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MASTER

Application Of Solar Energy
To Industrial Dehydration

california polytechnic state university
san luis obispo, california 93407

final report
phase IV
augmentation

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Research on the Application of Solar Energy
to Industrial Drying or Dehydration Processes

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by

California Polytechnic State University
San Luis Obispo, California
93407

FINAL REPORT
FOURTH PHASE
DECEMBER, 1981

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TEAM OF RESEARCHERS

California Polytechnic State University:

Edgar J. Carnegie

Project Director
Department of Agricultural
Engineering

Rollin D. Strohman

Department of Agricultural
Engineering

Philip W. B. Niles

Department of Environmental
Engineering

Paul Sakaguchi

Instrumentation Technician

Assisted by:

Lamanuzzi and Pantaleo

Bart Lamanuzzi

Nick Pantaleo

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FINAL REPORT ON THE APPLICATION OF SOLAR ENERGY TO INDUSTRIAL DEHYDRATION

1.0 INTRODUCTION:

The California Polytechnic State University at San Luis Obispo, California, under a continuing contract from the Department of Energy, has for the last four years operated and maintained a proof-of-concept solar dehydration facility in Fresno, California.

This report is an update on the operation and maintenance of this solar facility. The first part of this project was divided into three phases. Namely, the Analysis and Design, Phase I, ERDA Contract No. E(40-1)-5123; Construction, Phase II, Department of Energy Contract EY-C-05-5123 MOD A002; Evaluation, Phase III, Department of Energy Contract EY-C-05-5123; and Augmentation Phase, Department of Energy Contract DE-AC03-80SF11424.

Phase I of this project incorporated the analysis and design of an inexpensive solar collector unit, coupled with a commercial heat recovery unit and rock storage facilities. These three components supplied about 85% of the hot air required by a single tunnel of the Lamanuzzi and Pantaleo (L & P) dehydration facility in Fresno, California. A relatively simple air solar collector and heat storage system, designed jointly by Cal Poly and TRW Space and Energy Systems of Redondo Beach, California, was used. This facility was built during Phase II, and utilized local labor and tradesmen. The system is comprised of 22,000 square feet of single glazed air solar collectors, 700 tons of rock storage, and a heat recovery wheel, and is controlled by a microcomputer control system. The facility was monitored and evaluated over the

first drying season of 133 days in Fresno, California. In the last Phase, the Augmentation Phase, the glazings on the solar collectors were replaced. That is, one-third of the field was replaced with glass, another one-third of the field with Filon, and one-third of the field with Lexan. Also, a new microcomputer control system was designed, tested, and installed using readily available parts and based upon the Apple II microcomputer system.

The widespread acceptability of industrial solar applications has been hindered for a few major reasons. 1) The availability of natural gas and other fossil fuels has not decreased as predicted a few years ago. 2) The high cost of money detracts from the economic viability of industrial solar applications. 3) The tax incentives for industrial solar applications are not enough to offset the tight money market where industrial financiers have more attractive investments for their money.

The economic attractiveness of a solar industrial application is not here and now, but rather in the future. That is, when a solar application is installed, the cost of the solar energy is fixed. However, as years go by, fossil fuel costs escalate, while the cost of solar energy remains the same. This is a very sound economic argument in favor of solar applications. However, it is very difficult to convince conservative boards-of-directors to invest in solar systems when the advantages are many years in the future. To entice industrial financiers to invest in solar process heat, any doubts of the reliability of solar systems must be removed. It is only through proof-of-concept demonstrations, like the L & P facility in Fresno, and by observing solar systems that operate year after year that this doubt can be removed.

2.0 MAINTENANCE

The only way to get a reliable handle on the repair and maintenance cost of a solar system is to keep track of the actual expense. In 1979, the L & P solar system went into its second season of operation. Preceding the drying season, 25 hours of labor was spent cleaning the collectors and repairing one thermistor required in the control system. See Table 1 for details. During that season, plans were made to replace the Lexan glazings of the collectors, as they were rapidly deteriorating due to constant thermal stressing and fatiguing.

Table 1 Summary of Repair and Maintenance cost.

Job	Labor	Travel	Material	Total
1979				
Clean collectors	\$40	\$80		\$120
Replace therm.	85		40	125
		Total for 1979		\$245
1980				
Controller	450	160		610
A/D board			745	745
Timer & base			150	150
Damper motor	113	160	239	512
Repair insulation	225	80	156	461
Paint collectors	900	485	1136	2521
		Total for 1980		\$4999
1981				
Paint & seal	153	240	292	685
Clean collector	40			40
		Total for 1981		\$725

During the early summer of 1980, the collector glazings were removed and new glazings were installed. The collector surfaces were repainted at that time. This cost was considered to be maintenance for purposes of this report. The cost of replacing the glazings was handled as a capital improvement. Damage to the

project by vandals had also occurred. The surface insulation on the air ducts was damaged in various places. This required some patchwork and repainting in order to renew the surfaces. Likewise, it should be noted that the collector glazings received some mechanical abuse during these attacks, but, thanks to the strength of Lexan, no real damage was done. In order to keep the Rho Sigma 600 (a microcomputer controller) operating for one more season, all available spare parts were purchased from the manufacturer. At the end of the 1979 drying season, and prior to the onset of the next season, repairs were made on the control system that would allow it to operate efficiently again. One damper-control motor was rebuilt because of water damage. The instruments in the monitoring system required calibration and replacement of some transducers during the year. Also, the modems used to transmit data, from Fresno to San Luis Obispo, failed and needed to be replaced.

In 1981, some general maintenance, including painting and resealing of some of the expansion joints, was accomplished. The total maintenance cost for four years amounted to \$5,964. If this cost is adjusted back to 1976 dollars, when the L & P facility was built, the cost would be \$4,459. An annual average rate of inflation for this time span was assumed to be 10 per cent. This cost is just a little over three-tenths of one per cent for repairs and maintenance over a four year period. It should be noted that this is far below the one per cent estimated repair and maintenance assumed in the economic analyses of Phases I and III of this project.

The data acquisition system required to record and evaluate the operation of the solar system is not critical to the normal operation. Therefore, the cost of repair and maintenance of the data acquisition system was not included in the cost of general repair and maintenance of the solar system. In order to record

reliable operating data on the L & P facility in Fresno and to transmit that data to San Luis Obispo for storage and analysis, a total of \$7,555 was spent during the last three years.

Table 2 Summary of Required Cost of Data Acquisition

Job	Labor	Travel	Material	Phone	Total
1979					
Repair modem			\$171		\$171
Maintenance HP			416		416
					<hr/> \$587
1980					
Calibration	\$450	\$122			\$572
Transducer	225	80	661		966
Modems			1113		1113
Rent & repair					
Data cassette	450	210	938		1598
Paper & disks			184		184
Maintenance HP			416		416
Phone				737	737
					<hr/> \$5586
1981					
Calibration	\$500	\$182			\$682
Phone				700	700
					<hr/> \$1382

2.1 REPLACEMENT OF GLAZINGS

The glazings used in the design phase of this project were Lexan, a polycarbonate of 20-mil thickness. This material was recommended by General Electric to meet the requirements of a collector 4 feet wide and 180 feet long. Lexan was estimated to have a life of 15 years with approximately 15 per cent reduction in light transmissibility during that lifetime. For many reasons, the Lexan did not live up to the design expectations. Stress fatigue cracks started to appear within the first month after installation. General Electric was contacted about this problem and recommended the replacement of fastenings used to hold the Lexan down. This was done, and it did reduce the stress problems, but the Lexan was not able to withstand the compressive stresses

that were placed on the glazings during the heat of the day when the Lexan would stretch and buckle near the fastenings. General Electric's Lexan engineers made a site visit and informed the Cal Poly design team that: 1) Lexan cannot be used for a continuous 180-foot piece; 2) all fastening holes need to be predrilled, stress relieved, and then sealed with silicon prior to installation; and 3) the 20-mil Lexan used in this application was not the required thickness, but that 40-mil should have been used. After some negotiating with General Electric, they finally agreed to replace one-third of the Lexan at their cost. This enabled Cal Poly to install three different types of glazings in the collector field to observe what differences there are in the performance of the glazings during operating conditions. A special tool was designed to predrill the Lexan prior to fastening in order to allow a clearance space around the self-tapping screws which hold the Lexan to the collectors. The process was very time consuming and required three men for four weeks to replace less than one-third of the collectors in Lexan. See Table 3 for details. The Lexan that was used in this operation was 40-mils thick and came in sheets 4 feet by 12 feet in length. They were just long enough to be difficult to install. Because of the impact-resistance qualities of the Lexan, it was placed on the collectors that were vandalized (one of the outside rows). When the shipment arrived, there was only enough Lexan to complete nine collectors, rather than ten which would have been one-third of the field. Filon was chosen for the second glazing material installed at the facility. Enough Filon was obtained to cover eleven collectors, one extra to make up for that which was missed by the Lexan. Filon is a polyester-glass reinforced material. It is supplied in 50-foot rolls, and is relatively heavy and hard to handle in the space between the collector rows. Therefore, it was also placed on an outside row, which eased the labor of installing it. The replacement of the Filon was accomplished by three men in three and one-half weeks. See Table 3 for details.

Table 3 Summary of Glazing Replacement Cost

Material	Cost	Labor	Travel	Total
Lexan Silicon	(\$6156)* 91	\$2247 449 hr.	\$1469	\$3716 91
				<hr/> \$3807
Filon Silicon	5532 94	1831 366	1387	8750 94
				<hr/> \$8844
Glass Silicon	9798 224	960 192	1121	11879 224
				<hr/> \$12103

* This is the market value of the lexan supplied by GE.

The last material installed was glass. The glass panels were purchased from Radco Products, Inc. in Santa Maria, California, a manufacturer of doors, windows and solar collectors. They have manufactured an aluminum frame which supports the glass and allows for easy installation on the existing collectors. The glass has a higher initial cost, as can be seen in Table 3, but requires much less labor than either of the other two glazings. In fact, the job required only three weeks for two men to replace ten glazings with glass.

The total maintenance and repair costs and replacement of the glazings amounts to \$25,674. If this repair and maintenance cost is discounted to 1976 dollars, when the L & P facility was built, it would amount to only 1.5 percent a year of the original installed cost, which is near the one percent estimated in Phases I and III of this project. It is anticipated that the repair costs will drop below one percent in the next few years, since the glazings are holding up and performing quite well.

It is very useful to designers and engineers to have cost of construction components expressed in cost per unit area. The costs of the new glazings divided by the area covered by the respective materials are:

- o Lexan, \$1.54/foot sq.
- o Filon, \$1.12/foot sq.
- o glass, \$1.68/foot sq.

Market value was used for the cost of the Lexan. At the time of installation no operational differences could be detected between the different glazings. No doubt, as the poly surfaces deteriorate with time, a difference will appear. It is felt that over the life of the system the glass will eventually be the lowest in life-cycle cost.

3.0 CONTROL SYSTEM

There was a need to replace the Rho Sigma 600 programmable controller on the L & P solar drying facility in Fresno, California. The RS 600 became obsolete within one year after its installation. The reasons for its rapid obsolescence were:

- 1) Rho Sigma stopped building the RS 600 controller right after the unit was installed at the L & P facility. Within one year there were no spare parts; the company stopped supporting the one Rho Sigma 600 in the field.
- 2) The controller used a Fairchild F8 microprocessor, a unit that is no longer in production. The F8 is a 4-bit microprocessor and is very limited in its mathematical capabilities.

- 3) All programming and control functions on this microprocessor must be done in machine language. These programs then must be stored on an Eprom to be used by the processor. Any changes in constants or the program require sending the Eproms back to the factory to be reprogrammed and then returned to the user to be installed in the controller. The cost associated with this process was normally around \$600.

For these reasons it was decided to design and build a new programmable controller. The new controller was to meet all of the basic objectives of the original RS 600. Namely,

- 1) to operate 24 hours a day automatically without any manual input,
- 2) restart automatically after a power loss,
- 3) maintain a reasonably constant temperature delivered to the tunnel dehydrator,
- 4) maintain a relatively constant flow rate into the system, independent of the modes of operation, and
- 5) maximize the use and storage of solar energy.

It was also felt that some of the shortcomings of the RS 600 could be eliminated in a newer model controller. Namely,

All components for this controller should be made from readily available parts that could be obtained locally.

It should be able to use a high level language that would simplify programming and operation of the controller.

The input to the controller system should be isolated from the computer to stop inadvertently applied high voltages or currents from entering and destroying costly computer components. (Serious damage did occur to the RS 600 when a plant workman, while performing preventive maintenance, applied 110 volts AC to one of the signal inputs and totally destroyed several printed circuit boards in the controller.)

The controller should display engineering values of input parameters that are used in the control logic and display all control functions in a symbolic manner that would facilitate understanding of the system for operation and troubleshooting.

Design the controller so that it would be compatible with all the existing control hardware.

To meet the above-mentioned objectives, the general configuration of the controller was laid out, Figure 1, and components were picked and arranged to meet that general configuration.

An Apple II Plus, based on a 6502 microprocessor, was chosen for the heart of the controller. This single board microprocessor comes in one package, equipped with 48K of memory, 8 input/output ports, an autostart rom for immediate execution when the power is turned on, and a high level language, Basic. In addition to the Apple II Plus computer, the control system has a 16 channel data acquisition system, a 5 inch floppy disk and disk controller, a four-port parallel interface, a 16 channel output driver, and a video monitor, Figure 2.

Figure 1 Front Panel of Controller

FIGURE 2 Internal Arrangement of Control System Components

3.1 ANALOG INPUTS

An Analog Devices DAS 1128 data acquisition module was chosen for the input of this controller. This module is a 16 channel multiplexor and an analog to digital converter, (A/D), all in one plug-in package. The maximum conversion rate of the DAS 1128 is 50,000 conversions per second for a single channel. The DAS 1128 has a 12-bit digital output with an accuracy of $\pm 1/2$ L.S.B. This means that it has a resolution of 1 in 4096. The scan rate will drop drastically in a control mode when the logic is written in Basic, but is still relatively fast, for a solar system, at approximately 100 conversions every second. The output from the analog to digital converter is fed into a parallel port, by calling a machine language driver. See Appendix B. A John Bell Engineering Apple II parallel interface was chosen for data input/output function. This circuit board can be purchased assembled or as a kit. It has 32 input/output lines grouped into four 8-bit ports. This board uses a pair of 6522 VIAs each having two ports. One of the 6522s is used by the DAS 1128, and the other is connected to a buffer board to the control panel and relays. Analog Devices 2B30 signal conditioners were used for this project. These units have an adjustable gain from 1 to 2000 volt/volt and also have a high common mode rejection, and linearity. Isolation and signal conditioning were provided by the 2B30's for every channel in front of the A/D to protect the computer and auxiliary components from overloads. In addition to the 16 channels used in the A/D, the Apple II Plus has 4 additional ports that can be used for analog to digital inputs. In this configuration, these inputs were used for setpoints, one for temperature control and for flow control, Table 4. The Apple II Plus built-in analog inputs are directly called from a Basic program with the PDL command. The output from these ports are in the range of 0 to 255. If this is used directly for a temperature

setpoint, no conversion is necessary, and one is able to control to within one degree F. The flow setpoint could have a range of from 0 to 25,000 cfm by simply multiplying the output from the PDL command by 100.

Table 4 Input Requirements

	Input	channel			
1	V2	0	reference voltage		
2	TA2	1	collector surface		
3	TB2	2	hot air from collector		
4	T3	3	storage top		
5	T4	4	storage bottom		
6	T5	5	from Fan #1		
7	S2	6	damper D1A open		
8		7	spare		
9	T7	8	before burners		
10	S1	9	tunnel fan on		
				Open	Close
11	FV2	10	position of D2V	V2	0.0492
12	FD2	11	position of D2D	V2	0.0507
13	FA1	12	position of D1A	V2	0.0205
14	FB1	13	position of D1B	0.0300	V2
15	V1	14	flow through fan #1		
16		15	spare		
17	T1	PDL(0)	setpoint		
18	V3	PDL(1)	set flow for D3		

3.2 THERMISTOR INPUTS

Analog Devices 2B30 conditioning amplifiers were used with a standard reference resistor, R₁, to measure the temperature of each thermistor. Each channel was fed a reference voltage of 1.7 volts DC, Figure 3, and the output voltage was then fed to the A/D and converted in the computer into temperature by a mathematical equation of the form:

$$T = 1/(\text{third order polynomial of } R)$$

where R is the resistance of the thermistor. An accuracy of plus or minus 0.5 of a degree F over a range of 0 to 270 degrees F was obtained.

Figure 3 Simplified Diagram of Data Acquisition Circuit

3.3 FLOW INPUT

A pressure transducer was installed across the heat wheel and the pressure drop was converted into flow rate entering the system. It was found in analyzing the data from the monitoring system that the pressure drop across the heat wheel has been almost constant for the last three years.

3.4 POSITION INPUTS

A voltage of 1.7 volts was placed across a variable resistor that is internal to each damper-control motor. The wiper contact from this potentiometer is connected to a 2B30 conditioner amplifier which feeds voltage which is directly related to the position of the damper to the A/D. The digital output from the A/D is changed to a percentage of the damper position by the computer.

3.5 OUTPUTS

When the computer has finished with its logical operations, 1's or 0's are placed in appropriate memory locations in the computer, Table 5. One is equal to off, and zero is equal to on. The

Table 5 Controller Output

			memory location		
			hex.	dec.	
1	DA01	open	300	768	damper 1A from Fan #1 to field
2	DAC1	close	301	769	
3	DB01	open	302	770	damper 1B from Fan #1 to bottom of storage
4	DBC1	close	303	771	
5	DO2	open	304	772	damper 2D inlet control for Fan #2
6	DC2	close	305	773	
7	D40	open	306	774	damper 4A open and 4B close damper 4A close and 4B open
8	D4C	close	307	775	
9	D50	open	308	776	damper 5 from field to storage
10	D5C	close	309	777	
11	F1	on/off	30A	778	Fan #1
12	F2	on/off	30B	779	Fan #2
13	VO	open	30C	780	damper 3 flow control for Fan #1
14	VC	close	30D	781	

output status is read into the parallel interface by an output machine language driver, see Appendix C. These signals are sent to a buffer board, using LS7404, that plugs into one of the Apple

II Plus I/O ports. This board only requires electrical power from the Apple II. The buffer board and the parallel interface are connected by a ribbon cable. The output from the buffer board is always off unless it is sent an "on" signal. It is connected to LEDs on the display panel, Figure 1, that are illuminated when an "on" signal is sent. From the display panel the signal is sent to solid state relays which will either turn motors clockwise or counterclockwise or operate relays that turn the fans on or off. Each of these relays is capable of handling 125 volts AC at 10 amperes. In this controller 16 channels are possible, but only 14 are required by the control program. An output relay is required for each control function. This means that two relays are required for each damper-control motor, one to open it and one to close it. The "off" positions for these relays are the same, no movement, stop.

3.6 CONTROL

The control logic is divided into three subcategories: switch, feedback, and general control logic. Switches, both hardware and software, are used to make logical decisions. Switches in this control system are variables that have only two values 0 or 1, and are used to make control decisions. The switches required are shown in Table 6. A software switch could be thought of as answering a question such as, "Is the collector hotter than the air from Fan #1 or is the storage hotter than the air from Fan #1?"

Hardware switches actually move when something happens, and is sensed in the program. For instance, "Is the tunnel on?", "Is the

Table 6 Software and Hardware Switches

Description	Operation
Is storage hot	$T3 > (T5 + 2) ; C1 = 1 *$
Is collector hot	$T2 > (T5 + 2) ; C2 = 1$
Is tunnel on	$S1 \Rightarrow V2 ; S1 = 1$
Is damper 1A open	$S2 \Rightarrow V2 ; S2 = 1$
Is damper 2D closed	$FD2 > .05 ; S3 = 1$

* This is a logic 1 which is yes and 0 is no

damper all the way open?", or "Is the damper all the way closed?". Based upon these switches, different sensors can be used, a surface sensor or an air sensor. A surface sensor is more likely to know if the collector is getting hot, but once the collector is operating, a sensor in the air stream responds to the flow from the collector.

The deadband is the temperature change that must take place before the damper will move. It is controlled by the feedback from the damper positions. Table 7 defines the various feedback equations and the dampers that produce them. The dampers that use the feedback variables are proportionally controlled so the change in temperature required to cause movement will vary with damper position. This type of control will stabilize the system and eliminate hunting, dampers swinging from full open to full closed,

Table 7 Feedback Equations

Position	Operation
Damper 2V	$EV2 = FV2 / .283 + .0002$
Damper 2D	$ED2 = FD2 / .83$
Damper 1A	$EA1 = FA1 / .332$
Damper 1B	$EB1 = FB1 / .332$
Damper 2V open	$BF2 = ED2$
Damper 2D open	$BF2 = EV2$

and not being able to control temperature. Proportional control

was not needed for all the dampers all the time, therefore it was only used when hunting could be a problem. The control logic governing the fan and damper operation is shown in Tables 8 and 9. The fundamental logic is essentially the same system as outlined in Phase I Final Report with only slight modifications in details resulting from writing a program in Basic, as compared with machine language. Table 8 is for control components that are mode sensitive. Mode A is when the collector is used to supply hot air to the tunnel directly. Mode B is when the storage is in use, either charging or discharging. Dampers 4A and B are used in this mode to eliminate overheating. Mode C is when the drying tunnel is not in use, or is being loaded with produce.

Table 8 Control Logic of Mode Sensitive Components

Mode	condition	DAMPERS				Fan #1
		1A	1B	4A	4B	
A	S1 = 1 C1 = 0 C2 = 1	open	close	open	close	
	C1 = 0 C2 = 0	close				
B	S1 = 1 C1 = 1 T2-T3+5+EB1 > 0 T2-T4-5-EA1 > 0 T1-T7+2 > 1	open	close	open	close	O N
	C1 = 1 T2-T3+5+EB1 < -1 T2-T4-5-EA1 < -1 T1-T7+2 < -1	close	open	close	open	
C	S1=0 or C1 = 0 C2 = 0	close	open			O F F
				close	open	

The controls of dampers 2 and 3 and Fan #2 are shown in Table 9. They are not affected by the three modes discussed above. If the collector temperature is higher then the setpoint plus the

feedback variable from damper 2, damper 2 will open. The feedback from damper 2 is small when the damper is closed, and therefore it requires a small change in temperature to start to open it. When it is all the way open, the feedback variable is larger, and the change in temperature to close the damper must be larger. Damper 3 is only used to control the flow rate into the system. Fan #2, will turn on if damper 2 is starting to open.

Table 9 Control Logic for Components not Mode Sensitive

Conditions	DAMPERS 2D & 2V	3	Fan #2
$S2 = 1$ or $S1 = 0$ $T2-T1-BF2 > 0$	open		
$T2-T1-BF2 < -1$	close		
$S1 = 1$ $S2 = 0$	close		
$S1 = 1$ $V3-V1 > 1$ $V1-V3 > 1$		open close	
$S3 = 0$ $S3 = 1$			on off

In the actual control logic a decision has to be made for each damper. Damper 1A, which sends air to the solar field from Fan #1, will open when the tunnel is on, the storage is cold, and the collector is hot; or it will open if the storage is hot, the tunnel is on, and the collector is hotter than the storage. If these conditions are not met, the damper will stop where it is. Damper 1A will close if the tunnel is off, the storage is cold, and the collector is cold; or the storage is hot, and the storage is hotter than the collector.

Damper 1B, which is used to pull heat out of the storage, will open if the tunnel is not operating, or the storage is hot and the storage is also hotter than the collector. If these conditions are not met, damper 1B will stop. If the tunnel is on and the storage is closed, the damper will close as there is no heat in

the storage to utilize. If the tunnel is on and the collector is hotter than the storage, then it will also close.

Damper D2 which controls the flow of air for charging the rock storage will open if damper 1A is open, the tunnel is off and the collector is hotter than the reference temperature. This can be used to store heat in the rock storage when the drying facility is not in use. It will close if the tunnel is on and D1A is not all the way open. This is to guarantee that the dehydrator gets all the hot air that it needs. The damper will also close if the reference is hotter than the collector. This insures that it will get all of the required heat that is available in the collector.

Dampers 4A and B are located in the inlet to the tunnel itself. They are to guarantee that excessively hot air does not enter the tunnel. Damper 4A will open and damper 4B will close if the tunnel is on, the storage is cold, and the collector is hot. Damper 4A will close and damper 4B will open if the tunnel is on, the storage is hot, and the air is hotter than the reference. These dampers operate automatically, just like a person who adjusts the water temperature when taking a shower, i.e. blending hot and cold water to get the right temperature.

Damper 5 is used for isolation purposes, and it will close if damper D2 is closed and damper 1A is closed. Damper D2's being closed indicates that no air is going from the storage to the collector, and damper 1A's being closed means that no air is going from the Fan #1 to the collectors. Damper 5 is equipped with an electrical interlock that will prevent Fan #2 from coming on if the damper is not open.

The operation of Fan #1 is controlled only by switch 1, which senses whether the tunnel is on or off. Fan #2 controls the flow rate through the storage to store heat, and it will turn on if

damper D2 is not closed, and the interlock from damper 5 is closed. Damper 3 only maintains flow rate throughout the system. It only functions if the tunnel is on, and it will open if the setpoint is below the actual flow rate. If the setpoint and the actual flow are close, the damper will stop, and if the flow is greater than the setpoint, then the damper will close. Appendix A is the control logic program actually used in the controller.

3.7 DISPLAY

The controller is equipped with a 5-inch video monitor that can be turned on or off independently of the power to the controller. Its prime function is to indicate the operating characteristics of the solar system, Figure 4. All temperatures used by the control logic are displayed, as well as switch 1, S1, and key damper

```

L & P SOLAR DRYER
DRYER REFERENCE      T1 = 155
COLLECTOR SURFACE    TA2 = 170
AIR FROM COLLECTOR   TB2 = 168
STORAGE TOP          T3 = 163
STORAGE BOTTOM        T4 = 100
FROM FAN #1          T5 = 126

TUNNEL FAN ON / OFF  S1 = ON

DAMPER D1A POSITION    = 100
DAMPER D1B POSITION    = 0
DAMPER D2V POSITION    = 100
DAMPER D2D POSITION    = 100

FLOW THROUGH FAN #1   = 18000
SET FLOW FOR FAN #1   = 20000

01 10 01 01 01 00 01

```

Figure 4 Display Screen

positions. The measured flow rate through the heat wheel is displayed as flow through Fan #1. The setpoint is also shown.

The 0's and 1's at the bottom are the output values from the control program. These values can be used to check the operation of the system and are useful in trouble shooting the system. The display screen can also be used for check out and programming. On the side of the controller there is a plug for a keyboard. The keyboard has direct access to the computer and is used for trouble shooting or program modification. The keyboard is plugged in when needed.

4.0 EVALUATION

The L & P solar dehydrating facility has operated for four seasons since its construction in 1977. The first operating season is covered in the final report, Phase III, Evaluation. The 1979 season was 61 days commencing on August 17 and ending on October 17. The 1980 season was a total of 87 days starting on August 26 and terminating November 28. The 1981 season was plagued by a summer of bad weather and the fact that growers were forced into early harvest by fear of the Medfly incident in California and sold their grapes to the wine industry at a lower price. This season, therefore, was only 29 days long, commencing on August 16 and terminating on September 21. The monitoring equipment consisted of an Autodata 9 data acquisition unit, purchased in Phase I of this program, coupled with a Techtran 8410 data cassette capable of operating as a stand-alone or via the telephone line remotely to a Hewlett Packard 9825 calculator located in San Luis Obispo. During this phase, two Tek-Com 2121 modems, capable of transmitting data at 1200 baud via the phone line, were purchased and installed. The design and location of the transducer configurations used in this system were described previously in the Phase I report. The software designed to operate with this system was discussed in the Phase III report and has had minor modifications since that report.

4.1 MONITORING

To monitor the performance of the system, temperatures, flow rates and damper positions were recorded at 20 to 30 minute intervals throughout each year's drying period. In addition, the gas flows were recorded manually on gas meters at various times throughout the drying season. Gas flow rates were recorded both for the solar heated tunnel and a standard "control" tunnel next door to the solar tunnel. Daily and weekly energy consumption during the test periods are shown in Appendix D. The average temperatures of the dehydrator are shown in degrees fahrenheit or are flagged as 1's or 0's to depict days when the solar collector did operate and the dehydrator did not operate respectively. Energy measurements for the heat recovery unit, solar collectors, and burners are in millions of BTU's. This data is based upon the detailed daily reports as shown in Appendix E. The electric use is shown in kilowatt hours. This reading is from a standard kilowatt hour meter that registers all electrical power to the solar system and is read manually at the same intervals that are used in the gas flow readings. The annual totals for the last three years are shown in Table 10. The apparent discrepancy between the burner measurements and the gas meter can be explained in terms of the following factors:

- 1) The inefficiency of the combustion process is taken into account,
- 2) The dehydrator requires a continuous operating pilot light,
and
- 3) Air leaks surrounding the drying fan decrease the measured

temperature that is used to compute the burner requirements in the solar system.

During these test periods, the solar collector supplied from 26 to 33 per cent of the required heat energy, while the heat recovery unit supplied approximately 58 per cent, and the burners supplied the remaining 15 per cent. Figures 5, 6, and 7 are graphs of the weekly energy consumption throughout each test period respectively. The dehydrator normally operates seven days

Table 10 Annual Energy Use

		1979	1980	1981
Days of operation		61	87	29
Average drying temp. F		148	147	148
Heat recovery	MBTU	1224	2268	754
Collectors	MBTU	647	1073	469
Burners	MBTU	212	741	182
Gas meter solar	MBTU	889	1315	279
Gas meter control	MBTU	2307	3330	1416
Electric use	MWtHr	37.3	62.2	25.8

a week through the season, but in the early and later parts of the season it may drop off and operate only four or five days a week. This accounts for the lower weekly totals at the beginning and end of these graphs. The comparison of experimental results with the computer simulation model does not appear to have changed at all since the Phase III report and will not be discussed in this report. A reevaluation of the economics of the L & P solar plant has been completed, but with very little difference from what has already been reported. Using the standard rate of inflation that has occurred during the last four years and after-tax rate of return of 10 per cent, and a loan fraction of 50 per cent, the 20 per cent investment tax credit that has been allowed, and expressing the cost of the system in 1976 dollars, the price per

Figure 5 Weekly Energy Use Aug. 1979 to Oct. 1979

Figure 6 Weekly Energy Use Aug. 1980 to Nov. 1980

Figure 7 Weekly Energy Use Aug. 1981 to Sept. 1981

million BTU's is \$7.99. Today's price of natural gas at \$.50 a therm and 70 per cent conversion efficiency with only a \$.05 a therm of cost of overhead and operation amounts to \$7.64 per million BTU's. At the current rate of inflation of the cost of natural gas, the energy delivered from the solar system to the dehydrator will be cheaper than the price of natural gas by the 1982 season. The current dollar savings in fuel for the 1981 season amounts to \$171.00 per day. This was the daily cost savings in gas minus the electrical cost to operate the solar system.

5.0 DISSEMINATION OF INFORMATION

During the four phases of this project, requests were continually received for operational and design information on the L & P facility. Within the augmentation phase alone (6/20/80-12/31/81), twenty requests for copies of the Phase I Final Report were referred to National Technical Information Service. Forty five copies of the Phase II Final Report and eighty seven copies of the Phase III Final Report were mailed. Requests for information have had a wide geographical distribution, as reports have been sent to twenty five different states and fifteen different countries during the augmentation phase alone.

A total of twelve papers have been written about the project. Seven of these were published in national technical journals; one was written up in "Food Engineering," a world-wide publication; and a chapter on food dehydration was written for a book, Solar Energy Technology Handbook, edited by William C. Dickinson and Paul N. Cheremisinoff, Marcel Dekker, Inc., New York.

Personnel from this project have participated in every Solar Industrial Process Heat Workshop by presenting papers, poster presentation, or being in a panel discussion. In addition, presentations have been set up at four state-wide energy fairs

located at Davis, Santa Cruz, Ontario and San Luis Obispo.

6.0 REFERENCES

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2. Niles, P.W., Carnegie, E.J., Pohl, J., Cherne, J., "Design and Performance of An Air Collector for Industrial Crop Dehydration", Solar Energy, Volume 20, 1978.
3. California Polytechnic State University, "Research on the Application of Solar Energy to Industrial Drying or Dehydration Processes" (Final Phase II Report, Construction Phase, California Polytechnic State University, San Luis Obispo, California, September, 1978).
4. Carnegie, E.J., Niles, P.W., Hoffmann, J., Stine, W.B., Boche, R., "Design of a Solar Heat Source for Industrial Dehydration", p.34 Proceedings of 1977 Annual International Solar Energy Society Meeting, Orlando, Florida, June, 1977.
5. Niles, P.W., and Carnegie E.J., "Application of Solar Energy to Industrial Food Dehydration", Rural Energy Conference, Davis, California, January, 1978.
6. Stine, W.B., and Carnegie, E.J., "Design and Performance of An Industrial Sized Pebble Bed", p. 1006, Proceedings of the 1978 Annual Mfg. American Section International Solar Energy Society, Denver, Colorado, August, 1978.
7. Dickinson, W.C., Brown, K.C., Economic Analysis of Solar Industrial Process Heat Systems, UCRL-52814, August 17, 1979.
8. California Polytechnic State University, "Research on the Application of Solar Energy to Industrial Drying or Dehydration Processes" (Final Phase III Report, Evaluation, California Polytechnic State University, San Luis Obispo, California, October, 1979).

APPENDIX A
CONTROL PROGRAM

JPOKE1529.75

JLIST

```
5 HOME
7 PRINT : PRINT "L & P SOLAR DRYER": PRINT
8 PRINT "DRYER REFERANCE T1 = "
9 PRINT "COLLECTOR SURFACE TA2 = ": PRINT "AIR FROM COLLECTOR TB2 = ":
PRINT "STORAGE TOP T3 = "
10 PRINT "STORAGE BOTTOM T4 = ": PRINT "FROM FAN #1 T5 = ":
PRINT "BEFORE BURNERS T7 = ": PRINT
11 PRINT "TUNNEL FAN ON / OFF S1 = ": PRINT : PRINT "DAMPER D1A POSITION
= ": PRINT "DAMPER D1B POSITION = "
12 PRINT "DAMPER D2V POSITION = ": PRINT "DAMPER D2D POSITION = ":
PRINT
13 PRINT "FLOW THROUGH FAN #1 = ": PRINT "SET FLOW FOR FAN #1 = "
16 REM
17 REM DATA INPUT
18 REM
19 DS = CHR$(4)
20 PRINT DS"BLOAD Q"
21 PRINT DS"BLOAD BPRG3"
25 CALL 36864
30 POKE 11,32
35 POKE 12,144
48 GOTO 199
49 REM
50 REM RESISTANCE TO TEMP.
51 REM
53 IF R = 0 THEN R = 1
54 R = 6.001 * 6255 * (V2 / 5.1457) / R - 6255
55 IF R > 5300 GOTO 80
60 IF R > 1200 GOTO 90
70 T = .0026972613 + (4.225552172E - 6 + ( - 2.283453977E - 9 + 6.51218362E
- 13 * R) * R) * R: GOTO 95
80 T = .00554817093 + (8.161038818E - 7 + ( - 1.018537243E - 11 + 2.8521261
53E - 16 * R) * R) * R: GOTO 95
90 T = .003702484391 + (1.830426974E - 6 + ( - 2.18911896E - 10 + 1.5869540
62E - 14 * R) * R) * R
95 T = 1 / T: RETURN
199 REM
200 A = 1:TA2 = USR (A):A = 2:TB2 = USR (A):A = 3:T3 = USR (A):A = 4:T4
= USR (A):A = 5:T5 = USR (A):A = 8:T7 = USR (A):A = 9:S1 = USR (A)
205 A = 6:S2 = USR (A):A = 7:S3 = USR (A):A = 10:FV2 = USR (A):A = 11:FD
2 = USR (A):A = 12:FA1 = USR (A):A = 13:FB1 = USR (A):A = 15:V1 = USR (
A):A = 0:V2 = USR (A)
210 T1 = PDL (0)
215 V3 = PDL (1) * 100
220 R = TA2: GOSUB 50
225 TA2 = T
230 R = TB2: GOSUB 50
235 TB2 = T
240 R = T3: GOSUB 50
245 T3 = T
250 R = T4: GOSUB 50
255 T4 = T
260 R = T5: GOSUB 50
265 T5 = T
270 R = T7: GOSUB 50
275 T7 = T
280 IF V2 = 0 THEN V2 = 1
285 V1 = 40300 * .07 * (V1 / 406.9) ^ .5
399 REM
```



```

400 REM    FEEDBACK EQUATIONS
401 REM
410 IF FA1 > = 0 THEN EA1 = FA1 / 702
420 IF FB1 > = 0 THEN EB1 = FB1 / 702
430 IF FD2 > = 0 THEN ED2 = FD2 / 1757
440 IF FV2 > = 0 THEN EV2 = FV2 / 598 + .42
450 IF FV2 < 24 THEN BF2 = ED2
460 IF FD2 > V2 THEN BF2 = EV2
499 REM
500 REM    CONTROL EQUATIONS
501 REM
505 IF T3 > (T5 + 2) THEN C1 = 1: GOTO 515
510 C1 = 0
515 IF T2 > (T5 + 2) THEN C2 = 1: GOTO 525
520 C2 = 0
525 IF S1 > V2 - 100 THEN S1 = 1: GOTO 535
530 S1 = 0
535 IF S2 > V2 - 100 THEN S2 = 1: GOTO 545
540 S2 = 0
545 IF FD2 > 100 THEN S3 = 0: GOTO 555
550 S3 = 1
555 IF (S1 = 1 AND S2 = 1) OR F2 = 1 THEN T2 = TB2: GOTO 565
560 T2 = TA2
565 IF S1 = 1 AND C1 = 0 AND C2 = 1 THEN POKE 768,0: GOTO 585
570 POKE 768,1
575 IF C1 = 1 AND S1 = 1 AND (T2 - T3 + 5 + EB1) > 0 THEN POKE 768,0: GOT
O 585
580 POKE 768,1
585 IF S1 = 0 OR (C1 = 0 AND C2 = 0) THEN POKE 769,0: GOTO 605
590 POKE 769,1
595 IF C1 = 1 AND (T2 - T3 + 5 + EB1) < - 1 THEN POKE 769,0: GOTO 605
600 POKE 769,1
605 IF S1 = 0 THEN POKE 770,0: GOTO 625
610 POKE 770,1
615 IF C1 = 1 AND (T2 - T4 - 5 - EA1) < - 1 THEN POKE 770,0: GOTO 625
620 POKE 770,1
625 IF S1 = 1 AND C1 = 0 THEN POKE 771,0: GOTO 645
630 POKE 771,1
635 IF S1 = 1 AND (T2 - T4 - 5 - EA1) > 0 THEN POKE 771,0: GOTO 645
640 POKE 771,1
645 IF (S2 = 1 OR S1 = 0) AND (T2 - T1 - BF2) > 0 THEN POKE 772,0: GOTO 6
55
650 POKE 772,1
655 IF S1 = 1 AND S2 = 0 THEN POKE 773,0: GOTO 665
660 POKE 773,1
662 IF (T2 - T1 - BF2) < - 1 THEN POKE 773,0: GOTO 665
663 POKE 773,1
665 IF S1 = 1 AND C1 = 0 AND C2 = 1 THEN POKE 774,0: GOTO 685
670 POKE 774,1
675 IF C1 = 1 AND S1 = 1 AND (T1 - T7 + 2) > 1 THEN POKE 774,0: GOTO 685
680 POKE 774,1
685 IF S1 = 0 OR (C1 = 0 AND C2 = 0) THEN POKE 775,0: GOTO 705
690 POKE 775,1
695 IF C1 = 1 AND (T1 - T7 + 2) < - 1 THEN POKE 775,0: GOTO 705
700 POKE 775,1
705 IF S3 = 0 AND FA1 < = 16 THEN POKE 777,0: POKE 776,1: GOTO 715
710 POKE 776,0: POKE 777,1
715 IF S1 = 1 THEN POKE 778,0: GOTO 725
720 POKE 778,1
725 IF S3 = 1 THEN POKE 779,0: GOTO 735
730 POKE 779,1
735 IF S1 = 1 AND (V3 - V1) > 500 THEN POKE 780,0: GOTO 745
740 POKE 780,1
745 IF S1 = 1 AND (V1 - V3) > 500 THEN POKE 781,0: GOTO 755

```

```

750 POKE 781.1
754 REM
755 REM   END OF CONTROL EQUATIONS
999 REM
1000 REM   PRINT OUT ROUTINE
1001 REM
1020 HTAB 28: VTAB 4: PRINT "      ": HTAB 28: VTAB 4: PRINT INT (T1)
1021 HTAB 28: VTAB 5: PRINT "      ": HTAB 28: VTAB 5: PRINT INT (TA2)
1022 HTAB 28: VTAB 6: PRINT "      ": HTAB 28: VTAB 6: PRINT INT (TB2)
1023 HTAB 28: VTAB 7: PRINT "      ": HTAB 28: VTAB 7: PRINT INT (T3)
1024 HTAB 28: VTAB 8: PRINT "      ": HTAB 28: VTAB 8: PRINT INT (T4)
1025 HTAB 28: VTAB 9: PRINT "      ": HTAB 28: VTAB 9: PRINT INT (T5)
1026 HTAB 28: VTAB 10: PRINT "      ": HTAB 28: VTAB 10: PRINT INT (T7)
1028 IF S1 = > 1 THEN AS = "ON": GOTO 1030
1029 AS = "OFF"
1030 HTAB 28: VTAB 12: PRINT "      ": HTAB 28: VTAB 12: PRINT AS: PRINT
1031 HTAB 28: VTAB 14: PRINT "      ": HTAB 28: VTAB 14: PRINT INT (100 *
FA1 / V2)
1032 HTAB 28: VTAB 15: PRINT "      ": HTAB 28: VTAB 15: PRINT INT (100 -
100 * FB1 / V2)
1033 HTAB 28: VTAB 16: PRINT "      ": HTAB 28: VTAB 16: PRINT INT (100 *
FV2 / V2)
1034 HTAB 28: VTAB 17: PRINT "      ": HTAB 28: VTAB 17: PRINT INT (100 *
FD2 / V2): PRINT
1035 HTAB 28: VTAB 19: PRINT "      ": HTAB 28: VTAB 19: PRINT INT (V1)
1036 HTAB 28: VTAB 20: PRINT "      ": HTAB 28: VTAB 20: PRINT V3: PRINT
1100 A1 = PEEK (768):A2 = PEEK (769):A3 = PEEK (770):A4 = PEEK (771):A5
= PEEK (772):A6 = PEEK (773):A7 = PEEK (774):A8 = PEEK (775)
1110 B1 = PEEK (776):B2 = PEEK (777):B3 = PEEK (778):B4 = PEEK (779):B5
= PEEK (780):B6 = PEEK (781)
1120 PRINT "      ";A1;A2;" ";A3;A4;" ";A5;A6;" ";A7;A8;" ";B1;B2;" "
;B3;B4;" ";B5;B6
1200 REM
1201 REM   CALL CONTROL SUB
1202 REM
1210 CALL 25856
1230 GOTO 199

```

APPENDIX B
OUTPUT MACHINE LANGUAGE DRIVER

PAGES 36 to 37
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!AS

**END OF PASS 1

**END OF PASS 2

```
9020          1      ORG $9020          ;STORE THIS PROGRAM AT $9020
9020          2  BASE EQU $C400        ;THE LOWEST ADDRESS FOR THE 6522 IS $C400
9020 200CE1    3      JSR $E10C        ;CONVERTS MULTIPLEXER CHANNEL FROM FLOATING POINT TO INTEGER AND STORES IN $A1
9022 A5A1      4      LDA $A1         ;LOADS MULTIPLEXER CHANNEL IN ACCUMULATOR
9025 2A        5      ROL             ;MOVES MULTIPLEXER CHANNEL TO HIGHEST 4 BITS
9026 2A        6      ROL
9027 2A        7      ROL
9028 2A        8      ROL
9029 8D00C4    9      STA BASE         ;SENDS MULTIPLEXER CHANNEL TO MULTIPLEXER, CB2 STARTS A/D, AND CB1 FLAG CLEARED
902C AD0DC4   10  LOOP LDA BASE+$D     ;CHECK IFR TO SEE IF CB1 SET, I.E. CONVERSION COMPLETE
902F 2910     11      AND #200010000
9021 F0F9     12      BEQ LOOP        ;BRANCH BACK IF CB1 NOT SET
9033 AC01C4   13      LDY BASE+$1     ;STORE THE LOWEST 8 BITS OF THE A/D IN THE Y REGISTER
9036 AD00C4   14      LDA BASE         ;STORE THE HIGHEST 4 BITS OF A/D IN THE ACCUMULATOR
902D 290F     15      AND #200001111  ;CLEAR THE HIGHEST 4 BITS OF ACCUMULATOR
903B 20F2E2   16      JSR $E2F2       ;CHANGE THE A/D READING TO A FLOATING POINT NUMBER AND STORE IN FAC
903E 60       17      RTS
          18      END
```

***** END OF ASSEMBLY

```
*****
*
*  SYMBOL TABLE -- V 1.5 *
*
*****
```

LABEL. LOC. LABEL. LOC. LABEL. LOC.

** ZERO PAGE VARIABLES:

** ABSOLUTE VARIABLES/LABELS

BASE C400 LOOP 902C

SYMBOL TABLE STARTING ADDRESS:6000

SYMBOL TABLE LENGTH:0022

APPENDIX D
DAILY AND WEEKLY ENERGY CONSUMPTION
1979, 1980, and 1981

DATA FOR 1979

Aug.	13 Mon.	14 Tues	15 Wed.	16 Thur	17 Fri.	18 Sat.	19 Sun.	Total
Dry Temp degF					141.00	143.00	143.00	142.33
Heat Recovery MBTU					33.52	27.96	21.23	82.71
Collectors MBTU					11.97	15.23	13.86	41.06
Burners MBTU					0.56	0.68	0.93	2.17
Total MBTU					49.91	44.70	38.90	133.51
Gas MBTU					9.85	9.85	9.85	29.55
Electric KWthr					616.00	616.00	616.00	1848.00
Insolation BTUpFpH					1968.00	2074.00	2013.00	6055.00

Aug.	20 Mon.	21 Tues	22 Wed.	23 Thur	24 Fri.	25 Sat.	26 Sun.	Total
Dry Temp degF	142.00	142.00	142.00	145.00	141.00	144.00	146.00	143.14
Heat Recovery MBTU	27.57	27.57	27.57	16.43	18.62	20.06	16.51	154.33
Collectors MBTU	13.69	13.69	13.69	7.69	13.00	14.60	15.24	91.60
Burners MBTU	0.73	0.73	0.73	1.33	1.28	1.55	1.24	7.59
Total MBTU	44.50	44.50	44.50	31.67	35.68	36.54	32.69	270.08
Gas MBTU	9.85	9.85	9.85	6.97	6.97	6.97	6.97	57.43
Electric KWthr	616.00	616.00	616.00	732.00	732.00	732.00	732.00	4776.00
Insolation BTUpFpH	2018.00	2018.00	2018.00	1868.00	2131.00	2300.00	2171.00	14524.00

Aug.	27 Mon.	28 Tues	29 Wed.	30 Thur	31 Fri.	1 Sat.	2 Sun.	Total
Dry Temp degF	144.00	144.00	144.00	148.00	146.00	151.00	150.00	146.71
Heat Recovery MBTU	17.91	17.91	23.54	24.39	23.97	15.71	21.08	144.51
Collectors MBTU	12.63	12.63	10.55	15.18	12.87	16.88	14.84	95.58
Burners MBTU	1.35	1.35	2.43	4.58	3.50	2.21	4.74	20.16
Total MBTU	34.15	34.15	40.80	44.45	42.63	32.06	41.82	270.06
Gas MBTU	6.97	6.97	6.97	12.30	12.30	12.30	12.30	70.11
Electric KWthr	732.00	732.00	732.00	747.00	747.00	747.00	747.00	5184.00
Insolation BTUpFpH	2119.00	2119.00	1840.00	2016.00	1928.00	2000.00	1881.00	13903.00

Sept	3 Mon.	4 Tues	5 Wed.	6 Thur	7 Fri.	8 Sat.	9 Sun.	Total
Dry Temp degF	150.00	148.00	145.00	145.00	145.00	144.00	144.00	145.86
Heat Recovery MBTU	18.37	21.74	10.52	14.89	12.71	15.35	14.03	107.61
Collectors MBTU	14.25	14.10	14.27	11.68	12.98	12.24	12.61	92.13
Burners MBTU	3.08	3.42	0.35	0.88	0.62	0.48	0.55	9.38
Total MBTU	37.12	39.81	29.98	29.98	24.85	26.86	25.86	214.46
Gas MBTU	12.30	12.30	12.30	12.30	13.44	13.44	13.44	89.52
Electric KWthr	747.00	747.00	747.00	747.00	577.00	577.00	577.00	4719.00
Insolation BTUpFpH	1903.00	1928.00	1915.00	1736.00	1825.00	1985.00	1905.00	13197.00

Sept	10 Mon.	11 Tues	12 Wed.	13 Thur	14 Fri.	15 Sat.	16 Sun.	Total
Dry Temp degF	153.00	145.00	149.00	149.00	148.00	152.00	149.00	149.29
Heat Recovery MBTU	12.87	12.48	13.32	12.98	19.41	17.11	18.18	106.35
Collectors MBTU	12.87	12.48	13.32	12.89	13.95	11.75	11.50	88.76
Burners MBTU	0.79	0.27	0.18	0.41	1.17	1.49	1.27	5.58
Total MBTU	20.25	32.44	30.65	27.78	33.57	32.44	37.31	214.44
Gas MBTU	13.44	13.44	13.44	13.44	13.44	13.44	13.44	94.08
Electric KWthr	577.00	577.00	577.00	577.00	577.00	577.00	577.00	4039.00
Insolation BTUpFpH	1522.00	1430.00	1548.00	1500.00	1761.00	1761.00	1730.00	11252.00

Sept	17 Mon.	18 Tues	19 Wed.	20 Thur	21 Fri.	22 Sat.	23 Sun.	Total
Dry Temp degF	151.00	151.00	151.00	151.00	151.00	148.00	151.00	150.57
Heat Recovery MBTU	17.40	19.43	18.42	22.49	22.12	19.63	16.99	136.48
Collectors MBTU	14.41	12.19	13.30	13.75	12.76	13.37	13.85	93.63
Burners MBTU	0.96	1.72	1.36	2.40	2.65	3.33	0.89	13.31
Total MBTU	32.82	34.77	33.80	38.29	39.74	36.83	32.03	248.28
Gas MBTU	13.44	13.44	13.44	13.44	13.44	13.44	13.44	94.08
Electric KWthr	577.00	577.00	577.00	577.00	577.00	577.00	577.00	4039.00
Insolation BTUpFpH	1709.00	1821.00	1765.00	1802.00	1692.00	1698.00	1678.00	12165.00

Sept	Oct.		24	25	26	27	28	29	30
	Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	Total	
Dry Temp degF	154.00	155.00	154.00	151.00	151.00	152.00	153.00	152.86	
Heat Recovery MBTU	24.49	24.22	28.96	24.94	25.69	26.13	25.72	180.15	
Collectors MBTU	7.92	11.34	5.95	5.72	5.70	4.11	6.79	47.53	
Burners MBTU	6.05	4.69	8.30	7.86	7.72	10.91	7.59	53.12	
Total MBTU	40.23	40.66	42.28	38.20	43.02	42.17	41.10	287.66	
Gas MBTU	13.44	13.44	13.44	13.44	13.44	22.00	22.00	111.20	
Electric KWthr	577.00	577.00	577.00	577.00	577.00	518.00	518.00	3921.00	
Insolation BTUpFpH	1443.00	1722.00	1355.00	1316.00	1316.00	961.00	1352.00	9465.00	

Oct.	1	2	3	4	5	6	7	Total
	Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp degF	154.00	152.00	152.00	148.00	147.00	147.00	147.00	149.57
Heat Recovery MBTU	27.77	25.14	20.42	13.45	13.20	13.34	13.34	126.66
Collectors MBTU	11.99	14.13	3.39	11.21	7.69	9.45	9.45	67.31
Burners MBTU	5.98	3.69	8.36	1.21	1.11	1.16	1.16	22.67
Total MBTU	46.71	42.86	31.71	24.12	20.83	22.48	22.48	211.19
Gas MBTU	22.00	22.00	22.00	22.00	22.00	22.00	22.00	154.00
Electric KWthr	518.00	518.00	518.00	518.00	518.00	518.00	518.00	3626.00
Insolation BTUpFpH	1431.00	1507.00	880.00	1450.00	1398.00	1424.00	1424.00	9514.00

Oct.	8	9	10	11	12	13	14	Total
	Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp degF	145.00	145.00	145.00	0.00	146.00	148.00	148.00	125.29
Heat Recovery MBTU	14.22	17.66	17.66	0.00	21.10	22.98	22.98	116.60
Collectors MBTU	10.87	5.77	5.77	0.00	0.67	3.22	3.22	29.52
Burners MBTU	0.52	5.30	5.30	0.00	10.08	7.65	7.65	36.50
Total MBTU	21.74	26.65	26.65	0.00	31.55	32.70	32.70	171.99
Gas MBTU	22.00	22.00	22.00	0.00	22.00	20.40	20.40	128.80
Electric KWthr	518.00	518.00	518.00	0.00	518.00	622.00	622.00	3316.00
Insolation BTUpFpH	1302.00	1211.00	1211.00	1211.00	121.00	1165.00	1165.00	7386.00

Oct.	15	16	17	18	19	20	21	Total
	Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp degF	150.00	151.00	148.00	0.00	0.00	0.00	0.00	64.14
Heat Recovery MBTU	24.85	21.95	22.58	0.00	0.00	0.00	0.00	69.38
Collectors MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burners MBTU	12.13	16.19	13.45	0.00	0.00	0.00	0.00	41.77
Total MBTU	36.98	38.14	36.03	0.00	0.00	0.00	0.00	111.15
Gas MBTU	20.40	20.40	20.40	0.00	0.00	0.00	0.00	61.20
Electric KWthr	622.00	622.00	622.00	0.00	0.00	0.00	0.00	1866.00
Insolation BTUpFpH	1128.00	1228.00	1234.00	0.00	0.00	0.00	0.00	3590.00

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Aug.		25	26	27	28	29	30	31	Total
		Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp	degF		148.00	144.00	141.00	145.00	148.00	147.00	145.50
Heat Recovery	MBTU		10.96	33.92	17.52	22.83	23.81	22.49	131.53
Collectors	MBTU		11.21	12.00	12.17	17.93	15.18	16.63	85.12
Burners	MBTU		1.32	7.04	2.89	6.17	5.78	6.22	29.42
Total	MBTU		37.66	64.35	34.30	43.74	44.79	46.11	270.95
Gas	MBTU		2.68	5.40	12.30	11.80	11.80	11.80	55.78
Electric	KWthr		379.00	794.00	780.00	832.00	832.00	832.00	4449.00
Insolation	BTUpFph		2000.00	1900.00	1918.00	2200.00	2043.00	2081.00	12142.00

Sept		1	2	3	4	5	6	7	Total
		Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp	degF	143.00	147.00	148.00	151.00	150.00	149.00	144.00	147.43
Heat Recovery	MBTU	17.92	25.03	26.97	24.00	16.40	24.48	23.16	157.96
Collectors	MBTU	13.34	16.41	15.00	14.50	14.44	14.02	14.00	101.71
Burners	MBTU	13.34	16.41	15.00	14.50	14.44	14.02	14.00	101.71
Total	MBTU	35.62	44.38	36.27	41.00	35.74	45.03	47.38	285.42
Gas	MBTU	7.80	7.60	9.41	10.10	12.10	12.10	12.10	71.21
Electric	KWthr	782.00	845.00	845.00	830.00	794.00	794.00	794.00	5684.00
Insolation	BTUpFph	1800.00	2023.00	2000.00	1903.00	2000.00	1807.00	1750.00	13283.00

Sept		8	9	10	11	12	13	14	Total
		Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp	degF	150.00	150.00	148.00	148.00	147.00	147.00	1.00	148.33
Heat Recovery	MBTU	17.95	24.92	19.92	25.93	26.82	17.44	0.00	132.98
Collectors	MBTU	16.96	14.12	17.04	15.93	15.00	11.38	4.75	95.18
Burners	MBTU	3.16	7.14	4.36	5.62	10.25	3.75	0.00	34.28
Total	MBTU	43.20	45.14	42.92	45.41	46.63	21.87	0.00	245.17
Gas	MBTU	10.00	9.40	12.60	12.60	12.60	12.60	0.00	69.80
Electric	KWthr	785.00	803.00	813.00	813.00	813.00	813.00	400.00	5240.00
Insolation	BTUpFph	1750.00	1800.00	1866.00	1877.00	1877.00	1876.00	1730.00	12776.00

Sept		15	16	17	18	19	20	21	Total
		Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp	degF	1.00	151.00	153.00	145.00	147.00	150.00	151.00	149.50
Heat Recovery	MBTU	0.00	13.37	31.66	22.63	28.27	24.36	24.85	145.14
Collectors	MBTU	0.19	13.98	9.01	7.06	14.56	20.94	15.90	81.64
Burners	MBTU	0.00	3.59	5.27	9.71	9.19	5.25	6.07	39.08
Total	MBTU	0.00	34.05	50.42	42.23	48.08	44.15	46.87	265.80
Gas	MBTU	0.00	8.64	8.64	8.64	8.64	20.40	20.40	75.36
Electric	KWthr	200.00	633.00	633.00	633.00	633.00	943.00	943.00	4618.00
Insolation	BTUpFph	1753.00	1908.00	1538.00	1365.00	1748.00	2042.00	1766.00	12120.00

Sept		22	23	24	25	26	27	28	Total
		Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp	degF	152.00	152.00	148.00	152.00	149.00	150.00	149.00	150.29
Heat Recovery	MBTU	25.29	24.54	23.01	26.25	23.33	24.00	21.35	167.77
Collectors	MBTU	16.93	14.69	19.92	17.42	16.58	17.17	15.93	118.64
Burners	MBTU	5.29	3.32	4.22	5.96	5.34	4.10	6.37	34.60
Total	MBTU	40.21	38.29	47.54	47.46	43.77	48.08	43.86	309.21
Gas	MBTU	16.30	11.30	11.70	11.60	13.00	13.00	13.00	89.90
Electric	KWthr	760.00	760.00	780.00	770.00	743.00	743.00	743.00	5299.00
Insolation	BTUpFph	1911.00	1696.00	1785.00	1625.00	1579.00	1737.00	1614.00	11947.00

Sept		29	30	1	2	3	4	5	Total
		Mon.	Tues	Wed.	Thur	Fri.	Sat.	Sun.	
Dry Temp	degF	152.00	149.00	150.00	155.00	150.00	158.00	155.00	152.71
Heat Recovery	MBTU	22.37	27.12	16.34	30.71	16.14	20.44	24.40	157.52
Collectors	MBTU	23.24	16.00	15.88	15.00	14.96	14.00	13.78	112.86
Burners	MBTU	7.45	16.14	2.72	12.66	4.18	6.44	7.31	56.90
Total	MBTU	46.72	48.06	40.67	47.21	39.44	40.84	43.42	306.36
Gas	MBTU	12.90	12.90	12.90	12.90	12.90	12.90	20.20	97.60
Electric	KWthr	747.00	747.00	747.00	747.00	747.00	747.00	779.00	5261.00
Insolation	BTUpFph	1614.00	1762.00	1762.00	1626.00	1700.00	1622.00	1398.00	11484.00

Oct.		6 Mon.	7 Tues	8 Wed.	9 Thur	10 Fri.	11 Sat.	12 Sun.	Total
Dry Temp	degF	155.00	156.00	156.00	153.00	153.00	152.00	158.00	154.71
Heat Recovery	MBTU	24.74	27.36	27.93	28.73	36.63	34.00	30.60	209.99
Collectors	MBTU	14.52	13.91	14.52	14.60	13.00	12.50	12.15	95.20
Burners	MBTU	7.04	9.54	10.14	7.16	7.76	8.64	13.64	63.92
Total	MBTU	47.46	50.78	51.43	49.70	39.98	42.54	55.26	337.15
Gas	MBTU	20.20	20.20	20.20	20.20	20.20	20.20	20.20	141.40
Electric	KWthr	779.00	779.00	779.00	779.00	779.00	779.00	779.00	5453.00
Insolation	BTUpFph	1408.00	1416.00	1417.00	1400.00	1400.00	1400.00	1339.00	9780.00

Oct.		13 Mon.	14 Tues	15 Wed.	16 Thur	17 Fri.	18 Sat.	19 Sun.	Total
Dry Temp	degF	158.00	153.00	154.00	153.00	155.00	153.00	154.00	154.29
Heat Recovery	MBTU	33.32	32.36	30.61	40.54	35.24	28.40	25.92	226.39
Collectors	MBTU	11.87	9.94	11.87	6.05	12.06	14.96	13.25	80.00
Burners	MBTU	12.10	10.81	4.81	16.63	14.41	11.87	7.69	78.32
Total	MBTU	55.01	53.98	54.25	62.83	61.43	51.39	47.28	386.17
Gas	MBTU	20.20	20.20	20.20	20.20	18.30	18.30	18.30	139.70
Electric	KWthr	779.00	779.00	779.00	779.00	573.00	573.00	573.00	4835.00
Insolation	BTUpFph	1355.00	1260.00	1307.00	1062.00	1294.00	1479.00	1259.00	9016.00

Oct.		20 Mon.	21 Tues	22 Wed.	23 Thur	24 Fri.	25 Sat.	26 Sun.	Total
Dry Temp	degF	154.00	155.00	154.00	152.00	156.00	152.00	157.00	154.29
Heat Recovery	MBTU	36.49	34.54	36.26	43.86	32.09	38.58	38.92	260.74
Collectors	MBTU	11.88	12.30	11.66	11.50	11.28	0.00	12.45	71.07
Burners	MBTU	13.21	12.32	14.32	18.14	6.49	20.96	16.19	101.63
Total	MBTU	60.96	59.37	60.74	66.91	55.61	61.41	66.62	431.62
Gas	MBTU	18.30	18.30	18.30	18.30	18.30	18.30	18.30	128.10
Electric	KWthr	573.00	573.00	573.00	573.00	573.00	573.00	573.00	4011.00
Insolation	BTUpFph	1336.00	1230.00	1339.00	1280.00	1144.00	444.00	1250.00	8023.00

Oct.		27 Mon.	28 Tues	29 Wed.	30 Thur	31 Fri.	1 Sat.	2 Sun.	Total
Dry Temp	degF	156.00	155.00	150.00	150.00	152.00	151.00	149.00	151.86
Heat Recovery	MBTU	33.61	42.64	38.58	36.21	38.92	37.82	38.62	266.40
Collectors	MBTU	13.01	12.05	16.41	10.06	13.35	10.46	10.00	85.34
Burners	MBTU	10.01	12.77	9.70	11.84	12.82	12.21	14.72	84.07
Total	MBTU	55.77	64.04	64.45	59.60	60.65	60.59	56.18	421.28
Gas	MBTU	18.30	18.30	18.30	18.30	18.30	18.30	18.30	128.10
Electric	KWthr	573.00	573.00	573.00	573.00	573.00	573.00	573.00	4011.00
Insolation	BTUpFph	1260.00	1214.00	1272.00	1112.00	1197.00	1111.00	1000.00	8166.00

Nov.		3 Mon.	4 Tues	5 Wed.	6 Thur	7 Fri.	8 Sat.	9 Sun.	Total
Dry Temp	degF	155.00	152.00	150.00	152.00	151.00	139.00	1.00	149.83
Heat Recovery	MBTU	31.53	38.73	32.85	41.15	40.21	25.91	0.00	210.38
Collectors	MBTU	9.48	10.14	10.00	7.85	7.80	7.34	8.98	61.59
Burners	MBTU	7.54	15.46	11.61	15.90	18.51	7.46	0.00	76.48
Total	MBTU	45.10	62.47	54.98	65.14	66.13	37.97	0.00	331.79
Gas	MBTU	18.30	18.30	18.30	18.30	18.30	18.30	18.30	128.10
Electric	KWthr	573.00	573.00	573.00	573.00	573.00	573.00	573.00	4011.00
Insolation	BTUpFph	977.00	1031.00	770.00	983.00	83.00	938.00	930.00	5712.00

Nov.		10 Mon.	11 Tues	12 Wed.	13 Thur	14 Fri.	15 Sat.	16 Sun.	Total
Dry Temp	degF	150.00	137.00	1.00	1.00	1.00	1.00	1.00	143.50
Heat Recovery	MBTU	24.63	36.39	0.00	0.00	0.00	0.00	0.00	61.02
Collectors	MBTU	8.14	0.00	6.31	4.80	4.60	0.00	0.00	23.85
Burners	MBTU	1.83	8.98	0.00	0.00	0.00	0.00	0.00	10.81
Total	MBTU	33.71	45.37	0.00	0.00	0.00	0.00	0.00	79.08
Gas	MBTU	18.30	18.30	0.00	0.00	0.00	0.00	0.00	36.60
Electric	KWthr	573.00	573.00	300.00	300.00	250.00	0.00	0.00	1996.00
Insolation	BTUpFph	936.00	309.00	1135.00	947.00	440.00	281.00	144.00	4192.00

Nov.	17 Mon.	18 Tues	19 Wed.	20 Thur	21 Fri.	22 Sat.	23 Sun.	Total
Dry Temp degF	127.00	124.00	130.00	132.00	132.00	130.00	1.00	129.17
Heat Recovery MBTU	24.00	9.59	14.40	15.00	15.60	17.50	0.00	96.09
Collectors MBTU	7.10	6.54	6.10	0.60	0.50	6.77	0.00	27.61
Burners MBTU	2.20	1.04	1.10	4.40	4.10	5.06	0.00	17.90
Total MBTU	34.10	14.38	22.00	23.00	23.00	26.20	0.00	142.68
Gas MBTU	18.30	5.60	5.60	5.60	5.60	11.50	0.00	52.20
Electric KWthr	573.00	304.00	304.00	304.00	304.00	491.00	0.00	2280.00
Insolation BTUpFpH	940.00	939.00	900.00	360.00	370.00	834.00	800.00	5143.00

Nov.	24 Mon.	25 Tues	26 Wed.	27 Thur	28 Fri.	29 Sat.	30 Sun.	Total
Dry Temp degF	1.00	136.00	135.00	1.00	134.00	1.00	1.00	135.00
Heat Recovery MBTU	0.00	14.70	13.16	0.00	16.40	0.00	0.00	44.26
Collectors MBTU	4.28	8.09	8.08	5.20	8.09	0.00	0.00	33.74
Burners MBTU	0.00	4.06	3.56	0.00	4.60	0.00	0.00	12.22
Total MBTU	0.00	19.71	17.46	0.00	21.90	0.00	0.00	59.07
Gas MBTU	0.00	11.50	11.50	0.00	11.50	0.00	0.00	34.50
Electric KWthr	491.00	491.00	491.00	491.00	491.00	0.00	0.00	2455.00
Insolation BTUpFpH	611.00	836.00	827.00	849.00	907.00	745.00	420.00	5195.00

Dec.	1 Mon.	2 Tues	3 Wed.	4 Thur	5 Fri.	6 Sat.	7 Sun.	Total
Dry Temp degF	2.00	2.00	2.00	2.00	2.00	1.00	1.00	2.00
Heat Recovery MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Collectors MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burners MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas MBTU	11.50	11.50	11.50	18.50	18.50	0.00	0.00	71.50
Electric KWthr	491.00	491.00	491.00	563.00	563.00	0.00	0.00	2599.00
Insolation BTUpFpH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DATA FOR 1981

Aug.		10 Mon.	11 Tues	12 Wed.	13 Thur	14 Fri.	15 Sat.	16 Sun.	Total
Dry Temp	degF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Heat Recovery	MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Collectors	MBTU	0.00	0.00	0.00	0.00	0.00	0.00	5.80	5.80
Burners	MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas	MBTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric	KWthr	0.00	0.00	0.00	0.00	0.00	0.00	310.00	310.00
Insolation	BTUpFph	0.00	0.00	0.00	0.00	0.00	0.00	2155.00	2155.00

Aug.		17 Mon.	18 Tues	19 Wed.	20 Thur	21 Fri.	22 Sat.	23 Sun.	Total
Dry Temp	degF	1.00	1.00	1.00	150.00	145.00	146.00	145.00	146.50
Heat Recovery	MBTU	0.00	0.00	0.00	0.00	26.80	24.20	24.62	75.62
Collectors	MBTU	4.32	0.00	0.00	0.00	19.96	20.10	16.64	61.02
Burners	MBTU	0.00	0.00	0.00	0.40	4.01	4.43	4.94	13.78
Total	MBTU	0.00	0.00	0.00	12.70	49.23	49.57	49.64	161.14
Gas	MBTU	0.00	0.00	0.00	1.00	6.00	6.70	6.70	19.40
Electric	KWthr	60.00	0.00	0.00	183.00	880.00	869.00	869.00	2861.00
Insolation	BTUpFph	2160.00	2160.00	2160.00	2160.00	2101.00	2002.00	1941.00	14684.00

Aug.		24 Mon.	25 Tues	26 Wed.	27 Thur	28 Fri.	29 Sat.	30 Sun.	Total
Dry Temp	degF	145.00	144.00	146.00	141.00	155.00	155.00	150.00	148.00
Heat Recovery	MBTU	22.05	21.20	19.98	20.00	20.00	20.00	25.97	149.20
Collectors	MBTU	20.93	16.70	18.59	18.00	18.00	18.00	18.25	128.47
Burners	MBTU	4.57	5.22	6.42	6.00	6.00	6.00	3.70	37.91
Total	MBTU	47.32	44.82	43.76	45.00	45.00	45.00	47.81	318.71
Gas	MBTU	6.70	6.70	9.95	9.95	9.95	9.95	9.95	63.15
Electric	KWthr	869.00	869.00	869.00	876.00	876.00	775.00	775.00	5909.00
Insolation	BTUpFph	2094.00	1767.00	1891.00	1900.00	1900.00	1900.00	1910.00	13362.00

Sept		31 Mon.	1 Tues	2 Wed.	3 Thur	4 Fri.	5 Sat.	6 Sun.	Total
Dry Temp	degF	154.00	154.00	154.00	149.00	145.00	150.00	150.00	150.86
Heat Recovery	MBTU	25.00	22.00	22.00	24.69	29.76	22.33	26.88	172.66
Collectors	MBTU	29.18	15.00	15.00	13.44	14.00	17.64	17.22	121.48
Burners	MBTU	7.90	5.49	5.49	5.05	7.90	6.18	8.10	46.11
Total	MBTU	41.00	40.47	40.47	33.69	39.34	44.45	47.46	286.88
Gas	MBTU	9.95	9.95	9.95	9.95	9.95	9.95	9.95	69.65
Electric	KWthr	775.00	775.00	775.00	775.00	775.00	775.00	775.00	5425.00
Insolation	BTUpFph	2339.00	1900.00	1800.00	1776.00	1800.00	1765.00	1899.00	13279.00

Sept		7 Mon.	8 Tues	9 Wed.	10 Thur	11 Fri.	12 Sat.	13 Sun.	Total
Dry Temp	degF	149.00	148.00	148.00	145.00	150.00	152.00	150.00	148.86
Heat Recovery	MBTU	20.00	19.27	20.70	30.70	26.00	24.45	28.10	169.22
Collectors	MBTU	15.00	12.87	15.89	15.89	14.00	12.55	13.08	99.28
Burners	MBTU	5.00	2.40	3.72	4.72	5.00	5.00	4.50	30.34
Total	MBTU	39.00	37.83	38.15	45.15	40.00	41.30	47.92	289.35
Gas	MBTU	9.95	9.95	9.95	9.95	9.90	9.10	9.10	67.90
Electric	KWthr	775.00	775.00	775.00	775.00	899.00	899.00	899.00	5797.00
Insolation	BTUpFph	1700.00	1689.00	1200.00	614.00	1500.00	1468.00	1540.00	9711.00

Sept		14 Mon.	15 Tues	16 Wed.	17 Thur	18 Fri.	19 Sat.	20 Sun.	Total
Dry Temp	degF	149.00	146.00	148.00	155.00	152.00	1.00	1.00	150.00
Heat Recovery	MBTU	32.20	33.35	31.24	30.17	46.15	0.00	0.00	173.11
Collectors	MBTU	11.81	0.00	0.00	8.17	8.62	2.10	0.00	30.70
Burners	MBTU	7.74	11.84	17.22	8.40	8.74	0.00	0.00	53.94
Total	MBTU	48.29	48.29	48.46	45.29	60.90	0.00	0.00	251.23
Gas	MBTU	9.10	12.10	20.10	11.80	0.00	0.00	0.00	53.10
Electric	KWthr	899.00	899.00	899.00	899.00	899.00	120.00	0.00	4615.00
Insolation	BTUpFph	1554.00	1513.00	1696.00	1556.00	1328.00	1244.00	0.00	8891.00

Sept		21 Mon.	22 Tues	23 Wed.	24 Thur	25 Fri.	26 Sat.	27 Sun.	Total
Dry Temp	degF	151.00	1.00	1.00	1.00	1.00	1.00	1.00	151.00
Heat Recovery	MBTU	13.70	0.00	0.00	0.00	0.00	0.00	0.00	13.70
Collectors	MBTU	8.17	4.00	5.26	4.40	0.00	0.00	0.00	21.83
Burners	MBTU	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Total	MBTU	19.55	0.00	0.00	0.00	0.00	0.00	0.00	19.55
Gas	MBTU	6.50	0.00	0.00	0.00	0.00	0.00	0.00	6.50
Electric	KWthr	310.00	200.00	200.00	200.00	0.00	0.00	0.00	910.00
Insolation	BTUpFph	1482.00	1526.00	1460.00	1904.00	0.00	0.00	0.00	6372.00

APPENDIX E
DETAILED DAILY REPORT

COLLECTOR EVALUATION L&P

August 23 1981

54 Data points/scan

46 Scans

NORTH FIELD

SOUTH FIELD

Day	time	WB	DB	Supply	Out#1	Out#8	Out#15	Avg	Delta	Supply	Out#1	Out#8	Out#15	Avg	Delta
0223	00:02	67.9	71.5	86.6	70.5	70.0	69.6	72.2	-14.4	87.0	70.8	0.0	70.5	73.7	-13.3
0223	00:02	67.0	70.2	86.1	69.1	68.5	67.8	70.5	-15.6	86.6	68.9	68.6	69.1	71.9	-14.4
0223	01:02	66.2	69.4	83.8	67.7	67.1	66.4	69.1	-14.7	83.9	67.4	67.2	67.9	70.5	-13.4
0223	01:32	65.1	68.0	82.2	66.6	66.0	65.5	68.2	-14.0	82.2	66.3	65.9	66.7	69.6	-12.6
0223	02:02	64.4	67.0	82.6	65.3	64.7	64.5	67.3	-15.3	82.4	65.0	64.3	65.3	68.4	-14.0
0223	02:32	63.5	66.2	83.5	64.0	63.4	63.3	66.6	-17.3	83.2	63.7	62.5	63.3	67.1	-16.1
0223	03:02	63.1	65.6	84.4	62.8	62.1	62.0	65.5	-19.4	84.1	62.5	61.3	62.0	65.9	-18.5
0223	03:32	61.1	63.0	85.9	60.1	59.7	59.4	62.2	-23.4	85.7	60.0	59.1	59.7	63.4	-22.3
0223	04:02	60.6	62.5	86.0	59.1	58.7	58.6	61.1	-24.5	85.7	59.5	58.6	59.7	62.5	-22.3
0223	04:32	60.3	62.2	87.2	57.7	57.6	57.4	60.0	-27.1	87.0	58.5	57.9	57.8	61.4	-26.6
0223	05:02	58.8	60.9	87.4	56.3	56.6	56.0	59.1	-28.5	87.4	57.9	57.4	57.3	60.6	-27.3
0223	05:32	58.8	60.9	86.7	55.6	55.5	55.6	58.4	-29.0	87.0	57.0	56.4	56.5	59.7	-27.7
0223	06:02	58.6	60.5	86.7	55.6	55.5	55.6	57.9	-28.8	86.6	56.7	56.6	56.7	59.1	-27.7
0223	07:02	59.6	60.6	85.3	56.8	56.6	56.9	58.8	-24.5	85.9	57.2	56.7	57.5	59.2	-26.7
0223	07:32	61.8	63.7	85.3	60.0	60.0	60.8	61.1	-24.2	84.6	60.3	60.4	61.1	62.3	-32.3
0223	08:02	63.8	65.9	87.7	66.7	67.0	68.8	65.9	-19.9	85.0	67.6	68.4	67.3	67.5	-17.5
0223	08:32	66.7	69.4	90.6	78.7	78.7	80.8	75.3	-15.3	86.7	79.1	81.1	80.6	72.7	-13.0
0223	09:02	68.5	71.3	90.4	92.8	92.4	94.2	85.5	-4.9	89.4	91.2	94.0	94.0	85.3	-4.1
0223	09:32	70.9	74.7	96.5	129.1	128.0	128.4	127.4	30.9	96.0	131.8	131.0	129.0	129.0	33.0
0223	10:02	72.8	77.3	110.6	139.8	140.5	140.6	139.7	29.0	109.9	141.8	141.5	141.8	140.2	30.3
0223	10:32	73.5	79.7	114.6	146.5	147.1	147.4	146.6	33.0	114.4	148.2	147.4	147.4	146.5	32.5
0223	11:02	76.5	82.0	116.4	154.5	156.0	156.4	155.6	38.7	115.9	156.6	156.3	156.3	155.1	39.2
0223	11:32	77.7	83.3	117.3	162.2	163.9	164.6	163.1	45.7	117.1	164.0	163.5	163.4	162.2	45.1
0223	12:02	78.4	84.6	116.7	168.3	169.8	170.9	169.1	51.8	117.4	170.1	169.4	169.4	168.3	50.9
0223	12:32	79.5	87.0	115.9	173.7	173.9	174.7	172.9	56.2	117.1	174.0	172.9	172.7	172.0	54.9
0223	13:02	81.0	88.8	115.7	174.6	176.8	177.4	175.5	59.8	116.6	175.2	174.8	174.5	173.5	56.9
0223	14:02	80.5	88.1	115.5	173.1	174.5	175.4	173.6	55.0	116.6	176.6	175.4	175.4	174.6	58.0
0223	14:32	82.4	89.8	115.8	171.3	172.6	173.2	171.7	55.9	116.6	175.3	174.0	173.9	173.2	56.4
0223	15:02	81.8	88.8	117.8	167.2	168.4	168.8	167.6	49.8	119.8	169.6	168.3	167.9	167.7	48.7
0223	16:02	82.3	89.4	119.7	145.7	144.6	146.0	145.6	26.0	119.8	148.7	146.6	146.5	146.9	27.1
0223	17:02	82.0	88.8	116.0	142.2	139.8	143.2	142.0	15.3	116.6	148.7	145.8	145.6	146.0	29.4
0223	17:32	84.2	89.2	116.0	131.9	128.5	132.3	131.3	3.8	116.6	140.3	136.8	136.7	137.4	20.8
0223	18:02	84.3	90.8	114.3	117.5	114.8	118.3	118.1	-0.9	114.9	129.5	125.7	124.7	126.2	11.3
0223	18:32	81.4	87.8	108.4	106.0	104.0	105.8	107.5	-6.4	109.3	116.9	113.8	110.5	116.1	6.8
0223	19:02	77.6	83.1	104.3	98.6	97.2	97.5	99.9	-6.2	105.5	106.5	102.5	100.4	107.1	2.1
0223	19:32	75.6	80.7	99.3	92.6	90.6	90.7	93.1	-6.6	100.2	97.5	93.7	92.5	98.7	-1.5
0223	20:02	74.0	78.6	94.1	86.3	85.3	85.0	87.5	-6.4	95.2	90.1	86.8	86.3	91.8	-3.4
0223	21:02	72.1	76.1	89.9	82.2	81.4	81.0	83.5	-7.9	91.0	84.9	82.2	81.8	86.7	-4.3
0223	22:02	70.8	74.3	87.9	78.6	77.9	77.4	80.0	-9.4	88.8	80.4	78.4	78.0	82.5	-6.3
0223	23:02	69.5	72.7	86.5	75.7	75.0	74.5	77.1	-10.9	87.3	77.0	75.1	75.1	79.3	-8.0
0223	23:32	67.9	70.8	85.5	73.2	72.4	72.0	74.6	-11.8	86.0	73.9	72.7	72.4	76.5	-9.5
0223	23:52	66.7	69.7	84.2	71.0	70.5	70.0	72.4	-13.3	84.9	71.7	70.6	70.5	74.1	-10.8
0223	23:52	65.5	68.2	83.7	68.7	68.3	67.9	70.4	-14.6	84.3	69.3	68.5	68.6	72.0	-12.3
0223	23:52	64.2	66.7	83.0	66.9	66.5	66.1	68.4		83.5	67.4	66.7	66.8	70.1	-13.4

HEAT RECOVERY

Time	Air I	Air O	Delta	Ex I	Ex O	Delta	PcF1	AmpF1	HR	collector	burners	storage	total
0:02	78.8	117.5	38.7	129.7	84.3	45.4	0.81	31.80	23268	0	3574	18679	45522
0:03	72.3	93.3	21.0	129.5	73.1	56.4	0.85	32.57	13514	0	1223	29033	43770
0:03	71.0	93.4	21.4	129.3	71.9	57.4	0.84	32.44	13636	0	7951	30370	51957
1:03	72.5	116.9	44.4	130.4	79.5	50.9	0.78	31.29	26108	0	5387	19842	51336
2:03	70.4	117.7	47.4	131.8	77.7	54.1	0.85	31.75	29156	0	5747	14493	49397
3:03	69.4	118.0	48.6	132.3	76.7	55.6	0.70	31.13	21790	0	3715	19997	45501
3:03	69.3	119.3	50.0	132.7	76.7	56.0	0.82	31.71	30080	0	2373	13877	46330
3:03	69.3	119.3	50.0	132.7	76.7	56.0	0.82	31.71	30080	0	2373	13877	46330
4:03	66.4	119.4	53.0	132.5	74.9	57.6	0.67	31.78	28815	0	38	16394	45248
4:03	69.0	119.6	50.6	130.8	77.9	52.9	0.64	31.42	25400	0	0	14758	40158
5:03	69.1	119.4	50.3	129.9	77.9	52.0	0.66	31.07	25255	0	0	12401	37656
6:03	67.3	117.3	50.0	127.7	76.1	51.6	0.66	31.33	25274	0	0	10767	36041
6:03	63.4	114.5	51.1	125.0	72.2	52.8	0.66	31.61	26059	0	0	9689	35748
6:03	64.2	114.0	49.8	124.6	72.4	52.2	0.66	31.52	25268	0	1926	7560	34754
7:03	66.6	117.7	51.1	130.0	74.8	55.2	0.84	32.41	31560	0	13744	0	45304
7:03	65.6	115.8	50.2	130.0	73.3	56.8	0.84	32.93	30783	0	14419	0	45202
8:03	71.2	117.7	46.5	131.4	77.7	53.9	0.85	31.72	28194	0	11739	0	39932
8:03	75.2	119.4	44.2	132.3	81.4	50.9	0.85	31.57	27114	0	11735	0	38848
9:03	81.8	118.4	36.6	131.4	86.0	45.4	0.79	31.80	21669	0	6081	0	27750
9:03	81.7	96.0	14.3	101.5	84.3	17.2	0.65	31.89	7097	16849	5759	0	29705
10:03	84.9	103.9	19.0	108.4	88.4	20.0	0.46	30.04	7488	26566	1782	-13185	22652
10:03	86.8	108.3	21.5	111.7	91.9	19.8	0.40	28.35	7601	31267	717	-19558	20028
11:03	87.4	110.7	23.3	114.7	92.9	21.8	0.42	29.48	10151	36736	2211	-23511	25586
11:03	89.9	112.6	22.7	116.8	94.9	21.9	0.46	29.23	10604	42661	1411	-29382	25294
12:03	92.9	115.0	22.1	119.3	97.9	21.3	0.68	30.51	12310	41883	2748	-37296	19545
12:03	91.4	116.5	25.1	121.2	97.2	24.0	0.48	29.34	11577	49958	0	-35545	25989
13:03	94.2	118.3	24.1	122.8	99.4	23.4	0.50	30.23	11364	50837	0	-38850	23352
13:03	94.8	120.0	25.2	124.7	100.3	24.4	0.47	29.14	11542	53484	0	-39335	25690
14:03	95.6	121.4	25.8	126.1	101.3	24.8	0.75	30.16	14788	43131	3450	-45094	16275
14:03	96.4	122.4	26.0	127.1	102.3	24.9	0.46	29.35	11645	49952	1549	-36747	26398
15:03	96.1	123.5	27.4	128.0	102.5	25.5	0.47	29.39	12401	44605	0	-32849	24157
16:03	94.1	111.5	17.4	115.1	98.1	17.0	0.60	30.70	7716	16472	1195	-3945	21438
17:03	92.9	115.2	22.3	121.3	96.9	24.4	0.67	31.73	10676	12450	916	0	24041
17:03	91.7	116.1	24.4	122.8	96.0	26.8	0.69	31.19	12063	5124	1615	5136	23938
18:03	91.8	117.9	26.1	125.0	96.0	29.0	0.68	30.24	14351	0	0	15846	30197
18:03	91.8	118.9	27.4	127.4	95.4	32.0	0.74	31.02	15728	0	3635	16428	35792
19:03	88.6	119.8	31.2	129.2	93.0	36.2	0.75	30.12	17924	0	1273	17789	36986
19:03	81.8	99.7	17.9	129.8	82.8	47.0	0.88	31.84	11539	0	2846	21591	35977
20:03	79.9	90.6	10.7	128.4	80.4	48.0	0.88	31.76	7027	0	9461	30535	47023
20:03	81.5	102.5	21.0	110.4	85.8	24.6	0.73	31.19	9727	0	3713	29180	42619
21:03	80.8	105.4	24.6	114.0	85.2	28.7	0.85	32.11	15493	0	5405	19339	40237
22:03	79.5	107.1	27.6	116.4	84.6	31.8	0.88	32.32	17491	0	8749	18119	44359
22:03	77.5	108.5	31.0	118.4	83.4	35.0	0.87	31.60	19602	0	5949	18337	43888
23:03	75.6	109.6	34.0	120.5	82.9	37.6	0.72	31.24	18231	0	2472	27354	48056
23:03	76.8	111.6	34.8	123.1	81.4	41.7	0.88	31.82	22696	0	7222	16815	46733
23:03	73.3	104.0	30.7	114.5	79.3	35.2	0.75	31.63	18161	0	1962	27504	47627
totals 10^6 BTU										24.624	16.648	4.936	49.699

FLOWS

Time	AmpF2	PsF2	M105	M106	M107	M108	M*
0:02	0.0	1.4	20936.8	0.0	15523.8	0.0	15386.9
0:32	0.0	1.5	22772.1	0.0	17114.0	0.0	14478.7
1:02	0.0	1.5	24012.7	0.0	18725.1	0.0	12815.0
1:32	0.0	1.3	23532.9	0.0	17472.2	0.0	11965.4
2:02	0.0	1.3	18531.3	0.0	13680.6	0.0	18669.3
2:32	0.0	1.6	27123.2	0.0	19847.5	0.0	0.0
3:02	0.0	1.4	20723.9	0.0	14560.9	0.0	15753.7
3:32	0.0	1.4	20723.9	0.0	14560.9	0.0	15753.7
4:02	0.0	1.8	29507.3	0.0	20893.9	0.0	3469.8
4:32	0.0	1.8	30459.1	0.0	21319.8	0.0	0.0
5:02	0.0	1.8	30456.5	0.0	21422.3	0.0	0.0
5:32	0.0	1.8	30554.4	0.0	21296.6	0.0	0.0
6:02	0.0	1.8	30676.2	0.0	21536.6	0.0	0.0
6:32	0.0	1.7	30495.4	0.0	21222.8	0.0	0.0
7:02	0.0	0.8	4220.9	0.0	6125.1	0.0	32771.8
7:32	0.0	0.8	4249.5	0.0	5944.4	0.0	32710.3
8:02	0.0	0.8	4199.5	0.0	0.0	0.0	32856.8
8:32	0.0	0.8	3945.4	0.0	0.0	0.0	33240.0
9:02	0.0	1.4	32559.8	0.0	0.0	0.0	32559.6
10:02	46.3	2.5	28853.9	27301.0	20446.2	30674.9	0.0
10:32	60.4	4.6	23233.7	21399.5	17196.2	53326.1	0.0
11:02	59.7	5.0	21000.0	19431.1	16252.7	58197.7	0.0
11:32	59.7	5.1	20393.4	18134.5	16183.7	56802.8	5596.2
12:02	61.1	4.9	18334.0	16454.9	15010.4	56672.5	9013.6
12:32	61.1	3.8	6804.5	4030.1	6545.7	49197.3	26383.7
13:02	61.1	4.7	17473.9	15751.8	14567.3	54195.9	10301.0
13:32	61.1	4.9	15015.4	12930.4	12352.2	52983.0	13466.7
14:02	61.1	4.9	17506.3	15727.3	14499.8	54626.4	10230.5
14:32	60.2	3.4	1763.8	15584.3	4048.2	45371.6	33036.8
15:02	60.2	4.8	17450.1	16338.4	14940.4	54380.7	9778.5
16:02	39.5	4.8	18149.6	15951.8	14756.1	54689.4	9419.8
17:02	0.0	3.3	26454.5	24417.8	19944.7	37689.3	0.0
17:32	0.0	3.4	28747.1	26475.5	20666.7	27039.6	0.0
18:02	0.0	2.0	29715.5	15100.7	21563.1	17069.9	0.0
18:32	0.0	1.8	29859.1	0.0	21507.0	0.0	3297.3
19:02	0.0	1.7	27428.2	0.0	20106.8	0.0	7264.9
19:32	0.0	1.8	27627.8	0.0	19804.2	0.0	7170.5
20:02	0.0	1.5	21404.2	0.0	16146.1	0.0	16301.6
20:32	0.0	1.5	25804.8	0.0	20332.2	0.0	11989.3
21:02	0.0	1.8	27239.5	0.0	20792.4	0.0	0.0
21:32	0.0	1.6	18531.5	0.0	13359.0	0.0	18704.1
22:02	0.0	1.5	17704.2	0.0	13991.1	0.0	20018.9
22:32	0.0	1.5	18265.6	0.0	13555.1	0.0	19338.8
23:02	0.0	1.8	27770.4	0.0	20977.2	0.0	6394.4
23:32	0.0	1.4	17831.6	0.0	13586.1	0.0	19876.3
23:32	0.0	1.8	25973.9	0.0	19316.7	0.0	8943.2

DAMPERS

D1A	D1B	D2	D2V	D3	D4A
0	100	0	0	103	73
0	100	0	0	103	70
0	100	0	0	103	81
0	100	0	0	103	85
0	100	0	0	103	75
0	100	0	0	103	100
0	100	0	0	103	69
0	100	0	0	103	69
0	100	0	0	103	84
0	100	0	0	103	100
0	100	0	0	103	100
0	100	0	0	103	100
0	100	0	0	103	100
0	100	0	0	103	100
0	100	0	0	103	100
0	0	0	0	103	11
0	7	0	0	103	10
0	0	0	0	103	0
0	0	0	0	103	0
100	0	0	0	103	0
100	0	100	50	103	100
100	0	100	101	103	100
100	0	100	101	103	96
100	0	100	101	103	85
100	0	100	101	103	60
100	0	101	101	103	74
100	0	101	101	103	71
100	0	101	101	103	72
100	0	101	101	103	61
100	0	101	101	103	93
100	0	101	101	103	83
76	23	101	0	103	100
76	23	0	0	103	100
44	59	0	0	103	100
0	100	0	0	103	93
0	100	0	0	103	93
0	100	0	0	103	83
0	100	0	0	103	72
0	100	0	0	103	88
0	100	0	0	103	100
0	100	0	0	103	61
0	100	0	0	103	72
0	100	0	0	103	71
0	100	0	0	103	95
0	100	0	0	103	71
0	100	0	0	103	77

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Time	TempIn	ToField	BotSt	ToCol	FromCl	FromSt	FromHR	InTun	MidTun	EndTun	Sol136	SolHoz	Coll	Eff
00:00:00	78.8	1113	1117	86.8	73	171.6	117.7	147.2	154.5	129.7	25.2	1.2	0.0	0.0
00:00:01	72.3	1096	1096	86.6	71	170.3	117.5	146.2	148.5	129.9	25.2	1.2	0.0	0.0
00:00:02	71.1	1093	1093	86.3	69	168.6	117.3	146.6	145.6	129.9	25.2	1.2	0.0	0.0
00:00:03	72.7	1088	1088	86.2	67	167.3	117.4	145.3	145.9	129.9	25.2	1.2	0.0	0.0
00:00:04	70.5	1085	1085	86.3	66	165.3	117.7	145.5	147.7	129.9	25.2	1.2	0.0	0.0
00:00:05	69.9	1083	1083	86.4	66	163.3	117.8	144.9	149.8	129.9	25.2	1.2	0.0	0.0
00:00:06	69.9	1080	1080	86.4	66	159.8	117.9	144.4	149.8	129.9	25.2	1.2	0.0	0.0
00:00:07	66.4	1075	1075	85.9	66	153.0	117.9	145.6	145.7	129.9	25.2	1.2	0.0	0.0
00:00:08	66.4	1075	1075	85.5	66	148.9	117.9	145.0	142.9	129.9	25.2	1.2	0.0	0.0
00:00:09	69.0	1075	1075	85.5	66	144.1	117.9	145.1	140.0	129.9	25.2	1.2	0.0	0.0
00:00:10	67.7	1077	1077	87.7	66	138.9	117.7	143.7	140.0	129.9	25.2	1.2	0.0	0.0
00:00:11	63.4	1072	1072	86.4	65	133.3	117.4	143.3	136.3	129.9	25.2	1.2	0.0	0.0
00:00:12	66.1	1065	1065	86.6	66	129.9	117.4	142.8	133.3	129.9	25.2	1.2	0.0	0.0
00:00:13	65.6	1062	1062	86.5	66	122.6	117.7	141.9	140.5	129.9	25.2	1.2	0.0	0.0
00:00:14	71.7	1052	1052	85.4	66	118.5	117.8	139.6	139.6	129.9	25.2	1.2	0.0	0.0
00:00:15	75.2	1044	1044	87.7	66	108.7	117.9	142.1	142.1	129.9	25.2	1.2	0.0	0.0
00:00:16	81.1	1035	1035	89.6	65	107.3	118.4	142.6	142.9	129.9	25.2	1.2	0.0	0.0
00:00:17	84.9	1025	1025	96.6	64	129.4	118.8	142.5	142.5	129.9	25.2	1.2	0.0	0.0
00:00:18	86.8	1022	1022	114.3	66	146.9	118.8	142.4	145.2	129.9	25.2	1.2	0.0	0.0
00:00:19	87.7	1020	1020	116.2	66	162.7	118.8	143.8	145.2	129.9	25.2	1.2	0.0	0.0
00:00:20	89.2	1014	1014	117.7	68	168.9	118.5	141.0	146.1	129.9	25.2	1.2	0.0	0.0
00:00:21	91.4	1018	1018	116.9	72	172.2	116.5	151.0	151.0	129.9	25.2	1.2	0.0	0.0
00:00:22	94.2	1019	1019	112.5	74	174.5	118.3	150.8	149.0	129.9	25.2	1.2	0.0	0.0
00:00:23	95.6	1022	1022	116.6	75	175.5	120.0	153.9	150.0	129.9	25.2	1.2	0.0	0.0
00:00:24	96.6	1022	1022	116.6	73	174.1	121.4	141.8	147.5	129.9	25.2	1.2	0.0	0.0
00:00:25	94.1	1023	1023	117.7	67	168.7	122.3	139.7	143.7	129.9	25.2	1.2	0.0	0.0
00:00:26	94.1	1013	1013	119.8	64	147.6	111.5	144.4	148.2	129.9	25.2	1.2	0.0	0.0
00:00:27	91.7	1017	1017	116.3	64	145.4	111.6	139.8	144.5	129.9	25.2	1.2	0.0	0.0
00:00:28	91.5	1017	1017	114.6	66	150.8	117.7	147.9	147.1	129.9	25.2	1.2	0.0	0.0
00:00:29	91.5	1017	1017	108.8	66	156.1	118.9	138.9	147.3	129.9	25.2	1.2	0.0	0.0
00:00:30	88.6	1018	1018	104.7	65	159.5	119.9	147.0	150.0	129.9	25.2	1.2	0.0	0.0
00:00:31	81.9	1033	1033	99.8	66	162.0	124.2	143.2	148.6	129.9	25.2	1.2	0.0	0.0
00:00:32	79.9	1033	1033	99.9	66	164.4	124.5	142.5	148.6	129.9	25.2	1.2	0.0	0.0
00:00:33	81.1	1033	1033	99.9	66	166.7	124.8	142.8	147.5	129.9	25.2	1.2	0.0	0.0
00:00:34	80.8	1033	1033	99.9	66	168.1	125.1	141.1	151.6	129.9	25.2	1.2	0.0	0.0
00:00:35	79.6	1033	1033	99.9	66	168.8	125.4	141.4	148.9	129.9	25.2	1.2	0.0	0.0
00:00:36	77.7	1033	1033	99.9	66	169.0	125.5	141.5	152.2	129.9	25.2	1.2	0.0	0.0
00:00:37	77.5	1033	1033	99.9	66	168.4	125.6	143.3	149.3	129.9	25.2	1.2	0.0	0.0
00:00:38	73.3	1033	1033	99.9	66	168.4	125.6	143.3	148.5	129.9	25.2	1.2	0.0	0.0
00:00:39	73.3	1033	1033	99.9	66	167.2	125.6	147.6	152.0	129.9	25.2	1.2	0.0	0.0

STORAGE TEMPERATURE EVALUATION

Time	AirIn	3 ft. from top			6 ft. from top			AirOut
		Center	North	West	Center	North	West	
00:02	73.0	175.8	174.6	160.0	176.4	176.4	116.6	117.7
00:32	71.2	174.6	172.4	156.8	174.3	174.3	117.5	96.5
01:02	69.8	173.4	169.8	153.2	171.9	171.9	118.4	95.5
01:32	68.9	172.2	167.2	149.9	169.3	169.3	118.5	116.4
02:02	67.9	171.0	164.6	146.6	166.5	166.5	116.4	118.0
02:32	66.6	169.6	161.5	143.2	163.4	163.4	112.8	118.3
03:02	65.5	168.2	158.1	139.6	160.0	160.0	110.4	119.2
03:32	65.5	168.2	158.1	139.6	160.0	160.0	110.4	119.2
04:02	63.0	165.1	149.7	134.6	151.9	151.9	114.7	119.3
04:32	62.0	163.7	145.0	130.5	147.5	147.5	117.9	119.5
05:02	60.0	161.9	138.9	126.0	141.5	141.5	120.7	119.4
05:32	59.9	160.2	133.0	122.5	136.4	136.4	122.2	117.6
06:02	58.5	158.2	127.8	119.9	130.9	130.9	123.3	114.9
06:32	58.7	154.9	121.8	118.8	126.5	126.5	123.2	114.4
07:02	58.7	154.1	121.8	118.8	123.7	123.7	123.3	117.7
07:32	66.6	152.2	122.0	118.0	123.5	123.5	123.3	114.0
08:02	73.0	150.7	122.2	117.7	123.5	123.5	123.3	111.7
08:32	85.4	149.0	122.3	118.0	123.5	123.5	123.3	111.4
09:02	128.2	147.1	122.4	118.1	123.7	123.7	123.3	111.7
09:32	140.0	140.4	125.1	119.3	126.3	126.3	123.3	103.6
10:02	146.6	138.3	131.0	122.3	136.2	136.2	122.8	113.6
10:32	155.1	136.5	140.7	126.3	147.6	147.6	122.1	114.8
11:02	162.6	134.3	150.6	130.7	156.4	156.4	121.1	116.0
11:32	168.7	131.7	159.1	136.3	164.2	164.2	120.6	116.2
12:02	172.5	128.5	166.5	143.3	170.7	170.7	119.1	115.6
12:32	174.0	127.7	172.3	150.5	175.1	175.1	117.6	114.1
13:02	175.1	127.9	176.0	159.3	177.6	177.6	117.3	112.5
13:32	173.4	128.2	178.1	166.6	178.6	178.6	116.8	111.5
14:02	171.5	126.4	178.6	171.7	178.0	178.0	117.3	111.3
14:32	167.7	124.2	177.6	175.0	176.1	176.1	125.3	111.9
15:02	146.2	124.1	167.2	176.5	162.7	162.7	125.1	113.6
15:32	144.0	123.1	166.6	176.5	161.1	161.1	135.7	124.2
16:02	134.4	122.2	167.7	176.5	162.5	162.5	132.8	117.0
16:32	122.2	122.2	169.8	176.7	165.9	165.9	131.4	117.3
17:02	111.8	121.0	172.2	176.4	169.4	169.4	133.2	118.8
17:32	103.9	116.7	173.9	175.9	171.8	171.8	130.8	119.9
18:02	95.9	111.0	175.2	174.7	173.7	173.7	128.8	120.5
18:32	89.7	109.3	175.9	172.9	175.0	175.0	126.7	103.0
19:02	85.1	107.2	176.2	170.7	175.9	175.9	125.3	96.3
19:32	81.3	105.4	176.1	168.3	176.3	176.3	124.0	103.7
20:02	78.2	103.7	175.5	166.4	176.2	176.2	121.2	106.4
20:32	75.6	102.2	174.5	162.2	175.6	175.6	117.0	108.1
21:02	73.3	100.8	173.1	159.9	174.7	174.7	113.1	109.3
21:32	71.3	99.8	171.4	155.8	173.3	173.3	110.9	110.1
22:02	69.3	98.8	169.1	152.1	171.3	171.3	110.4	112.0
22:32							111.1	104.7