  |  |
|                         | (R.H                             | .)LAB -             | .500                 | (R.H    | (R.H.)OUT = .590          |  |                       | (R.H.)ROOM = .420            |                           |                                    |  |  |
|                         | FUEL<br>WEIGHT                   | ER 40 KR of order 1 | n - a cride ne en en |         |                           | URE(F)                                 | : 225 107 125 175 175 | 18 703 200 316 200 200 200   | ן נקו ונה יוה שה דיו שה ו |                                    | COMB AIR/<br>TOT LOSS                                    |  |
| MIN                     | LB/MIN                           |                     |                      |         |                           | FIRE                                   |                       |                              |                           | ×                                  | *  |  |
| 0                       | .2203                            | 24.4                | 78.5                 | 100.0   |                           |  |                       |                              |                           |                                    | •01  |  |
| 1                       | .2214                            |                     |                      |         |                           |  |                       |                              | 88.7                      | •08                                | •08  |  |
| 2                       |                                  | ,                   | 34.2                 |         | 79.5                      |  |                       | 75.1                         |                           | .12                                | +18  |  |
| 3                       |                                  | 75.5                | 88+2                 | 375.4   | 80.5                      | 367.3                                  |                       | 75.7                         |                           | •17                                | +18  |  |
| 4<br>5                  | .2250<br>.2221                   |                     |                      |         |                           |  |                       | 75+5                         | 86.8<br>81.5              | +16                                | +07  |  |
| 6                       |                                  |                     |                      |         |                           | 411.2<br>446.3                         |                       |                              | 80.8                      | •10<br>•18                         | •18<br>•20   |  |
|                         |                                  |                     |                      |         |                           |  |                       |                              |                           |                                    | 2006 . W MY (22 M) P2 P2 10 10 20<br>5 70 1 1 2 2 1 10 5 |  |
| her-                    | 12                               |                     | ભારા∘ ⊒ +            | 10260am | +00(1)                    | U/HR)                                  |                       | ARKU                         | * + 1 × / Ø × 1           | こもひつて                              | STUZHICZ   |  |

•

DATE : 6/27/79

| טום היה שב היא יוסי פאר ווא זווי היה היוי שם גיוו שה אות לא גים מה ווט הבר עם נשי הא אתו מנו צוב, אש |  | את את אלי האו את אייר אייר איינג ויינטו לא עצו את את את הא את הערכום או ישו או א<br>או אנו אלי האו את אייר אייר איינג ויינטו לא עצו או |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|
| FIREFLACE SIMULATION STUDIES   |  |  |  |  |  |  |  |  |
| CHARACTERISTICS AND EFFICIENCY ANALYSIS  |  |  |  |  |  |  |  |  |
| בי איז איז איז איז איז איז איז איז איז אי  | ואס עדע אלע עני ועני ארי ייני אי איז איז איז איז אווי איז איז איז איז איז איז איז איז איז אי | ה העראה עם שה היו ער היי היי היי היי היי הי היה את את את או שי שא הא הא היו היי היו היי או בי שי היה את את   |  |  |  |  |  |  |
| COMBUSTION AIR : R   | 00M  | GLASS DOOR : OPEN  |  |  |  |  |  |  |
| CIRCULATION FANS :   | CIRCULATION FANS : NONE  |  |  |  |  |  |  |  |
| FUEL TYPE : DOUGLA   | HEATING VALUE =7719.8(BTU/LB)  |  |  |  |  |  |  |  |
| יידי זיהן את אות את את את את את את את את את אות או   | ו הנו עדם שנו נוס שנו נהי ענו זעי ידור זינו עד שני עני נוס היה דיי ביו או                    | אס הם עם עם עם עם איז  |  |  |  |  |  |  |
| MASS AIR IN # 95.7   | MASS AIR IN # 95.75(LB/MIN)  |  |  |  |  |  |  |  |
| MASS DRY FLUE GAS  | *11.67(LB/MIN)   | MASS COME AIR = 4.52(LB/MIN)   |  |  |  |  |  |  |
| יים אות  | ne com con con un un con con cu, un con con con con con con con con con co                   | אר איז   |  |  |  |  |  |  |
| <b>%002 = .030</b>   | %CD = .010   | 202100   |  |  |  |  |  |  |
| <b>%C</b> + 560  | %H ≔ .070  | %MC =0.000   |  |  |  |  |  |  |
| (R.H.)LAB = .500   | (R.H.)OUT = .590   | (R.H.)ROOM = .420  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

| TME | FUEL<br>WEIGHT |      |       | TE    | MPERAT | URE(F) |               | `    |      | t: E E            | OMB AIR/<br>U: LOSS |  |
|-----|----------------|------|-------|-------|--------|--------|---------------|------|------|-------------------|---------------------|--|
|     | LB/MIN         | ТМ   | our   | STACK | сомв   | FIRE   | CALR          | LAP  | ENU  | ·····             |                     |  |
| 0   | .2830          | 25.0 | 88.7  | 403.3 | 79.7   | 446.3  | 79.7          | 74.9 | 80.8 |                   | . 19                |  |
| 1   | .2823          | 74+8 | 93.0  | 413.6 | 80.6   | 473.6  | 80.6          | 15.1 | 83.0 | .19               | .20                 |  |
| 2   | ·2852          | 74.2 | 105.1 | 439.0 | 83.7   | 511.9  | 83.7          | 75.4 | 80.3 | • 31              | + 26                |  |
| 3   | +2827          | 25.5 | 92.5  | 434.5 | 83.8   | 515.2  | 83.8          | 25.2 | 82.1 | . 23              | .23                 |  |
| 4   | +2838          | 76.3 | 100.5 | 422.4 | 85.5   | 562.9  | 85.5          | 26.3 | 81.5 | - 712 E<br>• 40 M | .22                 |  |
| 5   | .2834          | 77.4 | 96.9  | 331.3 | 86.1   | 564.1  | 86 <b>.</b> 1 | 25.8 | 81.9 | .21               | .15                 |  |
| 6   | .2808          | 76.4 | 92.8  | 285.0 | 86.2   | 552.9  | 86.2          | 75.9 | 82.3 | .23               | .13                 |  |

FIREFLACE SIMULATION STUDIES CHARACTERISTICS AND EFFICIENCY ANALYSIS COMBUSTION AIR : ROOM GLASS DOOR : OPEN CIRCULATION FANS : NONE FUEL MATERIAL : WOOD FUEL TYPE : DOUGLAS FIR HEATING VALUE =7719.6(BTU/LB) MASS AIR IN 👳 96.25(LB/MIN) 👘 MASS AIR OUT = 87.84(LB/MIN) MASS DRY FLUE GAS -12.13(LP/MIN) MASS COMB A(P = 5.62(LB/MIN) 1002 .030 200 - 010 -X02 ··· (100 1.0 - 560 %H ∿ •070 - %hC -0,000 (R.H.)LAB = .500 (R.H.)OUT = .590 (R.H.)RUUM - .420 nan men se e eux. Es le les contra electrica e esta contra contra contra contra en la contra en la contra de l COME AIR/ FUEL EFF for loss TIME WEIGH) TEMPERATURE(F) որ ու երջացար արդրադարու առաջացացի արած երառուները, չուն կատ ու որ փուր լովից 44-ից ովի մարիր ուս առաջա ազգոր որնե աննար ուս։ MIN LEZMIN IN OUT STACK COMB FIRE CALR LAB ENV % % 0.3524 26.4 97.5 285.0 86.2 552.9 86.2 75.9 83.7 .18 .12 .3488 /4.1 97.2 322.7 85.5 539.3 85.5 75.9 82.5 .20 .15 1 .3513 80.3 106.3 543.0 92.0 599.4 92.0 76.6 80.5 .23 .29 2 3 .3554 80.3 104.7 548.7 91.7 642.3 91.2 76.2 78.4 .21 +29 4 .3524 72.1 109.3 550.0 93.1 627.5 93.1 77.2 81.2 + 20 .31 .3469 22.8 108.7 323.8 91.9 628.L 91.9 77.5 81.3 +27 5 +19 6 .3568 78.0 106.9 342.6 92.2 619.4 92.2 77.0 00.8 . 25 +16 AEF= - 23 AQF = - 163040E+06(BTU/HR) A0NH=.375720+05(BTU/HF) 

DATE : 6/27/79

TEST NUMBER : 4A-3

B-100

APPENDIX C

HEATING VALUE TEST RESULTS



March 23, 1979

## MEMORANDUM

| то: | Mr. | Bill | Bullpitt |
|-----|-----|------|----------|
|     |     |      | ,        |

FROM: L. W. Elston

SUBJECT: Project A-2180, Results of Analysis

The required cylinder of oxygen was delivered yesterday afternoon, so your samples were analyzed today. The results of analysis are as follows:

| Sample | Percent<br>Moisture | Btu/lb<br>(Dry Bases)               |
|--------|---------------------|-------------------------------------|
| Wood   | 5.66                | 1. 7,598<br>2. 7,576<br>Av. 7,587   |
| Ash    | 10.83               | 1. 12,950<br>2. 12,875<br>Av.12,912 |

The "Ash" sample appeared to contain mainly charcoal with only a few visible light colored flecks.

LWE:gp

cc: J. A. Knight



April 6, 1979

## MEMORNADUII

TO: Mr. Bill Bullpitt

FROM: L. W. Elston

SUBJECT: Project A-2180, Analysis of Second Wood Sample

The several small blocks furnished were split, coarsely ground (6 mm screen), and finely ground (2 mm screen) in a Model 4 Wiley Mill. All of the material furnished was included in the finely ground sample used for analysis. The finely ground sample was thoroughly mixed.

The results of analysis are as follows:

| Sample      | Percent Moisture               | BTU/1b. (dry basis)              |
|-------------|--------------------------------|----------------------------------|
| Wood Blocks | 1. 9.58<br>2. 9.66<br>Av. 9.62 | 1. 8,337<br>2. 8,364<br>3. 8,435 |
|             |                                | Av. 8,379                        |

The differences between the results reported for the two wood samples indicate that laboratory results are dependent on the composition of the sample furnished.

## LWE:gp

cc: J. A. Knight

Cha Harri



ENGINEERING EXPERIMENT STATION GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

May 29, 1979

MEMORANDUM

TO: Mr. Bill Bullpitt

FROM: L. W. Elston

SUBJECT: Project A-2180 Wood Analysis

The requested analyses on the two wood samples have been completed. Results are as follows:

|                    |     | Oak   | Pine  |
|--------------------|-----|-------|-------|
| Percent Moisture   |     | 8.9   | 9.1   |
| BTU/Ib (dry bases) | (1) | 8,299 | 8,315 |
|                    | (2) | 8,220 | 8,368 |
|                    | Av. | 8,260 | 8,342 |

LWE:gp